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5. MIOCENE SILICOFLAGELLATE STRATIGRAPHY: ICELAND AND ROCKALL PLATEAUS[1]

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ABSTRACT

Silicoflagellate assemblages were analyzed for the Miocene intervals recovered during Ocean Drilling Program (ODP) Leg 162. The middle and late Miocene are represented in Holes 907B (Iceland Plateau) and 982B (Rockall Plateau) by well-preserved silicoflagellates. A zonal scheme is presented, which improves previous attempts to establish a comprehensive silicoflagellate stratigraphy for this realm, based on an increased resolution given by the analysis of this largest-ever number of samples for the given interval (about three times as many as those studied for ODP Leg 104). The most important change is the replacement of the last appearance of *Corbisema triacantha* by the first appearance of *Bachmannocena circulus apiculata* as the top of the upper *C. triacantha* Zone/bottom of the *B. c. apiculata* Zone. In addition, two important bioevents (the first appearance of *Bachmannocena diodon nodosa* and the last appearance of *Distephanus crux stradneri*) allow the subdivision of the *B. c. apiculata* Zone into three new subzones: *Caryocha* spp. Subzone, *D. c. stradneri* Subzone, and *B. d. nodosa* Subzone (oldest to youngest, respectively). This zonal scheme is correlated with the standard calcareous nannoplankton zonation and tentatively correlated with the magnetic polarity time scale.

A qualitative analysis of the changes in surface-water characteristics is given, based on the variation in abundances of the several silicoflagellate groups. This shows a replacement of silicoflagellates that are adapted to warm surface waters by those adapted to temperate surface waters during the middle Miocene. In turn, the latter are gradually replaced by those adapted to cool surface waters during the late Miocene. The taxonomy of the taxa encountered has been revised in an effort to bring together differing schools. Only one new taxon, *Distephanus crux lockerii*, is described herein.

INTRODUCTION

Scientists of Ocean Drilling Program (ODP) Leg 162 recovered sedimentary sequences from the Norwegian-Greenland Sea and the North Atlantic (Sites 907 and 980–987). The main purpose was to study the climate evolution of the North Atlantic–Arctic region, including a detailed analysis of the Neogene history of planktonic and benthic micro-organisms.

The present study focuses on the analysis of silicoflagellate assemblages from the Miocene, a critical time during the Cenozoic, when the transition from Paleogene to late Neogene climates occurred. Biosilica-bearing sediments of this age were cored at two sites (907 and 982), and samples were obtained from Holes 907B and 982B.

Both sequences provide long, almost continuous records of the middle to late Miocene and have allowed a high-resolution analysis of silicoflagellates. Consequently, pre-existing zonal schemes for this realm (Locker and Martini, 1989; Ciesielski et al., 1989) have been refined and correlated with calcareous nannoplankton zones in Hole 982B. The recovery of an excellent paleomagnetic record in Hole 907B allows a tentative correlation (Channell et al., Chap. 9, this volume) with the silicoflagellate stratigraphy presented herein. Because of the existence of other interpretations of the paleomagnetic record for the Miocene at Site 907 (Shipboard Scientific Party, 1996), no attempt is made toward such a correlation.

METHODS

Samples were collected by the Shipboard Scientific Party during Leg 162. Each sample was placed in a 250-mL beaker, then left on a hot plate for 5 min before adding diluted hydrogen peroxide to disaggregate the sediment and remove organic matter. Hole 982B samples averaged 90% calcium carbonate in composition; therefore, hydrochloric acid was added to remove it (this step was not necessary for Hole 907B samples). Once the reaction ceased, the beaker was filled with distilled water and left overnight to settle. The fluid was then decanted, and the residue was placed in 50-mL plastic centrifuge tubes in distilled water. This was centrifuged and decanted. The preparation phase ended with the addition of sodium pyrophosphate, centrifugation, and decanting at least three times, until most of the clays were removed through suspension (particularly for samples from Hole 907B). The residue was stored in distilled water in the same tubes, after the last decanting of sodium pyrophosphate. Whole-fraction slides were prepared from each sample, using Canada balsam as the mounting medium and 24- × 50-mm coverslips to provide a larger area for analysis and counting.

Slides were examined for silicoflagellates by traversing as many rows as needed to count at least 300 specimens. If no specimens were found in the first 11 traverses, the sample was considered barren. A maximum of 32 traverses was usually possible at the magnification used to scan the slide (250×); occasionally, the counts did not reach 300, even when the whole slide was examined. Counts are presented in table format, and abundance for the sample is given as follows: abundant (A) if counts were at least 250, common (C) between 150 and 250, rare (R) between 50 and 150, very rare (VR) lower than 50, and barren (B) if no silicoflagellates were found. The abundance of individual taxa is given by the actual number of specimens counted in the slide.

Certain taxonomic criteria were applied to try and establish a compromise between different schools of thought (see "Taxonomy" section, this chapter, for a complete discussion). The morphotypes found and counted are listed in the "Taxonomy" section, including a brief synonymy for each taxon to facilitate future comparisons and correlation with previous studies.

ZONATION

As opposed to the Paleogene, silicoflagellate assemblages show a marked latitudinal differentiation starting in the Miocene. This has

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led to the establishment of zonal schemes for high-latitude areas that are more adequate for stratigraphic purposes than the application of low-latitude zonations. Locker and Martini (1989) recognized this aspect and modified previous zonal schemes to improve the stratigraphic value of silicoflagellates in high-latitude realms such as the Norwegian-Greenland Sea. The zonation for the Norwegian Sea's Leg 104 sites that was presented by these authors was basically a refined version of that used for the Norwegian Sea's Leg 38 sites (Martini and Müller, 1976).

Unfortunately, the authors continued to use the *Corbisema triacantha* Zone without modifying it (other than subdividing it), which had been defined for low-latitude realms (Martini, 1971). This choice is not entirely convenient, since the top zonal boundary is given by the last occurrence of *C. triacantha*. This taxon is scattered and rare throughout its range at high latitudes, making it hard to clearly distinguish its last appearance. To circumvent this, Locker and Martini (1989) used the peak occurrence of *Distephanus stauracanthus* together with the last appearance of *Caryocha depressa* (listed by them as *Cannopilus depressus*) to identify the top of the zone. These criteria are questionable since *D. stauracanthus* is another rare taxon at high latitudes (Locker and Martini, 1989, table 1). The last appearance of *C. depressa*, therefore, might not be as clear-cut as proposed by these authors (see Ciesielski et al., 1989). For high latitudes, the first appearance of *Bachmannocena circulus apiculata* is a much better choice and is used here to replace the last appearance of *C. triacantha* as the top zonal boundary of the upper *C. triacantha* Zone.

This in turn changes the basal zonal boundary of the overlying *Bachmannocena circulus apiculata* Zone (Locker and Martini, 1989). This marks the extent of the modification of the basic zonal scheme since its top zonal boundary remains unchanged (last occurrence of *B. c. apiculata*). In this way, the zone now represents this taxon's entire range. The high-resolution sampling interval of Miocene sediments with silicoflagellates from the two high-latitude sites (907 and 982) from Leg 162 considered in this study, however, has allowed the identification of two important bioevents that permit the establishment of three subzones within the *B. c. apiculata* Zone (see below). Because no biosilica-bearing lower Miocene sections were recovered by Leg 162, early Miocene zonal schemes are not treated here. Miocene biosilica-bearing sections younger than the last occurrence of *B. c. apiculata* were analyzed but did not provide information useful to refine the pre-existing zones for that interval. Samples for these intervals are assigned to the *Bachmannocena diodon* Zone (Ciesielski, 1975) and the *Distephanus boliviensis* Zone (Ciesielski et al., 1989).

In this way, the detailed part of the zonal scheme is improved while maintaining the basic zones known by high-latitude biostratigraphers. Since most zones were found in both Holes 982B and 907B, any differences in the taxa present between the holes are indicated in the description of the assemblage, as well as any disparities between the abundance of the taxa. Given that the sites considered in this chapter are separated by ~10 degrees of latitude, there might be a slight factor of diachroneity in the datums used here to establish the zonal/subzonal boundaries. The taxa selected, however, are not only common constituents of the assemblages, but they also maintain a certain coherence amongst themselves; the datums appear in the same sequence regardless of their climatic sensitivity. Less reliable taxa were discarded for biostratigraphic purposes.

The details of the zonal scheme used herein are as follows:

Lower *Corbisema triacantha* Zone

Definition: Interval from the last occurrence of *Naviculopsis quadrata* to the first occurrence of *Bachmannocena diodon diodon*. Early to middle middle Miocene.

Reference: Locker and Martini (1989) subdivided Martini's (1971) *Corbisema triacantha* Zone into an upper zone and a lower zone based on the first occurrence of *Bachmannocena diodon diodon*. This zone is used herein without modification, other than pointing out that *B. diodon* has several subspecies. It is the above-mentioned subspecies that is used to define the top of this zone. Locker and Martini (1989) do not distinguish between the taxon's subspecies. Their use by other authors and within this chapter has been shown to be of stratigraphic value, however, and should be continued given the clear morphological distinction between them.

Occurrence interval: Found in Hole 982B, from Sample 162-982B-56X-5, 99–100 cm, to the bottom of the biosilica-bearing interval.

Assemblage: *Bachmannocena apiculata curvata*, *Corbisema triacantha* (rare), *Dictyocha arcuata*, *Dictyocha fibula*, *Distephanus crux* ssp. (abundant), *Distephanus schulzii*, and *Distephanus speculum* ssp.

Remarks: Only the upper part of this zone is present in the biosilica-bearing interval obtained from Hole 982B during Leg 162. It is placed within the CN4/CN3 nannoplankton zones of Okada and Bukry (1980) by the Shipboard Scientific Party of Leg 162.

Upper *Corbisema triacantha* Zone

Definition: Interval from the first occurrence of *Bachmannocena diodon diodon* to the first occurrence of *Bachmannocena circulus apiculata*. Middle middle Miocene.

Reference: As discussed above, this zone was introduced by Locker and Martini (1989) and composed the upper part of Martini's (1971) *Corbisema triacantha* Zone. The last occurrence of *Corbisema triacantha* marked the zone's upper boundary. As explained earlier, this datum is considered unreliable at high latitudes. It is here replaced by the first occurrence of *Bachmannocena circulus apiculata*, a common and conspicuous taxon throughout its range in high latitudes such as those examined herein and in Legs 38 and 104. Since the first appearance of *B. c. apiculata* is older than the last appearance of *C. triacantha*, the upper *C. triacantha* Zone as modified spans a shorter interval of time than it originally did.

Occurrence interval: Found in Hole 982B, from Samples 162-982B-50X-3, 99–100 cm, to 162-982B-56X-1, 99–100 cm; and in Hole 907B, from Sample 162-907B-22H-2, 109–110 cm, to the bottom of the biosilica-bearing interval.

Assemblage: *Bachmannocena apiculata apiculata*, *Bachmannocena apiculata curvata* (common), *Bachmannocena diodon diodon* (common in Hole 982B), *Bachmannocena elliptica elliptica* (in Hole 982B), *Bachmannocena elliptica miniformis*, *Caryocha depressa* (common in Hole 982B), *Corbisema triacantha* (rare), *Dictyocha arcuata* (common in Hole 982B), *Dictyocha fibula*, *Distephanus crux* ssp. (abundant), *Distephanus quinarius* (Hole 982B), *Distephanus schulzii* (Hole 982B), and *Distephanus speculum* ssp. (Hole 982B).

Remarks: It is placed in Hole 982B within the CN4 nannoplankton zone of Okada and Bukry (1980) by the Shipboard Scientific Party of Leg 162.

Bachmannocena circulus apiculata Zone

Definition: Interval from the first to the last occurrence of *Bachmannocena circulus apiculata*. Late middle Miocene to middle late Miocene.

Reference: Locker and Martini (1989) introduced the *Bachmannocena circulus apiculata* Zone as the interval from the last occurrence of *Corbisema triacantha* to the last occurrence of *Bachmannocena circulus apiculata* (= *Paramesocena circulus apiculata* of Locker and Martini, 1989). As discussed above, the last occurrence of *Corbisema triacantha* as the top of the upper *Corbisema triacantha* Zone is changed herein to the first occurrence of *Bachmannocena circulus apiculata*, which in turn changes the base of this zone. In this way, their zone would represent the total range of *Bachmannocena*

circulus apiculata. Two important bioevents allow the recognition of the following three subzones:

Caryocha *spp. Subzone*

Definition: Interval from the first occurrence of *Bachmannocena circulus apiculata* to the first occurrence of *Bachmannocena diodon nodosa*. Late middle Miocene.

Reference: This subzone spans the interval from the modified base of Locker and Martini's (1989) *Paramesocena circulus apiculata* Zone to the first of the important bioevents, the first occurrence of *Bachmannocena diodon nodosa*, comprising the lower part of their zone and the uppermost part of their upper *C. triacantha* Zone.

Occurrence interval: Found in Hole 982B, from Samples 162-982B-45X-1, 99–100 cm, to 162-982B-49X-2, 99–100 cm; and in Hole 907B, from samples 162-907B-17H-3, 109–110 cm, to 162-907B-22H-1, 109–110 cm.

Assemblage: *Bachmannocena apiculata apiculata*, *Bachmannocena apiculata curvata*, *Bachmannocena circulus apiculata* (common), *Bachmannocena diodon diodon* (common in Hole 982B), *Bachmannocena elliptica elliptica* (in Hole 982B), *Bachmannocena elliptica miniformis*, *Caryocha depressa* (common), *Caryocha ernestinae* (common in Hole 907B), *Corbisema triacantha* (rare), *Dictyocha fibula* (common in Hole 907B), *Dictyocha subclinata*, *Dictyocha varia* (common), *Dictyocha* sp. 1 (Hole 982B), *Distephanus crux* ssp. (common), *Distephanus speculum* ssp. (Hole 982B), and *Distephanus stauracanthus* (Hole 982B, first and last occurrence within this zone).

Remarks: The importance of using the first occurrence of *Bachmannocena circulus apiculata* was recognized by Ciesielski et al. (1989), who defined a similar interval in this new subzone as the *Bachmannocena circulus* var. *apiculata*/*Caryocha* Zone using this bioevent. Their choice of the last occurrence of *Caryocha* species as the top of their zone, however, is less defined than the first occurrence of *Bachmannocena diodon nodosa* (used herein) because caryochids become rare and scattered toward the top of their range. In Hole 982B, it spans the middle to lower CN5 nannoplankton zone of Okada and Bukry (1980), as indicated by the Leg 162 Shipboard Scientific Party (1996).

Distephanus crux stradneri *Subzone*

Definition: Interval from the first occurrence of *Bachmannocena diodon nodosa* to the last occurrence of *Distephanus crux stradneri*. Latest middle Miocene to earliest late Miocene.

Reference: As discussed above, under *Caryocha* spp. Subzone, this new subzone comprises the middle part of Locker and Martini's (1989) *Paramesocena circulus apiculata* Zone. Its top marks the second important bioevent during the range of *Bachmannocena circulus apiculata*, the time at which the *Distephanus crux* subspecies, which are common constituents of assemblages until then, disappear. Various of these subspecies disappear close to or at this time (see Tables 1, 2); *Distephanus crux stradneri* was chosen only because it is the last one to become extinct.

Occurrence interval: Found in Hole 982B, from Samples 162-982B-32X-3, 99–100 cm, to 162-982B-44X-3, 99–100 cm; and in Hole 907B, from Samples 162-907B-14H-1, 109–110 cm, to 162-907B-17H-2, 99–100 cm.

Assemblage: *Bachmannocena circulus apiculata* (abundant), *Bachmannocena circulus circulus* (Hole 907B), *Bachmannocena diodon diodon*, *Bachmannocena diodon nodosa* (common), *Bachmannocena diodon triodon* (first and last occurrence within this zone), *Bachmannocena elliptica elliptica*, *Caryocha depressa* (Hole 907B), *Dictyocha subclinata*, *Dictyocha varia*, *Dictyocha* sp. 2 (Hole 907B), *Dictyocha* sp. 3 (Hole 907B), *Distephanus crux* ssp. (common), *Distephanus polyactis* (Hole 982B, first and last occurrence within this zone), *Distephanus quinarius* (acme in Hole 907B), *Distephanus speculum* ssp. (common), and *Distephanus xenus* (Hole 982B).

