

7. ALBIAN-CENOMANIAN DINOFLAGELLATE CYSTS FROM SITES 627 AND 635, LEG 101, BAHAMAS¹

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ABSTRACT

The Albian-Cenomanian sediments in Holes 627B and 635B contain diverse dinoflagellate-cyst assemblages, which show affinities with coeval assemblages from offshore Morocco and northwest Europe. A total of 34 samples were analyzed from the shallow-water platform sediments and neritic marly chalk of Hole 627B and from the argillaceous chalk and limestone of Hole 635B. Dinoflagellate cysts indicate that the top of the shallow-water platform drilled at Hole 627B must be attributed to the late Albian. Dinocysts also date the drowning of the carbonate platform of the Blake Plateau. This drowning started in the latest Albian (Vraconian) and continued into the Cenomanian. The site area changed from an inner to intermediate or outer(?) neritic environment. The area around Hole 635B from the late Albian appears to have been situated in a deeper environment than the area around Hole 627B during the same period. The new dinoflagellate-cyst species *Compositosphaeridium? bahamaensis* n. sp., *Maghrebinia breviornata* n. sp., and *Subtilisphaera? habibi* n. sp. are described, and *Pervosphaeridium truncatum* is emended. Additional taxonomic remarks about other species are included.

INTRODUCTION

Holes 627B and 635B were drilled in the Bahamas area during Leg 101 (Fig. 1). Hole 627B is located on the southern Blake Plateau, on the northern continental slope of Little Bahama Bank at 27°38.1'N, 78°17.65'W in a water depth of 1025.5 m. Hole 635B is situated in the Northeast Providence Channel at 25°25.18'N, 77°19.98'W in a water depth of 3470 m (Austin, Schlager, et al., 1986).

One objective for Leg 101 was to explain the present topographic configuration of the platforms and troughs in the Bahamas and to date the drowning of the platform of southern Blake Plateau. Two hypotheses about their origin have been advanced. The graben hypothesis suggests that the present topography reflects underlying horsts and grabens developed during the separation of Africa and North America in the Late Triassic-Early Jurassic (Mullins and Lynts, 1977). The "megabank" hypothesis suggests a mid-Cretaceous drowning of a homogeneous carbonate platform or "megabank" (Sheridan et al., 1981). These authors identified a velocity discontinuity and correlated it with the boundary between shallow-water limestones (Aptian-Albian) and pelagic-hemipelagic carbonates (Cenomanian). The top of the inferred carbonate platform was not reached in Hole 635B, but this top was sampled in Hole 627B.

The 34 samples collected from Holes 627B and 635B were processed using standard palynological techniques. Most samples contain rich dinoflagellate-cyst assemblages, acritarchs, and rare sporomorphs. Preservation is good. In Hole 627B, 23 samples were collected from a 268-m-thick Cretaceous sequence between Samples 101-627B-57X, CC and 101-627B-29X-2, 50-52 cm. Most of these samples are from the interval between Cores 101-627B-49X and 101-627B-38X. In Hole 635B, 10 samples were collected from a 57-m sequence between Samples 101-635B-14R-3, 146-148 cm, and 101-635B-8R, CC. The examined samples are listed in the Appendix.

The purpose of this study is (1) to identify the dinoflagellate-cyst assemblages from Holes 627B and 635B, (2) to date the drowning of the carbonate platform of the Blake Plateau, and (3) to attempt to define the paleoenvironments of Holes 627B and 635B.

RESULTS

Most of the dinoflagellate cysts recovered here were previously reported from sediments of Albian-Cenomanian age in other parts of the world. Several zonations were proposed for the middle Cretaceous (Clarke and Verdier, 1967; Bujak and Williams, 1978; Habib, 1977; Foucher, 1980). Habib (1977) proposed three zones for the middle Albian to Cenomanian of western North Atlantic DSDP Sites 99, 100, 101, 105, 387, and 391. However, the diagnostic species *Spinidinium vestitum*, *Spinidinium echinoideum*, and *Trithyrodinium suspectum* noted by Habib were not observed during this study. Existing zonations could not be recognized here. Therefore, age assignments were based on first occurrences of selected species, whose ranges are known from the North Atlantic Ocean, from northwest Europe, and from the Mazagan Plateau, off the northwest African shore, DSDP Leg 79 (Below, 1984).

HOLE 627B, SOUTHERN BLAKE PLATEAU NORTH OF LITTLE BAHAMA BANK

Hole 627B is located at the base of the slope of the Little Bahama Bank, and its drilling penetrated the top of the middle Cretaceous "megabank." A total of 536 m of sediments was drilled, which ranged in age from late Albian to Miocene. Cretaceous sediments extend from 536 to 355 m in Cores 101-627B-60X through 101-627B-27X. From this interval, 24 samples were studied between Section 101-627B-57X, CC and Sample 101-627B-29X-02, 50-52 cm. Four lithologic units were differentiated, from bottom to top, by shipboard scientists (Austin, Schlager, et al., 1986): Unit VI, the carbonate platform (three samples); Unit V, marls with terrigenous components (18 samples); Unit IV, porous limestones (no samples); and Unit III, chinks and oozes (three samples). The lithology appears to represent a sequence that deepens from a shallow-water dolostone and evaporite (Unit VI), followed abruptly by outer-shelf marls (Unit V), through a condensed section (Unit IV), into an oceanic-plateau chalk (Unit III). Shipboard paleontologists dated the top of the

¹ Austin, J. A., Schlager, W., et al., 1986. *Proc. ODP, Sci. Results*, 101: College Station, TX (Ocean Drilling Program).

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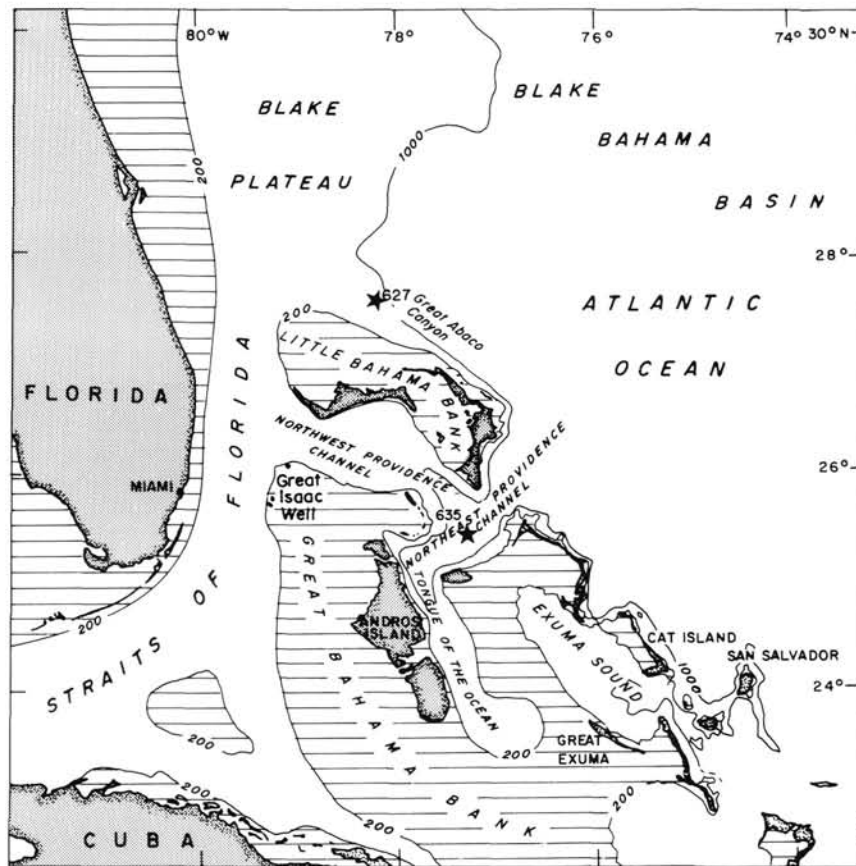


Figure 1. Location of Sites 627 and 635 in the Bahamas area. Bathymetry in meters.

platform (Unit VI) as late Albian (Core 101-627B-52X) using larger benthic foraminifers and dated the base of Unit V as latest Albian to early Cenomanian (Core 101-627B-49X) using calcareous nannofossils (Cores 101-627B-47X and 101-627B-45X) and planktonic foraminifers (Austin, Schlager, et al., 1986). The planktonic-foraminifer and calcareous-nannofossil zones correlated Cores 101-627B-38X and 101-627B-37X with the middle Cenomanian. Units IV and III are dated Coniacian-early Santonian (Core 101-627B-36X, using planktonic foraminifers) and Campanian (Cores 101-627B-34X through 101-627B-31X, using planktonic foraminifers and calcareous nannofossils), respectively.

Biostratigraphy

The distribution of the 67 taxa identified in Hole 627B is given in Figure 2. Full citations for all taxa are given in the "Taxonomy" section (this chapter).

Unit VI (Cores 101-627B-60X through 101-627B-50X; 68 m)

The three samples are located near the top of the platform; one sample (Section 101-627B-52X, CC) is barren. Many species found in the lowest sample (Section 101-627B-57X, CC) occur throughout the section. Stratigraphically useful forms include *Dinopterygium cladoides*, *Xiphophoridium alatum*, and *Xenascus plotei*. The oldest recorded occurrence of *Dinopterygium cladoides* is from the middle Albian. *Xiphophoridium alatum* is well known from the late Albian (Davey and Verdier, 1971; Williams and Bujak, 1985) but was reported in older sediments, in the upper part of the middle Albian of Boulonnais, France (Foucher, 1980). *Xenascus plotei* occurs in upper Albian sediments in DSDP Holes 545 and 547, drilled on the Mazagan Plateau (Below, 1984). Based on these ranges, a late Albian age is proposed for Section 101-627B-57X, CC. The upper, produc-

tive Section 101-627B-54X, CC collected from the "megabank" contains the same dinoflagellate-cyst associations, apart from *Cepadinium* sp. BAHA (BAHA denotes "from Bahamas"); thus a late Albian age also is indicated.

Unit V (Cores 101-627B-49X through 101-627B-37X; 124 m)

Among the 18 samples collected in these sediments, five groups can be differentiated regarding the dinoflagellate-cyst assemblages and the first occurrence of the stratigraphically useful forms.

Samples 101-627B-49X-1, 29-31 cm, and 101-627B-49X-1, 9-11 cm: 14 species have their first occurrence in these samples, four of which are of stratigraphic interest. These are *Cyclonephelium chabaca*, *Dapsilidinium laminaspinosum*, *Maghrebinia chleuh*, and *Maghrebinia perforata* ssp. *mirabilis* (Fig. 2). The oldest recorded occurrence of *Maghrebinia perforata* (= *Pterodinium perforata*) is in the middle Albian of France (Davey and Verdier, 1971; Foucher, 1980). *Cyclonephelium chabaca*, *Maghrebinia chleuh*, and *Maghrebinia perforata* ssp. *mirabilis* occur in the latest Albian (Vraconian) and range into the Cenomanian in DSDP Holes 545 and 547A (Below, 1984). Both these species also occur in the latest Vraconian of the Ida and Tanane sections, Morocco (Below, 1981). A latest Albian (Vraconian) age can be assigned to Samples 101-627B-49X-1, 29-31 cm, and 101-627B-49X-1, 9-11 cm.

