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28. THE STRATIGRAPHY OF NEOGENE SILICOFLAGELLATES FROM THE NORWEGIAN SEA, ODP LEG 104[1]

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ABSTRACT

A quantative study was made of silicoflagellates recovered from Sites 642 (lower Miocene–upper Pliocene), 643 (lower Miocene–upper Miocene), and 644 (upper Pliocene–Quaternary) on the Vøring Plateau. Although disconformities are present in these sequences, they represent a much more complete record of the Neogene than was recovered previously in the Norwegian Sea by DSDP Leg 38.

Silicoflagellates are rare or absent for glacial sequences younger than 2.65 Ma, and generally sparse and poorly preserved in the lower upper Pliocene and upper Miocene. Lower and middle Miocene assemblages are diverse and generally well preserved. Temporal changes in the silicoflagellate assemblage are indicative of major paleoceanographic changes in the Norwegian Sea. A regional zonation for the Neogene of the Norwegian Sea is proposed, consisting of eleven zones: *Naviculopsis lata* Zone, *N. quadrata* Zone (emended), *N. ponticula* Zone (emended), *Distephanus speculum hemisphaericus* Zone (new), *Caryocha ernestinae* Zone (new), *Bachmannocena circulus* var. *apiculata/Caryocha* Zone (new), *Distephanus crux scutulatus* Zone (new), *Bachmannocena diodon nodosa* Zone (new), *Distephanus boliviensis* Zone (new), *Ds. jimlingii* Zone (elevated from subzonal to zonal status) with Subzones a and b (new), and *Ds. speculum* Zone (new). The ranges and abundances of over 100 species and morphotypes are tabulated.

INTRODUCTION

The ODP Leg 104 drilling program was intended to examine the nature and origin of the Vøring marginal high and the Cenozoic paleoenvironment of the Norwegian-Greenland Sea, with eight holes drilled at three sites (Sites 642, 643, and 644; Fig. 1) along a short transect roughly perpendicular to the Vøring Plateau margin (Eldholm, Thiede, Taylor, et al., 1987). Our major emphasis here is on the silicoflagellate biostratigraphy of the Neogene sedimentary sequences recovered by Leg 104. In a separate contribution Ciesielski and Case (this volume) present a paleoenvironmental interpretation of the silicoflagellate assemblages described herein.

ODP Leg 104 drilled the first sedimentary sequences in the Norwegian Sea since the initial drilling in the region by Deep Sea Drilling Project Leg 38. Seventeen sites were drilled in the Norwegian-Greenland Sea by Leg 38; however, they were discontinuously rotary-cored, providing a sporadic record of the middle Eocene to Quaternary (Talwani, Udintsev, et al., 1976). In contrast, the three sites drilled by Leg 104 on the Vøring Plateau were continuously cored using nondisturbance coring techniques (Advanced Piston Corer (APC) and Extended Core Barrel Corer (XCB), providing the first undisturbed continuous sedimentary sequences from the Norwegian Sea.

The silicoflagellate-bearing sedimentary sequences recovered by Leg 104 include the lowermost Miocene to upper Pliocene. Silicoflagellates were extremely rare or absent from the Eocene and Oligocene of Site 643 and from the uppermost Pliocene and Quaternary at all three sites. A quantitative study of these silicoflagellate-bearing sequences is the basis of a local silicoflagellate zonation for the Neogene of the Norwegian Sea.

PREPARATION OF SAMPLES AND METHOD OF STUDY

All samples were collected by the Shipboard Scientific Party during Leg 104. Raw samples were placed in 200-mL beakers and heated with diluted hydrogen peroxide to disassociate the sediment and remove the organic carbon. Hydrochloric acid was then added to dissolve any carbonate present in the samples. The undissolved residues were diluted with distilled water, centrifuged, and decanted to remove the acid. This procedure was repeated three times. Next, the samples were washed with sodium pyrophosphate, centrifuged, and decanted to remove a significant proportion of clay present. This final processing step was repeated until the sediment suspension obtained a neutral pH. Processed residues were diluted with distilled water and stored in 50-mL plastic bottles. Whole fraction slides were made of processed residues utilizing the random settling technique (Moore, 1973; Laws, 1983), which provides an even distribution of all particle sizes on a slide.

Absolute abundances of silicoflagellate taxa are recorded in the accompanying Tables 1–3. A minimum of six traverses were made of each slide; if no whole or fragmented specimens were found, the sample was recorded as barren. If whole or fragmented silicoflagellates were encountered in the first six traverses, the entire slide was examined.

Photomicrography of many silicoflagellates was made from sieved (>45 μm) slide preparations to eliminate the clay fraction. For this reason, some specimens of rare species are shown in the plates but are not in the tables, which present census data from whole fraction slides. Some photographed specimens are from Hole 642B, from which we recovered the same sequence as in Hole 642C. Eldholm, Thiede, Taylor, et al. (1987) may be consulted to find the sub-bottom relationship between the two holes.

ZONATION

Previous studies of Neogene silicoflagellates from the Norwegian-Greenland Sea include those of DSDP Leg 38 sequences by Martini and Müller (1976) and Bukry (1976c). Bukry's study (1976c) is of little usefulness for biostratigraphic calibration of the Leg 104 Neogene because only six Neogene samples were examined. Martini and Müller (1976) described the Eocene to Pleistocene silicoflagellate assemblages from Leg 38 sites. The most complete Neogene sequence studied by Martini and Müller (1976) is that of Site 338, in close proximity to all Leg 104 sites on the Vøring Plateau. Unfortunately, most of the Hole 338 silicoflagellate assemblage is older than that encountered in the Neogene of Leg 104 sequences. Due to the lack of suitable correlative sections in the Norwegian Sea, a local zonal scheme is utilized in the present study. Taxa used to define zonal boundaries are ones which are common and exhibit the least diachroneity between Sites 642 and 643.

[1] Eldholm, O., Thiede, J., Taylor, E., et al., 1989. *Proc. ODP, Sci. Results*, 104: College Station, TX (Ocean Drilling Program).

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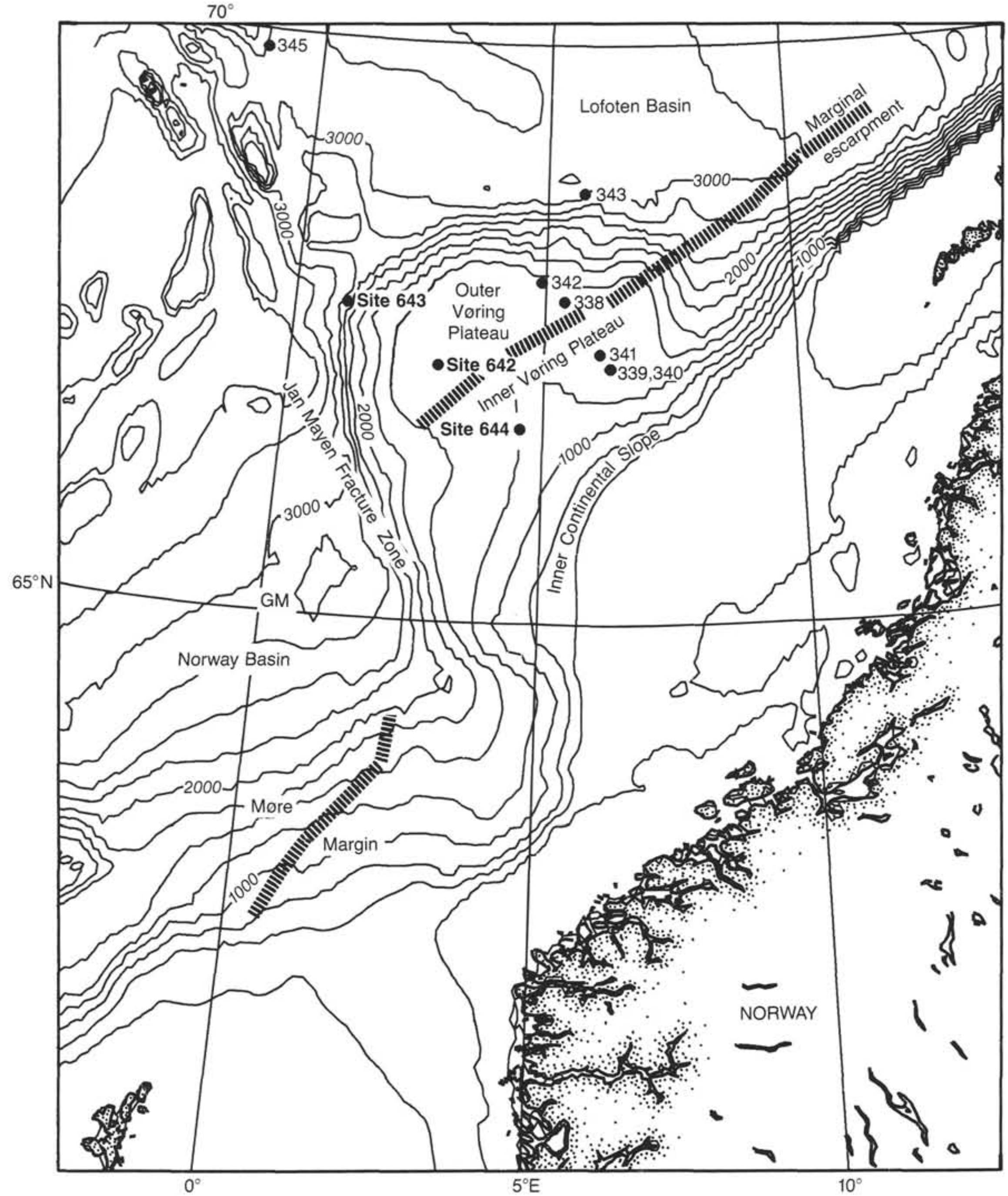

Figure 1. Bathymetry of the Norwegian continental margin (contour interval, 250 m) showing the location of Leg 104 and Leg 38 sites.

Silicoflagellates described from the Neogene of Leg 104 sites are for the most part cosmopolitan species which have been noted throughout the Pacific, Atlantic, and the high-latitude regions of both hemispheres. Unfortunately, very few studies were of sufficient detail to document the ranges of the diverse silicoflagellate assemblage, particularly those of the middle to upper Miocene.

The cosmopolitan nature of the Norwegian Sea silicoflagellate assemblage and its diversity should allow a much greater biostratigraphic resolution in the future than is presently possible. Our objective is to quantitatively document the Neogene silicoflagellate assemblages of Leg 104 sequences so future biostratigraphic interpretation is possible. Ongoing research of Leg 114 subantarctic Neogene sequences (by Ciesielski) with paleomagnetic control may allow much more precise stratigraphic knowledge of Leg 104 sections in the near future.

Naviculopsis lata Zone

Definition

Interval from the first *Naviculopsis lata* to the first *N. quadrata* (Martini, 1972, emend. Bukry, 1978a).

Assemblage

The most common species of the zone in Hole 642D include: *Distephanus crux* s.l., *Ds. crux scutulatus, Ds. crux parvus, Ds. stradneri, Ds. slavincii, Ds. boliviensis* (hemisphaericoid), *Ds. speculum hemisphaericus, Bachmannocena apiculata curvata*, and *Corbisema triacantha*. The genus *Naviculopsis* accounts for 2 to 15% of the assemblage, comprised primarily of *N. lata, N. navicula*, and *N. punctilia*.

Datums

1. The last consistent common occurrence (>15%) of the genus *Corbisema* (Ciesielski and Case, this volume) in Sample 104-642D-10X-2, 110–113 cm.
2. First Appearance Datum (FAD) of *N. navicula* in Sample 104-642D-9X-5, 109–112 cm.
3. Last Appearance Datum (LAD) of *N. biapiculata* in Section 104-642D-10X, CC.
4. LAD of *Corbisema flexuosa* in Sample 104-642D-10X-5, 110–113 cm. (occurs slightly higher in the *N. quadrata* Zone of Hole 643A).

Remarks

The portion of the zone represented here belongs to the lower Miocene. An estimate for the age of this zone may be obtained by a comparison of silicoflagellate ranges with those tabulated by Martini (1979) at Site 407, at a similar latitude (~64°N) on the western flank of the Reykjanes Ridge. At Site 407, silicoflagellates occur together with calcareous nannofossils providing a means of direct correlation to standard calcareous nannofossil zones. All four datums listed above occur in the upper NNl calcareous nannofossil zone at Site 407. *N. quadrata* only occurs in one sample from Site 407, where it is found in lower calcareous nannofossil Zone NN2. According to the time scale of Berggren et al. (1985) and the correlations to Site 407, Cores 104-642D-9 and -10 are equivalent to lower Chron C6B and upper Chron C6C. The upper boundary of the zone most likely occurs in lower NN2 or near Chron C6B. The portion of *N. lata* zone represented here is estimated therefore to have an age of ~22.6 to 23.4 Ma.

Interval

Samples 104-642D-10X-5, 110–113 cm to -642D-8X-5, 122–124 cm. Hole 643A, not present.

Naviculopsis quadrata Zone

Definition

Interval defined by the total range of *Naviculopsis quadrata* (Bukry and Foster, 1974; Ciesielski, et al., emended herein).

Assemblage

Most common species include: *Distephanus crux* s.l., *Ds. crux scutulatus, Ds. crux parvus, Ds. stradneri, Ds. speculum hemisphaericus, Ds. boliviensis* (hemisphaericoid), and *Ds. slavincii*. Species of *N. aviculopsis* include: *N. navicula, N. ponticula ponticula, N. ponticula spinosa, N. quadrata, N. lata*, and *N. biapiculata*.

Datums

1. FAD of *Caryocha, C. ernestinae* in Sample 104-642D-7X-5, 120–122 cm and *C. depressa* in Sample 104-642D-7X-2, 120–122 cm.

Remarks

Bukry and Foster (1974) defined the zone as the interval from the first *N. quadrata* to the first *N. ponticula* or last *N. quadrata*. Since *N. ponticula* is very rare and occurs prior to the last *N. quadrata*, the top of the zone is redefined, thus making this a total range zone. The last occurrence of the name species is not well documented; however, based upon European land sections Martini (1972) correlated it to approximately the NN3/NN4 boundary, which is assigned an age of 17.4 Ma by Berggren et al. (1985). In a later study, Martini (1979) found the only occurrence of *N. quadrata* in Site 407 on the Reykjanes Ridge to be within calcareous nannofossil zone NN2. Given the close proximity of Site 407 to Leg 104 sites, it appears likely that this zone encompasses most of NN2; however, it is uncertain that it also includes most or all of NN3 as it does in European sections. The maximum age range for the zone is likely from ~22.6 to 17.4 Ma (lower NN2 through NN3), although it appears unlikely that there was continuous deposition at Sites 642 and 643 during this interval.

Interval

Sample 104-642D-8X-2, 122–124 cm to -642D-7X-2, 120–122 cm. Sample 104-643A-29X-5, 70–72 cm to -643A-28X-6, 70–72 cm.

Naviculopsis ponticula Zone

Definition

Interval from the last *Naviculopsis quadrata* to the last occurrence of the genus *Naviculopsis* (Bukry, 1981b; Ciesielski, et al., emended herein).

Assemblage

Same as the *N. quadrata* Zone except for the absence of *N. quadrata*.

Datums

1. LAD of *N. navicula*.
2. LAD of *N. lata*.

Remarks

The base of the zone is emended as described for the top of the preceeding zone. Bukry (1981b) found this short zone in several DSDP holes from the Atlantic, indicating that the other species of *Naviculopsis* range higher than the last occurrence of *N. quadrata*. This was confirmed in Holes 642D and 643A where the genus was found only slightly higher than the *N. quadrata* Zone. According to Perch-Nielsen (1985), *Naviculopsis* has its last occurrence in calcareous nannofossil zone NN4. The age range for the zone is probably somewhat less than the age range of NN4 (~17.4 to 16.2 Ma).

Interval

Sample 104-642D-6X-4, 115–117 cm. Section 104-643A-27X, CC.

Distephanus speculum hemisphaericus Zone.

Definition

Interval from the last *Naviculopsis* to the last *Distephanus speculum hemisphaericus* (Ciesielski, et al., herein).

Assemblage

Dominated by *Distephanus crux parvus, Ds. crux* s.l., *Ds. boliviensis, Ds. speculum* (bolivienoid), *Ds. speculum hemisphaericus, Ds. boliviensis* (hemisphaericoid), *Ds. stradneri*, and *Ds. slavincii*. Consistently present, but less common are *Bachmannocena apiculata curvata* and *Caryocha depressa*.

Datums

1. FAD of *Distephanus hannai* in Samples 104-642C-23H-2, 125–128 cm, 104-643A-22X-5, 69–71 cm.
2. FAD of *Bachmannocena diodon nodosa* in Samples 104-642C-24H-4, 125–128 cm, 104-643A-13H-2, 69–71 cm.
3. LAD of *Distephanus boliviensis* (hemisphaericoid) in Sample 104-642C-21H-5, 125–128 cm.

Remarks

This long-ranging zone is equivalent to most of the *Corbisema triacantha* Zone defined by Locker and Martini (1985) as extending from the last occurrence of the genus *Naviculopsis* species to the last occurrence of *Corbisema triacantha*. Although generally rare and sporadically present, *C. triacantha* is found throughout the zone, indicating that the top of the zone is no younger than calcareous nannofossil zone NN6. The last occurrence of *Distephanus speculum hemisphaericus* is used as a zonal marker because of the scarcity of *C. triacantha* in high latitudes such as the Norwegian Sea.

The *Distephanus speculum hemisphaericus* Zone correlates to the following North Pacific diatom zones (defined in Barron, 1985): the upper portion of the *Thalassiosira fraga* Zone, *Actinocyclus ingens* Zone, and Subzone a and b of the *Denticulopsis lauta* Zone. Accordingly, the zone brackets the lower/middle Miocene boundary and encompasses most of calcareous nannofossil zone NN4, NN5, and possibly lower NN6.

Interval

Samples 104-642D-6X-2, 125–127 cm to -642C-21H-5, 125–128 cm. Samples 104-643A-27X-6, 70–72 cm to -643A-13H-2, 70–72 cm.

Caryocha ernestinae Zone

Definition

Interval from the last *Distephanus speculum hemisphaericus* to the first *Bachmannocena circulus* var. *apiculata* (Ciesielski, et al., herein).

Assemblage

Dominated by cruxoid silicoflagellates including *Distephanus crux* s.l., *Ds. crux parvus, Ds. crux scutulatus*, and *Ds. stradneri*. Consistently present are common *Caryocha depressa* and *C. ernestinae, Distephanus boliviensis*, and *Ds. speculum* (bolivienoid). In general, the zone marks the conspicuous middle Miocene demise of multiple-windowed silicoflagellates, except for *Caryocha* spp.

Datums

1. LAD of *Distephanus slavincii* in Sample 104-642C-21H-2, 125–128 cm.
2. FAD of *Bachmannocena diodon diodon* in Sample 104-642C-20H-5, 125–128 cm.

Remarks

This zone represents a brief stratigraphic interval of the middle Miocene. In Hole 642C the zone brackets the boundary between the *Denticulopsis lauta* and *D. hustedtii–D. lauta* diatom zones (Ciesielski, unpublished) with an assigned age of 13.7 Ma. Rare occurrences of *Corbisema triacantha* suggest that the *Caryocha ernestinae* Zone is correlative with the upper *Corbisema triacantha* Zone utilized by Martini and Müller (1976) in their silicoflagellate zonation of DSDP Leg 38 sites from the Norwegian–Greenland Sea.

Interval

Samples 104-642C-21H-2, 125–128 cm to -642C-20H-5, 125–128 cm. Sample 104-643A-12H-5, 70–72 cm.

Bachmannocena circulus var. *apiculata/Caryocha* concurrent range zone.

Definition

Interval from the first *Bachmannocena circulus* var. *apiculata* to the last *Caryocha* spp. (Ciesielski, et al., herein).

Assemblage

Dominated by quadrate species of *Distephanus* including *Ds. crux* s.l., *Ds. crux parvus, Ds. crux scutulatus*, and *Ds. crux hannai*. Other important contributions to the assemblage include: *Caryocha depressa, C. ernestinae, Bachmannocena circulus* var. *apiculata, B. apiculata curvata, B. diodon nodosa* (rare), and *B. diodon diodon* (rare). *Distephanus* species with a hexagonal basal ring are common in Hole 643A but sparse in Hole 642C, possibly reflecting paleoceanographic differences between these two sites.

Datums

Numerous species exhibit their last occurrence at this level in Holes 642C and 643A (Tables 1 and 2). This pile-up of last occurrences is attributed to a major disconformity at this level. More complete sequences of the upper middle Miocene to lower upper Miocene are needed to evaluate the stratigraphic ranges of species with first or last occurrences at this disconformity.