Remarks: Ciesielski et al. (1989) defined the *Distephanus crux scutulatus* Zone for an interval similar to this new subzone presented in this chapter. However, in addition to using a different base (see discussion above on their use of the last occurrence of *Caryocha* species), a different subspecies of *Distephanus crux* is here used as the top (*Distephanus crux stradneri* vs. *Distephanus crux scutulatus*). This is because the subspecies used by them has a less defined last occurrence, based on its low abundance toward the upper part of its range (see Tables 1, 2). In Hole 982B, it spans the upper CN5 nannoplankton zone to the lower part of the CN6/CN9 interval of Okada and Bukry (1980) as given by Shipboard Scientific Party (1996).

Bachmannocena diodon nodosa *Subzone*

Definition: Interval from the last occurrence of *Distephanus crux stradneri* to the last occurrence of *Bachmannocena circulus apiculata*. Middle late Miocene.

Reference: This new subzone comprises the upper part of Locker and Martini's (1989) *Paramesocena circulus apiculata* Zone.

Occurrence interval: Found in Hole 982B, from Samples 162-982B-24H-5, 99–100 cm, to 162-982B-31X-4, 99–100 cm; and in Hole 907B, from Samples 162-907B-12H-2, 109–110 cm, to 162-907B-13H-5, 120–121 cm.

Assemblage: *Bachmannocena circulus apiculata* (common), *Bachmannocena diodon diodon* (common), *Bachmannocena diodon nodosa* (common), *Dictyocha brevispina ausonia* (common in Hole 982B), and *Distephanus speculum* ssp. (abundant).

Remarks: The top part of this subzone is most likely missing in Hole 907B. In Hole 982B, it spans the middle part of the CN6/CN9 nannoplankton zones (Okada and Bukry, 1980) interval given by Shipboard Scientific Party (1996).

Bachmannocena diodon Zone

Definition: Interval from the last occurrence of *Bachmannocena circulus apiculata* to the last occurrence of *Bachmannocena diodon* ssp. Late Miocene.

Reference: Introduced by Perch-Nielsen (1975) as the *Mesocena diodon* Subzone of her *Paradictyocha dumitricae* Zone, with the last occurrence of *Bachmannocena diodon* as the upper boundary, modified by Ciesielski (1975) using the last occurrence of *Bachmannocena circulus apiculata* as the lower boundary.

Occurrence interval: The lower part of this zone is present in Hole 982B, from Sample 162-982B-23H-3, 99–100 cm, to the top of the biosilica-bearing interval considered in this study. In Hole 907B, Samples 162-907B-11H-4, 109–110 cm, to 162-907B-12H-1, 109–110 cm, are tentatively assigned to this zone based on the absence of *B. c. apiculata* throughout this interval and the presence of *B. d. nodosa* in Sample 162-907B-11H-4, 109–110 cm. The preservation of silicoflagellates within this interval, however, is poor, and reworked specimens were also noted (see Table 2). A clearer last occurrence of *B. diodon* is needed to assign this interval without doubts to the *B. diodon* Zone in this hole. For these reasons, the top of the zone is represented by a dotted line in Table 2.

Assemblage: *Bachmannocena diodon borderlandensis* (Hole 982B), *Bachmannocena diodon diodon* (Hole 982B), *Bachmannocena diodon nodosa* (common in Hole 982B, rare in Hole 907B), *Bachmannocena quadrata* (rare), *Dictyocha brevispina ausonia* (Hole 982B), *Dictyocha messanensis stapedia* f. *stapedia* (Hole 982B), and *Distephanus speculum* ssp. (abundant).

Remarks: The upper part of this zone is missing in Hole 982B, but the good preservation in the lower part provides information that is otherwise missing in Hole 907B. Preservation during this section is extremely poor, and at least some part of the zone toward its base

Table 1. Silicoflagellates in Hole 982B from the Miocene.

Hole 982B samples Core, section, interval (cm)	Counts	Traverses	Abundance	*B. apiculata apiculata*	*B. a. curvata*	*B. circulus apiculata*	*B. circulus circulus*	*B. diodon borderlandensis*	*B. diodon diodon*	*B d. diodon* (unspined)	*B. d. nodosa*	*B. d. triodon*	*B. elliptica elliptica*	*B. e. miniformis*	*B. quadrangula*	*B. triangula*	*B.* sp. cf. *B. d. borderlandensis*	*Caryocha depressa*	*Caryocha ernestinae*	*Caryocha picassoi*	*Corbisema triacantha*	*Da. arcuata*	*Da. brevispina ausonia*	*Da. fibula*	*Da. messanensis stapedia* f. *stapedia*	*Da. subclinata*	*Da. varia*	*Da.* sp. cf. *Da. rhombica*	*Da.* sp. 1	*Ds. boliviensis binoculus*	*Ds. b. boliviensis*	*Ds. b. major*	*Ds. crux crux*	Silicoflagellate zonation	
21H-1, 99–100	321	6	A	.	.	.	.	96	22	.	38	.	.	.	.	8	.	.	.	.	.	.	4	.	1	5	1	.	.	.	.	.	.	*B. diodon* Zone	*B. circulus apiculata* Zone
21H-6, 99–100	223	32	C	.	.	.	.	79	.	.	4	.	.	.	1	.	.	.	.	.	.	.	10	.	3	.	1	.	.	.	.	.	.		
22H-5, 99–100	0	13	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
23H-3, 99–100	115	32	R	.	.	.	.	49	38	.	13	.	.	.	.	.	.	.	.	.	.	.	3	.	.	.	.	.	.	.	.	.	.		
24H-5, 99–100	301	8	A	.	.	16	.	.	18	.	20	.	.	.	.	.	.	.	.	.	.	.	11	39	.	.	.	.	.	.	.	.	.	*B. diodon nodosa* Subzone	
25H-1, 99–100	262	30	A	.	.	1	.	.	34	.	198	.	.	.	.	1	.	.	.	.	.	.	10	.	.	.	1	.	.	.	.	.	.		
26H-1, 99–100	0	13	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
27X-4, 99–100	308	7	A	.	.	7	.	.	2	.	10	.	.	.	.	.	.	.	.	.	.	.	79	.	.	.	.	.	.	.	.	.	.		
28X-1, 99–100	314	3	A	.	.	25	.	.	15	.	76	.	.	.	.	.	.	.	.	.	.	.	37	.	.	.	.	.	.	.	.	.	.		
29X-2, 99–100	349	5	A	.	.	53	.	.	11	.	101	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	7	.	.	.	.	.	.		
31X-4, 99–100	0	13	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
32X-3, 99–100	309	7	A	.	.	130	.	.	.	.	102	14	.	.	.	.	.	.	.	.	.	.	.	.	.	1	2	.	.	.	.	.	.	*Distephanus crux stradneri* Subzone	
33X-3, 99–100	61	32	R	.	.	39	.	.	.	.	16	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
34X-2, 99–100	6	27	VR	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	.	.	.	.	.	.		
35X-3, 99–100	39	32	VR	.	.	33	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
36X-2, 99–100	39	32	VR	.	.	24	.	.	1	.	6	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
37X-2, 99–100	44	30	VR	.	.	22	.	.	1	.	5	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
38X-2, 99–100	6	32	VR	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
39X-3, 99–100	307	17	A	.	.	56	.	.	13	.	60	1	2	.	.	.	.	.	.	.	.	.	.	12	.	.	8	.	.	.	.	.	.		
40X-3, 99–100	78	32	R	.	.	23	.	.	8	.	11	1	.	.	.	.	2	.	.	.	.	.	.	.	.	1	10	.	.	.	.	.	.		
41X-1, 99–100	249	30	C	.	.	15	.	.	5	.	86	1	.	.	.	.	30	.	.	.	.	.	.	.	.	3	2	.	.	.	.	.	.		
41X-4, 99–100	18	32	VR	.	.	6	.	.	3	.	7	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
42X-3, 99–100	0	13	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
43X-1, 99–100	0	13	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
43X-3, 99–100	135	13	R	.	.	39	.	.	.	.	7	.	3	.	.	.	.	.	.	.	2	.	.	.	.	8	18	.	7	.	.	.	.		
44X-3, 99–100	133	13	R	.	.	64	.	.	9	.	29	.	.	.	.	1	.	.	.	.	.	.	.	.	.	5	1	.	.	.	.	.	.		
45X-1, 99–100	19	22	VR	.	.	4	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	.	3	.	.	.	.	*Caryocha* spp. Subzone	
45X-4, 99–100	180	32	C	.	.	89	5	.	53	.	.	.	.	.	.	.	.	4	.	.	.	.	.	.	.	.	7	.	.	.	.	.	.		
46X-3, 99–100	98	32	R	.	.	28	.	.	6	.	.	.	.	.	.	.	.	3	.	.	3	.	.	.	.	10	22	.	.	.	.	.	.		
47X-1, 99–100	300	21	A	.	.	55	.	.	4	.	.	.	2	.	.	.	.	11	.	.	1	.	.	.	.	12	6	.	2	.	.	.	2		
47X-4, 99–100	163	29	C	.	.	104	.	.	2	.	.	.	.	.	.	.	.	10	2	3	.	.	.	.	.	4	10	2	2	.	.	.	4		
48X-2, 99–100	20	32	VR	.	1	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5		
48X-4, 99–100	181	32	C	3	.	92	.	.	.	.	.	.	1	.	.	.	.	1	.	.	1	.	.	.	.	8	3	.	.	.	.	.	33		
48X-5, 99–100	319	20	A	2	7	70	.	.	12	.	.	.	1	.	.	.	.	10	.	1	1	.	.	.	.	5	5	.	16	.	1	.	28		
49X-2, 99–100	306	7	A	1	3	77	.	.	28	.	.	.	.	5	.	.	.	5	.	.	2	.	.	1	.	.	.	.	8	.	.	.	5		
50X-3, 99–100	71	29	R	4	4	.	.	.	44	.	.	.	.	2	.	.	.	2	.	.	2	2	.	.	.	.	.	.	.	.	.	.	2	upper *Corbisema triacantha* Zone	
51X-3, 99–100	235	26	C	3	4	.	.	.	146	.	.	.	2	.	.	.	.	40	.	.	.	5	.	.	.	.	.	.	.	.	.	.	.		
52X-2, 99–100	300	18	A	6	14	.	.	.	56	.	.	.	9	.	.	.	.	20	.	1	1	32	.	1	.	.	.	.	.	2	4	.	3		
52X-5, 99–100	76	30	R	.	.	.	.	.	6	.	.	.	2	.	.	.	.	6	.	.	8	5	.	1	.	.	.	.	.	.	.	.	2		
53X-4, 99–100	175	32	C	.	.	.	.	.	10	.	.	.	4	.	.	.	.	10	.	.	2	17	.	1	.	.	.	.	.	.	.	.	13		
54X-2, 99–100	10	32	VR	.	.	.	.	.	.	.	.	.	1	.	.	.	.	1	.	.	.	2	.	1	.	.	.	.	.	.	.	.	.		
55X-1, 99–100	367	8	A	.	6	.	.	.	33	7	.	.	19	.	.	.	.	29	.	.	3	4	.	5	.	1	1	3	.	15	7	5	26		
55X-4, 99–100	299	16	A	3	30	.	.	.	7	.	.	.	34	.	.	.	.	4	.	.	2	.	.	7	.	.	18	.	.	.	.	.	7		
56X-1, 99–100	173	29	C	3	6	.	.	.	5	.	.	.	15	.	.	.	.	.	.	.	.	1	.	1	.	.	3	.	.	1	1	.	19		
56X-5, 99–100	315	11	A	.	7	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	11	.	.	.	.	2	.	.	.	.	.	9	lower *Corbisema triacantha* Zone	
57X-2, 99–100	108	30	R	.	12	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	2	.	.	14	.	.	4	.	.	.	.	.	13		
57X-5, 99–100	0	13	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
58X-1, 99–100	0	13	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
58X-2, 99–100	0	13	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
60X-1, 99–100	0	13	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
60X-2, 99–100	0	13	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
61X-1, 99–100	0	13	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
61X-2, 99–100	0	13	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		

Notes: Numbers represent counts, if in brackets = reworked. B = *Bachmannocena*, Da = *Dictyocha*, Ds = *Distephanus*. Abundance key: A = abundant, C = common, R = rare, VR = very rare, B = barren (see text for further definitions).

is missing. In Hole 982B, the section studied herein spans the upper part of the CN6/CN9 nannoplankton zone interval (Okada and Bukry, 1980) as given by Shipboard Scientific Party (1996).

Distephanus boliviensis Zone

Definition: Interval from the last occurrence of *Bachmannocena diodon* ssp. to the first occurrence of *Distephanus jimlingii*. Latest Miocene to earliest Pliocene.

Reference: Introduced by Ciesielski et al. (1989).

Occurrence interval: Samples 162-907B-11H-3, 109–110 cm, to the top of the biosilica-bearing interval in Hole 907B are tentatively assigned to this zone, based on the last occurrence of *B. d. nodosa* in Sample 162-907B-11H-4, 109–110 cm. As discussed above under *B. diodon* Zone, this datum is not entirely reliable.

Assemblage: *Distephanus boliviensis* and *Distephanus speculum* ssp. (abundant).

Remarks: Given that *Distephanus jimlingii* was not encountered in the well-preserved samples of this interval (Samples 162-907B-10H-2, 70–71 cm, and 162-907B-10H-5, 117–118 cm), it is assumed that its first occurrence is in sediments younger than those examined in this study. Therefore, only the lower part of the zone is present in the section considered herein (Hole 907B). This interval would fit mostly within Subchron 3r according to Shipboard Scientific Party (1996).

Table 1 (continued).