Samples 101-627B-47X-5, 50-52 cm, 101-627B-47X-3, 50-52 cm, and 101-627B-46X-5, 50-52 cm: 11 species have their first stratigraphic occurrence in Sample 101-627B-47X-5, 50-52 cm. These include *Achomosphaera sagna*, *Cribroperidinium intricatum*, *Litosphaeridium siphoniphorum* ssp. *siphoniphorum*, *Maghrebinia perforata* ssp. *perforata*, and *Maghrebinia brevior-nata* n. sp. These species are characteristic of Vraconian assem-

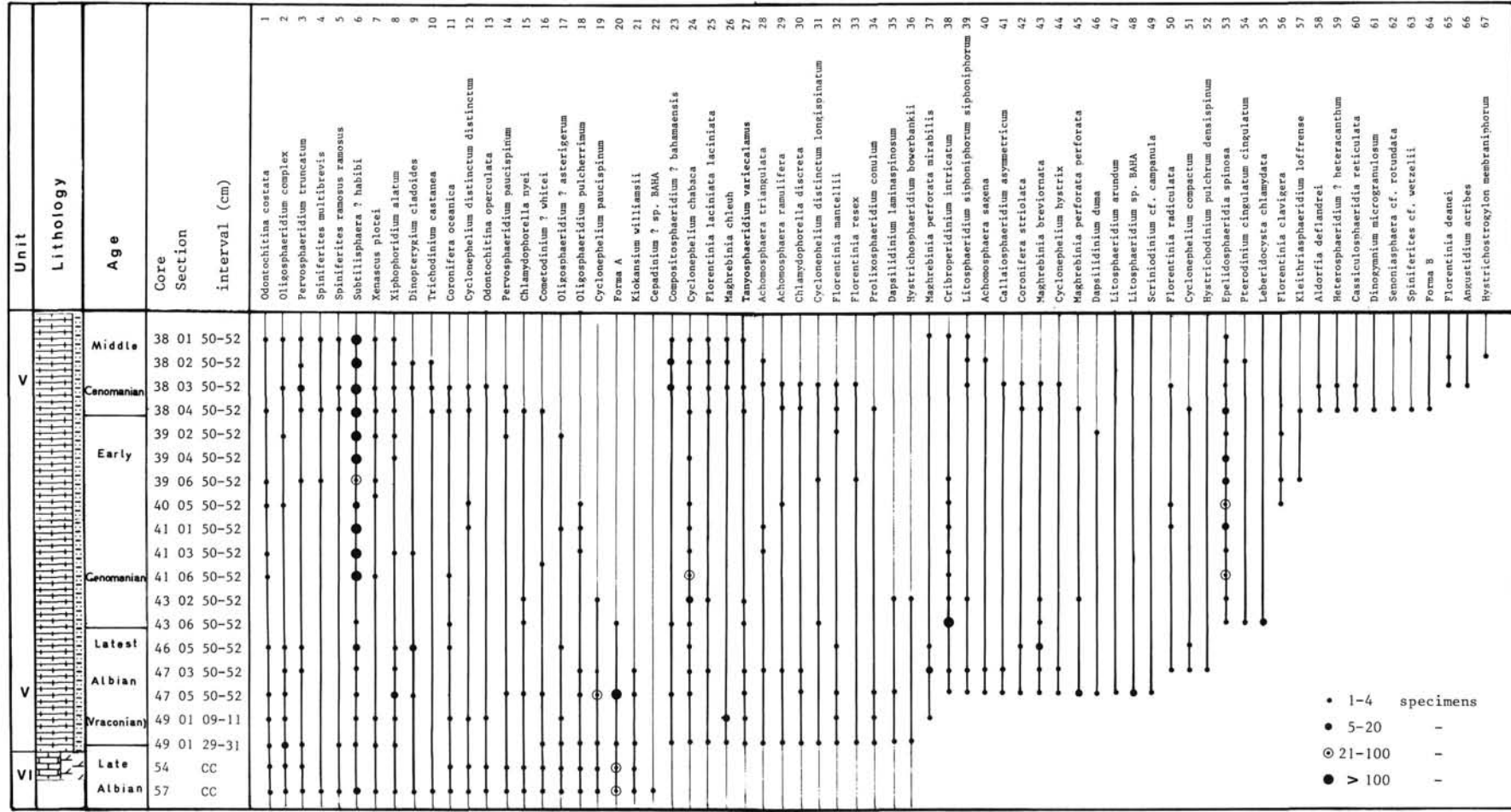


Figure 2. Distribution of dinoflagellate cysts in the mid-Cretaceous of Hole 627B.

blages. *Achomosphaera sagena* is known to have a basal occurrence in the Vraconian (Davey and Verdier, 1971, 1973), and it ranges into the Cenomanian (Davey, 1969; Foucher, 1980; Below, 1984). Based on this, a latest Albian (Vraconian) age is assigned to Samples 101-627B-47X-5, 50–52 cm, through 101-627B-46X-5, 50–52 cm.

Samples 101-627B-43X-6, 50–52 cm, through 101-627B-39X-2, 50–52 cm: problems exist in determining the exact position of the Albian/Cenomanian boundary. A comparison of dinoflagellate-cyst assemblages from well-dated Cenomanian onshore sections (including the type area of the Cenomanian Stage) seems to indicate that a peak abundance of *Epelidosphaera spinosa*, recorded in lower Cenomanian sediments, may characterize the Cenomanian (Fauconnier, 1983; Foucher, 1979, 1980). In Hole 627B, *Epelidosphaeridia spinosa* first occurs in Sample 101-627B-43X-6, 50–52 cm, in association with *Pterodinium cingulatum* ssp. *cingulatum* and *Leberidocysta chlamydata*. *Epelidosphaeridia spinosa* is abundant from Samples 101-627B-41X-6, 50–52 cm, through 101-627B-41X-3, 50–52 cm. On the Scotian Shelf and on the Grand Banks, *Epelidosphaeridia spinosa* is abundant in the *Cleistosphaeridium polytes* assemblage zone, which is Cenomanian in age (Bujak and Williams, 1978). Below (1984) used the abundance of *Epelidosphaeridia spinosa*, following Williams (1978), to suggest that samples in DSDP Holes 545 and 547A from the Mazagan Plateau area are no younger than earliest Cenomanian. From the above stratigraphical discussion, one may conclude that Sample 101-627B-43X-6, 50–52 cm, is early Cenomanian in age. Only two species of early Cenomanian age first appear in Samples 101-627B-43X-6, 50–52 cm, through 101-627B-39X-2, 50–52 cm. These are *Florentinia clavigera* and *Kleithriasphaeridium loffrense*.

Samples 101-627B-38X-4, 50–52 cm, and 101-627B-38X-3, 50–52 cm: many other species also occur in the dinoflagellate-cyst assemblages, including *Aldorfia deflandrei*, *Angustidium acribes*, *Dinogymnium microgranulosum*, *Florentinia deanei*, *Heterosphaeridium? heteracanthum*, *Hystrichostrogylon membraniphorum*, *Senoniasphaera* cf. *rotundata*, and *Forma B. Senoniasphaera* cf. *rotundata* has its basal occurrence in the middle Cenomanian in the type area of the Cenomanian Stage (Fauconnier, 1983). The oldest known occurrence of species of the genus *Dinogymnium* is in the Cenomanian of England (Davey, 1969), France (Azéma et al., 1981), Gabon (Boltenhagen, 1977), and at DSDP Sites 101 (Habib, 1972) and 105 (Habib and Knapp, 1982) in the Bahamas. In Sample 101-627B-38X-4, 50–52 cm, *Senoniasphaera* cf. *rotundata* and *Dinogymnium microgranulosum* are associated with *Epelidosphaeridia spinosa* and *Litosphaeridium siphoniphorum* ssp. *siphoniphorum*. The youngest occurrence of the last two species is in the late Cenomanian (Foucher, 1979) or early Turonian (Bujak and Williams, 1978; Williams and Bujak, 1985). The stratigraphical occurrences discussed above suggest a middle Cenomanian age for Samples 101-627B-38X-4, 50–52 cm, and 101-627B-38X-3, 50–52 cm.

Samples 101-627B-38X-2, 50–52 cm, and 101-627B-38X-1, 50–52 cm: in both samples only one species, *Hystrichostrogylon membraniphorum*, is additional. A middle Cenomanian age is proposed for this interval.

Unit III (Cores 101-627B-34X through 101-627B-27X; 76 m)

Three samples were collected in chalks and calcareous-ooze sediments; all are barren (Samples 101-627B-34X-3, 50–52 cm, 101-627B-33X-2, 50–52 cm, and 101-627B-29X-2, 50–52 cm).

Paleoenvironment

Unit VI (Cores 101-627B-60X through 101-627B-50X; 68 m)

The carbonate-platform sediments consist of dolostones and gypsum with minor limestones that were deposited in a restricted

shallow-water environment. Twenty-two species were recorded from this unit. Dinoflagellate-cyst assemblages are weakly dominated by *Forma A*. The lower sample collected from the carbonate platform, Section 101-627B-57X, CC, yields *Cepadinium* sp. BAHA. Sediments of this sample consist of gypsum with minor dolostone. This morphotype was not observed in sediments of the underlying samples, which consist of dolostone. *Cepadinium* sp. BAHA appears to be restricted to gypsum sediments.

Unit V (Cores 101-627B-49X through 101-627B-37X; 124 m)

The transition between the carbonate platform and the overlying strata appears to be abrupt. The sediments directly overlying the carbonate consist of marls having terrigenous components. Shipboard scientists interpreted Unit V as having been deposited in a shelf environment.

Few specimens in weakly diversified populations (22, 14 morphotypes) were recorded in Core 101-627B-49X. The dinoflagellate-cyst assemblages are more diverse from Core 101-627B-47X (23, 31 morphotypes) and contain numerous individual specimens. *Forma A* is abundant in Sample 101-627B-47X-5, 50–52 cm. From Samples 101-627B-43X-6 50–52 cm, through 101-627B-39X-2, 50–52 cm, the dinocyst populations commonly are dominated by abundant species. These include *Cribrroperidinium intricatum* (Sample 101-627B-43X-6, 50–52 cm), *Cyclonephellium chabaca* (Sample 101-627B-41X-6, 50–52 cm), *Epelidosphaeridia spinosa* and *Subtilisphaera? habibi* n. sp. (Sample 101-627B-41X-6, 50–52 cm). From Samples 101-627B-41X-3, 50–52 cm, through 101-627B-39X-2, 50–52 cm, dinoflagellate-cyst assemblages contain fewer individual specimens than in underlying samples, and populations are dominated by *Subtilisphaera? habibi*. In Sections 101-627B-38X-4 and 101-627B-38X-3, the dinoflagellate-cyst populations are diverse (35 morphotypes) and contain numerous individual specimens. Despite some assemblages containing few individual specimens and, correlatively, few species (Wall et al., 1977), the trend of species diversity of the dinoflagellate-cyst assemblages is an increase from Cores 101-627B-49X through 101-627B-38X. Most species of genus *Florentinia* appear to be restricted to Hole 627B (see taxal list, this chapter).

Unit III (Cores 101-627B-34X through 101-627B-27X; 76 m)

No dinoflagellate-cyst assemblages are recorded from sediments of the oceanic plateau.

HOLE 635B, NORTHEAST PROVIDENCE CHANNEL

Hole 635B was drilled in the thalweg of the Northeast Providence Channel. The 118-m-thick section ranges in age from late Albian to Quaternary. Ten samples were collected from the Cretaceous interval of lithologic Unit III (57 m) between Cores 101-635B-14R and 101-635B-8R. Unit III was divided into Subunits IIB and IIIA (Austin, Schlager, et al., 1986). Shipboard paleontologists dated Sections 101-635B-14R through 101-635B-13R-3 as early late Albian to early Vraconian, and Section 101-635B-13R-2 to Core 101-635B-8R as Vraconian, using planktonic foraminifers. Calcareous nannofossils suggest a late early through early late Albian age for Sections 101-635B-14R, CC through 101-635B-13R-2, a latest Albian or Cenomanian age for Sample 101-635B-12R-1, 110 cm, and a latest Albian through middle Cenomanian age for Cores 101-635B-12R-1 through 101-635B-8R.

Biostratigraphy

The distribution of the 65 dinoflagellate-cyst taxa found in these 10 samples is tabulated in Figure 3. Full citations for all taxa are given in the "Taxonomy" section (this chapter).

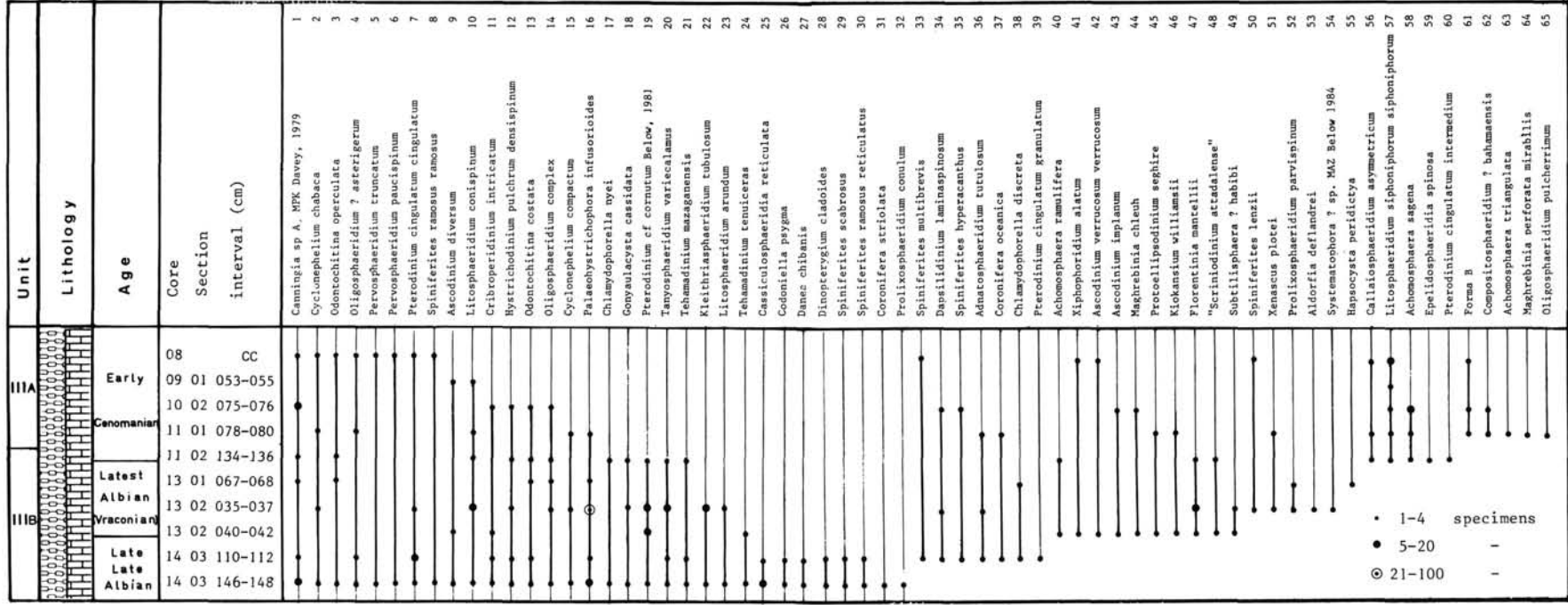


Figure 3. Distribution of dinoflagellate cysts in the mid-Cretaceous of Hole 635B.