Remarks

The previous study of silicoflagellates from the Iceland Plateau by Martini and Müller (1976) reveals that *B. circulus* var. *apiculata* and *Caryocha* have concurrent ranges throughout Cores 12 to 18.

Interval

Sample 104-642C-20H-2, 125–128 cm. Sample 104-643A-12H-2, 70–72 cm.

Distephanus crux scutulatus Zone

Definition

Interval from the last *Caryocha* spp. to the last *Distephanus crux scutulatus* (Ciesielski, et al., herein).

Assemblage

The assemblage characteristics are best demonstrated in Hole 642C, where more of the zone is represented. The variety of quadrate *Distephanus* species is less than in the preceeding zone with only *Ds. crux scutulatus* consistently present. Species of *Bachmannocena* present include: *B. circulus* var. *apiculata, B. dumitricae, B. diodon nodosa*, and *B. diodon diodon*. Common to abundant throughout are *Distephanus boliviensis* and *Ds. speculum* (bolivienoid).

Datums

1. LAD of *Distephanus crux parvus* in Sample 104-642C-18H-2, 125–128 cm.
2. LAD of *Ds. hannai* in Sample 104-642C-18H-2, 125–128 cm.
3. LAD of *Ds. stradneri* in Sample 104-642C-18H-2, 125–128 cm.

Remarks

The base of the *Distephanus crux scutulatus* Zone in Holes 642C and 643 is a disconformity. All but the youngest portion of the zone is missing in Hole 643A (see Goll, this volume) accounting for the absence of the above-mentioned datums.

The disconformable base of this zone is accompanied by the first occurrence of the foraminifer *Neogloboquadrina acostaensis* (Spiegler and Jansen, this volume) which marks the base of the upper Miocene.

Interval

Samples 104-642C-19H-5, 125–128 cm to -642C-17H-5, 125–126 cm. Samples 104-643A-11H-2, 70–72 cm to -643A-11H-1, 70–72 cm.

Bachmannocena diodon nodosa Zone

Definition

Interval from the last *Distephanus crux scutulatus* to the last *Bachmannocena diodon nodosa* (Ciesielski, et al., herein).

Assemblage

The *Bachmannocena diodon nodosa* Zone is notable for being the oldest stratigraphic interval characterized throughout by poor preservation. The interval is also noted for its conspicuous absence of quadrate *Distephanus* species, except for rare *Ds. crux*, which were dominant components of the lower and middle Miocene assemblage. Cold water distephanids with a hexagonal basal ring dominate along with fewer numbers of *Bachmannocena diodon nodosa, B. dumitricae*, and *B. circulus* var. *apiculata*.

Remarks

The first and only occurrence of *Neonaviculopsis neonautica* occurs in the upper portion of the zone. Locker and Martini (1985) directly correlated the range of *Neonaviculopsis* with the upper NN11b to within NN12. This zone is also correlative to the *Denticulopsis hustedtii* Zone, Subzone b of the North Pacific diatom zonation (Barron, 1985). Based upon correlation of the *Bachmannocena diodon nodosa* zone to the diatom zonation of Leg 104 (Ciesielski, et al., unpublished), this zone encompasses the middle upper Miocene.

Interval

Samples 104-642C-17H-2, 126–129 cm to -642C-15H-5, 125–127 cm. Samples 104-643A-10H-5, 68–70 cm to -643A-8H-5, 67–69 cm.

Distephanus boliviensis Zone

Definition

Interval from the last *Bachmannocena diodon nodosa* to the first *Distephanus jimlingii* (Ciesielski, et al., herein).

Assemblage

The assemblage is dominated by cold-water distephanids with a hexagonal basal ring. Quadrate distephanids are rare and may be reworked. *Bachmannocena diodon diodon* is common in the lower portion of the zone. Poor preservation and the rare occurrence of *B. elliptica* and *B. circulus* var. *apiculata* prevent reliable delineation of their upper ranges.

Remarks

Until such time as an upper Miocene sequence with good preservation can be identified in the region, this zone may be utilized to indicate the upper upper Miocene. The zone corresponds to the upper Miocene portion of Subzone a of the *Denticulopsis kamtschatica* diatom Zone (Ciesielski, unpublished) and encompasses most of the paleomagnetic Chrons C3AR and C3AN.

Interval

Samples 104-642C-15H-2, 125–127 cm to -642C-12H-2, 120–122 cm. Hole 643A, not present.

Distephanus jimlingii Zone

Definition

The zone is defined by the total range of the name species.

Assemblage

In the reference site, Site 642C, the zone is lacking *in-situ Dictyocha* spp. and is dominated by cold-water distephanids.

Remarks

Bukry and Monechi (1985) previously used the range of *Distephanus jimlingii* to define the *Ds. jimlingii* Subzone of the *Dictyocha fibula* Zone in their study of northwestern Pacific Leg 86 DSDP sites. Lacking the *Dictyocha* species so often utilized in zonal schemes of the Pliocene (Perch-Nielsen, 1985), the *Distephanus jimlingii* Subzone is herein elevated to zonal status for use in the Norwegian Sea.

Ds. jimlingii appears to have been widespread during the Pliocene in the mid- to high-latitude North Pacific (Bukry, 1975b, 1981a; Ling, 1973, 1975) and North Atlantic (Bukry, 1979, 1984). In Leg 63 sites off the California coast, Bukry (1981a) found the species in the lower Pliocene correlative with calcareous nannofossil zone CN10. Closer to the Norwegian Sea, Bukry (1979) also noted the co-occurrence of *Ds. jimlingii* in the lower Pliocene of the Rockall Bank and in the Pliocene of Site 407 (~64°N) on the western flank of the Reykjanes Ridge.

Second-order correlation of the range of *Ds. jimlingii* to the paleomagnetic time scale can be made by examination of the documented range of the species relative to the diatom zones in Leg 57 sites off northeastern Japan (Barron, 1980). Barron states that *Ds. jimlingii* ranges from the upper portion of Subzone a of the *Denticulopsis kamtschatica* diatom zone to the upper *Denticulopsis seminae* var. *fossilis-D.kamtschatica* Zone. Calibration of these diatom zones to paleomagnetic stratigraphy indicates that the range of *Ds. jimlingii* extends from near the Miocene/Pliocene boundary to the middle or late Gauss.

In Hole 642C, *Ds. jimlingii* has its first occurrence just below a paleomagnetic reversal, between Samples 104-642C-11H-5, 41 cm and 104-642C-11H-5, 111 cm (Bleil, this volume), suggesting that this reversal was correctly identified as the Chron C3AN/Gilbert Chron boundary. The age of the top of the zone cannot be accurately defined in Hole 642C where the last occurrence of the species coincides with the base of the overlying barren interval. At Site 644A, *Ds. jimlingii* is absent in Gauss Chron sediments (2.84–2.65 Ma) beneath a similar barren interval. Thus, the last occurrence of the species and the top of the zone must occur within the Gauss Chron, prior to 2.84 Ma, in close agreement with its age defined by second-order correlation to paleomagnetic stratigraphy as discussed previously. The age of the zone is estimated therefore to be between approximately 5.5 and 2.9 Ma.

Interval

Samples 104-642C-11H-5, 141–143 cm to -642C-9H-2, 103–105 cm. Hole 643A, not present. Sample 104-644A, not present.

Distephanus jimlingii Zone, Subzone a

Definition

Interval from the first occurrence of *Distephanus jimlingii* to the first *Ds. sulcatus* (Ciesielski, et al., herein).

Assemblage

Includes a variety of *Distephanus* species (see Table 1). Rare *Bachmannocena circulus* var. *apiculata* occur and a transitionary morphotype between *Ds. sulcatus* and *Ds. jimlingii* (tabulated as *Ds. jimlingii/sulcatus*) appears in the upper portion of the subzone.

Remarks

The age of the subzone ranges from ~5.5 Ma to the middle Gauss paleomagnetic Chron.

Interval

Samples 104-642C-11H-5, 141–143 cm to -642C-10H-2, 124–126 cm. Hole 643A, not present. Hole 644A, not present.

Distephanus jimlingii Zone, Subzone b

Definition

Interval from the first occurrence of *Distephanus sulcatus* to the last *Ds. jimlingii* (Ciesielski, et al., herein).

Assemblage

The assemblage of this subzone differs little from that described for the zone except for the added presence of *Distephanus sulcatus* and the lack of *Bachmannocena*.

Remarks

Distephanus sulcatus is a large and easily identified silicoflagellate with an abrupt appearance. The base of the subzone occurs in the mid-Gauss paleomagnetic Chron according to the paleomagnetic stratigraphy of Hole 642C (Bleil, this volume).

Interval

Sample 104-642C-9H-2, 103–105 cm. Hole 643A, not present. Hole 644A, not present.

Distephanus speculum Zone

Definition

Interval from the last *Distephanus jimlingii* to the last consistent occurrence of frequent to common silicoflagellates at the base of the upper Pliocene-Quaternary glacial sequence.

Assemblage

Consists mainly of *Distephanus speculum, Ds. boliviensis, Ds. sulcatus*, and *Ds. crux*.

Remarks

The base of the zone was unrecovered, but is estimated to be approximately 2.9 Ma as discussed in the remarks for the previous zone. The top of the zone has an age of 2.65 Ma based upon direct correlation to the paleomagnetic record of Hole 644A as defined by Bleil (this volume).

Interval

Samples 104-644A-34H-5, 70–72 cm to -644A-32H-1, 70–72 cm. Hole 643A, not present. Hole 642C, not present.

BIOSTRATIGRAPHY

Site 642 (Table 1)

Samples 104-642C-lH-1, 125–127 cm through 104-642C-8H-2, 124–126 cm are barren of silicoflagellates. Reference to the paleomagnetic stratigraphy of this interval (Bleil, this volume) indicates that the barren zone is Brunhes to late Gauss in age (~0–2.5 Ma). In Hole 644A, a similar upper Pliocene to Quaternary barren zone was encountered that has confidently been assigned an age of 0–2.65 Ma.

The *Distephanus jimlingii* Zone was identified between Samples 104-642C- 9H-2, 103–105 cm and 104-642C-11H-5, 141–143 cm. This interval is dominated by species of cold-water distephanids with the most common constituents being *Distephanus jimlingii, Ds. frugalis, Ds. sulcatus, Ds. speculum, Ds. boliviensis*, and cannopilean *Ds. boliviensis*. Because of the absence of *Ds. jimlingii* in 644A, the last occurrence of silicoflagellates in Hole 642C is older that the 2.84-Ma age of the oldest sample examined from Hole 644A. Thus, if no unconformity is present at the base of the overlying barren zones at both sites, there was a diachronous last occurrence of silicoflagellates within the Gauss between Sites 642 and 644.

The interval between Samples 104-642C-12H-2, 120–122 cm and 104- 642C-15H-2, 125–127 cm is assigned to the *Distephanus boliviensis* Zone. Silicoflagellates are sparse and are dominated by long-ranging species. Two samples, 104-642C-14H-2, 124–126 cm and 104-642C-15H-2, 125–127 cm, contain *Bachmannocena diodon diodon* and *Distephanus speculum giganteus* which occur together in the uppermost Miocene of the Southern Ocean (Chrons 5 and 6) (Ciesielski, 1985). Although both species have their last occurrence in the latter sample, poor preservation and low abundances in the upper portion of the interval prevent reliable definition of the last occurrences of these species. Low abundances in this interval were likely caused by low surface-water productivity. Several samples include common-to-abundant entire coccospheres, indicative of poorly oxygenated benthic conditions which may have resulted from weak vertical mixing of the water column.

Sample 104-642C-15H-5, 125–127 cm contains abundant silicoflagellates dominated by *Distephanus boliviensis, Ds. speculum*, and many of their subspecies and morphotypes. The last joint occurrence of *Bachmannocena diodon diodon* and *B. diodon nodosa* occur in the uppermost sample of the *B. diodon nodosa* Zone. Sparse occurrences of *Dictyocha brevispina* and *Neonaviculopsis neonautica* also occur in this sample. *N. neonautica* has a restricted range that brackets the Miocene/Pliocene boundary, ranging from the base of calcareous nannofossil zone NN11b to within NN12 (Locker and Martini, 1985).

Sample 104-642C-16H-2, 125–127 cm is barren. The remainder of the upper Miocene *B. diodon nodosa* Zone between Samples 104-642C-16H-5, 125–127 cm and 104-642C-17H-2, 126–129 cm is characterized by very poor preservation and a sparse assemblage of silicoflagellates, diatoms (Ciesielski, this volume), and radiolarians (Goll and Bjørklund, this volume). Although all siliceous microfossil assemblages are sparse and poorly preserved, there is no evidence for a disconformity in this interval.

The last occurrence of *Distephanus crux scutulatus* in Sample 104-642C-17H-2, 126–129 cm marks the top of the *Ds. crux scutulatus* Zone that continues down to Sample 104-642C-19H-5, 125–128 cm. This zone represents the last occurrence of diverse and well-preserved silicoflagellate assemblages in the Norwegian Sea. Within this interval is the last consistent occurrence of *Bachman nocena* and the last significant occurrence of *Dictyocha* and quadrate *Distephanus*.

Several lines of evidence point to a significant hiatus between the base of the *Ds. crux scutulatus* Zone in Sample 104-642C-

19H-5, 125–128 cm and the *Bachmannocena circulus* var. *apiculata/Caryocha* Zone in Sample 104-642C-20H-2, 125–128 cm. First, the concurrent ranges of *B. circulus* var. *apiculata* and *Caryocha* spp., which typify the latter zone are confined to Sample 104-642C-20H-2, 125–128 cm. These taxa should have a considerable concurrent stratigraphic range based upon the previously mentioned study of silicoflagellates from the Iceland Plateau by Martini and Müller (1976). Second, a number of first and last occurrences occur at this level (Table 1) suggesting a truncation of numerous stratigraphic ranges. Among these is the last occurrence of the genus *Caryocha* which does not range into the upper Miocene. Third, other siliceous microfossil assemblages, diatoms (Ciesielski, this volume) and radiolarians (Goll and Bjørklund, this volume) document the presence of a disconformity at a similar depth. The presence of *Neogloboquadrina acostaensis* in Sample 104-642C-19H, CC (Spiegler and Jansen, this volume) confirms the presence of the upper Miocene in this core. These and other data indicate that the hiatus brackets the middle/upper Miocene boundary and occurs between Samples 104-642C-19H, CC and 104-642C-20H-2, 125–128 cm.

Conformable with the *B. circulus* var. *apiculata/Caryocha* Zone is the underlying *Distephanus speculum hemisphaericus* Zone, extending between Samples 104-642C-21H-5, 125–128 cm through 104-642D-6X-2, 125–127 cm. This interval spans the upper lower Miocene through upper middle Miocene, exhibiting good preservation, high taxonomic diversity and very low taxonomic turnover. Although other microfossil groups indicate the presence of small disconformities within this interval, they are not detected in the silicoflagellate assemblages because of the lack of sufficient taxonomic turnover.

The genus *Naviculopsis* occurs within the lower portion of hole between Samples 104-642D-6X-4, 115–117 cm and 104-642D-10X-5, 110–113 cm. In the Norwegian Sea, as elsewhere globally, this cosmopolitan genus underwent its last diversification in the early Miocene. Unfortunately, *Naviculopsis* species are sparse and the record of the diversification of the genus is compressed in a relatively short interval. Further, more detailed study of this interval is needed to document the range of less-abundant species. As a consequence, some established lower Miocene silicoflagellate zones based upon *Naviculopsis* species are not utilized for zonal boundaries in this study. Instead, this interval is subdivided based upon easily recognized datums (FAD and LAD of *N. quadrata* and the LAD of the genus *Naviculopsis*) into the *N. ponticula* Zone, *N. quadrata* Zone and *N. lata* Zone.

Several samples were examined from lithologic Unit IV, volcaniclastic muds, sandy muds, and sands which lie beneath the thick Miocene and Pliocene biogenic sediments of Units II and III. Sample 104-642D-11X-2, 136–139 cm is from a volcaniclastic sand, immediately below the major unconformity in Core llX-1, 94 cm. Sample 104-642D-12X-2, 128–131 cm also is from a volcaniclastic sand, while Sample 104-642D-12X-5, 125–128 cm was recovered from a cyclic sequence of muds and silts. Eleven silicoflagellate species occur within these samples, which have ranges from the middle to upper early Miocene.

Unit IV was assigned an age of Eocene in the lithologic summary section of the Site 642 chapter (Eldholm, Thiede, Taylor, et al., 1987), although no reliable microfossil data were available for an age determination (see Biostratigraphy Section of Site 642 chapter of Eldholm, Thiede, Taylor, et al., 1987). The exclusive occurrence of Miocene silicoflagellates without any Paleogene species suggests that the upper portion of Unit IV may be largely downhole slump from between Cores 104-642D-21H and -642D-5X. Repeated downhole slumps may account for the cyclic sediment characteristics and other structures which were previously interpreted to be indicative of shallow water deposition in an area of active mass flow activity (Eldholm, Thiede, Taylor, et al., 1987, pp. 74–75).

Three additional samples were examined from within Unit IV and found to be barren. Of these, Samples 104-642D-13X-2, 125–128 cm and 104-642D-13X-4, 125–128 cm were obtained from a glauconite-rich volcanoclastic sandy mud. Sample 104-642D-14X-2, 124–125 cm is from a volcanoclastic mud directly above Unit V. Since the lower portion of Unit IV is barren, it is much more likely *in situ*, in contrast to the upper portion of the unit with considerable downhole contamination.

Sample 104-642D-16X-1, 4–6 cm was obtained from a pebble horizon that occurs beneath Unit IV and directly above the 914 m sequence of volcanic rocks and dikes drilled in Hole 642E. Silicoflagellates are abundant, well preserved, and diverse in this sample (Table 1). The assemblage includes species common within the lower Miocene of Hole 642D and probably represents downhole slump. The presence of a few *Naviculopsis* specimens suggests that the sediment originated from the walls of the hole between Cores 104-642D-6X and -642D-10X. Thus, while the pebbles are *in situ*, the fine-grained fraction is not.

Sample 104-642D-19N-1, 92–112 cm, the basal sample examined from Hole 642D, comes from drilling rubble accompanying basaltic vitric tuff. The sample is barren of all siliceous microfossils, suggesting that the fine fraction is drilling slurry.

Site 643 (Tables 2 and 3)

Silicoflagellates are absent above Sample 104-643A-8H-5, 67–69 cm. Upper Miocene assemblages are of low diversity and fragmented silicoflagellates generally outnumber whole specimens in Samples 104-643A-8H-5, 67–69 cm through 104-643A-11H-2, 70–72 cm. Beneath a hiatus bracketing the middle/upper Miocene boundary, silicoflagellates are abundant and diverse down to a lower Miocene diagenetic boundary (~284 mbsf, Section 104-643A-30X, CC), below which silicoflagellates are absent.

Sample 104-643A-8H-5, 67–69 cm contains mostly fragments, but also has a few *Bachmannocena diodon nodosa* and fragments of *B. circulus* var. *apiculata* (reworked?). This sample is assigned to the *B. diodon nodosa* Zone and has an upper Miocene age. Missing in Hole 643A are the younger *Distephanus speculum* Zone (in Hole 644A between Samples 104-644A-34H-5, 70–72 cm and 104-644A-32H-1, 70–72 cm), *Distephanus jimlingii* Zone, *Distephanus boliviensis* Zone (in Hole 642 between Samples 104-642C-9H-2, 103–105 cm and 104-642C-15H-2, 125–127 cm), and possibly the uppermost *Bachmannocena diodon nodosa* Zone. Accordingly, a hiatus must exist above Sample 104-643A-8H-5, 67- 69 cm which encompasses no less than the latest Miocene to late Pliocene (~6.5 to 2.65 Ma).

Sample 104-643A-9H-2, 70–72 cm also contains a high proportion of fragments, as well as *Bachmannocena dumitricae* (LAD), *B. diodon nodosa*, and *B. circulus* var. *apiculata* (LAD). This sample is also assigned to the *B. diodon nodosa* Zone and is late Miocene in age, older than the estimated ~6.5 Ma age for the LAD of *B. circulus* var. *apiculata* (Ciesielski, 1983).

Sample 104-643A-9H-5, 69–71 cm is barren and Sample 104-643A-10H-2, 68–70 cm contains only fragments of silicoflagellates. Fragments are also abundant in Samples 104-643A-10H-2, 68–70 cm and 104-643A-10H-5, 68–70 cm, but are also assigned to the *Bachmannocena diodon nodosa* Zone because of the presence of the name species and *B. circulus* var. *apiculata* above the last *Distephanus crux scutulatus*.