Hole 982B samples Core, section, interval (cm)	Counts	Traverses	Abundance	*Ds. c. crux* (rounded)	*Ds. c. hannai*	*Ds. c. lockerii*	*Ds. c. longispinus*	*Ds. c. parvus*	*Ds. c. scutulatus*	*Ds. c. stradneri*	*Ds. polyactis*	*Ds. quinarius* (regular)	*Ds. quinarius* (4-sided)	*Ds. schulzii*	*Ds. speculum binoculus*	*Ds. s. hemisphaericus*	*Ds. s. minutus* (regular)	*Ds. s. minutus* (equant spines)	*Ds. s. speculum*	*Ds. s. speculum* f. *pentagonus*	*Ds. s. triomata*	*Ds. stauracanthus* f. *octagonus*	*Ds. s.* f. *stauracanthus*	*Ds.* sp. aff. *Ds. slavincii*	*Ds. xenus*	*Naviculopsis eobioapiculata*	*Naviculopsis lata*	Silicoflagellate zonation	
21H-1, 99–100	321	6	A	.	.	.	.	.	.	.	.	.	.	.	1	1	10	43	87	3	1	.	.	.	.	.	.	*B. diodon* Zone	*B. circulus apiculata* Zone
21H-6, 99–100	223	32	C	.	3	.	.	.	.	.	.	.	.	.	4	5	8	5	100	.	.	.	.	.	.	.	.		
22H-5, 99–100	0	13	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
23H-3, 99–100	115	32	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	12	.	.	.	.	.	.	.	.		
24H-5, 99–100	301	8	A	.	.	.	.	.	.	.	.	.	.	.	1	.	14	.	177	.	.	.	.	.	5	.	.	*B. diodon nodosa* Subzone	
25H-1, 99–100	262	30	A	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	17	.	.	.	.	.	.	.	.		
26H-1, 99–100	0	13	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
27X-4, 99–100	308	7	A	.	.	.	.	.	.	.	.	.	.	.	2	5	11	.	189	.	3	.	.	.	.	.	.		
28X-1, 99–100	314	3	A	.	4	.	.	.	.	.	.	.	.	.	.	1	10	.	146	.	.	.	.	.	.	.	.		
29X-2, 99–100	349	5	A	.	.	.	.	.	.	.	.	.	.	.	2	.	50	.	125	.	.	.	.	.	.	.	.		
31X-4, 99–100	0	13	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
32X-3, 99–100	309	7	A	.	.	.	.	.	.	14	.	.	.	.	3	1	.	.	39	.	3	.	.	.	.	.	.	*Distephanus crux stradneri* Subzone	
33X-3, 99–100	61	32	R	.	.	.	.	.	3	2	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.		
34X-2, 99–100	6	27	VR	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.		
35X-3, 99–100	39	32	VR	.	.	.	1	.	2	1	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.		
36X-2, 99–100	39	32	VR	.	.	.	.	.	.	4	.	.	.	.	.	.	.	.	3	.	.	.	.	.	.	.	.		
37X-2, 99–100	44	30	VR	.	.	.	.	.	1	7	.	.	.	.	.	.	.	.	5	.	.	.	.	.	.	.	.		
38X-2, 99–100	6	32	VR	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	.	.	.	.	.	.	.	.		
39X-3, 99–100	307	17	A	.	.	.	13	.	46	58	1	.	.	.	.	.	.	.	35	.	1	.	.	.	1	.	.		
40X-3, 99–100	78	32	R	.	.	.	1	.	5	4	.	.	.	.	2	.	.	.	10	.	.	.	.	.	.	.	.		
41X-1, 99–100	249	30	C	.	.	7	15	.	29	37	1	.	.	.	1	.	.	.	14	.	.	.	.	.	3	.	.		
41X-4, 99–100	18	32	VR	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.		
42X-3, 99–100	0	13	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
43X-1, 99–100	0	13	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
43X-3, 99–100	135	13	R	.	.	.	9	.	17	11	.	.	.	4	.	.	.	.	10	.	.	.	.	.	.	.	.		
44X-3, 99–100	133	13	R	.	.	.	.	.	11	3	.	.	.	.	.	3	.	.	7	.	.	.	.	.	.	.	.		
45X-1, 99–100	19	22	VR	.	.	.	.	.	3	3	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	*Caryocha* spp. Subzone	
45X-4, 99–100	180	32	C	.	.	.	3	.	4	2	.	.	.	.	.	.	.	.	13	.	.	.	.	.	.	.	.		
46X-3, 99–100	98	32	R	.	.	.	.	.	9	.	.	.	.	.	.	.	.	.	11	1	.	5	.	.	.	.	.		
47X-1, 99–100	300	21	A	.	.	.	11	.	48	6	.	.	.	.	5	.	.	.	130	1	1	.	.	3	.	.	.		
47X-4, 99–100	163	29	C	1	.	.	3	.	3	.	.	.	.	.	2	1	.	.	10	.	.	.	.	.	.	.	.		
48X-2, 99–100	20	32	VR	.	.	.	.	.	6	1	.	.	.	.	.	.	.	.	4	.	.	.	.	.	.	.	.		
48X-4, 99–100	181	32	C	.	.	.	2	.	15	6	.	.	.	.	.	1	.	.	14	.	.	.	1	.	.	.	.		
48X-5, 99–100	319	20	A	5	.	.	1	5	56	29	.	.	.	.	4	.	.	.	57	.	.	3	.	.	.	.	.		
49X-2, 99–100	306	7	A	1	.	1	1	5	78	11	.	.	.	.	5	.	.	.	69	.	.	.	.	.	.	.	.		
50X-3, 99–100	71	29	R	.	.	.	.	.	6	1	.	.	.	.	1	.	.	.	1	.	.	.	.	.	.	.	.	upper *Corbisema triacantha* Zone	
51X-3, 99–100	235	26	C	.	.	.	.	.	3	1	.	20	1	.	2	.	.	.	7	.	.	.	.	.	.	.	[1]		
52X-2, 99–100	300	18	A	.	.	.	81	7	6	32	.	10	.	.	.	3	.	.	12	.	.	.	.	.	.	.	.		
52X-5, 99–100	76	30	R	.	.	.	21	3	10	3	.	1	.	.	.	1	.	.	6	.	.	.	.	.	.	[1]	.		
53X-4, 99–100	175	32	C	2	.	.	69	12	9	11	.	.	.	.	5	1	.	.	8	.	.	.	.	.	.	[1]	.		
54X-2, 99–100	10	32	VR	.	.	.	1	.	3	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.		
55X-1, 99–100	367	8	A	7	.	.	27	19	43	34	.	.	.	5	4	33	.	.	8	.	9	.	.	14	.	.	.		
55X-4, 99–100	299	16	A	6	.	.	11	11	34	96	.	.	.	7	5	4	.	.	6	1	.	.	.	6	.	.	.		
56X-1, 99–100	173	29	C	2	.	1	40	2	11	45	.	.	.	.	.	9	.	.	2	.	.	.	.	5	.	[1]	.		
56X-5, 99–100	315	11	A	5	.	36	31	.	47	91	.	.	.	18	3	20	.	.	19	.	4	.	.	11	.	[1]	.	lower *Corbisema triacantha* Zone	
57X-2, 99–100	108	30	R	.	.	1	8	.	9	12	.	.	.	.	4	7	.	.	8	.	5	.	.	7	.	.	.		
57X-5, 99–100	0	13	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
58X-1, 99–100	0	13	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
58X-2, 99–100	0	13	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
60X-1, 99–100	0	13	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
60X-2, 99–100	0	13	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
61X-1, 99–100	0	13	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
61X-2, 99–100	0	13	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		

BIOSTRATIGRAPHY AND GENERAL PALEOENVIRONMENTAL TRENDS

The following section sets forth a description of the silicoflagellate assemblages encountered in the Miocene section of the holes considered in this study. It is accompanied by a qualitative interpretation of the history of surface waters through the time interval represented by these phytoplanktonic micro-organisms. The latter is based on the analysis of variations in generic (and sometimes specific) abundance through time, using the affinities of the different silicoflagellate groups for both water temperature and nutrient concentrations. Locker and Martini (1989) and Ciesielski and Case (1989) provided a paleoenvironmental analysis for ODP Leg 104 sites, applying the criteria given in previous literature for the use of silicoflagellate groups for such purposes (e.g., Bukry, 1986) without considerable modifications. Most of their criteria are followed here: in this way, dictyochids and corbisemids are warm-water adapted (Martini, 1971, and Bukry, 1981b, respectively); hexagonal distephanids are cool-water adapted (Ciesielski, 1975); quadrate ("tetragonal") distephanids are temperate adapted (Bukry, 1985); and bachmannocenids are representative of nutrient-rich waters (Bukry, 1986).

One important aspect to consider, however, is that Locker and Martini (1989) place bachmannocenids within three separate genera, all with different temperature affinities. In this way, septamesocenids are warm adapted, mesocenids are warm to temperate adapted, and paramesocenids are cool to temperate adapted. Even though all bachmannocenids are placed within the genus *Bachmannocena* for this

Table 2. Silicoflagellates in Hole 907B from the Miocene.

Hole 907B samples Core, section, interval (cm)	Counts	Traverses	Abundance	*B. apiculata apiculata*	*B. a. curvata*	*B. circulus apiculata*	*B. c. circulus*	*B. d. diodon*	*B. d. nodosa*	*B. d. triodon*	*B. dumitricae*	*B. elliptica elliptica*	*B. elliptica miniformis*	*B. hexalitha*	*B. triangula*	*B. quadrangula*	*Caryocha depressa*	*Caryocha ernestinae*	*Caryocha jouseae*	*C. apiculata apiculata*	*C. hastata*	*C. inermis*	*C. triacantha*	*Da. fibula* (regular)	*Da. fibula* (5-sided)	*Da. fibula* (3-sided)	*Da. subclinata*	*Da. varia*	*Da.* sp. cf. *Da. rhombica*	*Da.* sp. 2	*Da.* sp. 3	*Da.* sp. 4	*Ds. boliviensis binoculus*	*Ds. b. boliviensis*	Silicoflagellate zonation	
10H-1, 73–74	0	13	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
10H-2, 70–71	314	3	A	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4		
10H-3, 81–82	0	13	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
10H-4, 105–106	0	13	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*Distephanus*	
10H-5, 117–118	308	3	A	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	*boliviensis*	
10H-6, 97–98	0	13	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	Zone	
11H-1, 109–110	0	13	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
11H-2, 109–110	0	13	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
11H-3, 109–110	7	32	VR	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	[5]	.	.	.	.	.	.	.	.	.	.	.		
11H-4, 109–110	142	30	R	.	.	.	.	.	1	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4		
11H-5, 109–110	2	32	VR	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*B. diodon*	
11H-6, 109–110	0	13	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	Zone	
12H-1, 109–110	0	13	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
12H-2, 109–110	355	6	A	.	.	22	.	5	7	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	53		
12H-3, 49–50	302	15	A	.	.	1	.	8	12	.	.	.	.	.	.	.	.	.	.	.	.	.	.	[2]	.	.	.	.	.	.	.	.	.	.	108		
12H-4, 109–110	7	32	VR	.	.	1	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	[1]	.	.	.	.	.	.	.	.	.	.	.		
12H-5, 109–110	2	32	VR	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	[1]	.	.	.	.	.	.	.	.	.	.	.	*B. diodon*	
12H-6, 109–110	0	13	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*nodosa*	
13H-1, 28–29	200	28	C	.	.	2	.	2	4	.	.	.	.	.	.	.	.	.	.	.	[2]	.	.	.	.	.	.	.	.	.	.	.	.	.	.	Subzone	
13H-3, 109–110	15	32	VR	.	.	.	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4		
13H-5, 120–121	304	19	A	.	.	151	1	1	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5	20			
14H-1, 109–110	321	8	A	.	.	83	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5	.	.	.	.	.	.			
14H-2, 109–110	313	16	A	.	.	94	12	6	18	1	1	2	.	1	.	.	.	.	.	.	.	.	.	.	.	.	8	8	.	.	.	.	.	5			
14H-3, 109–110	330	6	A	.	.	6	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1			
14H-4, 109–110	302	32	A	.	.	88	5	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	14	.	.	.	.	.	.	.			
14H-5, 109–110	312	24	A	.	.	14	.	.	4	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	34	9	.	.	.	.	1	4			
14H-6, 109–110	312	18	A	.	.	24	9	.	10	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	8	1	.	.	.	.	3	3			
15H-1, 109–110	177	32	C	.	.	36	11	15	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.			
15H-2, 109–110	312	27	A	.	.	58	7	4	7	.	.	.	.	.	.	.	2	.	.	.	.	.	1	.	.	.	8	8	.	.	.	.	.	3	*Distephanus*		
15H-3, 109–110	304	18	A	.	.	40	.	.	197	5	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	*crux*		
15H-4, 109–110	308	28	A	.	.	2	1	19	209	1	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	8	.	.	.	.	8	*stradneri*		
15H-5, 109–110	307	20	A	.	.	16	2	60	83	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	8	1	.	2	.	.	1	Subzone		
15H-6, 109–110	107	32	R	.	.	3	3	22	57	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	1	.	.	.	.			
16H-1, 109–110	101	32	R	.	.	51	4	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	1	4			
16H-2, 109–110	208	32	C	.	.	156	.	.	16	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	.	1	.	.	.				
16H-3, 109–110	14	32	VR	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2			
16H-5, 109–110	102	32	R	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	13	4	.	.	.	.	.	.			
16H-6, 109–110	299	24	A	.	.	1	.	.	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	6	.	.	.	.	.	7			
17H-1, 109–110	303	24	A	.	.	1	74	35	50	7	.	3	.	.	1	.	3	2	.	.	.	.	.	.	.	.	2	5	.	.	.	.	.	7			
17H-2, 109–110	309	12	A	.	.	14	.	1	9	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5	6	.	.	.	.	.	1			
17H-3, 109–110	80	32	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	6	.	.	.	.	.	.			
17H-4, 109–110	2	32	VR	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.			
17H-5, 109–110	18	32	VR	.	.	8	1	.	.	.	.	.	.	.	.	.	.	.	.	.	[1]	[1]	.	.	.	.	.	.	.	.	.	.	.	.			
17H-6, 109–110	118	32	R	.	.	88	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	1	.	.	.	2	.	.	.	.	.	.			
18H-1, 109–110	27	32	VR	.	.	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.			
18H-2, 109–110	304	31	A	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	.	.	.	3	5	.	.	.	.	.	.			
18H-3, 109–110	83	32	R	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.			
18H-4, 109–110	227	32	C	.	.	125	.	.	.	.	.	.	.	.	.	.	9	68	1	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.			
18H-5, 109–110	209	32	C	.	.	28	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	3	2	.	.	.	.	.	.			
18H-6, 109–110	246	32	C	.	.	49	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5	6	.	.	.	.	.	.			
19H-1, 109–110	228	32	C	.	.	75	.	.	.	.	.	.	.	.	.	.	14	117	.	.	.	.	.	.	.	.	.	6	.	.	.	.	.	.			
19H-2, 109–110	208	32	C	.	.	78	.	.	.	.	.	.	.	.	.	.	31	50	1	.	.	.	.	.	.	.	.	11	.	.	.	.	.	.			
19H-5, 109–110	249	32	C	.	.	141	.	.	.	.	.	.	.	.	.	.	.	70	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	*Caryocha*		
20H-1, 109–110	336	9	A	.	.	4	.	.	.	.	.	.	.	.	.	.	.	6	.	.	.	.	.	249	11	3	.	.	.	.	.	.	.	.	spp.		
20H-2, 109–110	302	12	A	.	.	1	.	.	.	.	.	.	.	.	.	.	.	7	.	.	.	.	.	180	23	1	.	.	.	.	.	.	.	.	Subzone		
20H-3, 109–110	308	8	A	.	.	7	.	.	.	.	.	.	.	.	.	.	1	11	.	.	.	.	.	146	6	.	.	2	.	.	.	.	.	.			
20H-4, 109–110	323	11	A	.	.	4	.	.	.	.	.	.	.	.	.	.	.	7	.	.	.	.	.	42	1	1	.	16	.	.	.	.	.	.			
20H-5, 109–110	87	32	R	.	.	3	.	.	.	.	.	.	.	.	.	.	.	7	.	.	.	.	.	10	.	2	.	.	.	.	.	.	.	.			
20H-6, 109–110	107	31	R	.	.	2	.	.	.	.	.	.	.	.	.	.	.	31	.	.	.	.	2	6	1	.	.	.	.	.	.	.	.	.			
21H-1, 106–107	27	32	VR	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5	.	.	.	.	.	2	.	.	.	3	.	.	.	.	.	.			
21H-2, 106–107	61	32	R	.	.	4	.	.	.	.	.	.	.	.	.	.	.	13	.	.	.	.	.	8	1	.	.	3	.	.	.	1	.	.			
21H-3, 106–107	33	32	VR	.	.	1	.	.	.	.	.	.	.	.	.	.	.	22	.	.	.	.	.	3	.	1	.	.	.	.	.	.	.	.			
21H-4, 106–107	120	32	R	.	.	1	.	.	.	.	.	.	.	.	.	.	.	89	.	.	.	.	.	7	1	.	.	.	.	.	.	2	.	.			
21H-5, 106–107	25	30	VR	2	2	7	.	.	.	.	.	.	.	.	.	.	.	3	.	.	.	.	.	.	.	.	.	11	.	.	.	.	.	.			
21H-6, 109–110	157	32	C	.	1	.	.	.	.	.	.	.	.	.	.	.	.	7	.	.	.	.	.	1	.	.	.	.	146	.	.	.	.	.			
22H-1, 109–110	67	32	R	8	29	17	.	.	.	.	.	.	.	.	.	.	3	1	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.			
22H-2, 109–110	93	32	R	11	18	.	.	.	.	.	.	.	1	.	.	.	.	2	.	.	.	.	.	5	2	.	.	.	.	.	.	.	.	.	upper		
22H-3, 109–110	12	32	VR	1	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	[1]	.	.	.	3	.	.	.	.	.	.	.	.	.	.	*Corbisema*		
22H-4, 109–110	0	13	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*triacantha*		
23H-1, 109–110	0	13	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	Zone		
23H-6, 109–110	0	13	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.			

Notes: Numbers represent counts; if in brackets = reworked. B = *Bachmannocena*, C = *Corbisema*, Da = *Dictyocha*, Ds = *Distephanus*. A = abundant, C = common, R = rare, VR = very rare, B = barren (see text for further definitions).

Bachmannocena circulus apiculata Zone

Table 2 (continued).