Subunit IIIB (Core 101-635B-14R through Sample 101-635B-11R-2, 40 cm; 26 m)

The sediments consist of two debris flows (Samples 101-635B-13R-2, 120 cm, through 101-635B-12R-2, 35 cm, and Samples 101-635B-12R-2, 25 cm, through 101-635B-11R-2, 40 cm), separated from one another by a cyclic chalky limestone.

Sample 101-635B-14R-3, 146–148 cm, and Sample 101-635B-14R-3, 110–112 cm: 39 species were identified in these two samples from the Northeast Providence Channel area. The dinocyst assemblages are diversified and show similarities to late Albian assemblages described from England, France, and offshore of Northwest Africa. Species common to all four areas are *Cyclonephelium chabaca*, *Cyclonephelium compactum*, *Litosphaeridium conispinum*, *Odontochitina costata*, *Palaeohystrichophora infusorioides*, *Pterodinium* cf. *cornutum*, and *Tehamadinium mazaganensis*. The first stratigraphic occurrence of *Tehamadinium mazaganensis* (= *Occisucysta mazaganensis*) was recorded in the late Albian near the Vraconian boundary of Hole 545 of offshore Northwest Africa (Below, 1984; Leckie, 1984). *Pterodinium* cf. *cornutum* was recorded from the Cenomanian of Morocco (Below, 1981). A late late Albian age is proposed for Samples 101-635B-14R-3, 146–148 cm, and 101-35B-14R-3, 110–112 cm.

Samples 101-635B-13R-2, 40–42 cm, 101-635B-13R-2, 35–37 cm, and 101-635B-13R-1, 67–68 cm: 15 species have their basal occurrence in Section 101-635B-13R-2. Those of stratigraphic interest include *Ascodinium verrucosum* ssp. *verrucosum*, *Maghrebinia chleuh*, and *Aldorfia deflandrei*. The first stratigraphic occurrences of *Ascodinium verrucosum* ssp. *verrucosum* and *Aldorfia deflandrei* are well known in the Vraconian. These two species range into the Cenomanian (Williams and Bujak, 1985). *Ascodinium verrucosum* ssp. *verrucosum* is associated with *Maghrebinia chleuh* in the Vraconian of the Mazagan Plateau (Below, 1984; Leckie, 1984). *Systematophora*? sp. MAZ, recorded from the Vraconian of Hole 545 (Below, 1984), was observed in Sample 101-627B-13R-2, 35–37 cm. In Sample 101-635B-13R-1, 67–68 cm, only one additional species, *Hapsocysta peridictia*, was observed. No reworked species were observed in samples from the lower debris flow. A latest Albian (Vraconian) age is suggested for these three samples from Core 101-635B-13R.

Sample 101-635B-11R-2, 134–136 cm: most of the dinocysts recorded are characteristic of Vraconian-Cenomanian assemblages. Any reworked species were observed in the sample from the upper debris flow. Two morphotypes of stratigraphic interest are *Achomosphaera sagena* and *Epelidosphaeridia spinosa*. *Achomosphaera sagena* is common in the Cenomanian of England (Davey and Williams, 1966a), France (Foucher, 1979), and off the shore of Northwest Africa (Below, 1984). *Epelidosphaeridia spinosa* was used in Hole 627B to delineate the early Cenomanian; this assignment is based on comparison with a similar peak offshore of southeastern Canada, the Scotian Shelf, and on the Grand Banks (Bujak and Williams, 1978). Peak abundances of *Epelidosphaeridia spinosa* were not observed in Hole 635B. The occurrence of this species in Sample 101-635B-11R-2, 134–136 cm, suggests an early Cenomanian age at this level, although problems exist in assigning this age, which may result from the rare occurrence of *Epelidosphaeridia spinosa*.

Subunit IIIA (Sample 101-635B-11R-2, 40 cm, through Core 101-635B-8R; 30.5 m)

Sediments consist of argillaceous chalk and limestone alternating with dark organic-rich carbonate.

Sample 101-635B-11R-1, 78–80 cm: *Compositosphaeridium bahamaensis* and *Forma B* are found in this sample. In Hole 627B, *Forma B* has its first occurrence in Sample 101-627B-38R-4, 50–52 cm, which is dated as middle Cenomanian; this age assignment is based on the occurrence of *Senoniasphaera* cf. *rotundata* and *Dinogymnium microgranulatum*. In Hole

635B, these latter species are not recorded. The basal stratigraphic occurrence of *Forma B* does not seem synchronous in Holes 627B and 635B. An early Cenomanian age might be expected for Sample 101-627B-11R-1, 78–80 cm.

Samples 101-635B-9R-1, 53–55 cm, and 101-635B-8R, CC: no additional species appear in the overlying samples. Therefore, these samples are probably of early Cenomanian age.

Paleoenvironment**Unit III (Cores 101-635B-14R through 101-635B-8R; 56.7 m)**

Based on its lithology and particularly on its benthic-foraminifer assemblage, shipboard scientists interpreted Unit III as having been deposited in a bathyal environment (Austin, Schlager, et al., 1986). However, the chalky limestone (Section 101-635B-14R, CC) may represent a shallow oceanic environment on the basis of the calcareous nannofossils.

Dinoflagellate-cyst populations from Core 101-635B-14R are relatively diverse (32 morphotypes). Section 101-635B-8R, CC indicates that the assemblage is poorly diversified and contains few individual specimens. Species diversity progressively decreases from Cores 101-635B-14R through 101-635B-8R. Species represented by abundant specimens were rarely observed throughout the section, except for *Palaeohystrichophora infusorioides* from Sample 101-635B-13R-2, 35–37 cm. *Pterodinium* appears to be restricted to Hole 635B.

CONCLUSIONS**Biostratigraphy**

Dinoflagellate-cyst biostratigraphy supports shipboard biostratigraphic results. In summary, age assignments are as follows.

Hole 627B

Unit VI: late Albian, Sections 101-627B-57X, CC (535.8 mbsf) through 101-627B-54X, CC (467.8 mbsf).

Unit V: latest Albian (Vraconian), Samples 101-627B-49X-1, 29–31 cm (458.5 mbsf) through 101-627B-46X-5, 50–52 cm (436 mbsf). Early Cenomanian, Samples 101-627B-43X-6, 50–52 cm (409.5 mbsf) through 101-627B-39X-2, 50–52 cm (365.1 mbsf). Middle Cenomanian, Samples 101-627B-38X-4, 50–52 cm (358.5 mbsf) through 101-627B-38X-1, 50–52 cm (324.7 mbsf).

Unit IV: not studied.

Unit III: samples barren, Samples 101-627B-34X-3, 50–52 cm (328.5 mbsf), 101-627B-33X-2, 50–52 cm (298 mbsf), and 101-627B-29X-2, 50–52 cm (269.5 mbsf).

Drowning of the carbonate platform started in the latest Albian (Vraconian).

Hole 635B

Subunit IIIB: late late Albian, Samples 101-635B-14R-3, 146–148 cm (118.1 mbsf) through 101-635B-14R-3, 110–112 cm (117.8 mbsf). Latest Albian (Vraconian), Samples 101-635B-13R-2, 40–42 cm (110.2 mbsf) through 101-635B-13R-1, 67–68 cm (108.9 mbsf). Early Cenomanian, Sample 101-635B-11R-2, 134–136 cm (92.4 mbsf).

Subunit IIIA: early Cenomanian, Sample 101-635B-11R-1, 78–80 cm (90.3 mbsf) through Section 101-635B-8R, CC (70.6 mbsf).

Although some Unit III rocks (Hole 635B) resemble the Cenomanian marls (Unit V) from Hole 627B, Unit III is older than Unit V.

Paleoenvironment**Hole 627B**

The morphotype *Cepadinium* sp. BAHA appears to be restricted to the gypsum sediments from the inner part of the ne-

neritic realm in Unit VI. Species dominances are recorded for sediments from the carbonate platform (Unit VI) and from the marls with terrigenous components (Unit V). An increase in species diversity is recorded from Unit VI to Unit V. In recent marine sediments, the trend of the species diversity indicates an increase from inner to outer parts of the neritic realm and a decrease from neritic to oceanic realms (Wall et al., 1977; Harland, 1983). Major dominances to monospecific assemblages are recorded in the inner part of the neritic realm (Goodman, 1979; Châteauneuf, 1980). These observations suggest that the dinoflagellate-cyst assemblages recorded the deepening of the carbonate platform. Drowning started in the latest Albian (Vriconian) and continued into the middle Cenomanian. The site changed from inner to intermediate or outer(?) parts of the neritic realm. These results support the "megabank" hypothesis (Sheridan et al., 1981). No dinoflagellate-cyst assemblages are recorded from sediments of the oceanic plateau.

Hole 635B

Significant dominances were not observed in samples from Hole 635B; the diversity of species progressively decreased throughout the section studied. The dinoflagellate-cyst assemblages appear to indicate a deepening of the area around Hole 635B during the late late Albian through the early Cenomanian.

Comparison

Dinoflagellate-cyst assemblages from Holes 627B and 635B show some differences in composition. Although most species are common to both holes, their relative abundances differ. A succession of species dominances was recorded from Hole 627B. Such significant dominances were not observed in Hole 635B. These observations suggest that Hole 635B was located in a deeper environment than Hole 627B.

Differences in the assemblages among sites studied by Habib (1972, 1978), DSDP Sites 99, 100, 101, 105, 387, and 391, and Holes 627B and 635B, may be caused by environmental control. The assemblages found in this study most closely resemble those described from the Mazagan Plateau, Holes 545 and 547, off-shore of Northwest Africa, DSDP Leg 79 (Below, 1984).

TAXONOMY

This section is divided into two parts. The first part lists (in alphabetical order) all dinoflagellate-cyst taxa encountered in the study, with references to plates and figures as well as number and position on the distribution charts. The numbers in parentheses refer to Holes 627B and 635B, respectively. A zero indicates that the species does not occur in that particular hole. The second part provides morphological descriptions of new species and comments about other species. Gonyaulacoid morphotypes are described using the Taylor-Evitt system (Evitt, 1985) and Helenes' arrangement (Helenes, 1986), and the peridinioid morphotypes are described according to the Kofoid system. The systematic section is arranged alphabetically according to genus.

New species are housed in the Centre Scientifique, G. Deflandre, of the Museum of Natural History in Paris, France.

Taxa List for Dinoflagellate Cysts

- Achomosphaera ramulifera* (Deflandre, 1937) Evitt, 1963; Plate 1, Fig. 1. (29-40)
Achomosphaera sagena Davey and Williams, 1966a; Plate 1, Fig. 2. (40-58)
Achomosphaera triangulata (Gerlach, 1961) Davey and Williams, 1969. (28-63)
Adnatosphaeridium tutulosum (Cookson and Eisenack, 1960) Morgan, 1980; Plate 1, Fig. 3. (0-36)
Aldorfia deflandrei (Clarke and Verdier, 1967) Stover and Evitt, 1978; Plate 1, Fig. 4. (58-53)
Angustidinium acribes (Davey and Verdier, 1971) Goodman and Evitt, 1981; Plate 1, Fig. 5. (66-0)
Ascadinium diversum (Davey, 1979b) Helenes, 1983; Plate 1, Fig. 6. (0-9)
Ascadinium implanum (Davey, 1979b) Helenes, 1983; Plate 1, Fig. 7. (0-43)