The upper portion of the *Distephanus crux scutulatus* Zone is represented in Sample 104-643A-11H-1, 70–72 cm where the last occurrence of *Ds. crux scutulatus* occurs. The stratigraphic level marks a major change in the silicoflagellate assemblage characterized by the demise of cruxoid forms and increased dominance of *Distephanus* and *Bachmannocena* during the middle late-to-late late Miocene. A similar assemblage occurs in Sam-

Table 1. Leg 104, Hole 642C and Hole 642D silicoflagellate abundances, occurrences, zones, and ages. Species listing in order of highest occurrences. Intraspecific variants are listed separately with diagnostic characteristics indicated in parentheses. The key to the abbreviations indicating morphologic characteristics is as follows: w/ = with, aw. = apical window, brs. = basal ring sides, sp. = basal ring spines, br. = basal ring, asym. = asymmetrical.

			Total Whole Specimens	unidentifiable fragments	*Dictyocha quadria* (reworked)	*Distephanus boliviensis* & *Ds. speculum* (bolivienoid)	*Distephanus boliviensis* & *Ds. speculum* (bolivienoid) — (w/ 2 aw.)	*Distephanus boliviensis* & *Ds. speculum* (bolivienoid) — (w/ 3 aw.)	*Distephanus boliviensis* & *Ds. speculum* (bolivienoid) — (w/ 3 aw., 7 brs.)	*Distephanus boliviensis* & *Ds. speculum* (bolivienoid) — (w/ > 4 aw.)	*Distephanus boliviensis* (w/ large aw.)	*Distephanus quinquangellus*	*Distephanus frugalis*	*Distephanus jimlingii*	*Distephanus jimlingii* (w/ 2 or 3 aw.)	*Distephanus jimlingii/sulcatus*	*Distephanus speculum speculum*	*Distephanus sulcatus*	*Distephanus frugalis* (w/ 2 aw.)	*Bachmannocena circulus* var. *apiculata*	*Distephanus speculum* (bolivienoid, w/ very long major sp.)	*Dictyocha aspera*	*Distephanus crux* s.l.	*Corbisema triacantha*	*Dictyocha fibula*
Age	Zone	Sample (cm)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
		Hole 642C	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		1H-2, 125-127	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		2H-2, 125-127	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		2H-5, 125-127	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		3H-2, 125-127	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Pleistocene		3H-5, 125-127	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		4H-2, 125-127	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	BARREN	4H-5, 125-127	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		5H-2, 124-126	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		5H-5, 125-127	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		6H-2, 125-127	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		6H-5, 125-127	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		7H-2, 120-122	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		7H-4, 120-122	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		8H-2, 124-126	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Pliocene	b	9H-2, 103-105	121	001	001	032	010	005	001	004	004	001	012	018	012	006	005	010	.	.	.	.	.	.	.
	Distephanus jimlingii	10H-2, 124-126	0	0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	a	10H-5, 124-126	155	005	.	031	016	020	.	004	006	012	007	011	010	010	026	.	002	.	.	.	.	.	.
		11H-2, 136-138	220	.	.	084	.	.	.	.	002	.	.	.	.	.	.	.	.	001	213	.	.	.	.
		11H-5, 141-143	049	001	.	005	003	005	.	006	008	.	001	015	002	.	.	.	.	001	.	001	002	.	.
		12H-2, 120-122	001	.	.	001	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		12H-5, 120-122	145	005	.	031	003	.	.	.	098	010	.	.	.	.	.	.	.	.	.	.	.	001	001
	Distephanus boliviensis	13H-2, 124-126	005	.	.	005	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		14H-2, 124-126	064	001	.	010	001	001	.	.	008	004	.	.	.	.	.	.	.	.	.	.	001	.	.
		14H-5, 125-127	002	.	.	002	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		15H-2, 125-127	061	004	.	012	.	.	.	.	004	005	.	.	.	.	.	.	.	001	.	.	002	.	.
		15H-5, 125-127	296	005	.	093	003	.	.	.	080	019	.	.	.	.	.	.	.	.	088	001	.	.	001
Late Miocene	*Bachmannocena diodon nodosa*	16H-2, 125-127	005	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		16H-5, 125-127	0	001	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		17H-2, 126-129	006	.	.	001	001	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	004	.	.
		17H-5, 125-126	074	001	.	011	.	001	.	.	004	001	.	.	.	.	.	.	.	004	.	001	.	.	.
		18H-2, 125-128	297	004	.	048	004	.	.	.	.	.	.	.	.	.	.	.	.	.	.	002	104	.	007
	Ds. crux scutulatus	18H-5, 125-128	076	007	.	024	001	.	.	.	.	.	.	.	.	.	.	.	.	018	.	.	012	.	001
		19H-2, 125-128	260	004	.	126	001	001	.	.	.	003	.	.	.	.	.	.	.	013	.	009	048	.	003
		19H-5, 125-128	229	011	.	075	003	.	.	.	001	002	.	.	.	.	.	.	.	025	.	007	057	001	008
	B. circulus v. *apiculata/Caryocha*	20H-2, 125-128	158	007	.	009	.	.	.	.	.	002	.	.	.	.	.	.	.	001	061	001	008		
	Caryocha ernestinae	20H-5, 125-128	190	014	.	012	.	003	.	.	.	001	.	.	.	.	.	.	.	.	.	003	012	001	004
		21H-2, 125-128	265	015	.	012	.	.	.	001	.	010	.	.	.	.	.	.	.	.	.	001	119	001	011
Middle Miocene		21H-5, 125-128	273	011	.	013	003	003	.	001	.	.	.	.	.	.	.	.	.	.	.	001	114	.	001
		22H-2, 125-128	336	006	.	025	003	007	.	.	.	.	.	.	.	.	.	.	.	.	.	.	160	002	.
		22H-4, 125-128	322	001	.	029	009	012	.	005	.	.	.	.	.	.	.	.	.	.	.	.	076	.	003
		23H-2, 125-128	292	008	.	022	005	007	.	004	.	001	.	.	.	.	.	.	.	.	.	008	125	.	003
		23H-5, 125-128	326	005	.	034	006	002	.	.	.	002	.	.	.	.	.	.	.	.	.	002	133	001	002
		24H-2, 125-128	312	013	.	015	002	004	.	002	.	.	.	.	.	.	.	.	.	.	.	.	084	.	003
		24H-4, 125-128	300	005	.	023	019	022	.	005	.	001	.	.	.	.	.	.	.	.	.	.	073	002	.
	Distephanus speculum hemisphaericus	Hole 642D	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		2X-2, 125-127	305	011	.	029	006	005	.	012	.	.	.	.	.	.	.	.	.	.	.	.	095	.	002
		2X-5, 125-127	309	005	.	015	003	002	002	003	.	.	.	.	.	.	.	.	.	.	.	.	046	001	.
		3X-2, 125-127	292	010	.	029	017	019	.	011	.	.	.	.	.	.	.	.	.	.	.	.	084	.	001
		3X-5, 125-127	293	021	.	014	005	017	.	004	.	001	.	.	.	.	.	.	.	.	.	.	104	001	001
		4X-2, 124-126	291	009	.	020	013	028	.	027	.	.	.	.	.	.	.	.	.	.	.	.	096	.	001
		4X-5, 115-117	315	011	.	019	009	027	001	014	.	001	.	.	.	.	.	.	.	.	.	.	081	002	.
Early Miocene		5X-2, 125-127	310	001	.	020	011	021	.	009	.	.	.	.	.	.	.	.	.	.	.	.	101	001	001
		5X-5, 126-128	296	012	.	015	012	025	.	006	.	001	.	.	.	.	.	.	.	.	.	.	070	.	.
		6X-2, 125-127	286	016	.	038	009	009	.	008	.	004	.	.	.	.	.	.	.	.	.	.	080	.	.
	Naviculopsis ponticula	6X-4, 115-117	294	009	.	019	001	004	.	.	.	.	.	.	.	.	.	.	.	.	.	001	134	.	.
		7X-2, 120-122	147	006	.	003	001	003	.	004	.	.	.	.	.	.	.	.	.	.	.	.	055	011	.
	Naviculopsis quadrata	7X-5, 120-122	126	005	.	002	002	002	.	004	.	.	.	.	.	.	.	.	.	.	.	.	043	.	001
		8X-2, 122-124	196	012	.	001	003	002	.	009	.	002	.	.	.	.	.	.	.	.	.	.	045	004	.
		8X-5, 122-124	076	003	.	003	002	001	.	001	.	.	.	.	.	.	.	.	.	.	.	.	025	002	001
		9X-2, 97-100	060	003	.	003	001	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	029	003	.
	Naviculopsis lata	9X-5, 109-112	274	019	.	003	.	001	.	007	.	.	.	.	.	.	.	.	.	.	.	002	115	004	001
		10X-2, 110-113	279	011	.	006	001	004	.	007	.	.	.	.	.	.	.	.	.	.	.	001	100	090	.
		10X-5, 110-113	205	006	.	002	001	.	.	003	.	.	.	.	.	.	.	.	.	.	.	004	047	041	001
		11X-2, 136-139	012	001	.	.	.	001	.	.	.	.	.	.	.	.	.	.	.	.	.	.	005	002	001
		12X-2, 128-131	011	.	.	.	.	001	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	002	.
	Downhole slumped Miocene silicoflagellates in Unit IV & pebble horizon above basement	12X-5, 125-128	003	001	.	001	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	001	.
Eocene		13X-2, 125-128	0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		13X-4, 125-128	0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		14X-2, 124-125	0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		16X-1, 04-06	294	008	.	012	005	006	.	014	.	.	.	.	.	.	.	.	.	.	.	.	072	002	011
		19N-1, 93-112	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Table 1 (continued).

Bachmannocena diodon diodon	*Bachmannocena diodon nodosa* (w/ 3 sp. asym.)	*Bachmannocena elliptica*	*Distephanus speculum giganteus*	*Bachmannocena apiculata*	*Bachmannocena diodon nodosa*	*Dictyocha brevispina*	*Distephanus* (aberrant forms)	*Neonaviculopsis neonautica*	*Bachmannocena dumitricae*	*Bachmannocena triangula*	*Distephanus crux scutulatus*	*Distephanus crux parvus*	*Distephanus hannai*	*Distephanus stradneri*	*Dictyocha longa*	*Caryocha depressa*	*Dictyocha* (aberrant forms)	*Dictyocha* cf. *angulata*	*Dictyocha* sp. 1	*Distephanus crux* ssp. 1	*Dictyocha pentagona*	*Bachmannocena apiculata curvata*	*Bachmannocena diodon nodosa* (w/ 1 sp.)	*Bachmannocena ovata*	*Caryocha ernestinae*	*Distephanus crux* (w/ 2 aw.)	*Dictyocha pulchella* var. *inflata*	*Dictyocha subclinata*	*Distephanus* cf. *xenus*	*Bachmannocena quadrangula*	*Distephanus boliviensis* & *Ds. speculum* (bolivienoid) — (w/ 8 brs.)	*Distephanus slavincii*
24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56
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Table 1 (continued).

			Distephanus speculum hemisphaericus & *Ds. boliviensis (hemisphaericoid)*	*Distephanus* aff. *pseudocrux*	*Distephanus quinquangellus* (w/ 2 ap.)	*Distephanus crux* ssp.2	*Distephanus boliviensis* & *Ds. speculum* (bolivienoid) — (w/ 7 brs.)	*Distephanus quinquangellus* (w/ 3 ap.)	*Caryocha* cf. *latifenestrata*	*Distephanus bachmanni*	*Distephanus longispinus*	*Distephanus speculum minutus*	*Distephanus crux* ssp. 3	*Distephanus pseudofibula*	*Corbisema* cf. *trigonus* (reworked?)	*Distephanus* aff. *fibula hexacantha*	*Corbisema* sp. 1	*Naviculopsis lata*	*Naviculopsis navicula*	*Naviculopsis biapiculata*	*Naviculopsis quadrata*
Age	Zone	Sample (cm)	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	22	73	74	75
		Hole 642C	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		1H-2, 125-127	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		2H-2, 125-127	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		2H-5, 125-127	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		3H-2, 125-127	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Pleistocene		3H-5, 125-127	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		4H-2, 125-127	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	BARREN	4H-5, 125-127	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		5H-2, 124-126	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		5H-5, 125-127	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		6H-2, 125-127	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		6H-5, 125-127	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		7H-2, 120-122	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		7H-4, 120-122	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		8H-2, 124-126	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Pliocene	*Distephanus jimlingii* b	9H-2, 103-105	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Distephanus jimlingii a	10H-2, 124-126	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		10H-5, 124-126	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		11H-2, 136-138	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		11H-5, 141-143	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Distephanus boliviensis	12H-2, 120-122	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		12H-5, 120-122	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		13H-2, 124-126	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		14H-2, 124-126	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		14H-5, 125-127	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		15H-2, 125-127	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Bachmannocena diodon nodosa	15H-5, 125-127	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Late Miocene		16H-2, 125-127	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		16H-5, 125-127	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		17H-2, 126-129	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Ds. crux scutulatus	17H-5, 125-126	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		18H-2, 125-128	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		18H-5, 125-128	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		19H-2, 125-128	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		19H-5, 125-128	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	B. circulus v. apiculata/Caryocha	20H-2, 125-128	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Caryocha ernestinae	20H-5, 125-128	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		21H-2, 125-128	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Middle Miocene	*Distephanus speculum hemisphaericus*	21H-5, 125-128	012	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		22H-2, 125-128	018	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		22H-4, 125-128	012	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		23H-2, 125-128	003	004	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		23H-5, 125-128	009	.	012	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		24H-2, 125-128	004	.	001	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		24H-4, 125-128	019	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		Hole 642D	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		2X-2, 125-127	009	.	.	010	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		2X-5, 125-127	009	.	.	.	001	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		3X-2, 125-127	014	.	.	.	001	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		3X-5, 125-127	033	.	.	.	.	001	001	001	002	021	.	.	.	.	.	.	.	.	.
		4X-2, 124-126	.	.	.	.	.	.	.	.	.	014	.	.	.	.	.	.	.	.	.
		4X-5, 115-117	017	.	.	.	.	.	.	.	.	015	001	.	.	.	.	.	.	.	.
Early Miocene		5X-2, 125-127	012	.	.	.	.	.	.	.	.	020	.	002	.	.	.	.	.	.	.
		5X-5, 126-128	011	.	.	.	.	001	002	.	001	036	001	.	001	.	.	.	.	.	.
		6X-2, 125-127	088	.	.	.	.	.	.	.	.	013	.	.	.	004	.	.	.	.	.
	Naviculopsis ponticula	6X-4, 115-117	026	.	.	.	.	.	.	001	.	012	.	.	.	.	001	022	001	.	.
	Naviculopsis quadrata	7X-2, 120-122	016	.	.	.	.	.	.	.	.	009	.	.	.	.	.	004	.	001	002
		7X-5, 120-122	010	.	.	.	.	.	.	.	.	002	.	.	.	.	003	001	.	.	002
		8X-2, 122-124	012	.	.	.	.	.	.	.	.	002	.	.	.	.	.	010	001	001	021
	Naviculopsis lata	8X-5, 122-124	.	.	.	.	.	.	.	.	.	009	.	.	.	.	.	002	010	.	.
		9X-2, 97-100	004	.	.	.	.	.	.	.	.	003	.	.	.	.	.	001	.	.	.
		9X-5, 109-112	020	.	.	.	.	.	.	.	.	022	.	.	.	.	.	003	001	.	.
		10X-2, 110-113	002	.	.	.	.	.	.	.	.	001	.	.	.	.	.	008	.	.	.
		10X-5, 110-113	010	.	.	.	.	.	.	.	.	.	.	.	.	.	.	003	.	028	.
	Downhole slumped Miocene silicoflagellates in Unit IV & pebble horizon above basement	11X-2, 136-139	.	.	.	.	.	.	.	.	.	002	.	.	.	.	.	.	.	.	.
		12X-2, 128-131	.	.	.	.	.	.	.	.	.	002	.	.	.	.	.	.	.	.	.
		12X-5, 125-128	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Eocene		13X-2, 125-128	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		13X-4, 125-128	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		14X-2, 124-125	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		16X-1, 04-06	016	.	.	.	.	.	.	.	.	027	.	.	.	.	.	.	001	001	.
		19N-1, 93-112	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Table 1 (continued).

Naviculopsis ponticula ponticula 76	*Naviculopsis ponticula spinosa* 77	*Naviculopsis punctilia* 78	INDEX NUMBER	SPECIES
.	.	.	28	*Bachmannocena apiculata*
.	.	.	46	*Bachmannocena apiculata curvata*
.	.	.	18	*Bachmannocena circulus* var. *apiculata*
.	.	.	24	*Bachmannocena diodon diod*
.	.	.	29	*Bachmannocena diodon nodosa*
.	.	.	47	*Bachmannocena diodon nodosa* (w/ 1 sp.)
.	.	.	25	*Bachmannocena diodon nodosa* (w/ 3 sp. asym.)
.	.	.	33	*Bachmannocena dumitricae*
.	.	.	26	*Bachmannocena elliptica*
.	.	.	48	*Bachmannocena ovata*
.	.	.	54	*Bachmannocena quadrangula*
.	.	.	34	*Bachmannocena triangula*
.	.	.	63	*Caryocha* cf. *latifenestrata*
.	.	.	40	*Caryocha depressa*
.	.	.	49	*Caryocha ernestinae*
.	.	.	69	*Corbisema* cf. *trigonus* (reworked?)
.	.	.	71	*Corbisema* sp. 1
.	.	.	22	*Corbisema triacantha*
.	.	.	41	*Dictyocha* (aberrant forms)
.	.	.	20	*Dictyocha aspera*
.	.	.	30	*Dictyocha brevispina*
.	.	.	42	*Dictyocha* cf. *angulata*
.	.	.	23	*Dictyocha fibula*
.	.	.	39	*Dictyocha longa*
.	.	.	45	*Dictyocha pentagona*
.	.	.	51	*Dictyocha pulchella* var. *inflata*
.	.	.	3	*Dictyocha quadria* (reworked)
.	.	.	43	*Dictyocha* sp. 1
.	.	.	52	*Dictyocha subclinata*
.	.	.	31	*Distephanus* (aberrant forms)
.	.	.	70	*Distephanus* aff. *fibula hexacantha*
.	.	.	58	*Distephanus* aff. *pseudocrux*
.	.	.	64	*Distephanus bachmanni*
.	.	.	4	*Distephanus boliviensis* & *Ds. speculum* (bolivienoid)
.	.	.	5	*Distephanus boliviensis* & *Ds. speculum* (bolivienoid) — (w/ 2 aw.)
.	.	.	6	*Distephanus boliviensis* & *Ds. speculum* (bolivienoid) — (w/ 3 aw.)
.	.	.	7	*Distephanus boliviensis* & *Ds. speculum* (bolivienoid) — (w/ 3 aw., 7 brs.)
.	.	.	61	*Distephanus boliviensis* & *Ds. speculum* (bolivienoid) — (w/ 7 brs.)
.	.	.	55	*Distephanus boliviensis* & *Ds. speculum* (bolivienoid) — (w/ 8 brs.)
.	.	.	8	*Distephanus boliviensis* & *Ds. speculum* (bolivienoid) — (w/ > 4 aw.)
.	.	.	9	*Distephanus boliviensis* (w/ large aw.)
.	.	.	53	*Distephanus* cf. *xenus*
.	.	.	50	*Distephanus crux* (w/ 2 aw.)
.	.	.	36	*Distephanus crux parvus*
.	.	.	21	*Distephanus crux* s.l.
.	.	.	35	*Distephanus crux scutulatus*
.	.	.	44	*Distephanus crux* ssp. 1
.	.	.	60	*Distephanus crux* ssp. 2
.	.	.	11	*Distephanus frugalis*
.	.	.	17	*Distephanus frugalis* (w/ 2 aw.)
.	.	.	37	*Distephanus hannai*
.	.	.	12	*Distephanus jimlingii*
.	.	.	13	*Distephanus jimlingii* (w/ 2 or 3 aw.)
.	.	.	14	*Distephanus jimlingii/sulcatus*
.	.	.	65	*Distephanus longispinus*
.	.	.	68	*Distephanus pseudofibula*
.	.	.	10	*Distephanus quinquangellus*
.	.	.	59	*Distephanus quinquangellus* (w/ 2 ap.)
.	.	.	62	*Distephanus quinquangellus* (w/ 3 ap.)
.	.	.	56	*Distephanus slavincii*
.	.	.	19	*Distephanus speculum* (bolivienoid, w/ very long major sp.)
.	.	.	27	*Distephanus speculum giganteus*
.	.	.	57	*Distephanus speculum hemisphaericus* & *Ds. boliviensis* (hemisphaericoid)
.	.	.	66	*Distephanus speculum minutus*
.	.	.	15	*Distephanus speculum speculum*
.	.	.	67	*Distephanus crux* ssp. 3
.	.	.	38	*Distephanus stradneri*
.	.	.	16	*Distephanus sulcatus*
.	.	.	74	*Naviculopsis biapiculata*
.	.	.	72	*Naviculopsis lata*
.	.	.	73	*Naviculopsis navicula*
.	.	.	76	*Naviculopsis ponticula ponticula*
.	.	.	77	*Naviculopsis ponticula spinosa*
.	.	.	78	*Naviculopsis punctilia*
.	.	.	75	*Naviculopsis quadrata*
.	.	.	32	*Neonaviculopsis neonautica*
.	.	.	1	Total Whole Specimens
.	.	.	2	unidentifiable fragments

ple 104-643A-11H-2, 70–72 cm which is assigned to the *Ds. crux scutulatus* Zone. The last occurrence of *Ds. longispinus* in this sample is indicative of a late Miocene age, as Martini and Müller (1976) correlate this event to within calcareous nannofossil zone NN10.