Hole 907B samples Core, section, interval (cm)	Counts	Traverses	Abundance	*Ds. b. major*	*Ds. crux crux*	*Ds. c. lockerii* (regular)	*Ds. c. lockerii* (3-sided)	*Ds. c. lockerii* (5-sided)	*Ds. c. longispinus*	*Ds. c. longispinus* (equant spines)	*Ds. c. parvus*	*Ds. c. scutulatus*	*Ds. c. stradneri*	*Ds. quinarius*	*Ds. quinarius* (no aw)	*Ds. quinarius* (2 aw)	*Ds. quinarius* (3 aw)	*Ds. quinarius* (4-sided)	*Ds. schulzii*	*Ds. speculum binoculus*	*Ds. s. hemisphaericus*	*Ds. s. minutus*	*Ds. s. minutus* (equant spines)	*Ds. s. speculum* (regular)	*Ds. s. speculum* (thickened)	*Ds. s. speculum* f. *notabilis*	*Ds. s. speculum* f. *pentagonus*	*Ds. s. speculum* f. *pseudofibula*	*Ds. s. speculum* f. *septenarius*	*Ds. s. triomata*	*Lyramula furcula*	*Naviculpsis constricta*	*Naviculopsis minor*	*Naviculopsis transitoria*	Silicoflagellate zonation	
10H-1, 73–74	0	13	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
10H-2, 70–71	314	3	A	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	71	31	199	.	1	5	.	.	.	.	.	.	.	.		
10H-3, 81–82	0	13	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
10H-4, 105–106	0	13	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*Distephanus boliviensis* Zone	
10H-5, 117–118	308	3	A	.	.	.	.	.	.	.	.	.	.	3	.	.	.	.	.	.	.	35	73	193	.	1	.	.	.	.	.	.	.	.	.		
10H-6, 97–98	0	13	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
11H-1, 109–110	0	13	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
11H-2, 109–110	0	13	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
11H-3, 109–110	7	32	VR	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	[2]	.	.	.		
11H-4, 109–110	142	30	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	.	123	5	.	2	.	.	2	.	.	.	.	.		
11H-5, 109–110	2	32	VR	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	[1]	.	*B. diodon* Zone	
11H-6, 109–110	0	13	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
12H-1, 109–110	0	13	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
12H-2, 109–110	355	6	A	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	242	20	5	.	.	.	.	.	.	.	.	.		
12H-3, 49–50	302	15	A	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	4	.	160	.	1	3	.	.	2	.	.	.	.	.		
12H-4, 109–110	7	32	VR	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	[1]		
12H-5, 109–110	2	32	VR	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*B. diodon nodosa* Subzone	
12H-6, 109–110	0	13	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
13H-1, 28–29	200	28	C	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	6	.	31	.	148	.	.	1	.	.	1	.	[3]	.	.	.		
13H-3, 109–110	15	32	VR	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	3	.	.	1	.	.	.	.	.	.	.	[1]		
13H-5, 120–121	304	19	A	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	14	.	107	.	.	.	.	.	.	.	.	.	.	.		
14H-1, 109–110	321	8	A	1	.	.	.	.	1	.	.	.	19	.	.	.	.	.	.	1	.	11	.	195	1	1	2	1	.	.	.	.	.	.	.		
14H-2, 109–110	313	16	A	3	1	.	.	.	49	3	.	28	5	5	.	.	.	.	.	6	.	4	.	46	.	.	2	.	.	.	5	.	.	.	.		
14H-3, 109–110	330	6	A	.	6	.	.	.	4	.	.	4	.	294	.	3	.	.	.	.	.	1	.	10	.	.	.	.	.	.	.	.	.	.	.		
14H-4, 109–110	302	32	A	.	.	.	.	.	30	3	2	18	14	35	.	.	.	.	.	1	.	10	.	80	.	.	.	.	.	.	.	.	.	.	.		
14H-5, 109–110	312	24	A	2	2	.	.	.	26	1	.	1	16	137	2	2	.	.	.	.	.	24	.	30	.	.	1	.	.	.	.	.	.	.	.		
14H-6, 109–110	312	18	A	.	.	.	.	.	13	2	4	23	32	131	.	2	1	1	.	4	1	11	.	25	.	.	.	.	.	.	3	.	.	.	.		
15H-1, 109–110	177	32	C	.	1	.	.	.	6	2	.	.	.	.	.	.	.	.	.	.	.	92	.	9	.	.	.	.	.	1	.	.	.	.	.		
15H-2, 109–110	312	27	A	.	3	.	.	.	29	.	10	23	28	3	.	.	.	.	.	3	.	49	.	64	.	.	.	.	.	.	2	.	.	.	.	*Distephanus crux stradneri* Subzone	
15H-3, 109–110	304	18	A	.	.	.	.	.	3	.	.	.	11	.	.	.	.	.	.	1	.	1	.	42	.	.	.	.	.	1	.	.	.	.	.		
15H-4, 109–110	308	28	A	.	.	.	.	.	.	.	.	1	.	3	.	.	.	.	.	1	.	7	.	46	.	.	1	.	.	.	.	.	.	.	.		
15H-5, 109–110	307	20	A	.	13	.	.	.	37	6	.	7	.	.	.	.	.	.	.	.	.	1	.	64	.	.	3	.	.	2	.	.	.	.	.		
15H-6, 109–110	107	32	R	.	.	.	.	.	3	.	.	4	2	.	.	.	.	.	.	.	.	.	.	10	.	.	.	.	.	.	.	.	.	.	.		
16H-1, 109–110	101	32	R	.	2	.	.	.	5	.	1	3	5	.	.	.	.	.	.	.	.	.	.	20	.	.	.	.	.	2	.	.	.	.	.		
16H-2, 109–110	208	32	C	.	.	.	.	.	6	.	.	.	.	.	.	.	.	.	.	1	.	3	.	19	.	.	.	.	.	.	2	.	.	.	.		
16H-3, 109–110	14	32	VR	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	11	.	.	.	.	.	.	.	[1]	.	.	.		
16H-5, 109–110	102	32	R	.	12	.	.	.	19	3	1	12	.	2	.	.	.	.	.	2	.	5	.	26	.	.	.	.	.	.	2	.	.	.	.		
16H-6, 109–110	299	24	A	.	11	.	.	.	10	.	.	.	.	.	.	.	.	.	.	12	4	45	.	181	.	2	12	.	.	3	1	.	.	.	.		
17H-1, 109–110	303	24	A	.	2	.	.	.	31	11	1	11	.	.	.	.	.	.	.	6	.	3	.	46	.	.	1	.	.	.	1	.	.	.	.		
17H-2, 109–110	309	12	A	.	10	.	.	.	252	.	.	.	.	.	.	.	.	.	.	.	.	2	.	9	.	.	.	.	.	.	.	.	.	.	.		
17H-3, 109–110	80	32	R	.	7	.	.	.	39	.	.	.	.	.	.	.	.	.	.	1	5	4	.	11	.	1	1	.	.	.	3	.	.	.	.		
17H-4, 109–110	2	32	VR	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.		
17H-5, 109–110	18	32	VR	.	.	.	.	.	1	.	.	.	1	.	.	.	.	.	.	.	.	.	.	3	.	.	.	.	.	.	.	[2]	.	.	.		
17H-6, 109–110	118	32	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	22	.	.	2	.	.	.	.	.	.	.	.		
18H-1, 109–110	27	32	VR	.	1	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	19	.	.	.	.	.	.	.	.	.	.	.		
18H-2, 109–110	304	31	A	.	.	.	.	.	244	.	.	.	.	.	.	.	.	.	.	2	2	.	.	45	.	.	.	.	.	.	.	.	.	.	.		
18H-3, 109–110	83	32	R	.	.	.	.	.	15	.	.	13	10	.	.	.	.	.	.	4	.	2	.	36	.	.	.	1	.	.	1	.	.	.	.		
18H-4, 109–110	227	32	C	.	2	.	.	.	4	.	.	.	.	.	.	.	.	.	.	1	1	.	.	14	.	.	.	.	.	.	.	.	.	.	.		
18H-5, 109–110	209	32	C	.	4	.	.	.	85	.	.	50	20	.	.	.	.	.	.	.	.	.	.	16	.	.	.	.	.	.	.	.	.	.	.		
18H-6, 109–110	246	32	C	.	11	18	.	.	63	.	.	.	.	.	.	.	.	.	.	.	.	.	.	91	.	.	2	.	.	1	.	.	.	.	.		
19H-1, 109–110	228	32	C	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	2	.	.	.	.	13	.	.	.	.	.	.	.	.	.	.	.		
19H-2, 109–110	208	32	C	.	3	.	.	.	6	.	.	.	.	.	.	.	.	.	.	.	5	.	.	23	.	.	.	.	.	.	.	.	.	.	.	*Caryocha* spp. Subzone	*Bachmannocena circulus apiculata* Zone
19H-5, 109–110	249	32	C	.	.	.	.	.	9	1	.	3	12	.	.	.	.	.	.	.	.	.	.	10	.	.	.	.	.	.	.	.	[1]	.	.		
20H-1, 109–110	336	9	A	.	3	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	58	.	.	.	.	.	.	.	.	.	.	.		
20H-2, 109–110	302	12	A	.	2	.	.	.	.	7	.	.	.	.	.	.	.	.	.	2	.	.	.	78	.	.	.	.	.	.	1	.	.	.	.		
20H-3, 109–110	308	8	A	.	.	3	.	.	.	27	.	2	.	.	.	.	.	.	.	1	.	.	.	102	.	.	.	.	.	.	.	.	.	.	.		
20H-4, 109–110	323	11	A	.	25	89	.	2	.	.	.	.	.	.	.	.	.	.	.	4	.	.	.	130	.	.	.	.	.	2	.	.	.	.	.		
20H-5, 109–110	87	32	R	.	.	59	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	.	.	.	.	.	.	.	.	.	.	.		
20H-6, 109–110	107	31	R	.	1	51	.	.	6	.	.	.	.	.	.	.	.	.	.	1	.	.	.	6	.	.	.	.	.	.	.	.	.	.	.		
21H-1, 106–107	27	32	VR	.	3	10	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	.	.	.	.	.	.	.	.	.	.	.		
21H-2, 106–107	61	32	R	.	.	30	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.		
21H-3, 106–107	33	32	VR	.	.	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.		
21H-4, 106–107	120	32	R	.	3	16	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.		
21H-5, 106–107	25	30	VR	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
21H-6, 109–110	157	32	C	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.		
22H-1, 109–110	67	32	R	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	.	.	.	.	.	.	.	.	.	.	.		
22H-2, 109–110	93	32	R	.	.	53	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	upper *Corbisema triacantha* Zone	
22H-3, 109–110	12	32	VR	.	.	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
22H-4, 109–110	0	13	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
23H-1, 109–110	0	13	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
23H-6, 109–110	0	13	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		

study (see "Taxonomy" section, this chapter) following the most accepted view on these morphotypes, there seem to be differences in the environmental tolerances of different species within the genus. In the discussion that follows, *B. apiculata* ssp. (the "septamesocenids" of Locker and Martini, 1989) are considered to be warm adapted, *B. circulus apiculata* (a "paramesocenid" of these authors) is considered to be temperate adapted, and *B. diodon nodosa* (a "mesocenid") is considered to be cool to temperate adapted. Only the latter interpretation differs from that of Locker and Martini (1989), who considered mesocenids to be warm to temperate adapted.

The other group in which temperature affinity is not clear-cut is the caryochids. Ciesielski and Case (1989) recognize this group but comment on the poorly established paleoenvironmental affinity of these taxa. Locker and Martini (1989) include most of these morphotypes in the genus *Cannopilus*, which they consider to be warm adapted. As discussed below, their occurrence together with quadrate distephanids identifies them as more temperate adapted than warm adapted. They do not, however, persist into the late Miocene as do the quadrate distephanids. Their true affinity, therefore, might be more temperate to warm adapted, as opposed to quadrate distephanids, which could be more temperate to cool adapted.

Hole 907B

Site 907 is located on the Iceland Plateau, at the center of a planned transect from Norway to Greenland, with ODP Leg 104 Vøring Plateau sites at the eastern end and Leg 162 Site 987 at its western end. Hole 907A was drilled during Leg 151, whereas Holes 907B and 907C were drilled during Leg 162. Hole 907B is positioned at 69°14.989′N and 12°41.898′W at a water depth of ~1800 m. Twenty-three cores were recovered using the advanced hydraulic piston corer (APC) system, totaling 211.7 m of sediment. Four lithologic units were described by shipboard scientists, of which only Units III and IV contain Miocene sediments. Only Unit III (63.1–196.1 meters below seafloor [mbsf], Cores 162-907B-8H-3 through 22H-3) yielded biosiliceous microfossils. The primary lithology of this unit is silty clay, and biosiliceous components increase from <5% at the upper boundary to 5%-20% in the lower portion of the unit (Jansen, Raymo, et al., 1996).

The oldest sample with biosilica is Sample 162-907B-22H-3, 109–110 cm. Together with the next oldest, Sample 162-907B-22H-2, 109–110 cm, the upper *Corbisema triacantha* Zone is represented. In both samples, preservation is low (see Table 2), and the assemblage is characterized by *Distephanus crux lockerii* n. ssp. and *Bachmannocena apiculata* ssp.

In Sample 162-907B-22H-1, 109–110 cm, the first occurrence of *Bachmannocena circulus apiculata* is recorded, which marks the bottom of the overlying *Caryocha* spp. Subzone of the *Bachmannocena circulus apiculata* Zone. This subzone extends to Sample 162-907B-17H-3, 109–110 cm, and is characterized by *B. c. apiculata* throughout. Preservation is very good in the middle part of the subzone and decreases toward the upper and lower parts. *Bachmannocena apiculata* ssp. are found only in the subzone's lowermost part, where an acme of a morphotype compared to *Dictyocha rhombica* is observed (Sample 162-907B-21H-6, 109–110 cm). The disappearance of the *Bachmannocena apiculata* ssp. (of warm surface-water affinities, according to this study) is followed by a sudden increase in *Caryocha ernestinae* and quadrate distephanids. These latter taxa are considered to have more temperate affinities (Bukry, 1985, and this study) and mark a decline in surface-water temperatures. Toward the middle part of the subzone, there is an acme of *Dictyocha fibula* (with concomitant decreases in caryochids and quadrate distephanids) marking a brief return of warmer surface temperatures (Martini, 1971), followed by a sudden increase in *Bachmannocena circulus apiculata*, caryochids, and quadrate distephanids. This signals a return to temperate conditions together with an increase in surface-water fertility (Bukry, 1986). The upper part of the subzone is marked by rare occurrences of the aforementioned taxa, together with some reworked Paleogene specimens (*Corbisema hastata*, *C. inermis*, and *Naviculopsis constricta*).

The first occurrence of *Bachmannocena diodon nodosa* in Sample 162-907B-17H-2, 109–110 cm, defines the beginning of the overlying *Distephanus crux stradneri* Subzone of the *B. c. apiculata* Zone, which straddles the middle/late Miocene boundary. Because preservation in the samples below this first occurrence is poor, this bioevent might actually be slightly older. The interval spanned by this subzone is characterized by good preservation, except for a small section (the bottom of Core 162-907B-15H and most of Core 16H). The abundant bachmannocenids point toward continuing high-productivity surface waters (Bukry, 1986), but the temperature signal differs from that of the subzone below. The persistence of temperate quadrate distephanids (Bukry, 1985), in spite of growing numbers of cool-water hexagonal distephanids (Ciesielski, 1975), suggests cool-temperate conditions instead of the warm-temperate conditions characteristic of the underlying subzone's assemblage. In addition, even though all bachmannocenids are considered to be upwelling indicators (Bukry, 1986), the fact that increases of *B. c. apiculata* go hand-in-hand with decreases of *B. diodon nodosa* (and vice versa) implies that they have different temperature affinities. Also, a peak abundance of *B. d. nodosa* within the middle part of the subzone (Sections 3 and 4 of Core 162-907B-15H) correlates with a marked decrease in quadrate distephanids. For these reasons, *B. d. nodosa* is considered herein to be a cool- to temperate-surface–water indicator, as opposed to *B. c. apiculata*, which would be more characteristic of temperate to somewhat warm surface waters.