- Ascadinium verrucosum* ssp. *verrucosum* Cookson and Hughes, 1964; Plate 1, Fig. 8. (0-42)
Callaiosphaeridium asymmetricum (Deflandre and Courteville, 1939) Davey and Williams, 1966b. (41-56)
Canningia sp. A. MPK *sensu* Davey, 1979b, Plate 3, Fig. 4; Plate 1, Fig. 9. (0-1)
Cassiculosphaeridia reticulata Davey, 1969; Plate 1, Fig. 10. (60-25)
Cepadinium? sp. BAHA; Plate 1, Fig. 11. (22-0)
Chlamydothrella discreta Clarke and Verdier, 1967; Plate 1, Fig. 12. (30-38)
Chlamydothrella nyei Cookson and Eisenack, 1958; Plate 1, Fig. 13. (15-17)
Codoniella psygma Davey, 1979b; Plate 1, Fig. 14. (0-26)
Cometodinium? *whitei* (Deflandre and Courteville, 1939) Stover and Evitt, 1978. (16-0)
Compositosphaeridium? *bahamaensis* n. sp.; Plate 2, Figs. 1, 2. (23-62)
Coronifera oceanica Cookson and Eisenack, 1958. (11-37)
Coronifera striolata (Deflandre, 1937) Stover and Evitt, 1978; Plate 2, Fig. 3. (42-31)
Cribroperidinium intricatum Davey, 1969. (38-11)
Cyclonephelium chabaca Below, 1981; Plate 2, Fig. 4. (24-2)
Cyclonephelium compactum Deflandre and Cookson, 1955; Plate 2, Fig. 5. (51-15)
Cyclonephelium distinctum ssp. *distinctum* Deflandre and Cookson, 1955; Plate 2, Fig. 6. (12-0)
Cyclonephelium distinctum ssp. *longispinatum* Davey, 1978. (31-0)
Cyclonephelium hystrix (Eisenack, 1958) Davey, 1978; Plate 2, Fig. 7. (44-0)
Cyclonephelium paucispinum Davey, 1969. (19-0)
Danea chibanis Below, 1981; Plate 2, Fig. 8. (0-27)
Dapsilidinium duma (Below, 1982) Lentin and Williams, 1985. (46-0)
Dapsilidinium laminaspinosum (Davey and Williams, 1966b) Lentin and Williams, 1981; Plate 2, Fig. 9. (35-34)
Dinogyminium microgranulosum Clarke and Verdier, 1967; Plate 2, Fig. 10. (61-0)
Dinopterygium cladoides Deflandre, 1935. (9-28)
Epelidosphaeridia spinosa (Cookson and Hughes, 1964) Davey, 1969a; Plate 2, Fig. 11. (53-59)
Florentinia clavifera (Deflandre, 1937) Davey and Verdier, 1973; Plate 3, Fig. 1. (56-0)
Florentinia deanei Davey and Williams, 1966b) Davey and Verdier, 1973; Plate 3, Fig. 2. (65-0)
Florentinia laciniata ssp. *laciniata* Davey and Verdier, 1973. (25-0)
Florentinia mantellii (Davey and Williams, 1966b) Davey and Verdier, 1973; Plate 3, Fig. 3. (32-47)
Florentinia radiculata (Davey and Williams, 1966b) Davey and Verdier, 1973; Plate 3, Fig. 4. (50-0)
Florentinia rex Davey and Verdier, 1976. (33-0)
Gonyaulacysta cassidata (Eisenack and Cookson, 1960) Sarjeant, 1966. (0-18)
Hapsocysta peridictya (Eisenack and Cookson, 1960) Davey, 1979b. (0-55)
Heterosphaeridium? *heteracanthum* (Deflandre and Cookson, 1955) Eisenack and Kjellström, 1971; Plate 3, Fig. 5. (59-0)
Hystrichodinium pulchrum ssp. *densispinum* (Deflandre, 1936) Lentin and Williams, 1973. (52-12)
Hystrichosphaeridium bowerbankii Davey and Williams, 1966b. (36-0)
Hystrichostrogylon membraniphorum Agelopoulos, 1964. (67-0)
Kiokansium williamsii Singh, 1983; Plate 3, Fig. 6. (21-46)
Kleithrasphaeridium loffrense Davey and Verdier, 1976. (57-0)
Kleithrasphaeridium tubulosum (Cookson and Eisenack, 1969) Stover and Evitt, 1978. (0-22)
Leberidocysta chlamydata (Cookson and Eisenack, 1962) Stover and Evitt, 1978. (55-0)
Litosphaeridium arundum (Eisenack and Cookson, 1960) Davey, 1979b; Plate 3, Fig. 7. (47-23)
Litosphaeridium conispinum Davey and Verdier, 1973; Plate 3, Fig. 8. (0-10)
Litosphaeridium siphoniphorum ssp. *siphoniphorum* (Cookson and Eisenack, 1958) Davey and Williams, 1966b; Plate 3, Fig. 9. (39-57)
Litosphaeridium sp. BAHA; Plate 3, Fig. 10. (48-0)
Maghrebinia breviornata n. sp.; Plate 3, Figs. 11, 12; Plate 5, Fig. 10; Text-fig. 4. (43-0)
Maghrebinia chleuh Below, 1981; Plate 3, Fig. 13. (26-44)
Maghrebinia perforata ssp. *mirabilis* Below, 1984; Plate 3, Fig. 14. (37-64)

- Maghrebinia perforata* ssp. *perforata* (Clarke and Verdier, 1967) Below 1981; Plate 3, Fig. 15. (45-0)
- Odontochitina costata* Alberti, 1961. (1-13)
- Odontochitina operculata* (O. Wetzel, 1933a) Deflandre and Cookson, 1955. (0-3)
- Oligosphaeridium? asterigerum* (Gocht, 1959) Davey and Williams, 1969; Plate 4, Fig. 1. (17-4)
- Oligosphaeridium complex* (White, 1842) Davey and Williams, 1966b. (2-14)
- Oligosphaeridium pulcherrimum* (Deflandre and Cookson, 1955) Davey and Williams, 1966b; Plate 4, Fig. 2. (18-65)
- Palaeohystrichophora infusorioides* Deflandre, 1935; Plate 4, Fig. 3. (0-16)
- Pervosphaeridium paucispinum* (Eisenack and Cookson, 1960) Jan du Chêne et al., 1986a; Plate 4, Fig. 4. (14-6)
- Pervosphaeridium truncatum* (Davey, 1969) Below, 1982, emend.; Plate 4, Figs. 5, 6, holotype; Text-fig. 5. (3-5)
- Prolixosphaeridium conulum* Davey, 1969. (34-32)
- Prolixosphaeridium parvispinum* (Deflandre, 1937) Davey et al., 1969. (0-52)
- Protoellipsoidinium seghire* Below, 1981; Plate 4, Fig. 7. (0-45)
- Pterodinium cingulatum* ssp. *cingulatum* (O. Wetzel, 1933b) Below, 1981; Plate 4, Fig. 8. (54-7)
- Pterodinium cingulatum* ssp. *granulatum* (Clarke and Verdier, 1967) Lentin and Williams, 1981. (0-39)
- Pterodinium cingulatum* ssp. *intermedium* (Cookson and Eisenack, 1974) Lentin and Williams, 1981; Plate 4, Fig. 9. (0-60)
- Pterodinium* cf. *cornutum* Cookson and Eisenack, 1962 *sensu* Below, 1981; Plate 4, Fig. 10. (0-19)
- "*Scriniodinium atadaleense*" (Cookson and Eisenack, 1958) Eisenack, 1967, *sensu* Habib, 1975, Plate 2, Fig. 8; see also Hochuli and Kelts, 1980, Plate 8, Figs. 7, 8. (0-48)
- Scriniodinium?* cf. *campanula* Gocht, 1959; Plate 4, Fig. 11. (49-0)
- Senoniasphaera cf. rotundata* Clarke and Verdier, 1967; Plate 4, Fig. 12. (62-0)
- Spiniferites hyperacanthus* (Deflandre and Cookson, 1955) Cookson and Eisenack, 1974. (0-35)
- Spiniferites lenzii* Below, 1982; Plate 4, Fig. 13. (0-50)
- Spiniferites multibrevis* (Davey and Williams, 1966a) Below, 1982; (4-33)
- Spiniferites ramosus* ssp. *ramosus* (Ehrenberg, 1838) Loeblich and Loeblich, 1966. (5-8)
- Spiniferites ramosus* ssp. *reticulatus* (Davey and Williams, 1966a) Lentin and Williams, 1973. (0-30)
- Spiniferites scabrosus* (Clarke and Verdier, 1967) Lentin and Williams, 1975. (0-29)
- Spiniferites* cf. *wetzeli* (Deflandre, 1937) Sarjeant, 1970; Plate 5, Fig. 1. (63-0)
- Subtilisphaera? habibi* n. sp.; Plate 5, Figs. 2, 3, 12; Text-fig. 6. (6-49)
- Systematophora?* sp. MAZ. *sensu* Below, 1984; Plate 5, Fig. 4. (0-54)
- Tanyosphaeridium varicelamus* Davey and Williams, 1966b; Plate 5, Fig. 5. (27-20)
- Tehamadinium mazaganensis* (Below, 1984) Jan du Chêne et al., 1986b; Plate 5, Fig. 6. (0-21)
- Tehamadinium tenuiceras* (Eisenack, 1958) Jan du Chêne et al., 1986b; Plate 5, Fig. 7. (0-24)
- Trichodinium castanea* (Deflandre, 1935) Clarke and Verdier, 1967. (10-0)
- Xenascus plotei* Below, 1981. (7-51)
- Xiphophoridium alatum* (Cookson and Eisenack, 1962) Sarjeant, 1966. (8-41)
- Forma A*, Plate 5, Figs. 8, 11; Text-fig. 7. (20-0)
- Forma B*, Plate 5, Fig. 9. (64-61)

Descriptions

Class DINOPHYCEAE Fritsch, 1929
Order PERIDINIALES Haeckel, 1894
Genus CEPADINIUM Duxbury, 1983

Type species. *Cepadinium variabile* Duxbury, 1983, pp. 58, 60; Plate 9, Figs. 1, 4, 8; Text-figs. 27, 28.

Cepadinium? sp. BAHA
(Plate 1, Fig. 11)

Description. Proximocavate peridinoid dinoflagellate cyst, dorsoventrally flattened with three horns. The single apical and the left antapical

are well developed; the right antapical is reduced. There are three wall layers: the endophragm forms the subspheroidal central body; the periphragm forms the three horns and is connected to the ectophragm by processes. The cyst is cornucavate with respect to the pericoel and irregularly cavate with respect to the ectocoel. The surface of the ectophragm is obscure. Archeopyle not observed.

Dimensions. Total length, 68, 64, 64 μm ; total breadth, 41, 36, 36 μm ; length of apical horns, 14, 14, 12 μm ; length of left antapical horns, 10, 10, 8 μm ; three specimens measured and observed.

Comparison. Three or four body layers usually are present in the genus *Cepadinium*. Three layers are present in *Cepadinium?* sp. BAHA, but an ectophragm has been observed. This does not conform to the diagnosis of the genus.

Remarks. BAHA denotes "from Bahamas."

Occurrence. Hole 627B (see Fig. 2, no. 22), Section 101-627B-57X, CC: late Albian.

Genus COMPOSITOSPHAERIDIUM Dodekova, 1974

Type species. *Compositosphaeridium polonicum* (Gorka, 1965) (= *Hystrichosphaeridium polonicum* Gorka, 1965, pp. 306-307; Plate 3, Figs. 5, 6) Erkmen and Sarjeant, 1980, pp. 67-69.

Compositosphaeridium? *bahamaensis* n. sp.
(Plate 2, Figs. 1, 2)

Derivation of name. Bahamas, location of Hole 627B, Leg 101.

Diagnosis. Proximochorate two-layered dinoflagellate cyst with subspheroidal central body. Smooth endophragm and periphragm appressed between processes. Periphragm with membranous reticulated ridges on the surface of central body. "Polytubular" intratabular processes, whose height is about 30% of the endocyst diameter. Gonyaulacoid paratabulation; processes represent 4 apicals, 6 precingulars, 6 cingulars, X sulcals, 5-6 postcingulars, ?1 posterior intercalary, 1 antapical. Apical archeopyle, type (4A).

Holotype. Slide 3: TU 43-44; Sample 101-627B-38X-2, 50-52 cm.

Type locality. Hole 627B, Leg 101, offshore Bahamas (east of Florida).

Type biohorizon. Cenomanian. Depth: 355.5 mbsf.

Dimensions. Holotype: central body diameter, 30 μm ; length of processes, 6-9 μm ; total diameter, 47 μm ; 20 specimens measured: central body diameter, 33 (31) 28 μm ; length of processes, 12 (9) 6 μm .

Description. The intratabular processes are "polytubular" and open distally. The number of processes and tubes varies according to the position and size of the paraplates they reflect. The pre- and post-cingular processes are larger than the apical and antapical ones. The cingular processes are narrow mono- or polytubular. All processes are joined proximally by membranous reticulate ridges with irregular meshes. The organization of the processes is difficult to observe when the detachment between the endophragm and periphragm is large.

Comparison. The number of processes is more than one for each paraplate. This does not conform to the diagnosis for the genus *Compositosphaeridium?* *bahamaensis* differs from *C. bulgaricum* and *C. polonicum* in having shorter intratabular processes and well-developed reticulate ridges proximally linking the processes on the central body.

Occurrence. Hole 627B (see Fig. 2, no. 23), Samples 101-627B-49X-1, 29-31 cm, to 101-627B-38X-1, 50-52 cm, latest Albian (Vraconian), middle Cenomanian; Hole 635B (see Fig. 3, no. 62), Samples 101-635B-11R-1, 78-80 cm, to 101-635B-10R-2, 75-76 cm, early Cenomanian.

Genus LITOSPHAERIDIUM Davey and Williams, 1966; emend.
Davey and Verdier, 1973; emend. Lucas-Clarke, 1984

Type species. *Litosphaeridium siphoniphorum* (Cookson and Eisenack, 1958) (= *Hystrichosphaeridium siphoniphorum* Cookson and Eisenack, 1958, p. 44; Plate 11, Figs. 8-10) Davey and Williams, 1966, pp. 80-82, emend. Lucas-Clark, 1984, p. 186.

Litosphaeridium sp. BAHA
(Plate 3, Fig. 10)

Description. Skolochorate, two-layered dinoflagellate cyst, with subspheroidal central body. Granular endophragm and smooth periphragm appressed between processes. Intratabular, hollow processes with secate or scutellate distal margin. Gonyaulacoid paratabulation, processes represent 4 apicals, 6 precingulars, X cingulars, X sulcals, 6 postcingulars, ?1 posterior intercalary, 1 antapical. Apical archeopyle, type (4A).