The most abrupt change in the silicoflagellate assemblage of Hole 643A occurs between Samples 104-643A-11H-2, 70–72 cm and 104-643A-12H-2, 70–72 cm. Table 2 reveals numerous last occurrences which occur in Sample 104-643A-12H-2, 70–72 cm; among those species with a last appearance at this level are *Bachmannocena apiculata, Caryocha depressa, C. ernestinae, Distephanus hannai, Ds. stradneri, Ds. crux parvus*, and *Ds. slavincii*. The multiple last appearances between these two samples are interpreted as the result of a significant hiatus between the *Distephanus crux scutulatus* Zone above and the *Bachmannocena circulus* var. *apiculata-Caryocha* Zone below. Missing is most of the upper portion of the *B. circulus* var. *apiculata-Caryocha* Zone that is defined by the concurrent range of these taxa. In Hole 643A, their concurrent range is limited to Sample 104-643A-12H-2, 70–72 cm. Elsewhere in the region (Site 348 on the Iceland Plateau), Martini and Müller (1976) documented the concurrent range of these taxa in the upper portion of their middle-late Miocene *Mesocena circulus* Zone. The age of the hiatus is problematic as a result of the scarcity of detailed census data of silicoflagellate assemblages across the middle/late Miocene boundary. Taxa within Sample 104-643A-12H-2, 70–72 cm are common constituents of the middle Miocene in Leg 104 holes and elsewhere throughout the world. On the basis of silicoflagellate assemblages, the hiatus either includes the upper middle Miocene and lowermost upper Miocene or may be confined to the lower upper Miocene.

Another hiatus may occur between Samples 104-643A-12H-2, 70–72 cm and -643A-12H-5, 70–72 cm. The latter sample is assigned to the *Caryocha ernestinae* Zone based upon its position between the last *Distephanus speculum hemisphaericus* and the first *Bachmannocena circulus* var. *apiculata*. The apparent last occurrence of *Corbisema triacantha* in this sample is indicative of an age not younger than NN7 of the middle Miocene.

The interval between Samples 104-643A-13H-2, 70–72 cm and 104-643A- 27X-6, 70–72 cm is assigned to the *Distephanus speculum hemisphaericus* Zone. The silicoflagellate assemblage of this interval is remarkably uniform in comparison to younger assemblages. Quadrate *Distephanus* species dominate along with *Caryocha* and *Distephanus* species with a subdivided apical apparatus. The interval represents the upper lower Miocene to upper middle Miocene (NN4-NN7). Disconformites defined in this zone by diatom and radiolarian biostratigraphic zonal schemes (Goll, this volume; Ciesielski, unpublished; Goll and Bjørklund, this volume) are not evident because of the lack of significant change in the silicoflagellate assemblage.

The brief *Naviculopsis ponticula* Zone is recognized in Sample 104-643A- 27X, CC where several *Naviculopsis* species were noted above the last occurrence of *N. quadrata* in Sample 104-643A-28X-6, 70–72 cm. The remaining two samples examined in the quantitative census of silicoflagellates, Samples 104-643A-28X-6, 70–72 cm and 104-643A-29X-5, 70–72 cm, both contain *N. quadrata,* indicative of the *N. quadrata* Range Zone of the lower Miocene. Although core-catcher samples are not tabulated in Table 2, shipboard examination of Section 104-643A-30X, CC revealed the presence of the *N. quadrata* Zone, its lowermost occurrence in Hole 643A.

The base of the *N. quadrata* Zone is marked by a sudden diagenetic transition to sediments almost entirely barren of siliceous microfossils. The base of the zone is clearly a diagenetic boundary and younger than the true first appearance of the name species. This conclusion is supported by the age of the diatom assemblage at this boundary (Ciesielski, unpublished).

Table 2. Hole 643A silicoflagellate abundances, occurrences, zones, and ages. Species listing in order of highest occurrences. Intraspecific variants are listed separately with diagnostic characteristics indicated in parentheses. The key to the abbreviations indicating morphologic characteristics is as follows: w/ = with, aw. = apical window, brs. = basal ring sides, sp. = basal ring spines, br. = basal ring, asym. = asymmetrical. See Table 3 for a listing of barren samples.

Age	Zone	Sample (cm)	1 Total Whole Specimens	2 Silicoflagellate fragments	3 *Bachmannocena diodon nodosa*	4 *Distephanus boliviensis*	5 *Distephanus boliviensis* (w/ large aw.)	6 *Distephanus crux*	7 *Distephanus pseudofibula*	8 *Distephanus speculum speculum*	9 *Bachmannocena circulus* var. *apiculata*	10 *Bachmannocena dumitricae*	11 *Distephanus speculum* bolivienoid w/ very long major spines)	12 *Dictyocha fibula*	13 *Distephanus boliviensis* (w/ 3 aw.)	14 *Neonaviculopsis* cf. *neonautica*
Late Miocene	*Bachmannocena diodon nodosa*	8H-5, 67–69	026	274	007	003	004	001	001	010	.	.	.	.	.	.
		9H-2, 70–72	151	152	004	013	.	.	001	011	036	006	080	.	.	.
		9H-5, 69–71	0	.	.	.	.	.	.	.	.	.	.	.	.	.
		10H-2, 68–70	0	010	.	.	.	.	.	.	.	.	.	.	.	.
		10H-5, 68–70	021	229	005	.	.	.	.	.	013	.	.	001	001	001
	Distephanus crux scutulatus	11H-1, 70–72	029	073	011	.	.	003	.	005	.	.	.	003	001	.
		11H-2, 70–72	038	053	.	003	001	010	.	.	006	.	.	.	.	.
	B. circulus v. *apiculata/Caryocha*	12H-2, 70–72	264	042	.	011	.	069	.	085	028	.	001	003	.	.
Middle Miocene	*Caryocha ernestinae*	12H-5, 70–72	274	028	010	003	.	054	.	007	.	.	.	003	.	.
	Distephanus speculum hemisphaericus	13H-2, 69–71	282	019	001	006	.	040	001	026	.	.	.	001	.	.
		13H-5, 69–71	285	014	.	007	.	038	.	029	.	.	.	.	006	.
		14H-2, 70–72	296	008	.	002	.	023	.	010	.	.	.	.	002	.
Early Miocene		15H-2, 71–73	292	011	.	021	.	040	.	016	.	.	.	001	001	.
		16H-2, 70–72	287	039	.	017	.	020	.	030	.	.	.	001	003	.
		17X-1, 32–34	282	016	.	028	.	013	.	020	.	.	.	.	006	.
		18X-2, 65–67	274	022	.	017	.	027	.	039	.	.	001	001	001	.
		19X-5, 70–72	290	010	.	027	.	017	.	031	.	.	001	.	015	.
		20X-5, 70–72	290	011	.	008	.	021	.	005	.	.	.	.	004	.
		22X-5, 69–71	289	012	.	017	.	017	.	011	.	.	.	.	017	.
		23X-5, 70–72	288	012	.	014	.	015	.	055	.	.	.	.	003	.
		25X-2, 70–72	291	009	.	006	.	013	.	039	.	.	.	.	010	.
		26X-5, 70–72	292	008	.	042	.	026	.	025	.	.	.	.	012	.
		27X-6, 70–72	288	012	.	025	.	029	.	029	.	.	.	001	004	.
	Naviculopsis quadrata	28X-6, 70–72	271	010	.	014	.	.	.	066	.	.	.	.	007	.
		29X-5, 70–72	282	019	001	006	.	040	001	026	.	.	.	001	.	.

All examined samples from beneath the diagenetic boundary at ~284 mbsf were barren except for two samples examined onboard ship. Sections 104-643A-33X, CC and 104-643A-34X, CC contain three specimens of *Distephanus crux* s.l. and *Ds. longispinus*. These specimens may represent downhole contaminants and alone may not be used for an age designation.

Site 644 (Tables 4 and 5)

Ninety samples were examined from Hole 644A for their silicoflagellate content (Tables 4 and 5). Only the basal five samples between 104-644A-32H-1, 70–72 cm and 104-644A-34H, CC had appreciable numbers of silicoflagellates (Table 4).

Ages of samples with silicoflagellates were estimated on the basis of an assumption of constant sedimentation rates between the paleomagnetic boundaries established by Bleil (this volume). Silicoflagellates are completely absent from sediments younger than the late Matuyama Chron (<0.756 Ma). Only one specimen of *Distephanus speculum speculum* and a few unidentifiable silicoflagellate fragments occur between the last significant occurrence of the group in sediments of the upper Gauss Chro-

Table 2 (continued).

15 *Distephanus crux bispinosus* f. *mesophthalmus*	16 *Distephanus crux scutulatus*	17 *Distephanus boliviensis* (w/ 2 aw.)	18 *Distephanus longispinus*	19 *Bachmannocena apiculata apiculata*	20 *Caryocha depressa*	21 *Caryocha ernestinae*	22 *Dictyocha* (aberrant forms)	23 *Dictyocha aspera*	24 *Dictyocha fibula angusta*	25 *Dictyocha longa*	26 *Dictyocha pentagona* (reworked?)	27 *Distephanus* aff. *pseudocrux*	28 *Distephanus boliviensis* (w/ 4 or more aw.)	29 *Distephanus crux* ssp. 1	30 *Distephanus hannai*	31 *Distephanus stradneri*	32 *Ds. crux parvus* & *Ds. slavincii*	33 *Bachmannocena diodon diodon*	34 *Bachmannocena quadrangula*	35 *Corbisema triacantha*	36 *Dictyocha brevispina*	37 *Dictyocha subclinata*	38 *Distephanus quinquangellus*
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
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001	005	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
.	015	001	002	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
003	016	001	.	001	001	010	001	002	001	001	004	001	001	001	010	009	004	.	.	.	.	.	.
.	050	.	007	001	022	008	001	001	.	.	.	.	.	.	005	033	051	008	003	002	002	002	001
.	082	.	002	002	003	.	.	002	.	.	.	.	002	.	001	038	061	.	001	002	001	.	001
002	072	004	005	001	008	006	.	.	.	.	.	.	004	.	004	017	066	.	.	.	.	.	.
001	095	.	003	003	003	004	.	001	.	.	.	.	.	.	003	021	116	.	.	001	.	.	.
002	057	006	001	003	007	005	.	002	.	.	.	.	003	.	001	034	081	.	.	.	.	.	001
.	049	.	001	002	004	004	.	001	.	.	.	.	001	.	018	027	089	.	.	.	.	.	.
.	053	006	001	003	001	.	.	.	.	.	.	.	005	.	007	025	091	.	.	001	.	.	.
.	068	002	002	.	002	001	.	003	.	.	.	.	002	.	.	017	068	.	.	.	.	.	.
.	066	012	001	007	015	002	.	.	.	.	.	.	010	.	.	019	045	.	.	.	.	.	.
.	080	004	.	008	004	001	.	.	.	.	.	.	014	.	.	037	091	.	.	.	001	.	.
.	066	003	.	006	008	001	.	.	.	.	.	.	012	.	002	040	073	.	.	.	.	.	.
.	071	009	.	004	002	.	.	.	.	.	.	.	006	.	.	035	047	.	.	.	.	.	.
.	055	006	.	003	.	.	.	.	.	.	.	.	008	.	.	039	057	.	.	.	.	.	.
.	054	009	.	007	003	.	.	.	.	.	.	.	010	.	.	023	048	.	.	.	.	.	.
.	055	005	.	003	001	.	.	.	.	.	.	001	011	.	.	025	060	.	.	.	.	.	.
.	036	006	.	.	.	.	001	010	.	.	.	001	021	.	.	019	042	.	.	.	.	.	.
.	082	.	002	002	003	.	.	002	.	.	.	.	002	.	001	038	061	.	001	002	001	.	001

nozone (2.65 Ma) and the uppermost Matuyana Chronozone (0.756 Ma).

Sample 104-644A-32H-1, 70–72 cm is assigned an age of 2.65 Ma and contains the youngest significant occurrence of silicoflagellates. Fifty-three silicoflagellates and fragments were counted with fragments being almost as abundant as whole specimens. The assemblage consists of rare to sparse occurrences of *Dictyocha fibula, Distephanus frugalis, Ds. sulcatus*, and subspecies of the *Ds. boliviensis*, and *Ds. speculum* groups.

Samples 104-644A-32H-3, 70–72 cm (2.69 Ma) and -644A-33H-1, 70–72 cm (2.73 Ma) contain only fragments and a few specimens of *Distephanus boliviensis boliviensis* and *Ds. speculum minutus*. Sample 104-644A-34H-2, 70–72 cm (2.78 Ma) contains common silicoflagellates and fragments with a relatively diverse assemblage including *Distephanus sulcatus* and a variety of subspecies and morphotypes of *Ds. crux, Ds. boliviensis*, and *Ds. speculum*. The greatest occurrence of silicoflagellates in Hole 644A occurs in the basal Sample 104-644A-34H-5, 70–72 cm where they are abundant. This lowermost sample contains *Distephanus septenarius, Ds. frugalis*, and numerous subspecies and morphotypes of *Distephanus boliviensis* and *Ds. crux*.

Table 2 (continued).

Age	Zone	Sample (cm)	39 *Bachmannocena hexalitha*	40 *Corbisema apiculata* (reworked)	41 *Ds. speculum hemisphaericus* & *Ds. boliviensis* (hemisphaericoid)	42 *Distephanus speculum* (bolivienoid w/ 2 or more aw.)	43 *Dictyocha* sp. 1	44 *Distephanus crux* ssp. 3	45 *Neonaviculopsis neonautica*	46 *Bachmannocena apiculata curvata*	47 *Bachmannocena apiculata evexa*	48 *Bachmannocena* cf. *oamaruensis*	49 *Dictyocha flexatella*	50 *Dictyocha deflandrei* (reworked)	51 *Distephanus crux* ssp. 2	52 *Dictyocha elongata*
Late Miocene	*Bachmannocena diodon nodosa*	8H-5, 67–69	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		9H-2, 70–72	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		9H-5, 69–71	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		10H-2, 68–70	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		10H-5, 68–70	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Distephanus crux scutulatus	11H-1, 70–72	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		11H-2, 70–72	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	B. circulus v. *apiculata/Caryocha*	12H-2, 70–72	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Middle Miocene	*Caryocha ernestinae*	12H-5, 70–72	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Distephanus speculum hemisphaericus	13H-2, 69–71	001	001	007	.	.	.	.	.	.	.	.	.	.	.
		13H-5, 69–71	.	002	012	002	.	.	.	.	.	.	.	.	.	.
		14H-2, 70–72	.	.	004	002	001	001	.	.	.	.	.	.	.	.
		15H-2, 71–73	.	.	003	005	.	001	001	.	.	.	.	.	.	.
Early Miocene		16H-2, 70–72	.	.	.	005	.	002	.	001	001	001	010	.	.	.
		17X-1, 32–34	.	001	004	008	.	001	.	002	.	.	001	001	004	.
		18X-2, 65–67	.	.	007	005	.	.	.	.	.	.	001	.	009	001
		19X-5, 70–72	.	.	001	014	.	.	.	004	.	.	.	.	002	.
		20X-5, 70–72	.	.	001	008	.	.	.	002	.	.	.	.		
		22X-5, 69–71	.	001	002	009	.	.	.	001	.	.	002	.	.	.
		23X-5, 70–72	.	.	.	023	.	.	.	001	.	.	.	001	.	.
		25X-2, 70–72	.	.	003	052	.	.	.	.	.	.	.	.	.	.
		26X-5, 70–72	.	.	003	027	.	.	.	001	.	.	.	.	.	.
		27X-6, 70–72	.	.	003	035	.	001	.	.	.	.	.	.	.	.
	Naviculopsis quadrata	28X-6, 70–72	.	.	.	025	.	.	.	.	001	.	.	.	.	.
		29X-5, 70–72	001	001	007	.	.	.	.	.	.	.	.	.	.	.

The basal portion of Hole 644A containing silicoflagellates is assigned to the *Distephanus speculum* Zone, which is defined as the silicoflagellate-bearing interval above the last occurrence of *Ds. jimlingii*. Comparison of this assemblage with those at Sites 642 and 643 indicates that this zone is younger than the uppermost silicoflagellate-bearing horizons at those sites. Either erosion has removed this interval of the Gauss Chronozone from these other sites or the onset of glacial conditions ended silicoflagellate productivity earlier in the vicinity of Sites 642 and 643.

TAXONOMY

In recent years there has been a proliferation of new silicoflagellate taxa. Many of these new taxa appear to have but minor skeletal differences from previously existing taxa. Until such time as sufficent data have been accumulated on the abundance and stratigraphic ranges of skeletal morphotypes it will remain difficult to evaluate the the degree of species variability and revise the taxonomic standing of fossil silicoflagellates. It was our objective to contribute to the body of knowledge on silicoflagellate speices variability, with the long-term goal of major taxonomic revisions which will undoubtedly result in the combining of taxa as it is recognized that many are but intraspecific variants. With this objective in mind we have, for the most part, tabulated skeletal morphotypes separately. From our tables it is apparent that some species have rare and sporadic occurrences, suggesting that they may be intraspecific variants. In spite of these observations, we have taken a conservative point of view

Table 2 (continued).

53 *Bachmannocena triangula*	54 *Distephanus speculum quintus*	55 *Distephanus schulzii*	56 *Dictyocha aserpa* (pentagonal form)	57 *Naviculopsis navicula*	58 *Naviculopsis ponticula ponticula*	59 *Naviculopsis quadrata*
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SPECIES LOCATION INDEX

Index numbers are the columns in which species appear.

INDEX NUMBER	SPECIES
19	*Bachmannocena apiculata apiculata*
46	*Bachmannocena apiculata curvata*
47	*Bachmannocena apiculata evexa*
48	*Bachmannocena* cf. *oamaruensis*
9	*Bachmannocena circulus* var. *apiculata*
33	*Bachmannocena diodon diodon*
3	*Bachmannocena diodon nodosa*
10	*Bachmannocena dumitricae*
39	*Bachmannocena hexalitha*
34	*Bachmannocena quadrangula*
53	*Bachmannocena triangula*
20	*Caryocha depressa*
21	*Caryocha ernestinae*
40	*Corbisema apiculata* (reworked)
35	*Corbisema triacantha*
22	*Dictyocha* (aberrant forms)
23	*Dictyocha aspera*
56	*Dictyocha aspera* (pentagonal form)
36	*Dictyocha brevispina*
50	*Dictyocha deflandrei* (reworked)
52	*Dictyocha elongata*
12	*Dictyocha fibula*
24	*Dictyocha fibula angusta*
49	*Dictyocha flexatella*
25	*Dictyocha longa*
26	*Dictyocha pentagona* (reworked?)
43	*Dictyocha* sp. 1
37	*Dictyocha subclinata*
27	*Distephanus* aff. *pseudocrux*
4	*Distephanus boliviensis*
17	*Distephanus boliviensis* (w/ 2 aw.)
13	*Distephanus boliviensis* (w/ 3 aw.)
28	*Distephanus boliviensis* (w/ 4 or more aw.)
5	*Distephanus boliviensis* (w/ large aw.)
6	*Distephanus crux*
15	*Distephanus crux bispinosus* f. *mesophthalmus*
16	*Distephanus crux scutulatus*
29	*Distephanus crux* ssp. 1
51	*Distephanus crux* ssp. 2
44	*Distephanus crux* ssp. 3
30	*Distephanus hannai*
18	*Distephanus longispinus*
7	*Distephanus pseudofibula*
38	*Distephanus quanquangellus*
55	*Distephanus schulzii*
42	*Distephanus speculum* (bolivienoid w/2 or more aw.)
11	*Distephanus speculum* (bolivienoid w/very long major spines)
54	*Distephanus speculum quintus*
8	*Distephanus speculum speculum*
31	*Distephanus stradneri*
32	*Ds. crux parvus* & *Ds. slavincii*
41	*Ds. speculum hemisphaericus* & *Ds. boliviensis* (hemisphaericoid)
57	*Naviculopsis navicula*
58	*Naviculopsis ponticula ponticula*
59	*Naviculopsis quadrata*
14	*Neonaviculopsis* cf. *neonautica*
45	*Neonaviculopsis neonautica*
2	Silicoflagellate fragments
1	Total Whole Specimens

by deferring taxonomic revisions until these data may be compared with other ongoing studies of Neogene silicoflagellates from other regions. While this may result in some delay to much-needed taxomomic revisions, it is our intent not to add to an already considerable taxonomic confusion.