Most quadrate distephanids have their last occurrence in Sample 162-907B-14H-1, 109–110 cm. This bioevent is extremely reliable because it occurs within an interval of excellent biosiliceous preservation and marks the top of the *D. c. stradneri* Subzone. Since all younger assemblages are characterized by hexagonal distephanids, this point would mark the beginning of cool surface-water conditions in the area. Species diversities decrease considerably as from this time, and surface-water productivity remains high, as evidenced by the continued presence of bachmannocenids throughout the overlying *Bachmannocena diodon nodosa* Subzone. The last occurrence of *B. c. apiculata* is recorded in Sample 162-907B-12H-2, 109–110 cm, but preservation above this sample is extremely poor, and an unconformity has been suggested at this depth (Jansen, Raymo, et al., 1996). This means that most probably the uppermost part of this subzone is missing, as well as the lowermost part of the overlying *Bachmannocena diodon* Zone. All of the *B. diodon* Zone in this hole has poor preservation, and its top is defined by the last occurrence of *B. diodon nodosa* (Sample 162-907B-11H-4, 109–110 cm). Most of the overlying *Distephanus boliviensis* Zone, which straddles the Miocene/Pliocene boundary, is also characterized by poor preservation, but a few samples with excellent preservation provide windows into this time period, showing a dominance of cool-water hexagonal distephanids.

Hole 982B

Site 982 is located on the Rockall Plateau, a shallow platform that lies roughly between Iceland and Ireland, underlain by continental crust, which separated from Greenland sometime during the Paleocene (Laughton, Berggren, et al., 1972). Four holes were drilled during Leg 162 (A through D), the deepest being Hole 982B, with a recovery of 614.9 m. The latter is positioned at 57°31.002′ and 15°51.993′W at a water depth of 1134 m. The first 26 cores were obtained with the APC system, and 39 further cores with the extended core barrel system. Two lithologic units were described by shipboard scientists, of which Unit II (57.4–614.9 mbsf, Cores 162-982B-7H-3 through 65H) contains Miocene sediments (Core 18H and older). Although the primary lithology of Unit II is a nannofossil ooze (with calcium carbonate percentages averaging around 90%), most sam-

ples from this unit yielded enough biosiliceous components to allow a detailed silicoflagellate analysis.

The oldest sample with biosilica is Sample 162-982B-57X-2, 99–100 cm, but preservation is poor. Preservation increases as from the next oldest sample (see Table 1) and remains good throughout the Miocene section of this hole's cores, with the exception of two intervals close to the middle/late Miocene boundary. The two abovementioned samples represent the uppermost part of the lower *Corbisema triacantha* Zone, of early middle Miocene age. The silicoflagellate assemblage is characterized by warm and temperate taxa, mainly *Bachmannocena apiculata curvata* and quadrate distephanids, respectively.

The first occurrence of *Bachmannocena diodon diodon* in Sample 162-982B-56X-1, 99–100 cm, marks the base of the overlying upper *Corbisema triacantha* Zone. This zone extends to Sample 162-982B-50X-3, 99–100 cm, above which *Bachmannocena circulus apiculata* is recorded. The zone is characterized by warm and temperate taxa: bachmannocenids such as *B. apiculata* ssp. and *B. elliptica elliptica*, together with several dictyochids and *Corbisema triacantha*, suggest warm surface-water temperatures, whereas common quadrate distephanids and caryochids (which appear for the first time in this zone) point to more temperate conditions. The common to abundant *B. diodon diodon* indicates highly productive surface waters.

The first occurrence of *Bachmannocena circulus apiculata* in Sample 162-982B-49X-2, 99–100 cm, denotes the base of the next interval, here defined as the *Caryocha* spp. Subzone of the *Bachmannocena circulus apiculata* Zone, which extends to Sample 162-982B-45X-1, 99–100 cm. This subzone is characterized by a silicoflagellate assemblage that suggests warm to temperate surface waters (*B. apiculata* ssp., dictyochids, caryochids, and quadrate distephanids), though the cool-water hexagonal distephanids begin to be present too. The abundant *B. c. apiculata* indicates highly fertile surface waters.

The first occurrence of *Bachmannocena diodon nodosa* in Sample 162-982B-44X-3, 99–100 cm, marks the base of the next interval, the *Distephanus crux stradneri* Subzone of the *Bachmannocena circulus apiculata* Zone, which extends to Sample 162-982B-32X-3, 99–100 cm, where all quadrate distephanids have their last occurrence. Both the lower and upper parts of this subzone have poor biosilica preservation, but the analysis of samples within these intervals still allows the identification and counting of taxa in spite of their low abundances. The middle interval, with good preservation, shows common quadrate distephanids (but no caryochids), *B. c. apiculata*, and *B. diodon* ssp. As discussed for Hole 907B, the appearance of *B. d. nodosa* marks a drop in sea-surface temperatures, although some temperate taxa are still part of the assemblage.

The interval above this subzone is characterized by taxa that are cool-water indicators dominating the assemblage (hexagonal distephanids and *B. d. nodosa*). The continued presence of bachmannocenids points to a high-productivity environment. Of interest is the presence of *Dictyocha brevispina ausonia* in the middle to upper part of the *Bachmannocena diodon nodosa* Subzone of the *Bachmannocena circulus apiculata* Zone, since it marks a brief period of warmth during a time of progressive cooling. This interval might be absent in Hole 907B because of the presence of the cited unconformity, or these warm waters may have not reached the higher latitudes at which Site 907 is located. The boundary between the *Bachmannocena circulus apiculata* Zone and the *Bachmannocena diodon* Zone is given by the last occurrence of *B. c. apiculata* (Sample 162-982B-24H-5, 99–100 cm). There is a marked decline in the preservation of biosilica toward the top of the overlying *B. diodon* Zone (i.e., above Sample 162-982B-21H-1, 99–100 cm), and no samples from this interval were studied herein. The top of the zone is therefore not recognized within the suite of samples analyzed in this study.

In summary, during the middle Miocene, silicoflagellates with affinities for temperate surface waters begin to form an important part of the assemblages replacing taxa with affinities for warm surface waters. Next, taxa with warm-temperate affinities disappear first, whereas those with cool-temperate affinities persist into the early to middle late Miocene. Last, taxa with cool-water affinities replace all others and become dominant components of the late late Miocene silicoflagellate assemblages.

TAXONOMY

A certain number of criteria are here applied to the taxonomy of silicoflagellates, with the main purpose of simplifying an otherwise profuse and complicated assignment of morphotypes to different taxa by different authors. This effort to try and unify the criteria used is of vital importance in the application of silicoflagellates to both stratigraphy and paleoecology. Difficulties in comparing previous silicoflagellate studies by various authors arise when ranges are examined. On one hand, lumping of morphotypes that have different stratigraphic ranges into one taxon (as in much of the older literature) precludes the stratigraphic value of silicoflagellates reaching its full potential. On the other hand, oversplitting of one taxon into a myriad of taxa (most of which are rare varieties that appear within the range of the regular morphotype) serves no purpose, either stratigraphic or paleoecological. In addition, assignment of the same taxon to different genera by different authors complicates matters when trying to assess the paleoecological signature of an assemblage.

For these reasons, when encountering a morphotype that deviates from an established taxon, its range and abundance were evaluated before taxonomic assignment. If it appears to be just a variety of a named taxon, it has been counted and tabulated separately for future reference. Such a morphotype, however, has been included within the taxon to avoid the creation of unnecessary taxa that increase the complexity of silicoflagellate systematics. In such cases, these varieties are described in the remarks section of the taxon, and their abundance and stratigraphic distribution can be observed in Tables 1 and 2 (e.g., *Dictyocha fibula* [regular], *D. fibula* [five-sided], and *D. fibula* [three-sided]). When morphotypes that cannot be assigned to any known taxon were encountered, they were considered new taxa only if they were at least relatively common within the assemblage and maintained their distinctive morphology throughout their range. A considerable effort was put into avoiding the establishment of new taxa in this study. As a result, only one new taxon is described herein, *Distephanus crux lockerii*, with a regular, four-sided morphology and three- and five-sided varieties. Other morphotypes (which, though distinctive, were rare) were described and illustrated but were only assigned to a genus and listed as such (e.g., *Dictyocha* sp. 1, *Dictyocha* sp. 2, etc.).

The unfortunate results of using different taxonomic criteria for silicoflagellates in the past can be evidenced clearly in the previous studies of silicoflagellates in the same realm considered here, the Norwegian-Greenland Sea. Locker and Martini (1989) and Ciesielski et al. (1989) both studied Vøring Plateau sections from Leg 104 and provided different lists of taxa encountered and a different zonal scheme. In addition, because of differences of generic assignment of taxa, their paleoecological interpretations do not coincide entirely. To avoid such complications, the taxonomic assignments herein result from a compromise between these two "schools" and purport to clarify previous and future assignments by providing a short but adequate synonymy. The first major generic criterion is the grouping of all silicoflagellates consisting solely of a basal ring into the genus *Bachmannocena* (Locker), avoiding the criteria followed by Locker and Martini (1986), which separate such morphotypes into the genera *Septamesocena*, *Mesocena*, and *Paramesocena*. The second major criterion is the use of the genus *Caryocha* Bukry and Monechi for morphotypes with a spherical subdivided apical apparatus and downpointing basal spines, and the retention of all morphotypes with a nonspherical subdivided apical apparatus and a distephanid morphology in the genus *Distephanus* Stöhr (Locker and Martini, 1989, in-

clude all morphotypes with a subdivided apical apparatus in the genus *Cannopilus*, which is dropped herein). Minor criteria are described within the taxonomic listing.

In addition to the remarks, a mention of the abundance and stratigraphic range of most taxa within the sections studied is given under the heading occurrence. Taxa that are stratigraphically valuable and do not figure extensively in the literature are shown in Plates 1 through 3.

Kingdom PROTISTA
Subkingdom PROTOPHYTA
Class CHRYSOPHYCEAE
Order SILICOFLAGELLATA Borgert, 1891

Genus *BACHMANNOCENA* (Locker, 1974) Bukry, 1987

Bachmannocena apiculata apiculata (Schulz, 1928) Bukry, 1987

Mesocena oamaruensis var. *apiculata* Schulz, 1928, p. 240, fig. 11.
Bachmannocena apiculata apiculata (Schulz) Bukry, 1987, p. 403, pl.1, fig. 1.
Septamesocena apiculata f. *apiculata* (Bukry) Locker and Martini, 1989, p. 570, pl. 5, fig. 4.

Occurrence: Restricted to the middle Miocene in Holes 982B and 907B.

Bachmannocena apiculata curvata (Bukry, 1976b) Bukry, 1987

Septamesocena apiculata (Schulz, 1928) Bachmann, 1970. Perch-Nielsen, 1975 (in part), p. 689, pl. 10, fig. 6.
Mesocena apiculata curvata (Schulz) Bukry, 1976b, p. 849, pl. 2, figs. 15, 16.
Bachmannocena apiculata curvata (Bukry) Bukry, 1987, p. 403.
Septamesocena apiculata f. *curvata* (Bukry) Locker and Martini, 1989, p. 570.

Occurrence: Restricted to the middle Miocene in Holes 982B and 907B.

Bachmannocena circulus apiculata (Lemmermann, 1901) nov. comb.
(Pl. 3, figs. 17–20)

Mesocena circulus var. *apiculata* Lemmermann, 1901, p. 257, pl. 10, figs. 9, 10.
Bachmannocena circulus var. *apiculata* (Lemmermann) Bukry, 1987, p. 404.
Paramesocena apiculata (Lemmermann) Locker and Martini, 1986, p. 909, pl. 9, figs. 1, 5; pl. 12, fig. 3.
Paramesocena circulus apiculata (Lemmermann) Locker and Martini, 1989, p. 570, pl. 4, fig. 4.

Remarks: This taxon was elevated to subspecies rank by Locker and Martini (1989) but placed within their genus *Paramesocena* Locker and Martini (1986). It is here transferred to the genus *Bachmannocena* (Locker), which is more widely used and accepted for silicoflagellate morphotypes that consist solely of a basal ring and lack an apical apparatus.

This taxon is characterized by having two sets of spines in different planes but is otherwise quite variable, as illustrated in Plate 3. The basal ring varies in size (small to large), thickness, and shape (circular to elliptical), while the spines themselves vary in number and shape (pointed to rounded). Future studies on high-resolution intervals such as those herein might elucidate the stratigraphic and ecological significance of these variations.

Occurrence: Common to abundant throughout its range in both Holes 907B and 982B.

Bachmannocena circulus circulus (Ehrenberg, 1841) nov. comb.
(Pl. 2, fig. 17)

Dictyocha (Mesocena) circulus Ehrenberg, 1841, p. 208.
Bachmannocena circulus (Ehrenberg) Locker, 1974, p. 636, pl. 2, fig. 11.
Paramesocena circulus (Ehrenberg) Locker and Martini, 1986, p. 909, pl. 9, figs. 2–4; pl. 12, figs. 4, 5.
Paramesocena circulus circulus (Ehrenberg) Locker and Martini, 1989, p. 570, pl. 3, fig. 6.

Remarks: This morphotype consists of a generally round basal ring, with many small spines extending within the plane of the basal ring. Locker and Martini (1989) elevated it to a subspecies rank, within their genus *Paramesocena* (Locker and Martini, 1986). It is herein retained at this rank but kept within the genus *Bachmannocena* (Locker) following the usage of most silicoflagellate specialists.

Occurrence: Rare in both Holes 907B and 982B.

Bachmannocena diodon borderlandensis (Bukry, 1981a) Bukry, 1987
(Pl. 3, fig. 13)

Mesocena diodon nodosa Bukry, 1978b (in part), p. 818, pl. 6, figs. 4, 5 (not figs. 1–3).
Mesocena diodon borderlandensis Bukry, 1981a, p. 547, pl. 4, figs. 5–9; pl. 5, figs. 1, 2.
Bachmannocena diodon borderlandensis (Bukry, 1981a) Bukry, 1987, p. 404.

Occurrence: Abundant in the *Bachmannocena diodon* Zone in Hole 982B.

Bachmannocena diodon diodon (Ehrenberg, 1844) Bukry, 1987
(Pl. 3, fig. 16)

Mesocena diodon Ehrenberg, 1844, pp. 71, 84.
Bachmannocena diodon (Ehrenberg) Bukry, 1987, p. 404.
Bachmannocena diodon diodon (Ehrenberg) Bukry, 1987. McCartney, Churchill, and Woestendiek, 1995, p. 143, pl. 4, fig. 8 (not fig. 2).

Remarks: It is important to distinguish between this subspecies and *B. d. nodosa* (Bukry), since its first occurrence predates the latter's first occurrence by a considerable amount of time (see Table 1). Its first occurrence marks an important bioevent recognizable in all latitudes. A few unspined specimens were observed in Sample 162-982B-55X-1, 99–100 cm (see Table 1).

Occurrence: Common throughout most of the Miocene section of Hole 982B, less common in that of Hole 907B.

Bachmannocena diodon nodosa (Bukry, 1978b) Bukry, 1987
(Pl. 3, fig. 14)

Mesocena diodon nodosa Bukry, 1978b, pp. 818–819, pl. 5, figs. 14, 15; pl. 6, figs. 1–3 (not figs. 4, 5).
Bachmannocena diodon nodosa (Bukry) Bukry, 1987, p. 404.
Bachmannocena diodon nodosa (Bukry) Bukry, 1987. McCartney, Churchill, and Woestendiek, 1995, p. 143, pl. 4, fig. 2; pl. 8, figs. 1, 2, 9 (not pl. 1, fig. 1).

Remarks: A very complete synonymy can be found in Bukry, 1978b. Its first occurrence marks an important bioevent during the latest middle Miocene, approximately coincident with the disappearance of the genera *Corbisema* Hanna and *Caryocha* Bukry and Monechi at high-latitude sites such as those studied herein (see Tables 1, 2).

Occurrence: Abundant throughout the Miocene as from its first occurrence in both Holes 907B and 982B.

Bachmannocena diodon triodon (Bukry, 1973) McCartney, Churchill and Woestendiek, 1995
(Pl. 2, fig. 18)

Mesocena triodon Bukry, 1973, p. 860, pl. 2, fig. 11.
Bachmannocena triodon (Bukry) Bukry, 1987, p. 405.
Bachmannocena diodon triodon (Bukry) McCartney, Churchill, and Woestendiek, 1995, p. 145.

Occurrence: This taxon is of extremely good stratigraphic value since its total range lies within the *Distephanus crux stradneri* Subzone (Amigo, this chapter) in both Holes 907B and 982B.