Dimensions. Diameter, 50 μm ; central body diameter, 40 μm ; length of processes, 8–10 μm .

Comparison. *Litosphaeridium* sp. BAHA differs from the other species in having secate or scutellate distal margin processes.

Remarks. Too few specimens are available to formally erect a new species.

Occurrence. Hole 627B (see Fig. 2, no. 48), Sample 101-627B-47X-5, 50–52 cm; latest Albian (Vraconian).

Genus *MAGHREBINIA* Below, 1981

Type species. *Maghrebinia perforata* (Clarke and Verdier, 1967) (= *Dinopterygium perforatum*, Clarke and Verdier, 1967, p. 36; Plate 6, Figs. 1–3; Text-fig. 15) Below, 1981, p. 23.

Maghrebinia breviornata n. sp.

(Plate 3, Figs. 11, 12; Text-fig. 4; Plate 5, Fig. 10)

Derivation of name. Latin *brevi*, reduced, and *ornata*, ornamentation.

Synonymy. 1978—? *Maduradinium* sp. A, Davey, pp. 894–895; Plate 5, Figs. 5, 6.

Diagnosis. Proximate gonyaulacoid dinoflagellate cyst, single-walled with subovoidal ambitus and smooth surface, divided into a small epicyst and large hypocyst. Low granular, penitabular ornamentation. Gonyaulacoid paratabulation with large undifferentiated ventral area: ?2 preapicals, 4 apicals, 1 anterior intercalary (K), 6 precingulars, 6 cingulars, 5 sulcals, 6 postcingulars, ?1 posterior intercalary, 1 antapical. Apical archeopyle, type (4A), operculum adnate; accessory archeopyle sutures well developed.

Holotype. Slide 1: J49; Sample 101-627B-47X-5, 50–52 cm.

Type locality. Hole 627B, Leg 101, offshore Bahamas (east of Florida).

Type biohorizon. Cenomanian. Depth: 409.5 mbsf.

Dimensions. Holotype: length, 72 μm ; breadth, 64 μm ; 10 specimens measured: length, 73 (64) 60 μm , breadth, 73 (70) 66 μm .

Description. Penitabular ornamentation weakly developed on apical paraplates, strongly expressed on precingular paraplates, and highly developed in antapical area, with intratabular granules on Z and Y. Cingular paraplates are delineated by penitabular granules on dorsal surface. The granule alignments are weakly developed between IV/V and V/VI paraplates. An additional K paraplate is present. A is in contact with ai, A/ai arrangement. Paraplate 5 is camarate with respect to K. The operculum is adnate. The principal archeopyle suture fails to open following adapical boundaries of the parasulcus and of the precingular paraplates, 2 and li. The accessory archeopyle sutures 2/3 and 6/li are well developed.

Comparison. *Maghrebinia breviornata* differs from the other species of *Maghrebinia* in having granular and reduced ornamentation.

Occurrence. Hole 627B (see Fig. 2, no. 43), Sample 101-627B-47X-5, 50–52 cm, to Sample 101-627B-38X-3, 50–52 cm, latest Albian-Vraconian, middle Cenomanian.

Genus *PERVOSPHAERIDIUM* Yun, 1981

Type species. *Pervosphaeridium pseudhystrichodinium* (Deflandre, 1937) (= *Hystrichosphaeridium pseudhystrichodinium* Deflandre, 1937, p. 73; Plate 15, Figs. 3, 4) Yun, 1981, p. 29.

Pervosphaeridium truncatum (Davey, 1969) Below, 1982 emend.

(Plate 4, Fig. 6; Text-fig. 5, holotype; Plate 4, Fig. 5)

Synonymy. 1969—*Exochosphaeridium striolatum* (Deflandre, 1937) var. *truncatum* var. nov. Davey, pp. 164–165; Plate 7, Fig. 2.

1982—*Pervosphaeridium truncatum* (Davey, 1969) Below, p. 27.

Emended diagnosis. Proximate, two-layered dinoflagellate cyst with subspheroidal central body and fibrous, lightly pitted periphragm. Processes intratabular, hollow, fibrous with broad bases, blunted distally, slender, some joined proximally. Apical and antapical processes well developed. Gonyaulacoid paratabulation; processes represent 1–?2 preapicals, 4 apicals, 6 precingulars, 6 cingulars, X sulcals, 5–6 postcingulars, ?1 posterior intercalary, 1 antapical. Precingular archeopyle, type 2P 3–4.

Emended description. The processes are intratabular, with one or more than one for each paraplate. The processes of the post-cingular paraplates (III, IV) may form a penitabular complex, with their broad

bases joined proximally. The preapical process is distinctive; the antapical Y is well developed.

Comparison. *P. truncatum* differs from other species of the genus in having some processes joined proximally. The archeopyle formula of the genus *Pervosphaeridium* is 2P (Yun, 1981). Below (1981, p. 60) specified that the archeopyle of *Pervosphaeridium paucispinum* was 2P 3–4. *P. truncatum* and *P. paucispinum* appear to have 2P 3–4 archeopyle formula.

Remarks. We based our emendation on reexamination of the holotype.

Occurrence. Hole 627B (see Fig. 2, no. 3), Section 101-627B-57X, CC to Sample 101-627B-38X-1, 50–52 cm, late Albian–middle Cenomanian; Hole 635B (see Fig. 3, no. 5), Sample 101-635B-14R-3, 146–148 cm, to Section 101-635B-8R, CC, late late Albian–early Cenomanian.

Genus *SUBTILISPHAERA* Jain and Millepieid, 1973

Type species. *Subtilisphaera senegalensis* Jain and Millepieid, 1973, pp. 27–28; Plate 3, Figs. 31, 33.

Subtilisphaera? habibi n. sp.

(Plate 5, Figs. 2, 3, 12; Text-fig. 6)

Derivation of name. In honor of Dr. D. Habib, palynologist.

Diagnosis. Bicavate, peridinoid dinoflagellate cyst, dorsoventrally flattened. Three horns: one apical, one well developed left antapical, and one highly reduced right antapical. Endophragm subspheroidal, slightly granular. Periphragm thin, with short to long flexuous intratabular spines and pandasutural bands. Very low parasutural ridges expressed only on periphragm where endophragm and periphragm are appressed. Peridinoid paratabulation: 1–? pr, 4', 3a, 7'', Xc, 5''', 2''', Xs, with ortho/hexa-type paratabulation. Endoarcheopyle, 313P, adherent?; periarcheopyle uncertain.

Holotype. Slide 1: N 0 34–35, Sample 101-627B-39X-6, 50–52 cm.

Type locality. Hole 627B, Leg 101, offshore Bahamas (east of Florida).

Type biohorizon. Cenomanian. Depth: 371.1 mbsf.

Dimensions. Holotype: length, 64 μm ; breadth, 40 μm ; length of endocyst, 42 μm ; length of apical horn, 12 μm ; length of left antapical horn, 10 μm ; length of spines, 1–2 μm ; 20 specimens measured: length, 68 (64) 60 μm ; breadth, 44 (40) 38 μm .

Description. Peridinoid bicavate cyst with well-developed apical and left antapical horns, and truncated right antapical horn. Endophragm granular. Periphragm smooth, with low parasutural ridges present only where the endophragm and periphragm are appressed. Some specimens show only penitabular spines, whereas others have intratabular spines. All have pandasutural bands. 1' paraplate is in contact with the two precingulars 1'' and 7'', and so is the ortho type; 2a is in contact with 3'', 4'' and 5'', and so is the hexa type.

Comparison. *Subtilisphaera? habibi* is a provisionally accepted species of *Subtilisphaera* because it has a paratabulation indicated by ornamentation. Parasutural ridges, pandasutural bands, and intratabular spines differentiate *Subtilisphaera? habibi* from *Palaeohystrichophora infusorioides*. Pericoels in *Subtilisphaera? habibi* are more developed than in *Chichaouadinium arabicum*. The archeopyles of the genera *Chichaouadinium* (13P), *Luxadinium* 313P/313P, *Laciniadinium* (313P)a, *Gingonodinium* (31Pa), and *Diconodinium* (1Pa), do not correspond to the archeopyle of *Subtilisphaera? habibi*.

Remarks. The paratabulation, which is of the ortho/hexa type, the pandasutural bands, and the intratabular spines suggest that *Subtilisphaera? habibi* may be related to the cyst of the modern freshwater dinoflagellate *Pterodinium limbatum*. Under the scanning electron microscope no grooves were observed on the inner surface of the endophragm as is found in *Pterodinium limbatum*. The periarcheopyle of *Pterodinium limbatum* is (A313P)a; that of *Subtilisphaera? habibi* is uncertain.

Occurrence. Hole 627B (see Fig. 2, no. 6), Section 101-627B-57X, CC to Sample 101-627B-38X-1, 50–52 cm, late Albian–middle Cenomanian; Hole 635B (see Fig. 3, no. 49), Samples 101-635B-13R-2, 40–42 cm, to 101-635B-13R-2, 35–37 cm, latest Albian (Vraconian).

Forma A

(Plate 5, Figs. 8, 11; Text-fig. 7)

Description. Proximate spheroidal dinoflagellate cyst. Autophragm thin and smooth. Gonyaulacoid paratabulation expressed by very low

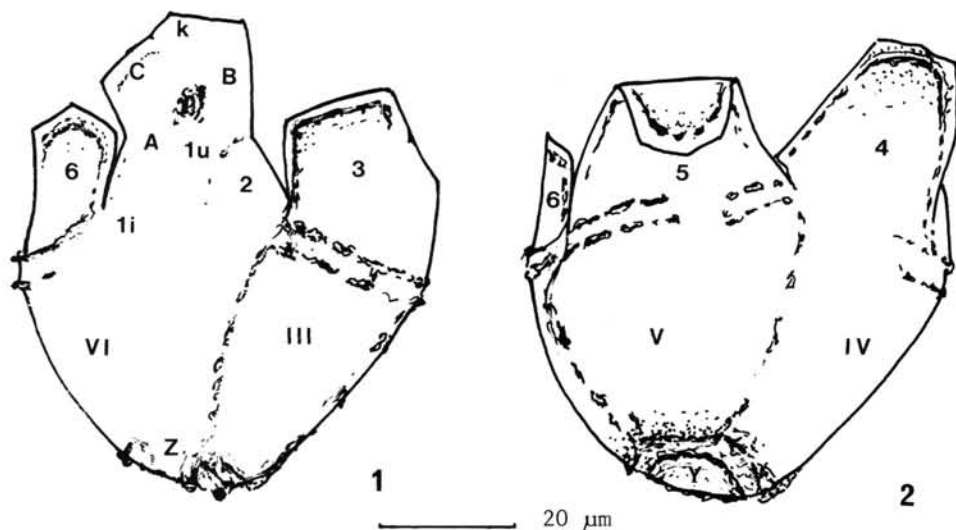


Figure 4. Paratabulation of *Maghrebinia breviornata* n. sp., according to the Taylor-Evitt system. 1. Ventral face. 2. Dorsal face, interior view.

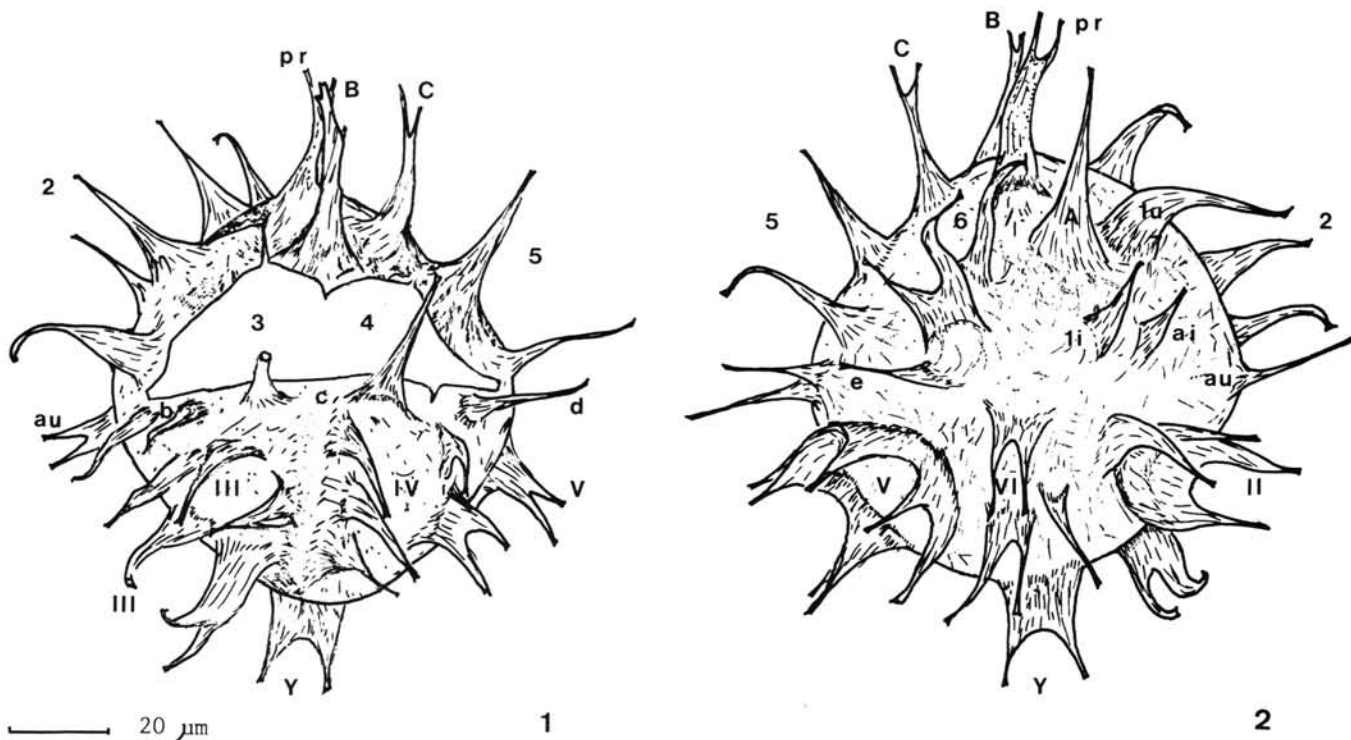


Figure 5. Paratabulation of the holotype of *Pervosphaeridium truncatum*, according to the Taylor-Evitt system. 1. Dorsal face. 2. Ventral face.

ridges with elongated Z and X, quinqueform hypocyst pattern. Archeopyle uncertain, not observed.