The following is a list of silicoflagellate taxa encountered in Leg 104 sequences from the Norwegian Sea. Also cited are references to the species authors, references to figures and plates herein, and appropriate remarks.

Bachmannocena apiculata apiculata (Schulz, 1928) Bukry, 1987.

B. apiculata curvata (Bukry, 1976c) Bukry, 1987 (Pl. 2, Figs. 1-3, figs. 5-6).

Remarks. The amount of indentation of the shorter side is highly variable. Specimens in Pl. 2, Figs. 4 and 5 show no appreciable indentation but have an isosocles ring and are associated with normal specimens of *B. apiculata curvata*.

B. apiculata evexa (Bukry, 1985) Bukry, 1987 (Pl. 2, Fig. 7).

B. apiculata glabra (Schulz, 1928) Bukry, 1978b (Pl. 2, Fig. 4).

B. apiculata inflata Bukry, 1978c (Pl. 2, Figs. 9, 12).

B. circulus var. *apiculata* (Lemmermann, 1901) Bukry, 1987 (Pl. 1, Figs. 1-2).

B. diodon borderlandensis Bukry, 1981a (Pl. 2, Fig. 11).

B. diodon diodon (Ehrenberg, 1844) Locker, 1974 (Pl. 3, Fig. 1).

B. diodon nodosa (Bukry, 1978c) Bukry, 1987 (Pl. 1, Figs 3-9).

B. dumitricae (Perch-Nielsen, 1975) Bukry, 1987.

Table 3. Samples from the upper Eocene-lower Miocene, Pliocene, and Quaternary of Hole 643A which are barren of silicoflagellates.

104-643A-1H-1, 70-72 cm	104-643A-37X-2, 63-65 cm
104-643A-1H-3, 70-72 cm	104-643A-38X-1, 69-71 cm
104-643A-2H-2, 70-72 cm	104-643A-39X-1, 66-69 cm
104-643A-2H-5, 70-72 cm	104-643A-41X-1, 70-72 cm
104-643A-3H-2, 65-67 cm	104-643A-42X-2, 71-73 cm
104-643A-3H-5, 65-67 cm	104-643A-44X-2, 70-72 cm
104-643A-4H-2, 68-70 cm	104-643A-45X-2, 70-72 cm
104-643A-4H-5, 70-72 cm	104-643A-46X-2, 70-72 cm
104-643A-5H-2, 66-68 cm	104-643A-46X-5, 70-72 cm
104-643A-5H-5, 69-71 cm	104-643A-47X-2, 70-72 cm
104-643A-6H-2, 72-74 cm	104-643A-47X-5, 70-72 cm
104-643A-6H-5, 72-74 cm	104-643A-48X-2, 70-72 cm
104-643A-7H-2, 69-71 cm	104-643A-48X-5, 70-72 cm
104-643A-7H-5, 69-71 cm	104-643A-49X-2, 70-72 cm
104-643A-8H-2, 67-69 cm	104-643A-49X-5, 70-72 cm
104-643A-31X-2, 70-72 cm	104-643A-50X-1, 70-72 cm
104-643A-31X-4, 70-72 cm	104-643A-50X-2, 70-72 cm
104-643A-32X-2, 70-72 cm	104-643A-51X-5, 70-72 cm
104-643A-33X-2, 70-72 cm	104-643A-52X-2, 69-71 cm
104-643A-34X-2, 70-72 cm	104-643A-52X-5, 69-71 cm
104-643A-36X-2, 65-67 cm	104-643A-53X-2, 70-72 cm
	104-643A-53X-5, 70-72 cm

B. eliiptica (Ehrenberg, 1844) Bukry, 1987.
B. hexalitha (Bukry, 1981b) Bukry, 1987.
B. oamaruensis (Schulz, 1928) Bukry, 1987.
B. ovata (Bukry, 1978c) Bukry, 1987 (Pl. 2, Fig. 8).
B. quadrangula (Ehrenberg ex Haeckel, 1887) Bukry, 1987 (Pl. 3, Fig. 2).
B. schulzii (Martini et Müller, 1976) Bukry 1987 (Pl. 2, Fig. 10).
B. triangula (Ehrenberg, 1839) Locker, 1974.
B. sp. (Pl. 3, Figs. 4-5).

Genus *Caryocha* Bukry et Monechi, 1985.

Remarks. We follow the practice of Bukry and Monechi (1985) of not recognizing the genus *Cannopilus* and include phenotypic varieties with nonglobular and subdivided apical apparatus in *Distephanus*. The genus *Caryocha* has a more restrictive geologic range than taxa of *Distephanus* with a subdivided apical apparatus, the former only being a major component of the assemblage in the lower and middle Miocene. *Caryocha* is distinctive for its globular form, multiple apical windows, nearly equant basal spines, and a basal ring equal to, or less than, the diameter of the apical structure.

Caryocha depressa (Ehrenberg, 1854) Bukry et Monechi, 1985 (Pl. 6, Figs. 2-3, 5-6).
C. ernestinae (Backmann, 1962) Bukry et Monechi, 1985 (Pl. 6, Figs. 7-8).
C. cf. *latifenestrata* (Bachmann *in* Ichikawa et al., 1964) Bukry et Monechi, 1985.
Corbisema apiculata (Lemmermann, 1901) Hanna, 1931.
C. flexuosa (Stradner, 1961) Perch-Nielson, 1975.
C. triacantha (Ehrenberg, 1844) Bukry et Foster, 1973 (Pl. 8, Fig. 15).
C. sp. 1.

Remarks. Three-sided basal ring indented in the middle where lateral rods join the basal ring. Lateral rods join to form a small triangular apical window centered above the basal apparatus, possessing only two long basal spines at two corners of the basal apparatus.

Dictyocha angulata Bukry, 1982.
D. aspera (Lemmermann, 1901) Bukry et Foster, 1973.
D. brevispina (Lemmermann, 1901) Bukry, 1976a (Pl. 3, Fig. 3; Pl. 8, Fig. 12).

Remarks. Barless variants such as those found in Sample 104-642B-10H, CC were also noted in the lower Pliocene by Dumitrica (1973b) from Site 206 and by Bukry from Site 504.

D. deflandrei Frenguelli (1940) ex Glezer, 1966.
D. elongata Glezer, 1960.
D. fibula Ehrenberg, 1839.
D. fibula angusta Bukry, 1976b.
D. flexatella (Bukry, 1979) Bukry, 1985.
D. hexacantha Schulz, 1928.
D. longa Bukry, 1982.

Remarks. A few of the specimens have an apical bar slightly out of alignment with the major axis.

D. pentagona (Schulz, 1928) Bukry and Foster, 1973 (Pl. 8, Fig. 13).
D. pulchella var. *inflata* Bukry, 1985 (Pl. 8, Fig. 14).
D. quadria (Mandra, 1969) Martini et Müller, 1976 (Pl. 7, Fig. 15).
D. subclinata Bukry, 1981a.
D. sp. 1

Remarks. Equal-sided basal ring with five or six sides, basal ring sides strongly indented where an equal number of straight apical bars join the basal apparatus. Possessing relatively long and symmetrically aligned basal spines. Relatively rare in the lower to middle Miocene.

Distephanus bachmanni (Dumitrica, 1967) n. comb.
Dictyocha bachmanni Dumitrica, p. 1, Pl. 1, Figs. 1-17; Pl. 2, Figs. 15-17.
Ds. boliviensis (Frenguelli, 1940) Bukry, 1973a (Pl. 5, Fig. 1).

Remarks. Bukry (1979) designated a lectotype from Frenguelli's type suite as *Ds. boliviensis boliviensis* which has relatively short equant spines and a single apical ring that is particularly common in the Pliocene and lower Quaternary. Spine length was not observed here, has a stable phenotype within the *Ds. boliviensis* and *Ds. speculum* stock. Herein all specimens are tabulated as *Ds. boliviensis*, regardless of spine length, so long as the basal spine lengths are equal.

Ds. boliviensis (cannopilean) (Pl. 5, Figs. 3-7).

Remarks. Cannopilean forms of *Ds. boliviensis* are considered to be those which have a multiwindowed apical apparatus but otherwise are similar to *Ds. boliviensis*, except they may possess more than six sides to the basal ring and longer basal spines than *Ds. boliviensis boliviensis*. The relatively flat apical apparatus may be comprised of two to seven or more apical windows which do not completely fill the intrabasal ring space. Not included in this designation are distinctive cannopilean forms which are tabulated separately (e.g., *Ds. jimlingii* and *Ds. sulcatus*). Cannopilean forms of *Ds. boliviensis* are identified in the tables as *Ds. boliviensis* followed by an abbreviated descriptor in parentheses and include the following morphotypes: with two apical windows; with three apical windows; with four or more apical windows. Reference to the tables reveals that cannopilean forms of *Ds. boliviensis* occurred most frequently during times of abundance of other species of *Distephanus* and *Caryocha* with a subdivided apical apparatus. The stratigraphic relation ship of these cannopilean forms to *Ds. boliviensis* suggests that they are intraspecific variants whose abundance was controlled by paleoceanographic conditions. Further taxonomic division based upon the number of apical windows is discouraged as there is no apparent stratigraphic significance to their occurrence.

Ds. boliviensis (cannopilean-irregular) (Pl. 3, Figs. 6, 8-11).

Remarks. While photographing several core-catcher samples from Hole 643A, several specimens were encountered which are equant-spined and similar to *Ds. boliviensis* but have a highly variable apical appara tus. Specimens may exhibit wavy apical bars, small and large apical spines, extra lateral rods, and extra radial spines. Unusual paleoenvironmental conditions may have caused increased skeletal plasticity represented in these speciens.

Ds. boliviensis (hemisphaericoid) (Pl. 5, Fig. 8, Pl. 6, Fig. 1).

Remarks. Similar in all respects to *Ds. boliviensis* (cannopilean) except the multiwindowed apical apparatus is almost as wide as the basal ring; whereas, *Ds. boliviensis* (cannopilean) has a multiwindowed apical apparatus which is distinctly less than the width of the basal ring. Differs from *Ds. speculum hemisphaericus* by its near-equal basal spine length and larger basal ring. *Ds. boliviensis* (hemisphaericoid) and *Ds. speculum hemisphaericus* exhibit identical ranges in Site 642 and 643, suggesting that they may intraspecific variations of the same taxa. Because of their identical stratigraphic range, both groups are tabulated together in Tables 1 and 2.

Ds. crux s.l. (Pl. 7, Figs. 4, 9)

Remarks. *Distephanus crux* is herein regarded as a group of subspecific taxa generally characterized by a tetragonal basal ring surmounted by an apical ring. Several subspecies are tabulated separately which conform to existing subspecies definitions. Other variants are tabulated as *Ds. crux* s. 1.

Ds. crux bispinosus Dumitrica, 1973.
Ds. crux bispinosus f. mesophthalmus (Ehrenberg, 1845) Locker et Martini, 1986.
Ds. crux parvus Bukry, 1982 (Pl. 7, Fig. 7).

Remarks. This subspecies was inadvertently tablulated together with *Ds. slavincii* by one of us in our examination of Hole 643. Time constraints prevented a recounting of this hole, therefore, both taxa are listed collectively. Both taxa are listed separately in the occurrence chart of Holes 642C and 642D.

Ds. crux scutulatus Bukry, 1982 (Pl. 7, Figs. 5, 10).
Ds. crux ssp. 1 (Pl. 7, Fig. 11).

Remarks. Quadrate and scalloped basal ring, very small basal spines, large apical window, sometime with knobby ornamentation.

Ds. crux ssp. 2.

Remarks. Small and quadrate basal ring, very strongly indented where the lateral rods join the basal ring, giving the basal ring a wavy appearance. Accessory spines may be present at the juncture of the lateral rods with the basal ring.

Ds. crux ssp. 3

Remarks. Elongate basal ring with the maximum dimension approximately twice that of its minimum dimension. Distinguished by the presence of moderate length basal spines aligned with the major axis, and the absence of minor axis spines.

Ds. aff. *fibula hexacantha* n. comb. *Dictyocha fibula* f. *hexacantha* Frenguelli, 1935, pl. 1, Figs. 1–14.

Remarks. Four specimens were found in early Miocene Sample 104-642D-6X-2, 125–127 cm, which have a close affinity to specimens described by Frenguelli from the Holocene of Gulfo San Matias, Argentina. Due to its hexagonal basal ring the species is reassigned to *Distephanus*.

Ds. frugalis (Bukry, 1975b) Bukry, 1979.
Ds. hannai (Bukry, 1975b) Bukry, 1979.
Ds. jimlingii (Bukry, 1975b) Bukry, 1979 (Pl. 4, Figs. 3–4).

Remarks. Most specimens follow the description of Bukry's (1979) *Ds. jimlingii* by having a regularly arranged apical apparatus with a rounded central opening surrounded by a cycle of five to seven openings. Occasional specimens have two central openings surrounded by a cycle of other openings (Pl. 4, Figs. 3–4).

Ds. jimlingii/Ds. sulcatus (Pl. 4, Figs. 5–7).

Remarks. A number of specimens were observed in the Pliocene of Hole 642C which exhibit morphologic characteristics intermediate between *Ds. jimlingii* and *Ds. sulcatus* and are tablulated as *Ds. jimlingii/Ds. sulcatus*. These intermediate forms first occur in the upper range of *Ds. jimlingii* and range concurrently with the lower range of *Ds. sulcatus*. Apical windows are less regularly arranged than in *Ds. jimlingii* and do not exhibit the size variation of *Ds. sulcatus*. Tubular elements of the lateral rods are not as narrow with respect to the basal ring as in *Ds. sulcatus* and often have hyaline areas (Pl. 4, Figs. 6–7).

Ds. longispinus (Schulz, 1928) Bukry, 1979 (Pl. 7, Fig. 8).
Ds. polyactis (Ehrenberg, 1838) Dumitrica, 1973.
Ds. polyactis crassus Bukry, 1977 (P1. 6, Fig. 10).
Ds. pseudocrux (Schulz, 1928) Bukry, 1973b.
Ds. pseudofibula (Schulz, 1928) Bukry, 1976c.
Ds. quinquangellus Bukry et Foster, 1973 (Pl. 7, Figs. 12–14, 16).

Remarks. Pentagoanl forms assigned to this species may have arisen independantly from *Distephanus speculum* and *Ds. boliviensis*. Specimens with a small basal apparatus (Pl. 7, Fig. 13) and long basal spines are more common in association with *Ds. speculum*; whereas larger varieties are associated with common *Ds. boliviensis*.

Ds. quintus (Bukry and Foster, 1973) Bukry, 1981.
Ds. schauinslandii Lemmermann, 1901.
Ds. schultii n. comb. (Pl. 6, Fig. 4).
Cannopilus schulztii Deflandre in Bachmann and Ichikawa, 1962, p. 171. = *Cannopilus cyrtoides* Schulz, 1928, Fig. 65.
Ds. septenarius (Ehrenberg, 1844); Perch-Nielsen, 1975.
Ds. slavincii (Jerkovic, 1965) Bukry, 1973c (Pl. 7, Figs. 1–3).

Remarks. This subspecies was inadvertently tablulated together with *Ds. crux parvus* by one of us in our examination of Hole 643. Time constraints prevented a recounting of this hole, therefore, both taxa are listed collectively. Both taxa are listed separately in the occurrence chart of Holes 642C and 642D.

Ds. speculum (bolivienoid).

Remarks. Silicoflagellates similar to Ds. boliviensis, but having two opposing spines with lengths in excess of the remainder of the basal ring spines, may not be classified with this species which has somewhat equant spine lengths. However, specimens similar to *Ds. boliviensis*, but having two long opposing spines are tabulated here as *Ds. speculum* (bolivienoid) pending a revision of the taxonomic status of *Distephanus* species by the authors.

Ds. speculum f. coronata Schulz, 1928 (Pl. 6, Fig. 12).
Ds. speculum hemisphaericus (Ehrenberg, 1844) Bukry 1975 emend. (Pl. 5, Fig. 9).

Remarks. Recent detailed quantitative analyses of silicoflagellates with multiple windowed apical structures by Shaw and Ciesielski (1983) and herein, reveal justification for emendation of this species. This taxon is emended to include forms with a six- to eight-sided basal ring similar to or slightly larger in size than *Ds. speculum speculum*, but distinctly smaller than *Ds. boliviensis*, with a relatively flat to slightly domed apical apparatus bearing four or more apical windows, which has a width almost as great as the basal apparatus. Supporting rods connecting the apical apparatus to the basal ring are indistinct because of the width of the apical apparatus. Apical windows may be arranged in any fashion, as there is no stratigraphic significance to particular arrangements. Apical windows may be irregularly arranged and sized. Basal accessory spines are usually present on the basal ring.

Ds. speculum giganteus Bukry, 1976c.
Ds. speculum minutus (Backmann in Ichikawa et al., 1967) Bukry, 1976b emend. Bukry, 1981a (Pl. 6, Fig. 13).
Ds. speculum s.l. (Ehrenberg, 1839) Haeckel, 1887 (Pl. 4, Figs 1, 2, Pl. 6, Figs. 11, 14).
Ds. speculum triomata (Ehrenberg, 1845) Bukry, 1976a.
Ds. stradneri (Jerkovic, 1965) Bukry, 1978b (Pl. 7, Fig. 6).
Ds. sulcatus Bukry 1979 (Pl. 4, Figs. 8–10).

Remarks. Most specimens, such as those illustrated herein, have a basal ring which is not as sulcate as those illustrated by Bukry (1979). In other respects, those tabulated herein adhere to the original description of Bukry (1979).

Ds. trigonus Uchio, 1974.
Ds. cf. *xenus* Bukry, 1985.
Naviculopsis biapiculata (Lemmerman, 1901) Frenguelli, 1940.
N. constricta (Schulz, 1928) Bukry emend., in Barron, Bukry, and Poore, 1984 (Pl. 8, Fig. 11).

Table 4. Leg 104, Hole 644A silicoflagellate abundances, occurrences, zones, and ages. Species listing in order of highest occurrences. Intraspecific variants are listed separately with diagnostic characteristics indicated in parentheses. The key to the abbreviations indicating morphologic characteristics is as follows: w/ = with, aw. = apical window, brs. = basal ring sides, sp. = basal ring spines, br. = basal ring, asym. = asymmetrical. See Tables 3 and 5 for listings of barren samples.