Bachmannocena dumitricae (Perch-Nielsen, 1975) Bukry, 1987

Paradictyocha dumitricae Perch-Nielsen, 1975, p. 689, pl. 11, figs. 1, 5–8.
Mesocena dumitricae (Perch-Nielsen) Bukry, 1986, p. 930, pl. 5, figs. 1, 2.
Bachmannocena dumitricae (Perch-Nielsen) Bukry, 1987, p. 404.

Occurrence: Few specimens, restricted to the *Distephanus crux stradneri* Subzone of Hole 907B.

Bachmannocena elliptica elliptica (Ehrenberg, 1841) Bukry, 1987
(Pl. 1, figs. 18–21)

Dictyocha (Mesocena) elliptica Ehrenberg, 1841, p. 208.
Mesocena elliptica (Ehrenberg) Ehrenberg, 1845, pp. 71, 84.
Mesocena elliptica (Ehrenberg) Bukry, 1978b, p. 819, pl. 6, figs. 6–13.
Bachmannocena elliptica (Ehrenberg) Bukry, 1987 (in part), p. 404.

Remarks: Bukry (1978c) argued against the necessity to subdivide elliptical to rhomboid bachmannocenid morphotypes with four spines according to size, as proposed by Bachmann and Papp, 1967. However, the stratigraphic range of small morphotypes is different from that of large morphotypes (see Table 1), and Bachmann and Papp's (1967) criterion is followed here. In this way, large morphotypes, which resemble in shape and size *B. d. diodon* (Ehrenberg) except for the presence of four spines instead of two, are placed within this taxon, while small morphotypes are placed within *B. e. miniformis* (Bachmann and Papp; see below).

Occurrence: Common in middle Miocene samples from Hole 982B.

Bachmannocena elliptica miniformis (Bachmann and Papp, 1967) Bukry, 1987
(Pl. 1, fig. 17)

Mesocena elliptica miniformis Bachmann and Papp, 1967, p. 121, pl. 3, fig. 9.
Bachmannocena elliptica (Ehrenberg) Bukry, 1987 (in part), p. 404.

Remarks: See discussion under *B. e. elliptica* (Ehrenberg) above.

Occurrence: Restricted to the uppermost upper *Corbisema triacantha* Zone in both Holes 907B and 982B.

Bachmannocena hexalitha (Bukry, 1981a) Bukry, 1987
(Pl. 2, fig. 16)

Mesocena hexalitha Bukry, 1981a, p. 547, pl. 5, figs. 5–10.
Bachmannocena hexalitha (Bukry) Bukry, 1987, p. 404.

Remarks: Locker and Martini (1986) erected a new forma (*M. hexalitha* f. *heptalitha*) for morphotypes with seven (instead of the regular six) spines. Their new form seems unnecessary since only one specimen with that morphology was found. Such specimens are herein considered aberrant, following Bukry's (1981a) description (p. 548), and not separated from the six-spined taxon.

Occurrence: Only two specimens were found, both in the early late Miocene of Hole 907B.

Bachmannocena quadrangula (Ehrenberg ex Haeckel, 1887) Bukry, 1987
(Pl. 3, fig. 1)

Mesocena quadrangula Ehrenberg, 1873, pp. 145, 273 (nomen nudum).
Mesocena quadrangula Ehrenberg ex Haeckel, 1887, p. 1556.
Mesocena quadrangula Ehrenberg ex Haeckel, 1887. Locker and Martini, 1986, p. 908, pl. 8, figs. 1, 2; pl. 12, figs. 6, 7.
Bachmannocena quadrangula (Ehrenberg ex Haeckel) Bukry, 1987, p. 405.

Occurrence: Rare, restricted to uppermost upper Miocene samples in both Holes 907B and 982B.

Bachmannocena triangula (Ehrenberg, 1840) Locker, 1974
(Pl. 2, fig. 12)

Dictyocha triangula Ehrenberg, 1840, p. 129.
Mesocena triangula (Ehrenberg) Ehrenberg, 1845, pp. 65, 71.
Bachmannocena triangula (Ehrenberg) Locker, 1974, p. 636, pl. 2, fig. 10.

Occurrence: Rare, scattered throughout upper middle and upper Miocene samples in both Holes 907B and 982B.

Bachmannocena sp. cf. *B. diodon borderlandensis*
(Pl. 3, fig. 15)

Remarks: This morphotype is similar to *B. d. borderlandensis* (Bukry) but is about half its size and has therefore been tabulated separately (see Table 1). In addition, its range is quite older than that of *B. d. borderlandensis* (Bukry).

Occurrence: Restricted to Samples 40X-3, 99–100 cm, and 41X-1, 99–100 cm, in Hole 982B (middle part of the *Distephanus crux stradneri* Subzone).

Genus *CARYOCHA* Bukry and Monechi, 1985

Caryocha depressa (Ehrenberg, 1854) Bukry and Monechi, 1985

Halicalyptra depressa Ehrenberg, 1854, pl. 18, fig. 111.
Cannopilus depressus (Ehrenberg) Locker, 1974, p. 639, pl. 4, fig. 3. Locker and Martini, 1989, p. 566, pl. 1, figs. 1, 2.
Caryocha depressa (Ehrenberg) Bukry and Monechi, 1985, p. 378. Ciesielski et al., 1989, p. 512, pl. 6, figs. 2, 3, 5, 6.

Remarks: Locker and Martini (1989) include morphotypes traditionally assigned to *Caryocha ernestinae* (or, according to them, *Cannopilus ernestinae*) within this species. However, they illustrate *C. ernestinae* separately (in their pl. 1, fig. 6) but do not include this illustration within their listing of figures for *C. depressus*.

Occurrence: Common throughout the upper *C. triacantha* Zone and *Caryocha* spp. Subzone in Hole 982B, less common in the same interval for Hole 907B, but present (though rare) in younger sediments in the latter.

Caryocha ernestinae (Bachmann, 1962) Bukry and Monechi, 1985

Cannopilus ernestinae Bachmann, 1962, p. 255, fig. 1.
Caryocha ernestinae (Bachmann) Bukry and Monechi, 1985, p. 378. Ciesielski et al., 1989, p. 512, pl. 6, figs. 7, 8.

Occurrence: Common throughout the *Caryocha* spp. Subzone in Hole 907B but rare in Hole 982B (only two specimens were found, in Sample 162-982B-47X-4, 99–100 cm).

Caryocha jouseae (Bachmann in Ichikawa et al., 1964) Bukry and Monechi, 1985

Cannopilus jouseae Bachmann in Ichikawa et al., 1964, p. 110, pl. 6, figs. 54–58.
Caryocha jouseae (Bachmann) Bukry and Monechi, 1985, p. 378.

Occurrence: Only two specimens were found, both within the *Caryocha* spp. Subzone of Hole 907B.

Caryocha picassoi (Stradner, 1961) Bukry and Monechi, 1985

Cannopilus picassoi Stradner, 1961, p. 92, pl. 3, figs. 101–104.
Caryocha picassoi (Stradner) Bukry and Monechi, 1985, p. 378.

Occurrence: Rare, found mostly within the *Caryocha* spp. Subzone of Hole 982B.

Genus *CORBISEMA* Hanna, 1931

Corbisema hastata hastata (Lemmermann, 1901) Amigo, 1995

Dictyocha triacantha var. *hastata* Lemmermann, 1901, p. 259, pl. 10, figs. 16, 17.
Corbisema hastata hastata (Lemmermann) Bukry, 1976a, p. 892, pl. 4, figs. 9–12 (not figs. 13–16).
Corbisema hastata hastata (Lemmermann) Amigo, 1995, p. 184, pl. 4-3, fig. 14.

Remarks: Many subspecies have been erected since Bukry's (1976b) transfer of the species, in such a way that all the morphotypes he included are no longer within it. In his study of Paleogene sections, Amigo (1995) revised this taxon to restrict it to the morphotypes that do not belong in any of those subspecies (*Corbisema hastata alta* Ciesielski, *C. h. cunicula* Bukry, *C. h. georgia* Amigo, *C. h. globulata* Bukry, and *C. h. miranda* Bukry).

Occurrence: Rare, scattered throughout the Miocene of Hole 907B as reworked specimens.

Corbisema inermis inermis (Lemmermann, 1901) Amigo, 1995

Dictyocha triacantha var. *inermis* Lemmermann, 1901, p. 259, pl. 10, fig. 21.

Corbisema inermis inermis (Lemmermann) Bukry, 1976a (in part), p. 892, pl. 5, figs. 1–3.
Corbisema inermis inermis (Lemmermann) Amigo, 1995, p. 189, pl. 4-1, fig. 28.

Remarks: Amigo (1995) gives a thorough discussion on the revision of this taxon and includes only unspined, piked trilobate basal-ringed morphotypes, with rounded portals and only slightly indented junctures.
Occurrence: One (reworked) specimen was found in Sample 162-907B-17H-5, 109–110 cm.

Corbisema triacantha (Ehrenberg, 1844) Hanna, 1931
(Pl. 1, fig. 22)

Dictyocha triacantha Ehrenberg, 1844, p. 80.
Corbisema triacantha (Ehrenberg) Hanna, 1931, p. 198, pl. D, fig. 1.

Occurrence: Rare but present (though scattered) until the top of the *Caryocha* spp. Subzone in Hole 982B. In Hole 907B, the distribution is similar but the taxon is even rarer, although some specimens were recorded in samples younger than the top of the above-mentioned subzone.

Genus *DICTYOCHA* Ehrenberg, 1837

Dictyocha arcuata Curto, 1990
(Pl. 1, fig. 16)

Dictyocha arcuata Curto, 1990, pp. 65–66, pl. 1, figs. 5–7.

Remarks: This taxon was described for the first time by Curto (1990) from the Betic ranges of southern Spain, where it ranges from the late early Miocene to the early middle Miocene. As pointed out by Curto (1990), his new taxon has affinities to *Dictyocha rhombica* (Schulz). For this reason, this taxon may have been included within the latter in previous studies of high-latitude sections of the Atlantic Ocean and the Norwegian-Greenland Sea.
Occurrence: Restricted to the upper and lower *C. triacantha* Zones in Hole 982B.

Dictyocha brevispina ausonia (Deflandre, 1950) Bukry, 1978a
(Pl. 3, fig. 6)

Dictyocha ausonia Deflandre, 1950, p. 195, figs. 194–196, 199–202.
Dictyocha brevispina ausonia (Deflandre) Bukry, 1978a, p. 697, pl. 1, figs. 17–19.

Occurrence: Common in upper Miocene samples from Hole 982B.

Dictyocha fibula Ehrenberg, 1840
(Pl. 1, figs. 8–10)

Dictyocha fibula Ehrenberg, 1840, p. 129.

Remarks: This taxon was observed in three-sided and five-sided varieties during peak abundances of the regular, four-sided variety (see Pl. 1, figs. 9, 10; Table 2, lower *Bachmannocena circulus apiculata* Zone).
Occurrence: Abundant in the middle part of the *Caryocha* spp. Subzone in Hole 907B, scattered throughout the rest of the zone. Present in the upper *C. triacantha* Zone of both Holes 907B and 982B.

Dictyocha messanensis stapedia f. *stapedia* (Haeckel, 1887) Locker and Martini, 1986

Dictyocha stapedia Haeckel, 1887 (in part), p. 1561, pl. 101, figs. 10–12.
Dictyocha messanensis stapedia f. stapedia (Haeckel) Locker and Martini, 1986, p. 905, pl. 3, figs. 6, 7.

Occurrence: Rare, only in the upper upper Miocene samples from Hole 982B.

Dictyocha subclinata Bukry, 1981a
(Pl. 2, figs. 8, 9)

Dictyocha subclinata Bukry, 1981a, pp. 546–547, pl. 1, figs. 4–8; pl. 2, figs. 1–10.
Dictyocha subclinata Bukry. Locker and Martini, 1986, p. 905, pl. 2, fig. 9.

Occurrence: Scattered throughout the Miocene of both Holes 907B and 982B.

Dictyocha varia Locker, 1975

Dictyocha varia Locker, 1975 (in part), pp. 99–100, text-figs. 1/1, 3/1; not 1/2, 1/3, 3/2, 3/3.
Dictyocha pulchella Bukry, 1975a, p. 687, pl. 4, figs. 1–3.

Occurrence: Scattered throughout the Miocene of both Holes 907B and 982B.

Dictyocha sp. cf. *D. rhombica* (Schulz, 1928) Deflandre, 1941
(Pl. 1, fig. 11)

Remarks: This morphotype is similar in all aspects to *Dictyocha rhombica (*Schulz) but differs in having longer spines, particularly those aligned with the major axis of the basal ring.
Occurrence: This morphotype was found to be markedly abundant in Sample 162-907B-21H-6, 109–110 cm, where it made up more than 90% of the assemblage (see Table 2) but was absent in all other samples from the same hole. This horizon was not found at Hole 982B, where only a few specimens were observed (see Table 1).

Dictyocha sp. 1
(Pl. 1, fig. 2)

Remarks: This morphotype is similar in most aspects to the medusoid *Dictyocha medusa* Haeckel, but the presence of an apical bar (though small) precludes assignment to this taxon.
Occurrence: Found almost exclusively in the *Caryocha* spp. Subzone of Hole 982B.

Dictyocha sp. 2
(Pl. 2, fig. 13)

Remarks: This morphotype is characterized by a circular basal ring with relatively long and equant spines and a short apical bar. In addition, all elements are conspicuously thin.
Occurrence: Restricted to the *Distephanus crux stradneri* Subzone of Hole 907B.

Dictyocha sp. 3
(Pl. 2, figs. 14, 15)

Remarks: This morphotype is characterized by a highly elevated apical apparatus with curved elements.
Occurrence: Restricted to the *Distephanus crux stradneri* Subzone of Hole 907B.

Dictyocha sp. 4
(Pl. 1, figs. 6, 7)

?*Dictyocha* sp. 3 Perch-Nielsen, 1975, p. 687, pl. 4, fig. 16.

Remarks: This morphotype is characterized by a slightly medusoid apical apparatus consisting of thin and flattened elements. A similar morphotype was found in lower Miocene sediments from Deep Sea Drilling Project Site 278 by Perch-Nielsen (1975).
Occurrence: Restricted to the lower part of the *Caryocha* spp. Subzone of Hole 907B.

Genus *DISTEPHANUS* Stöhr, 1880

Distephanus boliviensis binoculus (Frenguelli, 1940) Amigo and Ciesielski, in press

Dictyocha boliviensis Frenguelli, 1940 (in part), p. 44.
Dictyocha boliviensis f. *binoculus* Frenguelli, 1951, p. 276.
Distephanus boliviensis var. *binoculus* (Frenguelli) Ciesielski, 1975, p. 660, pl. 8, figs. 6, 7.
Distephanus aculeatus f. *binoculus* (Ehrenberg, 1841) Locker and Martini, 1986, p. 905 (in part), pl. 6, figs. 11, 12.
Distephanus boliviensis binoculus (Frenguelli) Amigo and Ciesielski, in press, pl. 4, fig. 10.

Remarks: Locker and Martini, 1986 (table 5), place all morphotypes with a subdivided apical window in their forma *D. acul*eatus f. *binoculus*. The synonymy given here includes only those in which the apical window is subdivided into two. Morphotypes with more than two subdivisions are included in *D. boliviensis major* (Frenguelli) Bukry, 1975a.

Distephanus boliviensis boliviensis (Frenguelli, 1940) Bukry, 1975a

Dictyocha boliviensis Frenguelli, 1940 (in part), p. 44, fig. 4a.
Distephanus boliviensis (Frenguelli) Bukry and Foster, 1973, p. 827, pl. 4, figs. 1–3.
Distephanus boliviensis boliviensis (Frenguelli) Bukry, 1975a, p. 688. Bukry, 1979, p. 985, pl. 4, fig. 12; pl. 5, fig. 1.
Distephanus aculeatus (Ehrenberg, 1841) f. *aculeatus* Locker and Martini, 1986, p. 905, pl. 6, fig. 5.

Remarks: This subspecies is restricted to morphotypes with an undivided apical window. Ciesielski et al. (1989, p. 512) did not formally use a subspecies rank to accommodate the variation in the morphology of the apical window, choosing to separate the varieties as "cannopilean" (multiwindowed, including two, three, or four or more windows), "cannopilean-irregular," and "hemisphaericoid." Locker and Martini (1989) restrict those with an undivided apical window in *D. aculeatus* f. *aculeatus*, placing all morphotypes with a subdivided apical window in *D. a.* f. *binoculus* (Ehrenberg) Locker and Martini, 1986.