Dimensions. Diameter, 48 to 58 μm ; 20 specimens measured.

Comparison. *Forma A* should be attributed to the genera *Chytroisphaeridia* (Sarjeant, 1962) Downie and Sarjeant, 1965; emend. Pocock, 1972; emend. Davey, 1979c, in regard to its smooth hyaline unstructured autophragm as seen under the light microscope. *Chytroisphaeridia* has a precingular archeopyle, type P; the archeopyle of *Forma A* is uncertain.

Remarks. Under the light microscope the paratabulation, which is expressed by low ridges, is not visible. The thin, fragile autophragm tears in a random fashion. The delicacy of the wall and the absence of

independent indications of paratabulation may contribute to this situation.

Occurrence. Hole 627B (see Fig. 2, no. 20), Section 101-627B-57X, CC to Sample 101-627B-43X-6, 50-52 cm, late Albian-early Cenomanian.

Forma B
(Plate 5, Fig. 9)

Description. Skolochorate double-walled dinoflagellate cyst, with subspheroidal central body. Endophragm and periphragm appressed between processes. Endophragm slightly granular; periphragm with ridges proximally joining the processes on the central body. Intratabular hol-

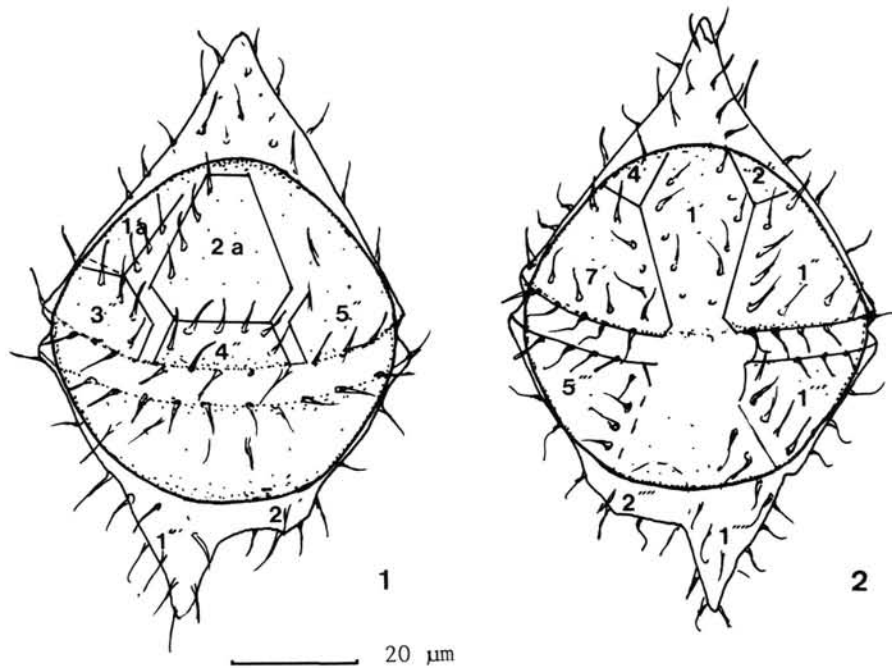


Figure 6. Paratabulation of *Subtilisphaera? habibi* n. sp., according to the Kofoid system. 1. Dorsal face. 2. Ventral face.

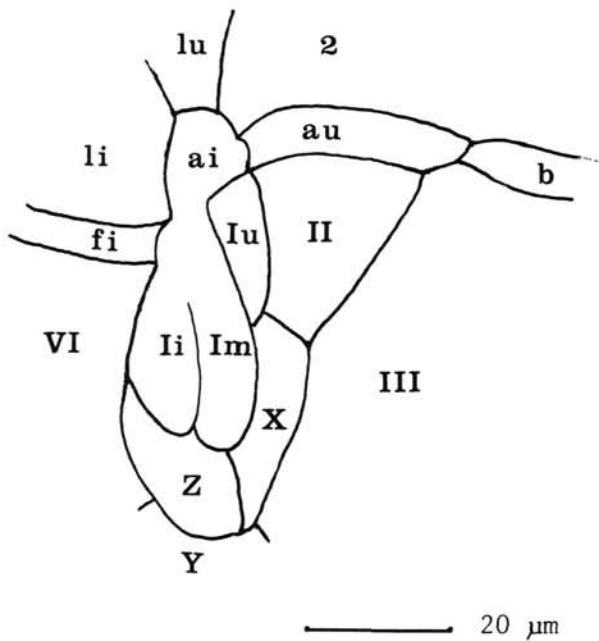


Figure 7. Paratabulation of the sulcal area of *Forma A*, according to the Taylor-Evitt system.

low processes distally closed, with ridges and granular proximal bases. Gonyaulacoid paratabulation, processes represent ?1-2 preapicals, 4 apicals, 6 precingulars, X cingulars, X sulcals, 5-6 postcingulars, ?1 posterior intercalary, 1 antapical. Precingular archeopyle, type 2P, formula uncertain.

Dimensions. Breadth included processes 44 µm.

Comparison. *Forma B* should be attributed to the genus *Pervosphaeridium*, Yun, 1981, with respect to the 2P archeopyle. *Forma B* differs from *Pervosphaeridium* in having one process for each paraplate (more than three for *Pervosphaeridium*) and striate processes (fibrous for *Per-*

vosphaeridium). *Forma B* differs from *Kleithrisphaeridium* in having 2P archeopyle, rather than P, and processes distally closed.

Remarks. Only 4 specimens, none of which was well preserved or favorably oriented, were observed.

Occurrence. Hole 627B (see Fig. 2, no. 64), Sample 101-627B-38X-4, 50-52 cm, middle Cenomanian. Hole 635B (Fig. 3, no. 61), Sample 101-635B-11R-1, 78-80 cm, to Section 101-635B-8R, CC, early Cenomanian.

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Ms 101B-127

APPENDIX Sample List

Hole 627B (interval in cm)

101-627B-29X-2, 50-52
101-627B-33X-2, 50-52
101-627B-34X-3, 50-52
101-627B-38X-1, 50-51
101-627B-38X-2, 50-52
101-627B-38X-3, 50-52
101-627B-38X-4, 50-52
101-627B-39X-2, 50-52
101-627B-39X-4, 50-52
101-627B-39X-6, 50-52
101-627B-40X-5, 50-52
101-627B-41X-1, 50-52
101-627B-41X-3, 50-52
101-627B-41X-6, 50-52
101-627B-43X-2, 50-52
101-627B-43X-6, 50-52
101-627B-46X-5, 50-52
101-627B-47X-3, 50-52
101-627B-47X-5, 50-52
101-627B-49X-1, 9-11
101-627B-49X-1, 29-31
101-627B-52X, CC
101-627B-54X, CC
101-627B-57X, CC

Hole 635B (interval in cm)

101-635B-8R, CC
101-635B-9R-1, 53-55
101-635B-10R-2, 75-76
101-635B-11R-1, 78-80
101-635B-11R-2, 134-136
101-635B-13R-1, 67-68
101-635B-13R-2, 35-37
101-635B-13R-2, 40-42
101-635B-14R-3, 110-112
101-635B-14R-3, 146-148

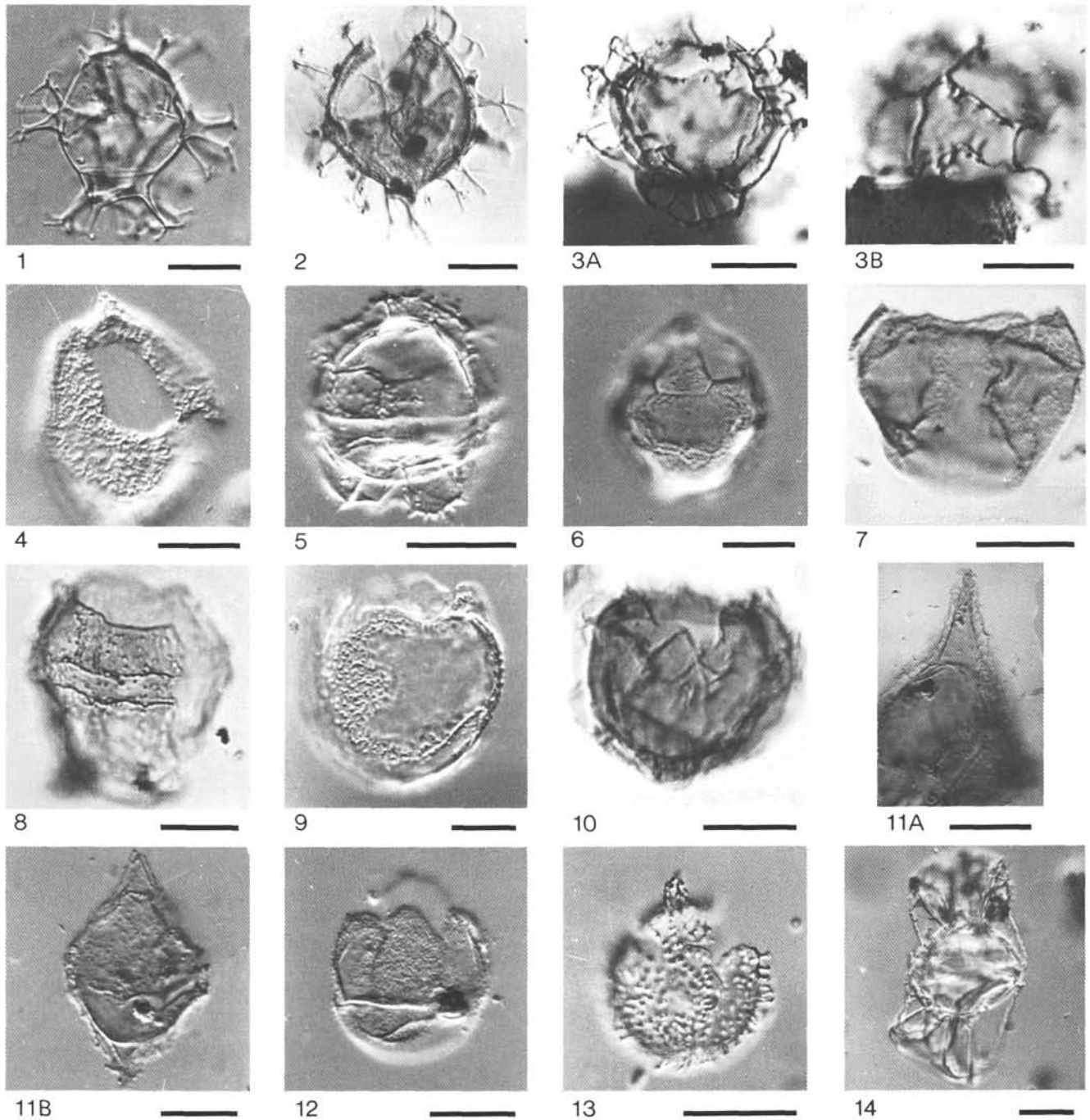


Plate 1. (Scale bar = 20 μm .) 1. *Achomosphaera ramulifera*; length, 60 μm ; optical section; slide 2: LM 35-36; Sample 101-627B-38X-3, 50-52 cm. 2. *Achomosphaera sageña*; length, 71 μm ; general view; slide 3: Z 43; Sample 101-627B-47X-5, 50-52 cm. 3. *Adnatosphaeridium tutulosum*; length, 48 μm ; A, ventral face; B, dorsal face, interior view; slide 1: Z 34; Sample 101-635B-11R-1, 78-80 cm. 4. *Aldorfia deflandrei*; length, 52 μm ; dorsal face; slide 1: NO 50-51; Sample 101-627B-38X-4, 50-52 cm. 5. *Angustidinium acribes*; length, 39 μm ; dorsal face, interior view, slide 1: V 34; Sample 101-627B-38X-3, 50-52 cm. 6. *Ascodinium diversum*; length, 48 μm ; dorsal face; slide 1: Q 24-25; Sample 101-635B-13R-2, 35-37 cm. 7. *Ascodinium implanum*; length, 36 μm ; dorsal face, interior view, slide 2: P 48-49; Sample 101-635B-13R-2, 40-42 cm. 8. *Ascodinium verrucosum* ssp. *verrucosum*; length, 54 μm ; dorsal face, slide 1: UV 40-41; Sample 101-635B-13R-2, 40-42 cm. 9. *Canningia* sp. A. MPK 1681, *sensu* Davey, 1979; length, 72 μm ; focus on the granulations; slide 3: UV 42-43; Sample 101-635B-11R-1, 78-80 cm. 10. *Cassiculosphaeridia reticulata*; length, 45 μm ; ventral face; slide 1: RS 32-33; Sample 101-635B-14R-3, 146-148 cm. 11. *Cepadinium?* sp. BAHA; length, 64 μm ; A, detail of the apical horn with endophragm, periphragm, and ectophragm; B, general view; slide 2: P 40; Section 101-627B-57X, CC. 12. *Chlamydochorella discreta*; length, 40 μm ; dorsal face, interior view; slide 1: M 28; Sample 101-627B-38X-4, 50-52 cm. 13. *Chlamydochorella nyei*; length, 35 μm ; ventral face; slide 1: L 33; Sample 101-635B-13R-2, 35-37 cm. 14. *Codoniella psygma*; length, 84 μm ; optical section; slide 3: X 25; Sample 101-635B-14R-3, 110-113 cm.