Sample (cm)	Silicoflagellate fragments	*Ds. speculum speculum*	*Ds. sulcatus*	*Dictyocha fibula*	*Ds. boliviensis*	*Ds. boliviensis* (w/large aw.)	*Ds. frugalis* (w/2 aw.)	*Ds. speculum* (bolivienoid w/large aw.)	*Ds. speculum* (w/3 aw.)	*Ds. speculum* (w/long curved major spines)	*Ds. speculum minutus*	*Bachmannocena triangula* (reworked)	*Ds. boliviensis* (robust and large)	*Ds. crux* (large aw., long major sp., short minor sp.)	*Ds. crux* (large)	*Ds. crux* (large, w/small aw., long major sp., short minor sp.)	*Ds. crux* (small w/equal sp.)	*Ds. crux* (small, w/large aw., long major sp.)	*Ds. crux* (very large, w/medium aw., equal sp.)	*Ds. speculum* (bolivienoid)	*Ds. speculum* f. *coronata*	*Ds. crux* (small, w/long major sp.)	*Ds. crux* (w/large aw., equal sp.)	*Ds. septenarius*	*Ds. speculum* (w/small aw., curved long sp. > br. width)	*Ds. speculum* (w/small double aw., curved long sp.)	*Ds. speculum pentagonus*
1H-2, 70–72	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1H-5, 70–72	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
2H-2, 70–72	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
2H-5, 56–58	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
3H-2, 68–70	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
3H-5, 68–70	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
4H-2, 70–72	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
4H-5, 70–72	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
5H-2, 70–72	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
5H-5, 70–72	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
6H-2, 69–71	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
6H-5, 69–71	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
7H-2, 70–72	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
7H-4, 70–72	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
8H-2, 70–72	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
8H-5, 56–58	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
9H-2, 70–72	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
9H-5, 70–72	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
9H, CC	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
10H-2, 55–57	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
10H-2, 84–86	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
10H-2, 70–72	001	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
10H-5, 70–72	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
10H, CC	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
11H-2, 70–72	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
11H-5, 70–72	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
11H, CC	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
12H-2, 70–72	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
12H-5, 70–72	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
12H, CC	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
13H-2, 70–72	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
13H-5, 70–72	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
13H, CC	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

14H-2, 70–72	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
14H-5, 70–72	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
14H, CC	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
15H-2, 70–72	001	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
15H-5, 70–72	001	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
15H, CC	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
16H-2, 70–72	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
16H-5, 70–72	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
16H, CC	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
17H-3, 70–72	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
17H-5, 70–72	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
17H, CC	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
18H-2, 70–72	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
18H-5, 70–72	001	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
18H, CC	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
19H-2, 70–72	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
19H-4, 70–72	001	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
19H, CC	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
20H-2, 70–72	.	001	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
20H-5, 70–72	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
20H, CC	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
21H-1, 70–72	001	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
21H, CC	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
22H-2, 70–72	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
22H-5, 70–72	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
22H, CC	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
23H-2, 68–70	002	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
23H-4, 68–70	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
23H, CC	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
24H-1, 70–72	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
24H-3, 70–72	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
24H, CC	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
25H-1, 70–72	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
25H-3, 70–72	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
25H, CC	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
26H-2, 70–72	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
26H, CC	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
27H-1, 70–72	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
27H, CC	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
28H-1, 32–34	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
28H-1, 70–72	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
28H-3, 70–72	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
28H, CC	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
29H-1, 70–72	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
29H-3, 70–72	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
29H, CC	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
30H-1, 70–72	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
30H-3, 70–72	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
30H, CC	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
31H-1, 70–72	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
31H-3, 70–72	001	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
31H-4, 70–72	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
31H, CC	.	.	001	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
32H-1, 70–72	025	009	005	001	002	003	001	001	001	001	004	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
32H-3, 70–72	006	.	.	.	001	.	.	.	.	.	001	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
33H-1, 70–72	005	.	.	.	001	.	.	.	.	.	001	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
34H-2, 70–72	062	.	007	.	001	.	.	.	001	.	008	002	009	002	003	003	002	007	001	001	001	.	.	.	.	.	.
34H-5, 70–72	080	012	.	.	013	027	.	.	.	.	012	.	.	.	.	.	.	.	.	.	.	001	001	001	229	001	001

Table 5. Samples from the Pliocene-Quaternary of Hole 644A which are barren of silicoflagellates.

104-644A-1H-2, 70-72 cm	104-644A-16H, CC
104-644A-1H-5, 70-72 cm	104-644A-17H-3, 70-72 cm
104-644A-2H-2, 70-72 cm	104-644A-17H-5, 70-72 cm
104-644A-2H-5, 56-58 cm	104-644A-17H, CC
104-644A-3H-2, 68-70 cm	104-644A-18H-2, 70-72 cm
104-644A-3H-5, 68-70 cm	104-644A-18H, CC
104-644A-4H-2, 70-72 cm	104-644A-19H-2, 70-72 cm
104-644A-4H-5, 70-72 cm	104-644A-19H, CC
104-644A-5H-2, 70-72 cm	104-644A-20H-5, 70-72 cm
104-644A-5H-5, 70-72 cm	104-644A-20H, CC
104-644A-6H-2, 69-71 cm	104-644A-21H, CC
104-644A-6H-5, 69-71 cm	104-644A-22H-2, 70-72 cm
104-644A-7H-2, 70-72 cm	104-644A-22H-5, 70-72 cm
104-644A-7H-4, 70-72 cm	104-644A-22H, CC
104-644A-8H-2, 70-72 cm	104-644A-23H-4, 68-70 cm
104-644A-8H-5, 56-58 cm	104-644A-23H, CC
104-644A-9H-2, 70-72 cm	104-644A-24H-1, 70-72 cm
104-644A-9H-5, 70-72 cm	104-644A-24H-3, 70-72 cm
104-644A-9H, CC	104-644A-24H, CC
104-644A-10H-2, 55-57 cm	104-644A-25H-1, 70-72 cm
104-644A-10H-2, 84-86 cm	104-644A-25H-3, 70-72 cm
104-644A-10H-5, 70-72 cm	104-644A-25H, CC
104-644A-10H, CC	104-644A-26H-2, 70-72 cm
104-644A-11H-2, 70-72 cm	104-644A-26H, CC
104-644A-11H-5, 70-72 cm	104-644A-27H-1, 70-72 cm
104-644A-11H, CC	104-644A-27H, CC
104-644A-12H-2, 70-72 cm	104-644A-28H-1, 32-34 cm
104-644A-12H-5, 70-72 cm	104-644A-28H-1, 70-72 cm
104-644A-12H, CC	104-644A-28H-3, 70-72 cm
104-644A-13H-2, 70-72 cm	104-644A-28H, CC
104-644A-13H-5, 70-72 cm	104-644A-29H-1, 70-72 cm
104-644A-13H, CC	104-644A-29H-3, 70-72 cm
104-644A-14H-2, 70-72 cm	104-644A-29H, CC
104-644A-14H-5, 70-72 cm	104-644A-30H-1, 70-72 cm
104-644A-14H, CC	104-644A-30H-3, 70-72 cm
104-644A-15H, CC	104-644A-30H, CC
104-644A-16H-2, 70-72 cm	104-644A-31H-1, 70-72 cm
104-644A-16H-5, 70-72 cm	104-644A-31H-4, 70-72 cm

N. iberica Deflandre, 1950 (Pl. 8, Fig. 7).
N. lata (Deflandre, 1932) Bukry, 1982 (Pl. 8, Figs. 1-3, 6).
N. navicula (Ehrenberg, 1840) Deflandre, 1950 (Pl. 8, Fig. 9).
N. ponticula ponticula (Ehrenberg, 1844) Bukry, 1982 (Pl. 8, Figs. 4-5).
N. ponticula spinosa Bukry, 1982.
N. punctilia Perch-Nielsen, 1976.
N. quadrata (Ehrenberg, 1844) Locker (1974).
N. sp. (Pl. 8, Figs. 8, 10).

Remarks. These specimens may possibly be intraspecific variations of *N. navicula*.

Neonaviculopsis neonautica (Bukry, 1981) Locker et Martini, 1986.

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REFERENCES

Bachmann, A., 1962. Eine neu entdeckte Silicoflagellidenart: *Cannopilus ernestinae* Bachmann, nov. spec. *Mikrokosmos*, 51: 255.

Barron, J. A., 1980. Lower Miocene to Quaternary diatom biostratigraphy of Leg 57, off northeastern Japan, Deep Sea Drilling Project. *Init. Repts.* DSDP, 56, 57, Pt. 2: Washington (U.S. Govt. Printing Office), 641-685.

———, 1985. Miocene to Holocene planktic diatoms. *In* Bolli, H. M., Saunders, J. B., and Perch-Nielsen, K. (Eds.), *Plankton Stratigraphy*: Cambridge (Cambridge University Press), 811-846.

Berggren, W. A., Kent, D. V., Flynn, J. J., and Van Couvering, J. A., 1985. Cenozoic geochronology. *Geol. Soc. Am. Bull.*, 96:1407-1418.

Bukry, D., 1973a. Coccolith and silicoflagellate stratigraphy, Deep Sea Drilling Project Leg 18, eastern North Pacific. *In* Kulm, L. D., von Huene, R., et al., *Init. Repts. DSDP*, 18: Washington (U.S. Govt. Printing Office), 817-831.

———, 1973b. Coccoliths and silicoflagellates from Deep Sea Drilling Project Leg 19, North Pacific Ocean and Bering Sea. *In* Creager, J. S., Scholl, D. W., et al., *Init. Repts. DSDP*, 19: Washington (U.S. Govt. Printing Office), 857-867.

———, 1975a. Silicoflagellate and coccolith stratigraphy, Deep Sea Drilling Project Leg 29. *In* Kennett, J. P., Houtz, R. E., et al., *Init. Repts. DSDP*, 29: Washington (U.S. Govt. Printing Office), 845-872.

———, 1975b. Coccolith and silicoflagellate stratigraphy, northwest Pacific Ocean, Deep Sea Drilling Project Leg 32. *In* Larson, R. L., Moberly, R., et al., *Init. Repts., DSDP*, 32: Washington (U.S. Govt. Printing Office), 677-701.

———, 1976a. Silicoflagellate and coccolith stratigraphy, southeastern Pacific Ocean, Deep Sea Drilling Project Leg 34. *In* Yeats R. S., Hart, S. R., et al., *Init. Repts. DSDP*, 34: Washington (U.S. Govt. Printing Office), 715-735.

———, 1976b. Cenozoic silicoflagellate and coccolith stratigraphy, South Atlantic Ocean, Deep Sea Drilling Project Leg 36. *In* Hollister, C. D., Craddock, C., *Init. Repts. DSDP*, 35: Washington (U.S. Govt. Printing Office), 885-917.

———, 1976c. Silicoflagellate and coccolith stratigraphy, Norwegian-Greenland Sea, Deep Sea Drilling Project Leg 38. *In* Talwani, M., Udintsev, G., et al., *Init. Repts. DSDP*, 38: Washington (U.S. Govt. Printing Office), 843-855.

———, 1977. Coccolith and silicoflagellate stratigraphy, central and North Atlantic, Deep Sea Drilling Project Leg 37. *In* Aumento, F., Melson, W. G., et al., *Init. Repts. DSDP*, 37: Washington (U.S. Govt. Printing Office), 907-927.

———, 1978a. Cenozoic silicoflagellate and coccolith stratigraphy, southeastern Atlantic Ocean, Deep Sea Drilling Project Leg 40. *In* Bolli, H. M., Ryan, W. B. F., et al., *Init. Repts. DSDP*, 40: Washington (U.S. Govt. Printing Office), 635-639.

———, 1978b. Cenozoic silicoflagellate and coccolith stratigraphy, northwestern Atlantic Ocean, Deep Sea Drilling Project Leg 43. *In* Benson, W. E., Sheridan, R. E., et al., *Init. Repts. DSDP*, 44: Washington (U.S. Govt. Printing Office), 775-805.

———, 1978c. Cenozoic coccolith, silicoflagellate, and diatom stratigraphy, Deep Sea Drilling Project Leg 44. *In* Benson, W. E., Sheridan, R. E., et al., *Init. Repts. DSDP*, 44: Washington (U.S. Govt. Printing Office), 807-863.

———, 1979. Comments on opal phytoliths and stratigraphy of Neogene silicoflagellates and coccoliths at Deep Sea Drilling Project Site 397 off northwest Africa. *In* Luyendyk, B. P., Cann, J. R., et al., *Init. Repts. DSDP*, 49: Washington (U.S. Govt. Printing Office), 977-1009.

———, 1981a. Pacific Coast silicoflagellates, Deep Sea Drilling Project Leg 63. *In* Yeats, R. S., Haq, B. U., et al., *Init. Repts. DSDP*, 63: Washington (U.S. Govt. Printing Office), 539-557.

———, 1981b. Synthesis of silicoflagellate stratigraphy for Maestrichtian to Quaternary marine sediment. *Soc. Econ. Paleontol. Mineral. Spec. Publ.*, 32:433-444.

———, 1982. Cenozoic silicoflagellates from offshore Guatemala, Deep Sea Drilling Project Site 495. *In* Aubouin, J., von Huene, R., et al.,*Init. Repts. DSDP*, 67: Washington (U.S. Govt. Printing Office), 425-445.

———, 1984. Cenozoic silicoflagellates from Rockall Plateau, Deep Sea Drilling Project Leg 81. *In* Roberts, D. G., Schnitker, D., et al., *Init. Repts. DSDP*, 81: Washington (U.S. Govt. Printing Office), 547-563.

———, 1985. Tropical Pacific silicoflagellate zonation and paleotemperature trends of the Late Cenozoic. *In* Mayer, L., Theyer, F., et al., *Init. Repts. DSDP*, 85: Washington (U.S. Govt. Printing Office), 477-497.

———, 1987. Eocene siliceous and calcareous phytoplankton, Deep Sea Drilling Project Leg 95. *In* Poag, C. W., Watts, A. B., et al., *Init. Repts. DSDP*, 95: Washington (U.S. Govt. Printing Office), 395–415.

Bukry, D., and Foster, J. H., 1973. Silicoflagellate and diatom stratigraphy, Leg 16, Deep Sea Drilling Project. *In* van Andel, T. H., Heath, G. R., et al., *Init. Repts. DSDP*, 16: Washington (U.S. Govt. Printing Office), 815–871.

———, 1974. Silicoflagellate zonation of Upper Cretaceous to lower Miocene deep-sea sediment. *J. Res. U.S. Geol. Surv.*, 2:303–310.

Bukry, D., and Monechi, S. 1985. Late Cenozoic silicoflagellates from the northwest pacific, deep sea drilling project leg 86: paleotemperature trends and texture classification. *In* Heath, G. R., Burckle, L. H., et al., *Init. Repts. DSDP*, 86: Washington (U.S. Govt. Printing Office), 367–397.

Ciesielski, P. F., 1975. Biostratigraphy and paleoecology of Neogene and Oligocene silicoflagellates from cores recovered during Antarctic Leg 28, Deep Sea Drilling Project. *In* Hayes, D. E., Frakes, L. A., et al., *Init. Repts. DSDP*, 28: Washington (U.S. Govt. Printing Office), 625–691.

———, 1983. The Neogene and Quaternary diatom biostratigraphy of sub-Antarctic sediments, Deep Sea Drilling Project Leg 71. *In* Ludwig, W. J., Krasheninnikov, V. A., et al., *Init. Repts. DSDP*, 71, Pt. 2: Washington (U.S. Govt. Printing Office), 635–665.

———, 1985. Middle Miocene to Quaternary diatom biostratigraphy of Deep Sea Drilling Project Site 594, Chatham Rise, southwest Pacific. *In* Kennett, J. P., von der Borch, C. C., et al., *Init. Repts. DSDP*, 90, Pt. 2: Washington (U. S. Govt. Printing Office, 863–885.

Deflandre, G., 1932. Sur la systématique des Silicoflagellés. *Soc. Bot. France Bull.*, 79:494–506.

———, 1950. Contribution a l'étude des silicoflagellidés actuels et fossiles. *Microscopie,* 2:72–108, 117–142, 191–210.

Dumitrica, P., 1967. *Dictyocha bachmanni* n. sp. et considérations phylogénétique *Dictyocha crux*-D. *stauracantha*-D. *bachmanni. Cahiers Micropaléont.*, Sér. 1, No. 4:1–6.

———, 1973. Paleocene, late Oligocene and post-Oligocene silicoflagellates in southwestern Pacific sediments cored on DSDP Leg 21. *In* Burns, R. E., Andrews, J. E., et al., *Init. Repts. DSDP*, 21: Washington (U.S. Govt. Printing Office), 837–883.

Ehrenberg, C. G., 1839. über die Bildung der Kreidefelsen und des Kreidemergels durch unsichtbare Organismen. *K. Akad. Wiss. Berlin, Abh.* 1838 (1840, separate 1839), 59–148.

———, 1844. Untersuchungen über die kleinsten Lebensformen im Quellenlande des Euphrats und Araxes, so wie über eine an neuen Formen sehr reiche marine Tripelbildung von den Bermuda-Inseln vor. *Ber. Verh. K. Preuss. Akad. Wiss. Berlin*, 1844, 253–275.

———, 1854. *Mikrogeologie, das Erde und Felsenschaffende Wirken des unsichtbar kleinen selbständigen Lebens auf der Erde*: Leipzig (Leopold Voss), 1–374.

Eldholm, O., Thiede, J., Taylor, E., et al., 1987. *Proc. ODP, Init. Repts.*, 104: College Station (Ocean Drilling Program).

Frenguelli, J., 1940. Consideraciones sobre los silicoflagelados fósiles. Rev. Mus. LaPlata, Ser. 2, Vol. 2, *Paleontology*, 7: 37–112 (Jan. 31, 1940).

———, 1935. Variaciones de *Dictyochafibula* en Gulfo de San Matías (Patagonia Septentrional): An. Mus. Argentino Cienc. Nat. *Bernadino Rividavia, Protistol.*, 38:265–281.

Glezer, Z. I., 1960. Paleogenovye kremnevye zhgutikovye vodorosli (Silicoflagellatae) Zapadnoy Sibiri. Vses. Nauchno-Issledov. Geol. Inst. (VSEGEI), *Inform. Sbornik*, No. 35, Stratigr. i Paleont., 127–136.

———, 1966. Silicoflagellatophyceae. *In* Gollerbakh, M. M., (Ed.), *Cryptogamic plants of the U.S.S.R.*: Akad. Nauk. SSSR, V. A. Komarova Bot. Inst. (Translated from Russian by Israel Program for Scientific Translations Ltd., Jerusalem, 1970, 7:1–363.)

Haeckel, E. H. P. A., 1862. *Die Radiolarien (Rhizopodaradiaria)*. Eine Monographie: Berlin (Georg Reimer).

———, 1887a. Report on the radiolaria collected by H.M.S. Challenger during the years 1873–1876. *Rep. Sci. Results of H.M.S. Challenger 1873-6*, 18:1–1803.

———, 1887b. Cannorrhaphida. *Challenger Report*, 18: 1546–1569.

Hanna, G. D., 1931. *Diatoms and silicoflagellates of the Kreyenhagen Shale*: Mining in Calif., 197–201.

Ichikawa, W., Fuji, N., and Bachmann, A., 1964. Fossil diatoms, pollen grains and spores, silicoflagellates and arachaeomonads [sic] in the Miocene Hojuji Diatomaceous Mudstone, Noto Peninsula, central Japan. *Sci. Rep. Kanazawa Univ.*, 9: 25–118.

Ichikawa, W., Shimizu, I., and Bachmann, A., 1967. Fossil silicoflagellates and their associated uncertain forms in Iida Diatomite, Noto Peninsula, Central Japan. *Kanazawa Univ. Sci. Repts.*, 12: 143–172.

Jerkovic, L. 1965. *Sur quelques silicoflagellides de Yugoslavie*: Paris (Lab. Micropaleont., Inst. Paleont. Museum), 1–8.

Laws R. A. 1983. Preparing strewn slides for quantitative microscopical analysis: a test using calibrated microspheres. *Micropaleontology*, 29: 60–65.

Lemmermann, E., 1901. Silicoflagellatae. *Deutsche Bot. Gesell., Ber.*, 19: 247–271.

Ling, H. Y., 1973. Silicoflagellates and ebridians from Leg 19. *In* Creager, J. S., Scholl, D. W., et al., *Init. Repts. DSDP*, 19: Washington (U.S. Govt. Printing Office), 751–775.

———, 1975. Silicoflagellates and ebridians from Leg 31. *In* Karig, D. E., Ingle, J. C., et al., *Init. Repts. DSDP*, 31: Washington (U.S. Govt. Printing Office), 763–777.

Locker, S., 1974. Revision der Silicoflagellaten aus der Mikrogeologischen Sammlung von C. G. Ehrenberg. *Eclog. geol.* Helv., 67: 631–646.

Locker, S., and Martini, E., 1985. Silicoflagellates and some sponge spicules from the southwest Pacific, Deep Sea Drilling Project, Leg 90. *In* Kennett, J. P., von der Borch, C. C., et al., *Init. Repts. DSDP*, 90: Washington (U.S. Govt. Printing Office), 887–924.

Mandra, Y. T., 1969. A new genus of silicoflagellata from an Eocene South Atlantic deep-sea core (Protozoa: Mastigophora). *Occas. Pap. California Acad. Sci.*, 77.

Martini, E., 1972. Silicoflagellate zones in the late Oligocene and early Miocene of Europe. *Senckenbergiana lethaea*, 53: 119–122.

———, 1979. Calcareous nannoplankton and silicoflagellate biostratigraphy at Reykjanes Ridge, Northeastern North Atlantic (DSDP Leg 49, Sites 407 and 409). *In* Luyendyk, B. P., Cann, J. R., et al., *Init. Repts. DSDP*, 49: Washington (U.S. Govt. Printing Office), 533–549.

Martini, E., and Müller, C., 1976. Eocene to Pleistocene silicoflagellates from the Norwegian–Greenland Sea (DSDP Leg 38). *In* Talwani, M., Udintsev, G., et al., *Init. Repts. DSDP*, 38: Washington (U.S. Govt. Printing Office), 857–895.