Distephanus boliviensis major (Frenguelli, 1940) Bukry, 1975a

Dictyocha boliviensis Frenguelli, 1940 (in part), p. 44, fig. 4b–d.
Dictyocha boliviensis f. *major* Frenguelli, 1951, p. 277, fig. 3a–c.
Distephanus boliviensis major (Frenguelli) Bukry, 1975a, p. 688.
Distephanus aculeatus (Ehrenberg, 1841) f. *binoculus* Locker and Martini, 1986, p. 905 (in part), not pl. 6, figs. 11, 12.

Remarks: All varieties of this species that have its apical window subdivided into more than two are placed in this subspecies (see discussion above under *D. b. binoculus* (Frenguelli)).

Distephanus crux crux (Ehrenberg, 1840) Haeckel, 1887
(Pl. 1, fig. 1)

Dictyocha crux Ehrenberg, 1840, p. 207.
Distephanus crux (Ehrenberg) Haeckel, 1887, p. 1563.

Remarks: *Distephanus crux* (Ehrenberg) counts with many subspecies of widely accepted usage, which have specific morphologies and stratigraphic ranges. Only small and square morphotypes with small and equant spines are included within the subspecies with the species' epithet herein. A few specimens with a rounded rather than square basal ring were found in samples from Hole 982B (see pl. 1, fig. 1), where they have been tabulated separately.

Distephanus crux hannai Bukry, 1975b

Distephanus crux hannai Bukry, 1975b, p. 855, pl. 4, figs. 4–6.

Occurrence: Rare, only in upper Miocene samples from Hole 982B.

Distephanus crux lockerii n. ssp.
(Pl. 1, figs. 12–15)

Diagnosis: Large quadrate basal ring with moderate and equant spines and a square apical window supported by four rods that leave the basal ring at the midpoint between vertices. Three- and five-sided varieties are included within this new taxon.

Etymology: This new taxon is named in honor of Dr. Sigurd Locker of the Geologisch-Palaontologisches Institut der Universität in Kiel, Germany.

Remarks: This new subspecies resembles *Distephanus crux crux* (Ehrenberg) in most ways, except for its size, which is considerably larger (see measurements below) and curiously similar to *Dictyocha fibula* Ehrenberg, with which it also shares basal ring shape (see Pl. 1, figs. 8, 13). Basal ring shape and size of its three- and five-sided varieties (Pl. 1, figs. 12, 14, 15) are also almost identical to the three- and five-sided varieties of *D. fibula* Ehrenberg (Pl. 1, figs. 9, 10). Because of their shared stratigraphic ranges, this new subspecies could be more related to *D. fibula* Ehrenberg than it is to *D. crux crux* (Ehrenberg).

Measurements: basal ring diameter 55(60)65 µm, spine length 16(20)24 µm; holotype: basal ring diameter 62 µm, spine length 21 µm.

Holotype: Florida Museum of Natural History #UF84989 (Pl. 1, fig. 13).

Type locality: Iceland Plateau, Hole 907B.

Occurrence: Restricted to the middle Miocene in both Holes 907B and 982B; more common in the former.

Distephanus crux longispinus (Schulz, 1928) Locker and Martini, 1989
(Pl. 2, figs. 1, 6, 7)

Distephanus crux f. *longispinus* Schulz, 1928, p. 256, fig. 44.
Distephanus longispinus (Schulz) Bukry and Foster, 1973, p. 828, pl. 4, figs. 7 and 8.
Distephanus crux longispinus (Schulz) Locker and Martini, 1989, p. 567.

Remarks: A variety with equant spines was encountered in Hole 907B and tabulated separately (see Table 2).

Occurrence: Middle to early late Miocene in both Holes 907B and 982B.

Distephanus crux parvus (Bachmann in Ichikawa et al., 1967) Bukry, 1982
(Pl. 2, fig. 2)

Dictyocha crux f. *parva* Ichikawa et al., 1967, pp. 156–157, pl. 4, figs. 14–31.
Distephanus crux parvus (Bachmann) Bukry, 1982, p. 433, pl. 4, fig. 7.

Occurrence: Middle to early late Miocene in both Holes 907B and 982B.

Distephanus crux scutulatus Bukry, 1982
(Pl. 2, fig. 3)

Distephanus crux scutulatus Bukry, 1982, p. 433, pl. 4, figs. 8–12; pl. 5, figs. 1–2; pl. 9, fig. 8. Ciesielski et al., 1989, p. 513, pl. 7, figs. 5 and 10.

Occurrence: Middle to early late Miocene in both Holes 907B and 982B.

Distephanus crux stradneri (Jerkovic, 1965) Locker and Martini, 1989
(Pl. 2, figs. 4, 5)

Dictyocha schauinslandii stradneri Jerkovic, 1965, p. 3, pl. 2, fig. 2.
Distephanus schauinslandii stradneri (Jerkovic) Bukry, 1975b, p. 866, pl. 4, fig. 7.
Distephanus stradneri (Jerkovic) Bukry, 1978a, p. 698.
Distephanus crux stradneri (Jerkovic) Locker and Martini, 1989, p. 567, pl. 2, fig. 6.

Occurrence: Middle to early late Miocene in both Holes 907B and 982B.

Distephanus polyactis (Ehrenberg, 1840) Deflandre, 1932

Dictyocha polyactis Ehrenberg, 1840, p. 129.
Distephanus polyactis (Ehrenberg) Deflandre, 1932, pp. 497, 501.

Occurrence: Rare, restricted to the middle part of the *Distephanus crux stradneri* Subzone in Hole 982B.

Distephanus quinarius Locker and Martini, 1989
(Pl. 2, figs. 10, 11, 19–22)

Distephanus quinarius Locker and Martini, 1989, p. 568, pl. 4, figs. 1 and 2.

Remarks: The importance of distinguishing between this taxon and *Distephanus speculum pentagonus* is evidenced in its stratigraphic distribution (see Tables 1, 2).

Occurrence: In the uppermost *Distephanus crux stradneri* Subzone of Hole 907B this taxon dominates the assemblage, constituting a true horizon (see Table 2). This horizon was not detected in Hole 982B, but low preservation for that interval might be responsible for this. However, an older lesser acme for this taxon was found in this hole, in the upper *C. triacantha* Zone (see Table 1), which is unfortunately a barren interval in Hole 907B.

Distephanus schulzii (Deflandre in Bachmann and Ichikawa, 1962)
Ciesielski et al., 1989

Cannopilus schulzi Deflandre in Bachmann and Ichikawa, 1962, p. 171
(= C*annopilus cyrtoides* Schulz, 1928, fig. 65).

Distephanus schulzii (Deflandre) Ciesielski et al., 1989, p. 513, pl. 6, fig. 4.

Distephanus speculum binoculus (Ehrenberg, 1844) Bukry, 1975b

Dictyocha binoculus Ehrenberg, 1844, pp. 63, 79.
Distephanus speculum binoculus (Ehrenberg) Bukry, 1975b, p. 855.

Distephanus speculum hemisphaericus (Ehrenberg, 1844) Bukry, 1975b

Dictyocha hemisphaerica Ehrenberg, 1844, pl. 17, fig. 5.
Cannopilus hemisphaericus (Ehrenberg) Lemmermann, 1901, p. 268, pl. 11, fig. 21.
Distephanus speculum hemisphaericus (Ehrenberg) Bukry, 1975b, p. 855, pl. 4, fig. 8.

Occurrence: Most common in the upper and lower *C. triacantha* Zones of Hole 982B.

Distephanus speculum minutus (Bachmann in Ichikawa et al., 1967) Bukry,1976a
(Pl. 3, figs. 7–12)

Dictyocha speculum f. *minuta* Bachmann in Ichikawa et al., 1967, p. 161, pl. 7, figs. 12–15.
Distephanus speculum minutus (Bachmann) Bukry, 1976c, p. 895, pl. 8, figs. 1–3.

Remarks: A variety of this subspecies with equant spines (Pl. 3, figs. 9, 10) was tabulated separately, since its first occurrence is much younger than the regular variety (see Tables 1, 2). This equant-spined variety was observed to occasionally have five (Pl. 3, fig. 11) or seven sides (Pl. 3, fig. 12) instead of the usual six.
Occurrence: This taxon is common in the *B. diodon nodosa* Subzone and younger intervals of both Holes 907B and 982B, but its range extends to slightly below the bottom of the *Distephanus crux stradneri* Subzone in Hole 907B (see Table 2).

Distephanus speculum pentagonus (Lemmermann, 1901) Bukry, 1976a

Distephanus speculum var. *pentagonus* Lemmermann, 1901, p. 264, pl. XI, fig. 19.
Distephanus speculum pentagonus (Lemmermann) Bukry, 1976a, pp. 895–896.

Distephanus speculum speculum (Ehrenberg, 1840) Haeckel, 1887
(Pl. 3, figs. 2–4)

Dictyocha speculum Ehrenberg, 1840, p. 129, pl. 4, fig. X n.
Distephanus speculum (Ehrenberg) Haeckel, 1887, p. 1565.

Remarks: Some upper Miocene samples from Hole 907B contained a variety of this subspecies with a thickened apical apparatus, causing a reduction in the size of the apical window. These morphotypes were tabulated separately.
Occurrence: This taxon is abundant throughout the Miocene of both Holes 907B and 982B.

Distephanus speculum speculum f. *notabilis* (Locker and Martini, 1987) McCartney and Wise, 1990

Distephanus speculum notabilis f. *notabilis* Locker and Martini, 1987, pp. 46–48, pl. 5, figs. 40, 41.
Distephanus speculum speculum f. *notabilis* (Locker and Martini) McCartney and Wise, 1990, p. 750, pl. 5, figs. 5, 10–12, and 13 (lower); pl. 6, figs. 5, 7.

Occurrence: Rare, scattered throughout the late Miocene of Hole 907B.

Distephanus speculum speculum f. *pseudofibula* (Schulz, 1928) Locker and Martini, 1986

Distephanus speculum f. *pseudofibula* Schulz, 1928, p. 262, figs. 51a, 51b.
Distephanus speculum speculum f. *pseudofibula* (Schulz) Locker and Martini, 1986, p. 907, pl. 7, fig. 11.

Occurrence: Only two specimens of this conspicuous taxon were found in upper Miocene samples from Hole 907B.

Distephanus speculum speculum f. *septenarius* (Ehrenberg, 1845) Locker and Martini, 1986

Dictyocha septenaria Ehrenberg, 1845, p. 80.
Distephanus speculum speculum f. *septenarius* (Ehrenberg) Locker and Martini, 1986, p. 907, pl. 7, fig. 5.

Distephanus speculum triommata (Ehrenberg, 1845) Bukry, 1976a

Dictyocha triommata Ehrenberg, 1845, pp. 56, 76.
Distephanus speculum triommata (Ehrenberg) Bukry, 1976a, p. 896.

Distephanus stauracanthus (Ehrenberg, 1845) Haeckel, 1887
(Pl. 1, figs. 3–5)

Dictyocha stauracanthus Ehrenberg, 1845, p. 76.
Distephanus stauracanthus (Ehrenberg) Haeckel, 1887, p. 1564.

Remarks: Two varieties are recognized within this species: those with an apical ring (like f. *stauracanthus* [see Pl. 1, figs. 4, 5]) and those with an apical bar (like f. *octagonus* [see Pl. 1, fig. 3]).
Occurrence: Rare, restricted to the *Caryocha* spp. Subzone of Hole 982B.

Distephanus xenus Bukry, 1985
(Pl. 3, fig. 5)

Distephanus xenus Bukry, 1985, p. 557, pl. 1, figs. 11, 12; pl. 2, figs. 1–8.

Occurrence: Rare, only in upper Miocene samples from Hole 982B.

Distephanus sp. aff. *D. slavincii* (Jerkovic, 1965) Bukry, 1973

Dictyocha slavinci slavinci Jerkovic, 1965, p. 124, pl. 1, figs. 18, 19; pl. 2, figs. 7, 10.
Distephanus slavincii (Jerkovic) Bukry, 1973, p. 859, pl. 2, figs. 1, 2.

Remarks: This morphotype differs from *D. slavincii* (Jerkovic) in having longer spines.
Occurrence: Relatively common only in the middle Miocene of Hole 982B.

Genus *LYRAMULA* Hanna, 1928

Lyramula furcula Hanna, 1928

Lyramula furcula Hanna, 1928, p. 262, pl. 41, figs. 4, 5.

Remarks: Present only as reworked specimens.
Occurrence: Rare, scattered throughout Miocene samples from Hole 907B.

Genus *NAVICULOPSIS* Frenguelli, 1940

Naviculopsis constricta (Schulz, 1928) Bukry in Barron, Bukry, and Poore, 1984

Dictyocha navicula var. *biapiculata* f. *constricta* Schulz, 1928, p. 246, fig. 21.
Naviculopsis constricta (Schulz) Bukry in Barron, Bukry, and Poore, 1984, p. 151, pl. 5, fig. 6.

Remarks: Present only as reworked specimens.
Occurrence: Rare, scattered throughout Miocene samples from Hole 907B.

Naviculopsis eobioapiculata Bukry, 1978c

Naviculopsis eobioapiculata Bukry, 1978c, p. 787, pl. 4, figs. 9–16.

Remarks: Present only as reworked specimens.
Occurrence: Rare, restricted to the middle Miocene of Hole 982B.

Naviculopsis lata (Deflandre, 1932) Frenguelli, 1940

Dictyocha biapiculata lata Deflandre, 1932, p. 500, figs. 30, 31.
Naviculopsis lata (Deflandre) Frenguelli, 1940, p. 61, fig. 1h.

Remarks: Present only as a reworked specimen.
Occurrence: Only one specimen was found, in Sample 162-982B-51X-3, 99–100 cm.

Naviculopsis minor (Schulz, 1928) Bukry in Barron, Bukry, and Poore, 1984

Dictyocha navicula var. *minor* Schulz, 1928, p. 246, fig. 22.
Naviculopsis minor (Schulz) Bukry in Barron, Bukry, and Poore, 1984, p. 152.

Remarks: Present only as a reworked specimen.
Occurrence: Only one specimen was found, in Sample 162-907B-11H-5, 109–110 cm.

Naviculopsis transitoria Deflandre nov. comb.

Dictyocha transitoria Deflandre, 1932, p. 500, figs. 32, 33.

Remarks: Given its morphology, this species is herein transferred to the genus *Naviculopsis* Frenguelli. Present only as reworked specimens in this study. This is only the second mention of this taxon in the Norwegian-Greenland Sea basins, the first being from Cores 151-908A-27X through 34X (Fram Strait), as recorded by Locker, 1996.
Occurrence: Two reworked specimens were found within the *B. diodon nodosa* Subzone of Hole 907B.