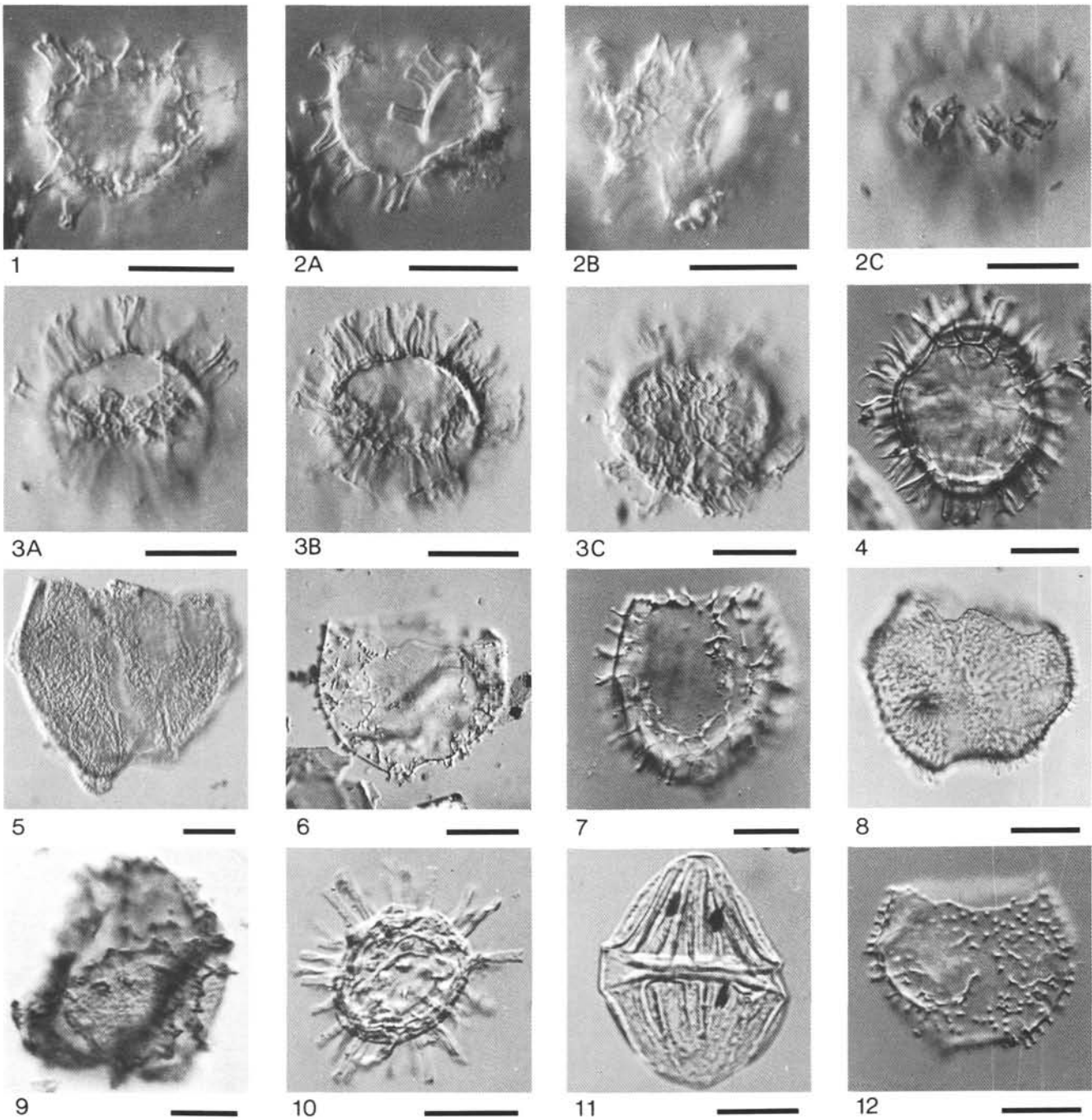


Plate 2. (Scale bar = 20 μ m.) 1. *Compositosphaeridium? bahamaensis* n. sp.; length, 36 μ m; holotype; A, ventral face; B, optical section; operculum inside the central body; C, dorsal face, interior view; slide 3: TU 43-44; Sample 101-627B-38X-2, 50-52 cm. 2. *Compositosphaeridium? bahamaensis* n. sp.; length 48 μ m; A, focus on the "polytubular" precingular processes; B, focus on the archeopyle; C, focus on the cingular processes; D, focus on the reticulate ridges of the periphragm; slide 3: X 28; Sample 101-627B-47X-5, 50-52 cm. 3. *Coronifera striolata*; length, 72 μ m; focus on the antapical process; slide 1: R 38-39; Sample 101-627B-46X-5, 50-52 cm. 4. *Cyclonephelium chabaca*; length, 78 μ m; ventral face, interior view; slide 1: VW 26-27; Sample 101-627B-43X-6, 50-52 cm. 5. *Cyclonephelium compactum*; length, 68 μ m; ventral face, interior view; slide 1: Q 39-40; Sample 101-627B-47X-5, 50-52 cm. 6. *Cyclonephelium distinctum*; length, 68 μ m; ventral face; slide 1: Z 39; Sample 101-627B-38X-3, 50-52 cm. 7. *Cyclonephelium hystrix*; length, 54 μ m; ventral face, interior view; slide 3: LM 40; Sample 101-635B-11R-1, 78-80 cm. 8. *Danaea chibanis*; length, 69 μ m; right-lateral side; slide 3: K 40-3; Sample 635B-14-3, 146-148 cm. 9. *Dapsilidinium laminaspinosum*; length, 48 μ m; general view; slide 2: Y 38; Sample 101-635B-14R-3, 110-113 cm. 10. *Dinogymnium microgranulosum*; length, 59 μ m; slide 3: MN 25-26; Sample 101-627B-38X-4, 50-52 cm. 11. *Epelidosphaeridia spinosa*; length, 36 μ m; dorsal face, interior view; slide 1: PQ 50; Sample 101-627B-38X-4, 50-52 cm.

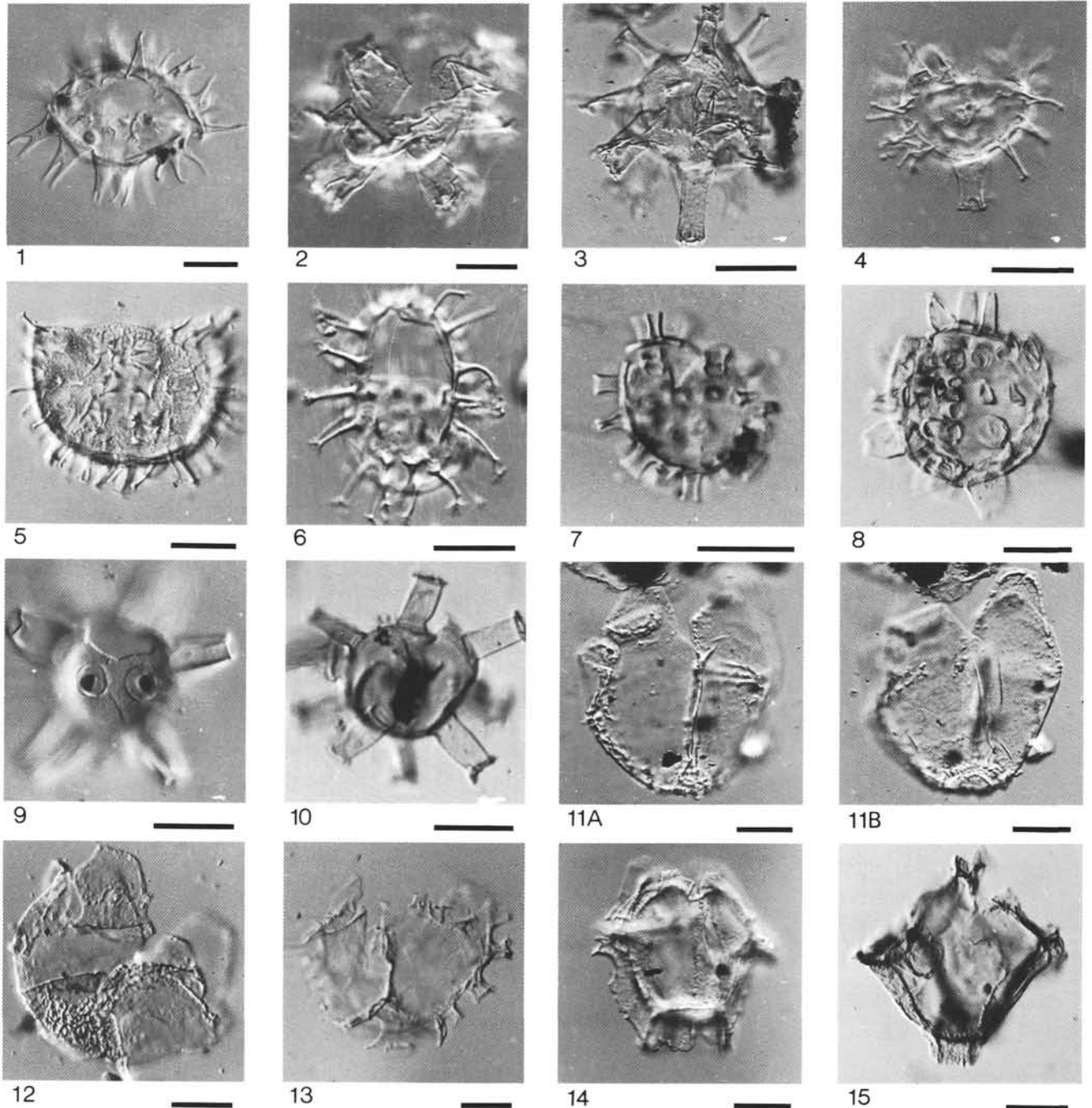


Plate 3. (Scale bar = 20 μm .) 1. *Florentinia clavigera*; length, 84 μm ; general view; slide 3: KL 29-30; Sample 101-627B-38X-4, 50-52 cm. 2. *Florentinia deanei*; length, 96 μm ; general view; slide 1: V 26; Sample 101-627B-47X-5, 50-52 cm. 3. *Florentinia mantelli*; length, 76 μm ; general view; slide 1: YZ 26-27; Sample 101-627B-38X-3, 50-52 cm. 4. *Florentinia radiculata*; length, 44 μm ; general view; slide 1: Y 32-33; Sample 101-627B-38X-3, 50-52 cm. 5. *Heterosphaeridium? heteracanthum*; length, 48 μm ; dorsal face; slide 3: WX 43-44; Sample 101-627B-38X-4, 50-52 cm. 6. *Kiokansium williamsii*; length, 61 μm ; focus dorsal face with 2P 4-5 archeopyle; slide 1: KL 49-50; Sample 101-627B-47X-3, 50-52 cm. 7. *Litosphaeridium arundum*; length, 38 μm ; general view; slide 2: S 38; Sample 101-635B-13R-2, 35-37 cm. 8. *Litosphaeridium conispinum*; length, 64 μm ; low focus; slide 2: Z 43; Sample 101-635B-13R-2, 35-37 cm. 9. *Litosphaeridium siphoniphorum* ssp. *siphoniphorum*; length, 55 μm ; lateral view; slide 1: Y 43-44; Sample 101-627B-38X-1, 50-52 cm. 10. *Litosphaeridium* sp. BAHA; length, 56 μm ; general view; slide 3: Z 34-35; Sample 101-627B-47X-5, 50-52 cm. 11. *Maghrebinia breviornata* n. sp.; length, 72 μm ; holotype; A, ventral face, with adnate operculum; B, dorsal face, interior view; slide 1: J 49; Sample 101-627B-47X-5, 50-52 cm. 12. *Maghrebinia breviornata*; length, 72 μm ; focus on the adnate operculum; slide 1: X 26; Sample 101-627B-43X-6, 50-52 cm. 13. *Maghrebinia chleuh*; length, 73 μm ; general view; slide 2: NO 50-51; Sample 101-627B-49X-1, 29-31 cm. 14. *Maghrebinia perforata* ssp. *mirabilis*; length, 64 μm ; low focus; slide 3: DE 34-35; Sample 101-635B-11R-1, 78-80 cm. 15. *Maghrebinia perforata* ssp. *perforata*; length, 66 μm ; low focus; slide 1: Q 48; Sample 101-627B-47X-3, 50-52 cm.