Moore, T. C., Jr., 1973. Method of randomly distributing grains for microscopic examination. *J. Sediment. Petrol.*, 43: 904–906.

Perch-Nielsen, N., 1975. Late Cretaceous to Pleistocene silicoflagellates from the southern south west Pacific, DSDP Leg 29. *In* Kennett, J. P., Houtz, R. E., et al., *Init. Repts. DSDP*, 29: Washington (U.S. Govt. Printing Office), 677–721.

———, 1985. Silicoflagellates. *In* Bolli, H. M., Saunders, J. B., and Perch-Nielsen, N. (Eds.), *Plankton Stratigraphy*: Cambridge, U.K. (Cambridge University Press), 811–846.

Schulz, P., 1928. Beiträge zur Kenntnis fossiler und rezenter Silicoflagellaten. *Bot. Arch.*, 21: 225–292.

Shaw, C. A., and Ciesielski, P. F., 1983. Silicoflagellate biostratigraphy of middle Miocene to Holocene subantarctic sediments recovered by Deep Sea Drilling Project Leg 71. *In* Ludwig, W. J., Krasheninnikov, V. A., et al., *Init. Repts. DSDP*, 71: Washington (U.S. Govt. Printing Office), 687–737.

Stradner, H., 1961. Über fossile Silicoflagelliden und die Möglichkeit iher Verwendung in der Erdölstratigraphie. *Erdoel Kohee*, 14: 87–92.

Talwani, M., Udintsev, G., et al., 1976. *Init. Repts. DSDP*, 38: Washington (U.S. Govt. Printing Office).

Uchio, T., 1974. Tertiary nannoplankton stratigraphy of Sado Island, Niigata Prefecture and a proposal of the *Braarudosphaera bigelowii-Coccolithupelagicus* Zone for the Pliocene of Japanese oil fields of Japan Seaside. *Japan Geol. Surv.*, 201: 235–254.

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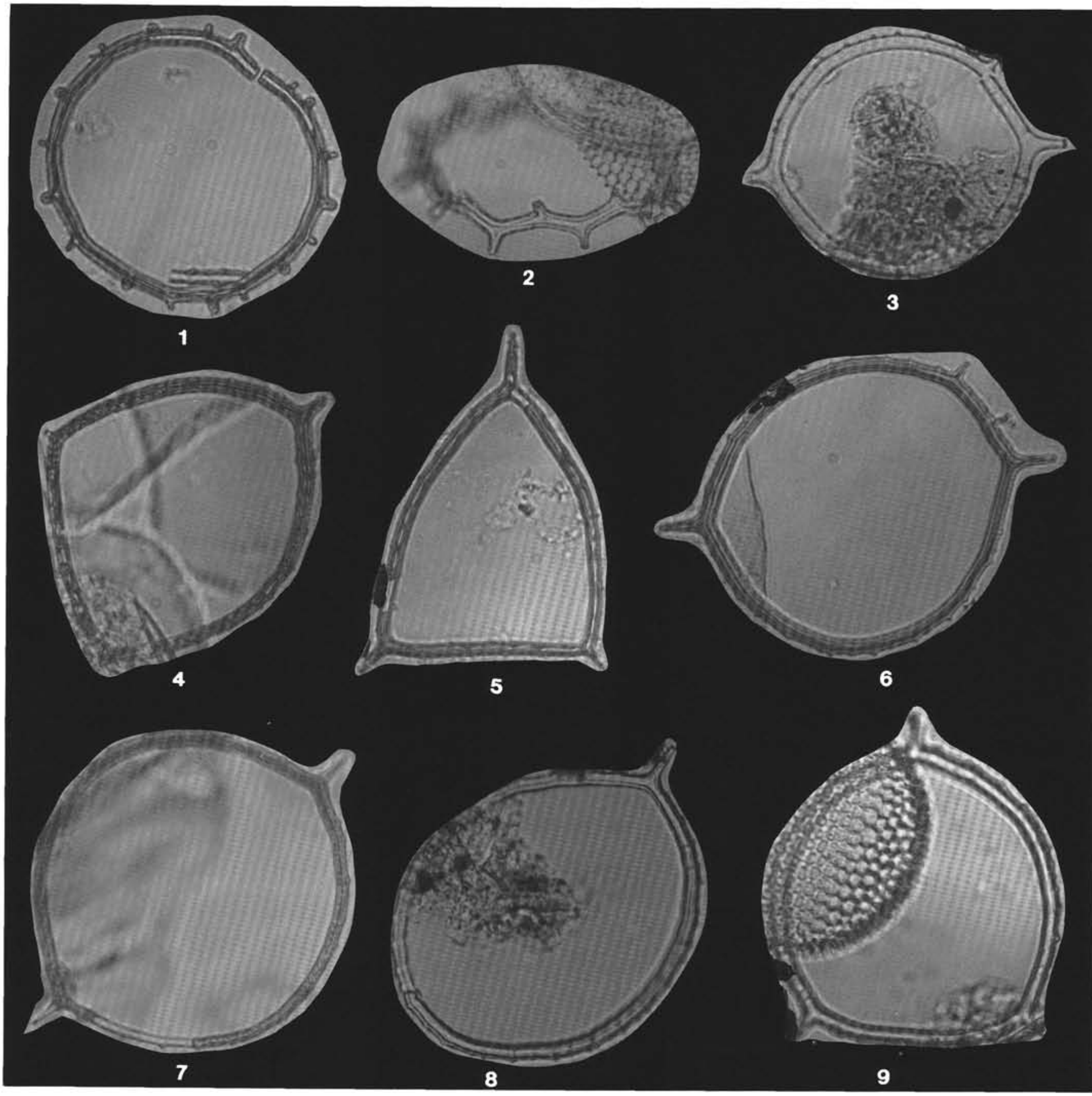

Plate 1. (All figures ×480). **1–2.** *Bachmannocena circulus* var. *apiculata* (Lemmermann) Bukry, **1.** Section 104-642B-16H, CC, **2.** Side view, Section 104-642C-18H, CC. 3–9. *Bachmannocena diodon nodosa* (Bukry) Bukry, **3.** Three-spined form, Section 104-642B-16H, CC, **4.** Rare three-spined triangular morphotype, Section 104-642B-16H, CC, **5.** Rare three-spined triangular morphotype, Section 104-642B-13H, CC, **6.** Three-spined form, Secton 104-642B-15H, CC, **7.** Section 104-642B-13H, CC, **8.** One-spined form, Section 104-642B-13H, CC, **9.** Three-spined triangular form with inflated sides.

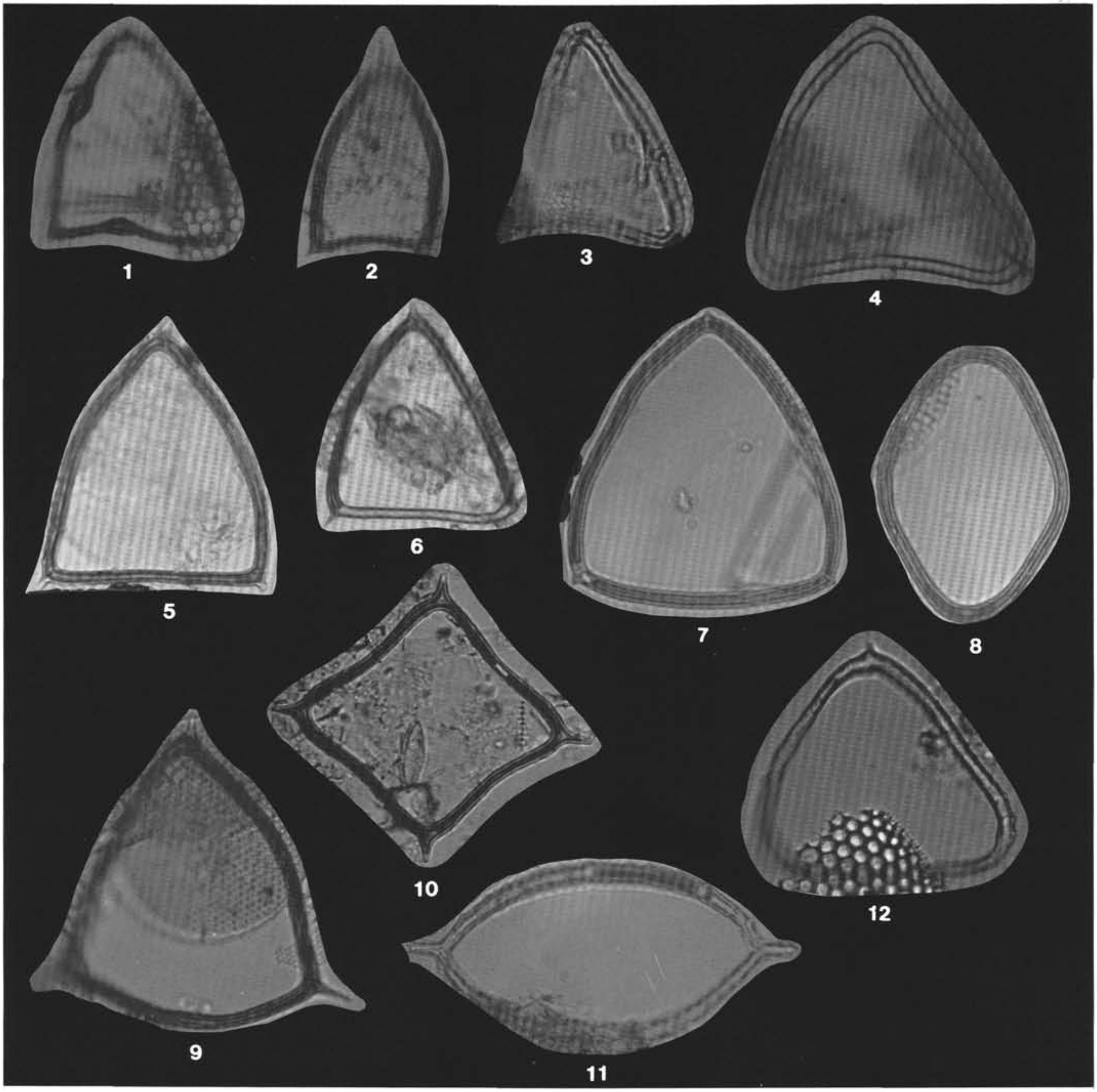

Plate 2. (All figures ×480). **1–3.** *Bachmannocena apiculata curvata* (Bukry) Bukry, **1.** With bulbous thickenings, Section 104-643A-22X, CC, **2.** Section 104-643A-22X, CC, **3.** Section 104-643A-13H, CC. **4.** *Bachmannocena apiculata glabra* (Schulz) Bukry, Section 104-643A-22X, CC. **5–6.** *Bachmannocena* sp. cf. *B. apiculata curvata* (see taxonomic note), **5.** Section 104-642D-4X, CC, **6.** Section 104-643A-22X, CC. **7.** *Bachmannocena apiculata evexa* (Bukry) Bukry, Section 104-642C-14H, CC. **8.** *Bachmannocena ovata* (Bukry) Bukry, Section 104-642B-20H, CC. **9.** *Bachmannocena apiculata inflata* Bukry, Section 104-643A-26, CC. **10.** *Bachmannocena schulzii* (Martini and Müller) Bukry, reworked, 104-643A-12H, CC. **11.** *Bachmannocena diodon borderlandensis* (Bukry) Bukry, Sample 104-642B-12H, CC. **12.** *Bachmannocena* cf. *apiculata inflata*. (Bukry) Bukry, Section 104-643A-13H, CC.

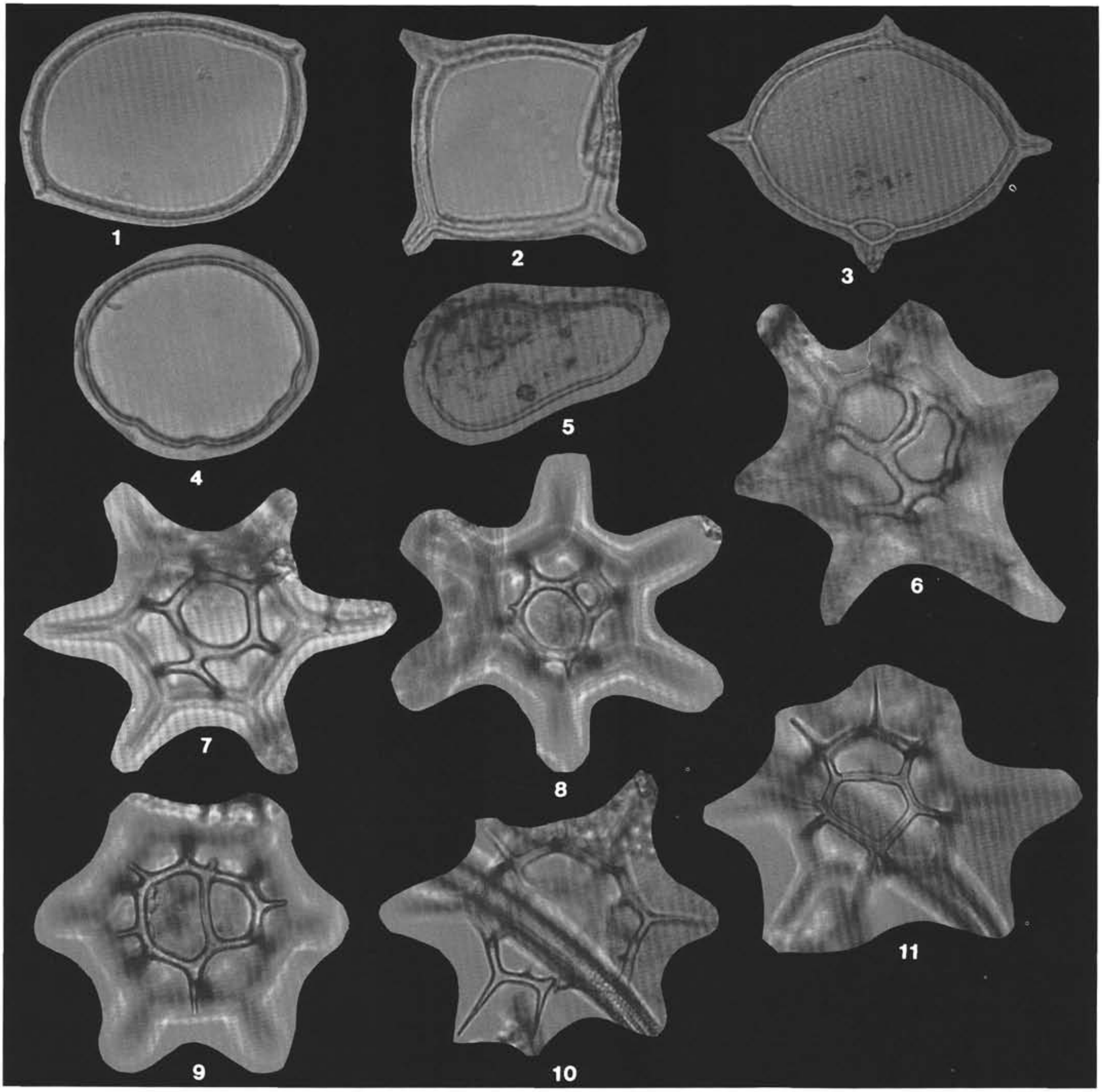

Plate 3. (All figures ×480). **1.** *Bachmannocena diodon diodon* (Ehrenberg) Locker, Section 104-642B-19H, CC. **2.** *Bachmannocena quadrangula* (Ehrenberg ex Haeckel) Bukry, Section 104-642B-12H, CC. **3.** *Dictyocha brevispina* (Lemmermann), nearly mesocenoid with only one small portal, Section 104-642B-lOH, CC. **4.** *Bachmannocena* sp., with thin and wavy oval ring, Sample 104-643A-24H, CC. **5.** *Bachmannocena* sp., with thin, pinched, pear-shaped ring, Section 104-644A-34H, CC. **7.** *Distephanus boliviensis* (irregular), with five-sided apical apparatus and bifurcating lateral rod (not encountered in census), Section 104-643A-15H, CC. **6, 8–11.** *Distephanus boliviensis* (cannopilean-irregular), see taxonomic notes (not encountered in census) **6., 8.** Section 104-643A-15H, CC, **9.** Section 104-643A-13H, CC. **10–11.** Sample 104-643A-13H, CC 10. Basal focus. **11.** apical focus.

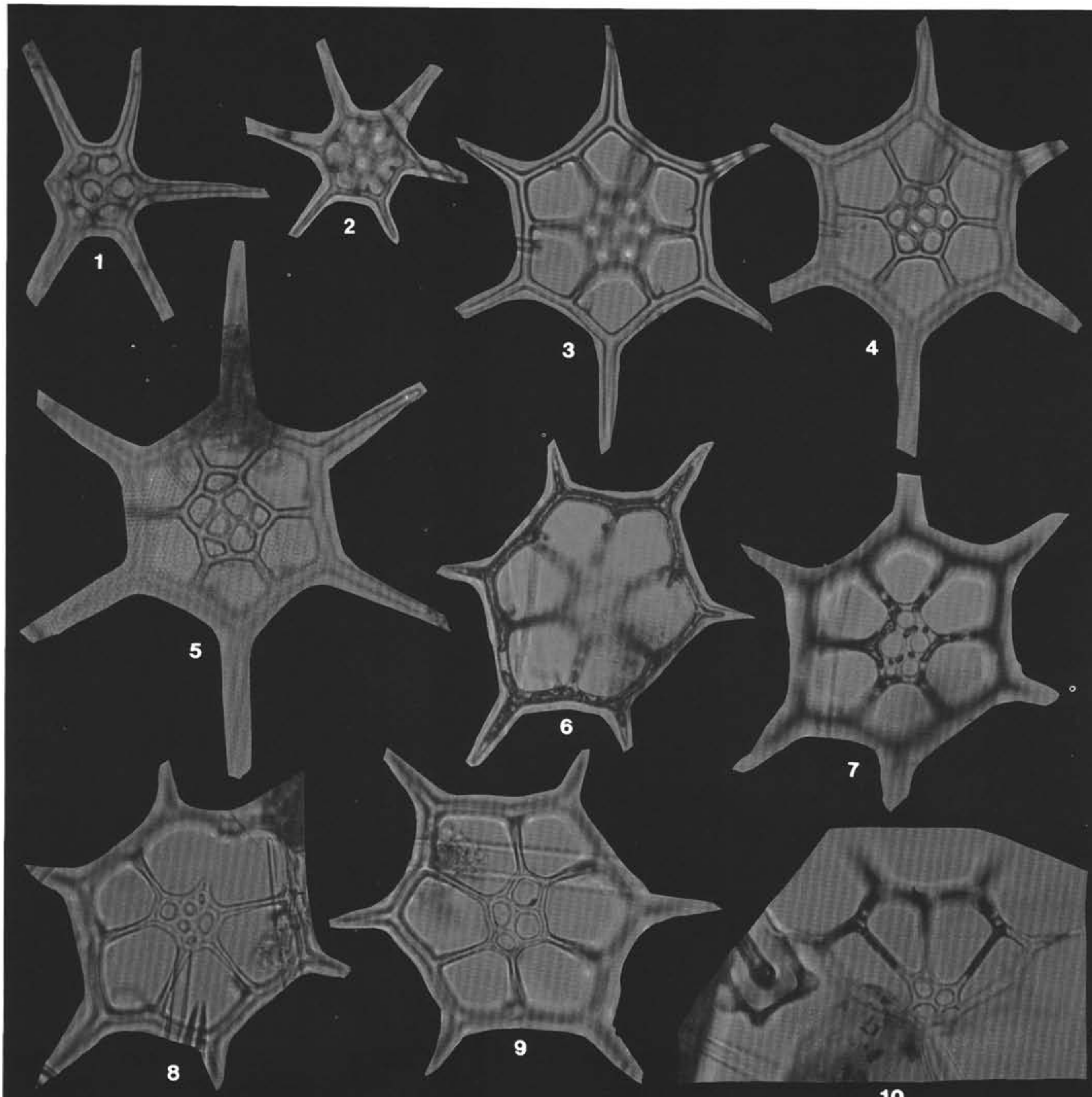

Plate 4. (All figures ×480). **1–2.** *Distephanus speculum* s.l. (Ehrenberg) Haeckel, Section 104-644A-34H, CC. **3–4.** *Distephanus jimlingii* (Bukry) Bukry, **3.** Basal focus. **4.** Apical focus, Section 104-642C-llH, CC. **5–7.** *Distephanus jimlingii/Ds. sulcatus* (see taxonomic notes). **5.** Sample 104-642C-llH, CC. **6.** Basal focus and **7.** Apical focus of same specimen from Sample 104-642C-lOH, CC. **8–10.** *Distephanus sulcatus* Bukry, Section 104-642C-lOH, CC.