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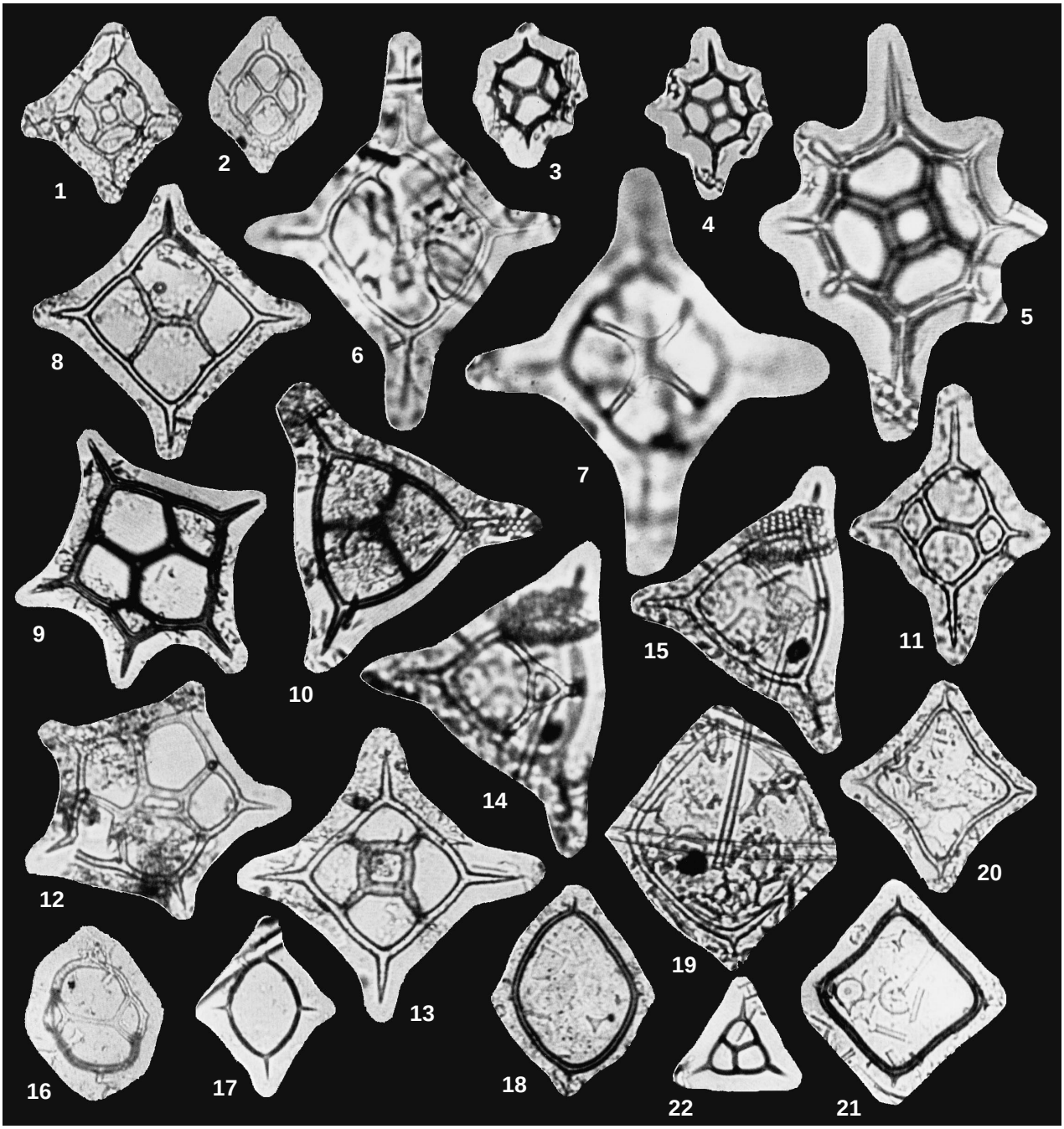

Plate 1. Middle Miocene silicoflagellates. All specimens magnified at 500×, unless otherwise stated. **1.** *Distephanus crux crux* (Ehrenberg), rounded variety, Sample 162-982B-47X-4, 99–100 cm. **2.** *Dictyocha* sp. 1, Sample 162-982B-43X-3, 99–100 cm. **3.** *Distephanus stauracanthus* (Ehrenberg) f. *octagonus*, Sample 162-982B-46X-3, 99–100 cm. **4, 5.** *Distephanus stauracanthus* (Ehrenberg) f. *stauracanthus*, Sample 162-982B-48X-5, 99–100 cm (5 magnified at 1250×). **6, 7.** *Dictyocha* sp. 4, Sample 162-907B-21H-4, 106–107 cm, same specimen at high and low focus, both magnified at 1250×. **8–10.** *Dictyocha fibula* Ehrenberg. (8) Sample 162-907B-21H-1, 106–107 cm; (9) Sample 162-907B-20H-1, 109–110 cm, five-sided variety; (10) Sample 162-907B-20H-1, 109–110 cm, three-sided variety. **11.** *Dictyocha* sp. cf. *D. rhombica*, Sample 162-907B-21H-6, 109–110 cm. **12–15.** *Distephanus crux lockerii* n. ssp.; (12) five-sided variety, Sample 162-907B-21H-4, 106–107 cm; (13) holotype, Sample 162-907B-20H-5, 109–110 cm; (14, 15) three-sided variety, Sample 162-907B-20H-5, 109–110 cm, same specimen at high and low focus. **16.** *Dictyocha arcuata* Curto, Sample 162-982B-53X-4, 99–100 cm. **17.** *Bachmannocena elliptica miniformis* Bachmann and Papp, Sample 162-982B-50X-3, 99–100 cm. **18–21.** *Bachmannocena elliptica elliptica* (Ehrenberg). (18) Sample 162-982B-51X-3, 99–100 cm; (19) Sample 162-982B-52X-2, 99–100 cm; (20) Sample 162-982B-55X-1, 99–100 cm; (21) Sample 162-982B-55X-4, 99–100 cm. **22.** *Corbisema triacantha* (Ehrenberg), Sample 162-982B-55X-1, 99–100 cm.

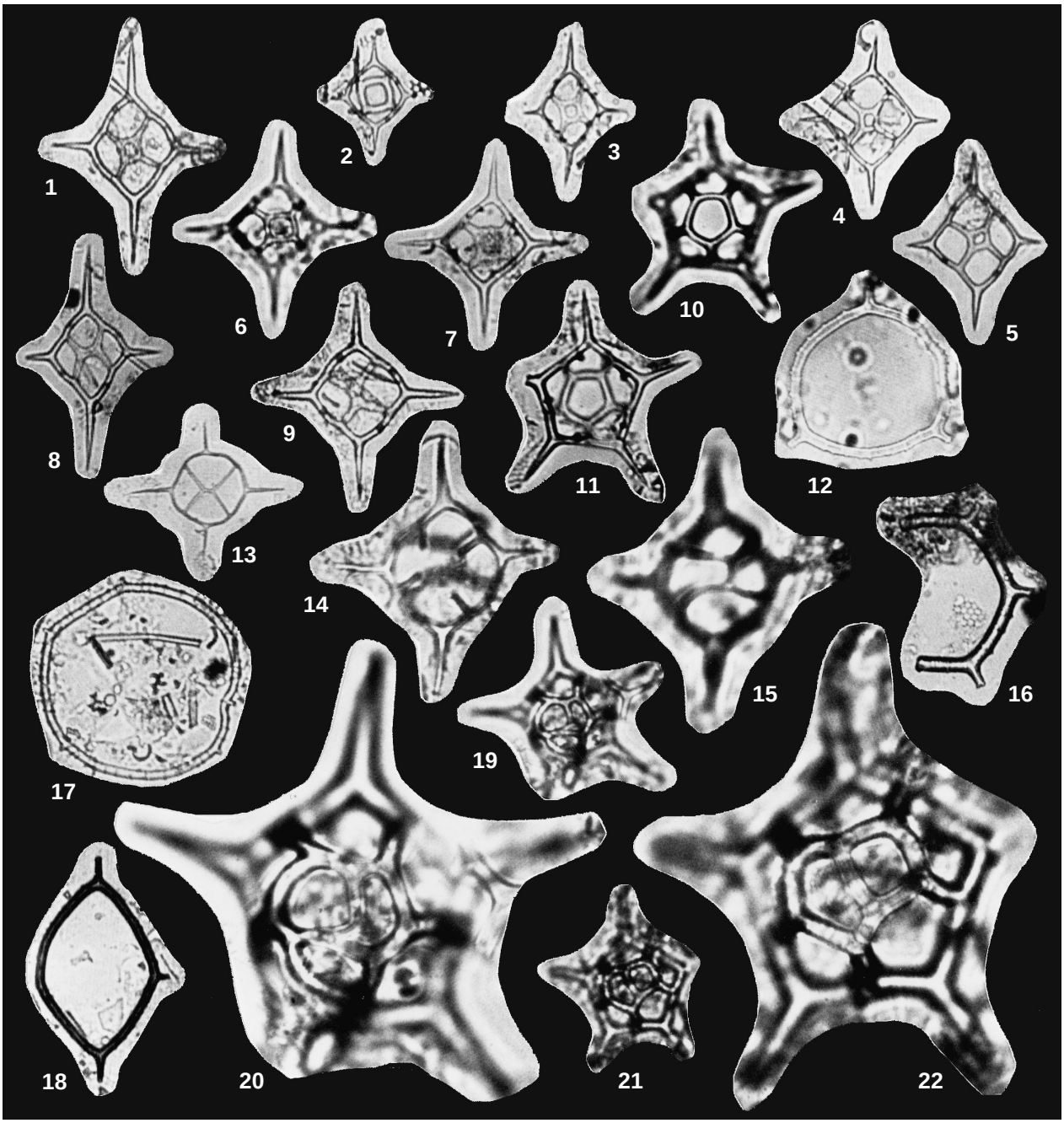

Plate 2. Middle and upper Miocene silicoflagellates. All specimens magnified 500× unless otherwise stated. **1, 6, 7.** *Distephanus crux longispinus* (Schulz). (1) Sample 162-907B-14H-5, 109–110 cm; (6, 7) variety with equant spines, Sample 162-907B-14H-6, 109–110 cm, same specimen at high and low focus. **2.** *Distephanus crux parvus* (Bachmann), Sample 162-982B-48X-5, 99–100 cm. **3.** *Distephanus crux scutulatus* Bukry, Sample 162-982B-39X-3, 99–100 cm. **4, 5.** *Distephanus crux stradneri* (Jerkovic). (4) Sample 162-982B-55X-4, 99–100 cm; (5) Sample 162-907B-14H-1, 109–110 cm. **8, 9.** *Dictyocha subclinata* Bukry. (8) Sample 162-907B-14H-5, 109–110 cm; (9) Sample 162-907B-18H-5, 109–110 cm. **10, 11, 19–22.** *Distephanus quinarius* Locker and Martini. (10, 11) Sample 162-907B-14H-3, 109–110 cm, same specimen at high and low focus; (19, 20) variety with three apical windows, Sample 162-907B-14H-6, 109–110 cm, same specimen (20 magnified at 1250×); (21, 22) variety with two apical windows, Sample 162-907B-14H-5, 109–110 cm, same specimen (22 magnified at 1250×). **12.** *Bachmannocena triangula* (Ehrenberg), Sample 162-982B-25H-1, 99–100 cm. **13.** *Dictyocha* sp. 2, Sample 162-907B-15H-4, 109–110 cm. **14, 15.** *Dictyocha* sp. 3, Sample 162-907B-15H-3, 109–110 cm, same specimen at high and low focus, both magnified at 1250×. **16.** *Bachmannocena hexalitha* (Bukry), Sample 162-907B-14H-2, 109–110 cm. **17.** *Bachmannocena circulus circulus* (Ehrenberg), variety with six irregularly placed spines, Sample 162-907B-17H-1, 109–110 cm. **18.** *Bachmannocena diodon triodon* (Bukry), Sample 162-982B-39X-3, 99–100 cm.

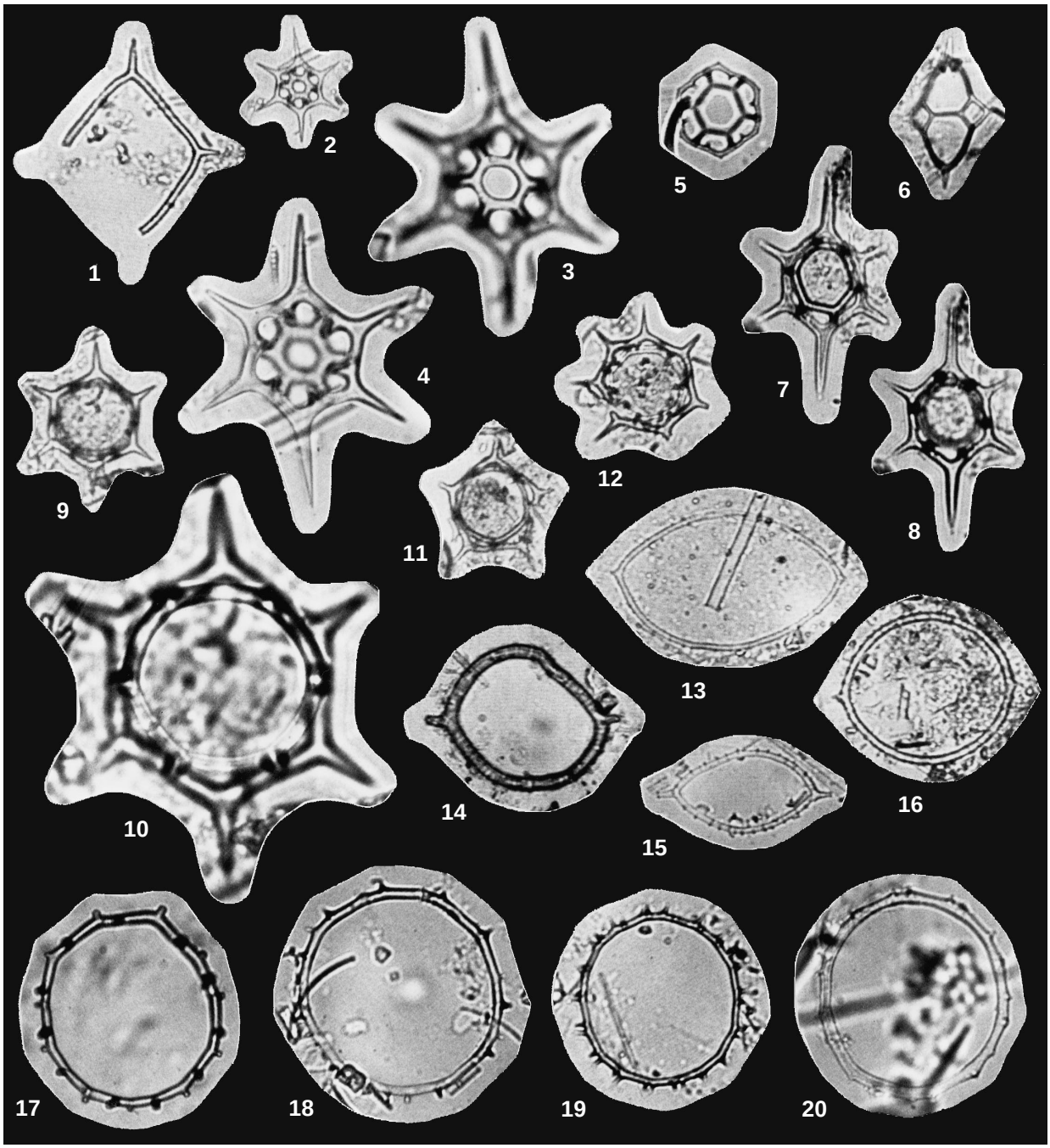

Plate 3. Upper Miocene silicoflagellates. All specimens magnified 500× unless otherwise stated. **1.** *Bachmannocena quadrangula* (Ehrenberg ex Haeckel), Sample 162-907B-11H-4, 109–110 cm. **2–4.** *Distephanus speculum speculum* (Ehrenberg), same specimen from Sample 162-907B-12H-2, 109–110 cm (3, 4 are shown at high and low focus, respectively, both magnified at 1250×). **5.** *Distephanus xenus* Bukry, Sample 162-982B-41X-1, 99–100 cm. **6.** *Dictyocha brevispina ausonia* (Lemmermann), Sample 162-982B-24X-5, 99–100 cm. **7–12.** *Distephanus speculum minutus* (Bachmann). (7, 8) Sample 162-907B-15H-1, 109–110 cm, same specimen at high and low focus; (9, 10) variety with equant spines, Sample 162-907B-10H-5, 117–118 cm, same specimen (10 magnified at 1250×); (11) five-sided variety, Sample 162-907B-10H-5, 117–118 cm; (12) seven-sided variety, Sample 162-907B-10H-5, 117–118 cm. **13.** *Bachmannocena diodon borderlandensis* Bukry, Sample 162-982B-21H-6, 99–100 cm. **14.** *Bachmannocena diodon nodosa* (Bukry), Sample 162-907B-17H-2, 109–110 cm. **15.** *Bachmannocena* sp. cf. *B. diodon borderlandensis*, Sample 162-982B-41X-1, 99–100 cm. **16.** *Bachmannocena diodon diodon* (Ehrenberg), Sample 162-907B-17H-1, 109–110 cm. **17–20.** *Bachmannocena circulus apiculata* (Lemmermann). (17) Sample 162-907B-15H-3, 109–110 cm; (18, 20) Sample 162-982B-44X-3, 99–100 cm; (19) Sample 162-982B-39X-3, 99–100 cm.