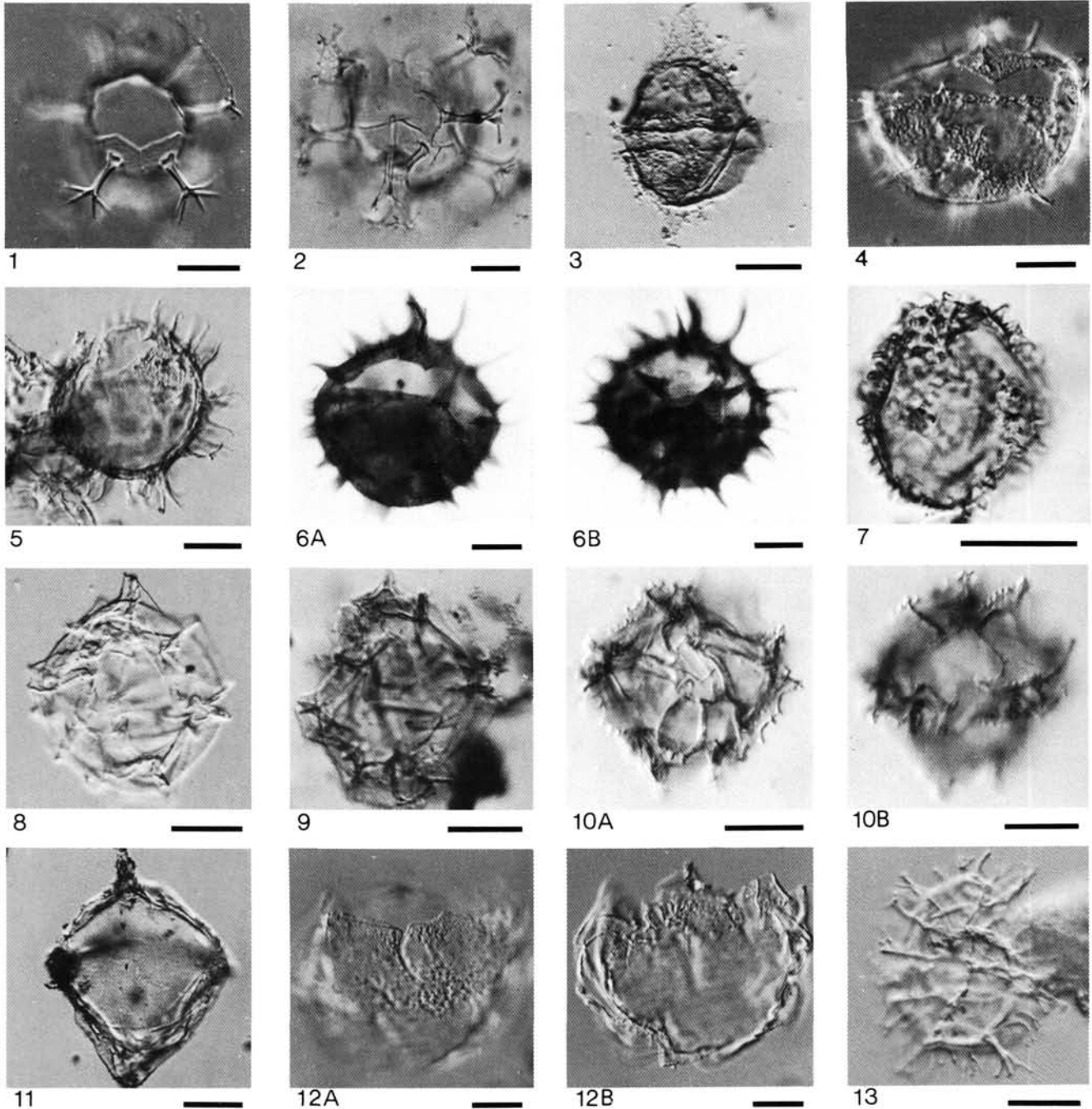


Plate 4. (Scale bar = 20 μm .) 1. *Oligosphaeridium? asterigerum*; length, 72 μm ; lateral side; slide 1: K 42; Sample 101-635B-13R-2, 35-37 cm. 2. *Oligosphaeridium pulcherrimum*; length, 72 μm ; focus on the distal end of the processes; slide 1: FG 47; Section 101-627B-57X, CC. 3. *Palaeohystrichophora infusorioides*; length, 68 μm ; general view; slide 2: Z 29; Sample 101-635B-14R-3, 146-148 cm. 4. *Pervosphaeridium paucispinum*; length, 52 μm ; high-focus dorsal view; slide 1: HJ 41-42; Sample 101-627B-38X-3, 50-52 cm. 5. *Pervosphaeridium truncatum*; length, 76 μm ; high-focus archeopyle 2P 3-4; slide 1: RS 31-32; Sample 101-627B-46X-5, 50-52 cm. 6. *Pervosphaeridium truncatum*; length, 84 μm ; holotype; A, dorsal face, archeopyle, type 2P 3-4; B, ventral face, interior view; stored in the British Museum (N.H.), London. 7. *Protoellipsodinium seghiris*; length, 36 μm ; slide 1: Y 36; Sample 101-635B-11R-1, 78-80 cm. 8. *Pterodinium cingulatum* ssp. *cingulatum*; length, 60 μm ; general view; slide 2: D 33; Section 101-635B-8R, CC. 9. *Pterodinium cingulatum* ssp. *intermedium*; length, 64 μm ; general view; slide 1: D 33-34; Sample 101-635B-11R-2, 134-136 cm. 10. *Pterodinium* cf. *cornutum* sensu Below, 1981; length, 54 μm ; A, ventral face; B, dorsal face; interior view; slide 2: MN 25; Sample 101-635B-14R-3, 146-148 cm. 11. *Scriniodinium* cf. *campanula*; length, 76 μm ; general view, short spines along the parasutures of the cingulum, operculum inside the inner body; slide 3: T 32-33; Sample 101-627B-47X-5, 50-52 cm. 12. *Senoniasphaera* cf. *rotundata*; length, 64 μm ; A, dorsal face; B, ventral face; interior view; slide 3: K 41-42; Sample 101-627B-38X-4, 50-52 cm. 13. *Spiniferites lenzi*; length, 55 μm ; high focus; slide 2: EF 38; Section 101-635B-8R, CC.

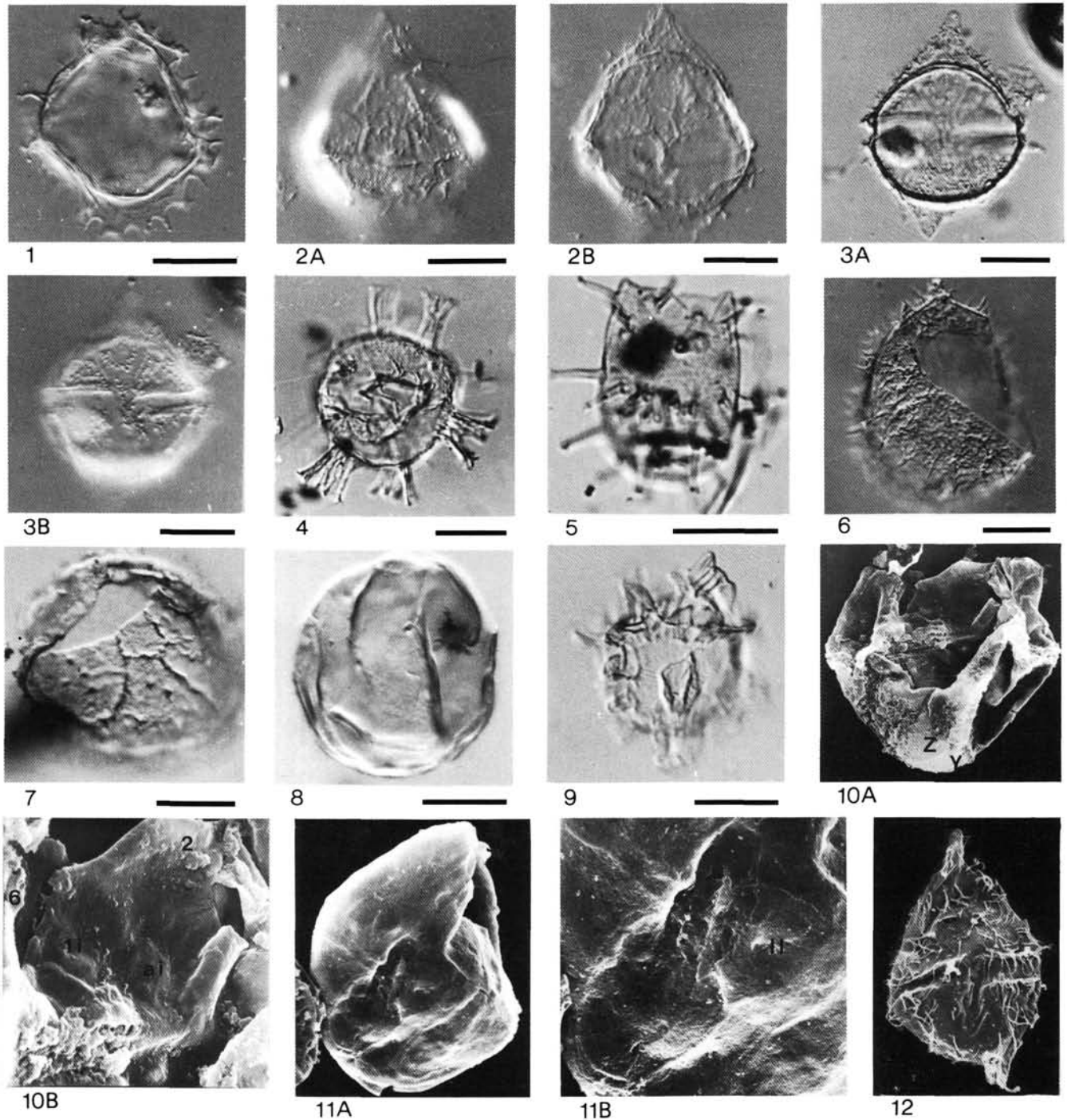


Plate 5. (Scale bar = 20 μm .) 1. *Spiniferites* cf. *wetzeli*; length, 52 μm ; optical section; slide 3: Z 42; Sample 101-627B-38X-4, 50–52 cm. 2. *Subtilisphaera?* *habibi* n. sp.; length, 65 μm ; holotype; A, dorsal view, see intratabular spines, pandasutures, and endoarcheopyle; B, ventral face, interior view; slide 1: NO 34-35; Sample 101-627B-39X-6, 50–52 cm. 3. *Subtilisphaera?* *habibi* n. sp.; length, 68 μm ; A, optical section, accumulation body(?) in the central body; B, ventral face, interior view, see intratabular spines, pandasutures, and parasutural ridges; slide 2: VW 45; Section 101-627B-54X, CC. 4. *Systematophora?* sp. MAZ; diameter, 65 μm ; slide 2: K 41-42; Sample 101-635B-13R-2, 35–37 cm. 5. *Tanyosphaeridium variecalamus*; length, 45 μm ; ventral face; slide 1: UV 49; Sample 101-627B-47X-5, 50–52 cm. 6. *Tehamadinium mazaganensis*; length, 70 μm ; dorsal lateral face; slide 1: X 40-41; Sample 101-635B-13R-2, 35–37 cm. 7. *Tehamadinium tenuiceras*; diameter, 56 μm ; apical view; slide 1: XY 25-26; Sample 101-635B-14R-3, 110–112 cm. 8. *Forma* A; length, 52 μm ; optical view; slide 3: L 45; Sample 101-627B-47X-5, 50–52 cm. 9. *Forma* B; length, 52 μm ; lateral view; slide 1: UV 27; Sample 101-627B-38X-4, 50–52 cm. 10. *Maghrebinia breviornata* n. sp.; A, ventral face, $\times 700$; B, detail of the undifferentiated ventral area, see the 6/1i accessory archeopyle suture and the alignment of granules; A/ai arrangement, $\times 2000$; Sample 101-627B-43X-6, 50–52 cm. 11. *Forma* A, SEM; A, general view, $\times 350$; B, detail of the sulcus, $\times 750$; Sample 101-627B-43X-6, 50–52 cm. 12. *Subtilisphaera?* *habibi*, SEM, $\times 600$; ventral view; Sample 101-627B-38X-3, 50–52 cm.