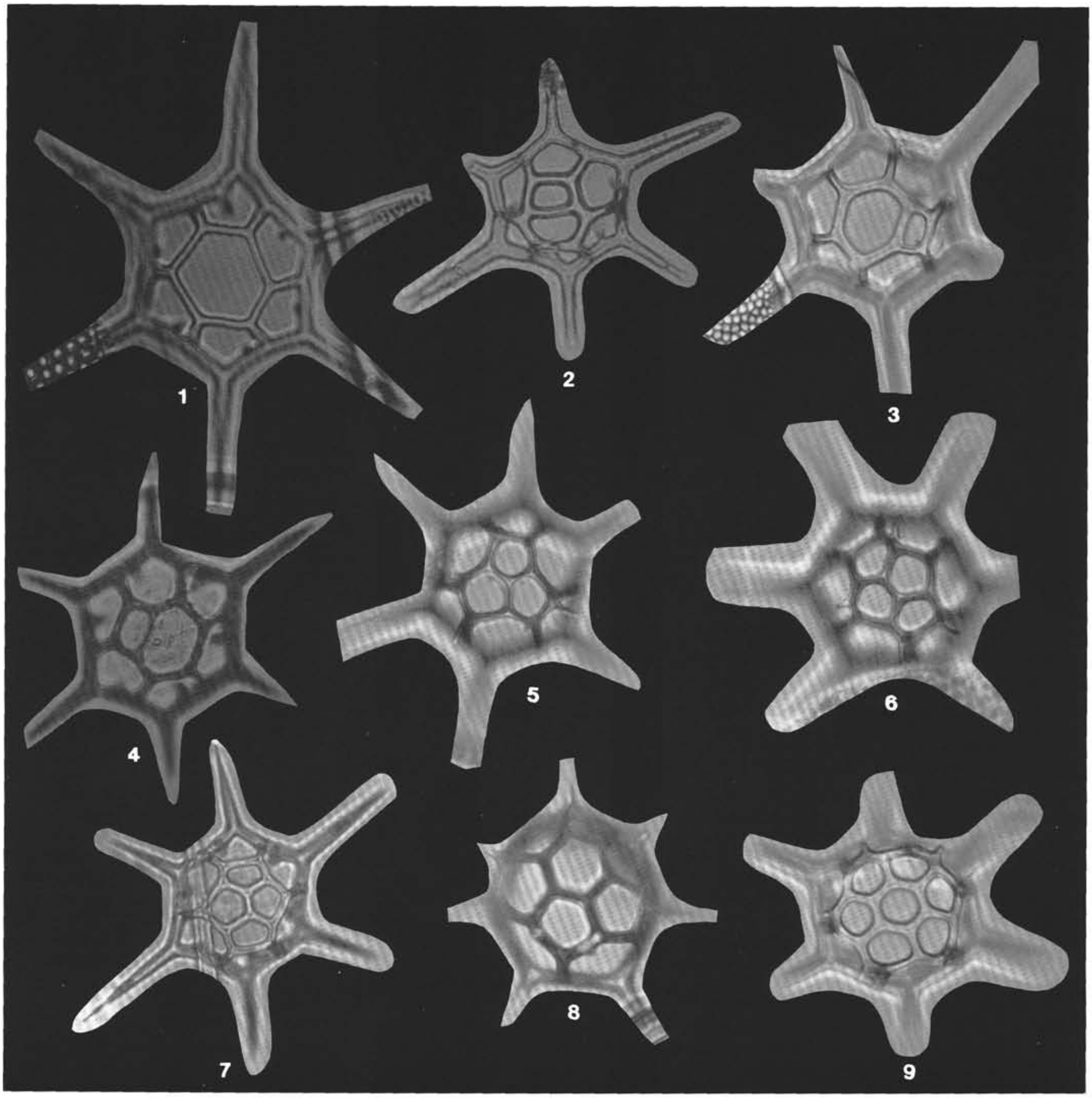

Plate 5. (All figures ×480). **1.** *Distephanus boliviensis* (Frenguelli) Bukry, Sample 104-642B-llH, CC. **2.** *Distephanus speculum* (Ehrenberg) Haeckel, with two apical windows, Sample 104-642B-lOH, CC. **3–7.** *Distephanus boliviensis* (cannopilean), **3.** With two apical windows, Section 104-642D-2X, CC. **4.** With two apical windows, Section 104-642B-lOH, CC. **5.** With three apical windows, Sample 104-642D-2X, CC. **6.** With four apical windows, Sample 104-642D-2X, CC. **7.** with four apical windows, Section 104-642C-13H, CC. **8.** *Distephanus boliviensis* (hemisphaericoid), equal spine lengths, apical apparatus filling interapical area. Section 104-642D-3X, CC. **9.** *Distephanus speculum hemisphaericus* (Ehrenberg) Bukry, Section 104-642D-2X, CC.

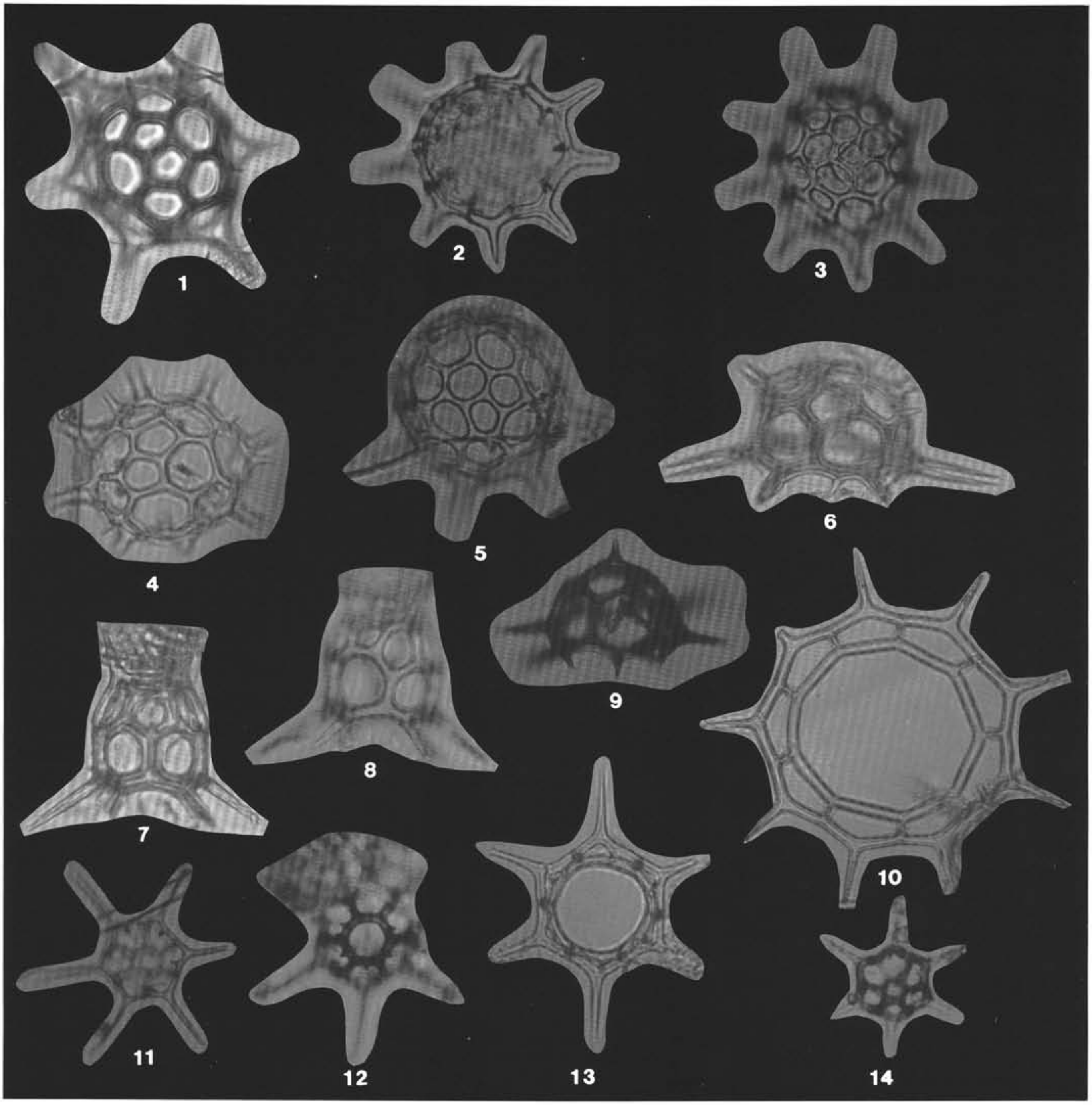

Plate 6. (All Figures ×480). **1.** *Distephanus boliviensis* (hemisphaericoid), Section 104-642D-3X, CC. **2–3.** *Caryocha* cf. *depressa* (Ehrenberg) Bukry et Monechi, basal focus (2) and apical focus (3), Sample 104-643A-13H, CC. **4.** *Distephanus schulzii* (Deflandre) Ciesielski, Section 104-642B-24H, CC. **5.** *Caryocha* aff. *depressa*, (Ehrenberg) Bukry et Monechi, nine-sided, five spines broken or not visible, Section 104-642D-2X, CC. **6.** *Caryocha depressa* (Ehrenberg) Bukry et Monechi, side view, Section 104-642B-25H, CC. **7–8.** *Caryocha ernestinae* (Bachmann) Bukry et Monechi, side view, Section 104-642C-18H, CC. **9.** *Caryocha* sp. Section 104-643A-15H, CC. **10.** *Distephanus polyactis crassus* Bukry, Section 104-642C-llH, CC. **11.** *Distephanus speculum*, with one long, curved spine, Section 104-644A-34H, CC. **12.** *Distephanus speculum* f. *coronata* Schulz, Sample 104-642C-9H-2, 103–105 cm. **13.** *Distephanus speculum minutus* (Bachmann) Bukry, Section 104-642B-llH, CC. **14.** *Distephanus speculum*, Section 104-644A-34H, CC.

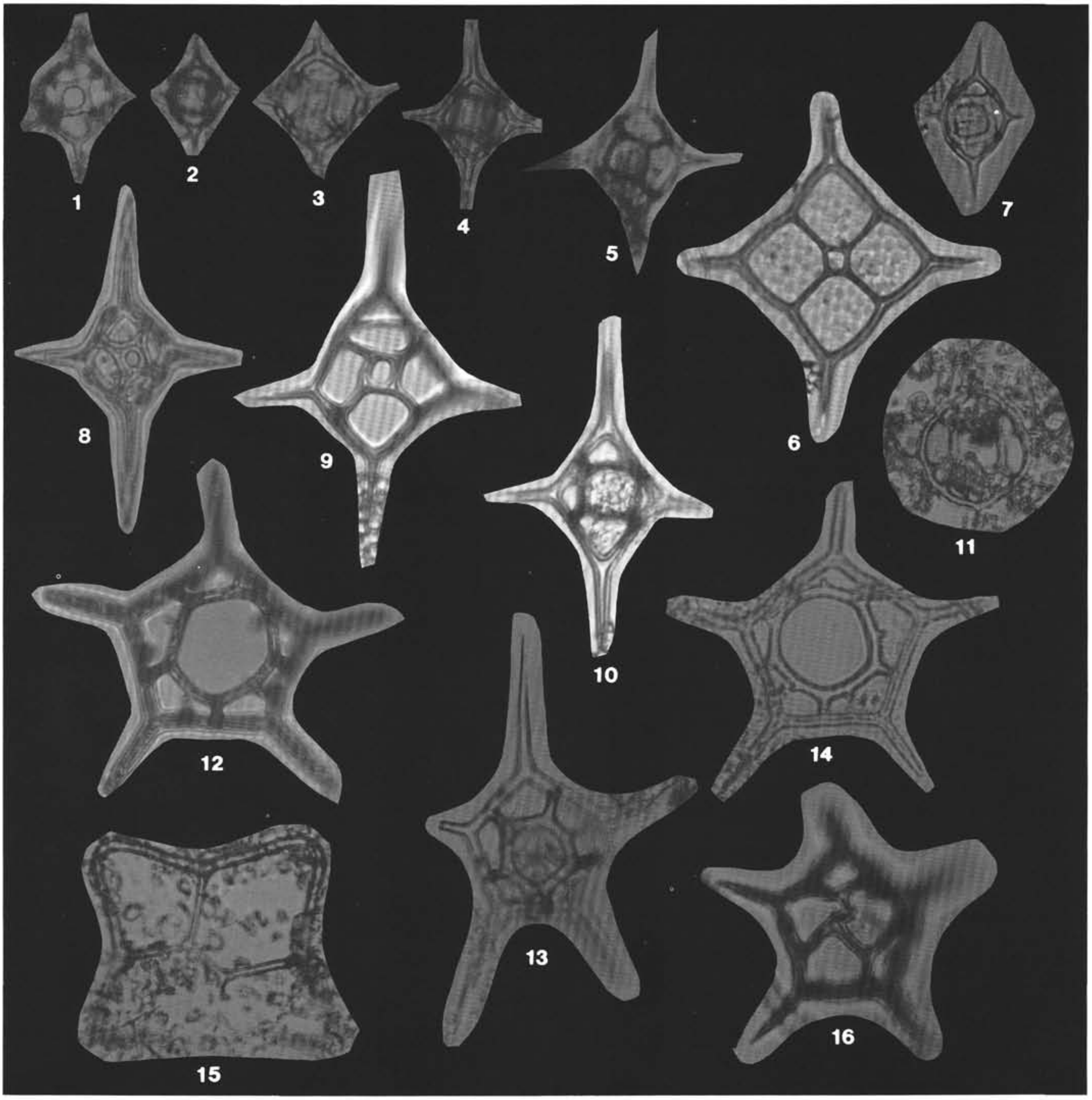

Plate 7. (All Figures ×480). **1–3.** *Distephanus* aff. *slavnicii* (Jerkovic) Bukry. **1.** Sample 104-642C-21H-2 125–128 cm, **2.** With elongate basal ring, Section 104-642C-21H-5, 125–128 cm, **3.** Sample 104-642C-21-5, 125–128 cm. **4.** *Distephanus crux* s. ampl., Sample 104-642C-21H-2, 125–128 cm. **5.** *Distephanus crux scutulatus* (Ehrenberg) Bukry, Section 104-643A-20X, CC. **6.** *Distephanus stradneri* (Jerkovic) Bukry, Section 104-643A-15H, CC. **7.** *Distephanus crux parvus* (Bachmann) Bukry, Section 104-643A-13H, CC. **8.** *Distephanus longispinus* (Schulz) Bukry, Section 104-642B-17H, CC. **9.** *Distephanus crux crux* (Ehrenberg) Locker et Martini, Section 104-642D-2X, CC. **10.** *Distephanus crux scutulatus* Bukry Sample 104-642D-4X, CC. **11.** *Distephanus crux* ssp. 1, Sample 104-642C-19H-2, 125–128 cm. **12–14.** *Distephanus quinquangellus* Bukry et Foster. **12.** Section 104-642B-llH, CC. **13.** With seven connecting rods (two extra) and very long spines, Section 104-643A-15H, CC. **14.** With apical spines (= *Distephanus speculum pentagonus armata* Lemmermann), Section 104-642B-llH, CC. **15.** *Dictyocha quadria* (Mandra) Martini et Müller, Sample 104-642C-9H-2, 103–105 cm. **16.** *Distephanus quinquangellus* Bukry et Foster, with irregular apical apparatus, Section 104-643A-15H, CC.

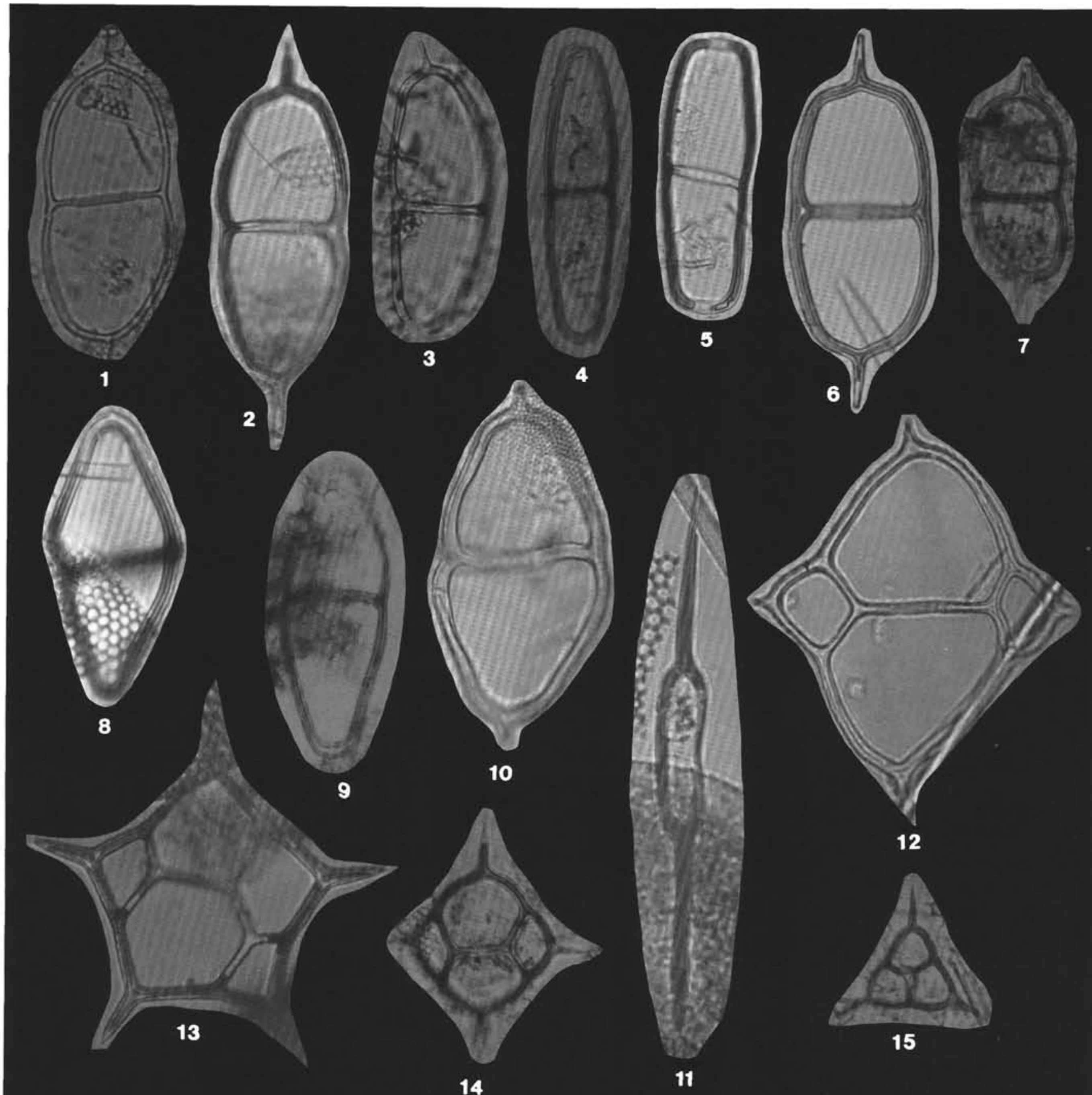

Plate 8. (All figures ×480). **1–3, 6.** *Naviculopsis lata* (Deflandre) Bukry, **1.** Section 104-643A-28X, CC, **2.** Section 104-642D-6X, CC, **3.** Section 104-643A-28X, CC, **6.** Section 104-642D-6X, CC. **4–5.** *Naviculopsis ponticula ponticula* (Ehrenberg) Bukry, **4.** Section 104-643A-30X, CC, **5.** Section 104-642D-5X, CC. **7.** *Naviculopsis iberica* Deflandre, Section 104-643A-30X, CC. **8.** *Naviculopsis* sp., Section 104-642D-6X, CC. **9.** *Naviculopsis navicula* (Ehrenberg) Deflandre, Section 104-643A-26X, CC. **10.** *Naviculopsis* sp., Section 104-642D-6X, CC. **11.** *Naviculopsis constricta* (Schulz) Bukry, Section 104-642C-14H, CC (reworked). **12.** *Dictyocha brevispina* (Lemmermann) Bukry, Section 104-642C-12H, CC. **13.** *Dictyocha pentagona* (Schulz) Bukry et Foster, Section 104-642C-19H, CC. **14.** *Dictyocha pulchella* var. *inflata* Bukry, Section 104-643A-28X, CC, basal accessory spines not visible. **15.** *Corbisema triacantha* (Ehrenberg) Bukry et Foster, Section 104-643A-26X, CC.