Srivastava, S. P., Arthur, M., Clement, B., et al., 1989
Proceedings of the Ocean Drilling Program, Scientific Results, Vol. 105

20. AN OLIGOCENE DIATOM BIOSTRATIGRAPHY FOR THE LABRADOR SEA: DSDP SITE 112 AND ODP HOLE 647A[1]

Jack G. Baldauf[2] and Anne-Lise Monjanel[3]

ABSTRACT

The Oligocene diatom assemblage observed in samples from Hole 647A consists of a mixture of species characteristic of the low latitudes, the high southern latitudes, and the Norwegian-Greenland Sea. This diverse and well-preserved diatom assemblage allows a diatom stratigraphy to be established for the Labrador Sea and to be correlated with previously established diatom zonations. Changes in the composition of the diatom assemblage from warm-temperate to temperate species suggest a change in oceanographic conditions in the Labrador Sea during the early Oligocene.

INTRODUCTION

Ocean Drilling Program (ODP) Site 647 is located at 53° 19.876′N, 45°15.717′W, at a water depth of 3869 m in the southern Labrador Sea (Fig. 1). A nearly continuous middle Eocene to lower-upper Oligocene sequence and a Pliocene to Holocene sequence were recovered at this site. These two sediment sequences are separated by several unconformities that encompass most of the Miocene interval when combined. Diatoms in relatively high abundance were observed in the uppermost Eocene to lowermost Miocene sediments recovered. However, diatoms virtually are absent from the underlying Paleocene?–Eocene and the underlying upper Miocene to Holocene sediments. The Labrador Sea Oligocene diatom assemblage consists of species typical of the Norwegian-Greenland Sea, the low latitudes, and the high southern latitudes. This assemblage allows testing of the utility of published late Paleogene diatom zonations in the Labrador Sea.

The nearly continuous sequence of abundant microfossils at Site 647 was correlated with samples examined from nearby DSDP Site 112 (54°01.00′N, 46°36.24′W; 3657 m water depth) in an effort to establish a regional stratigraphic zonal scheme. The completion of such a zonal scheme provides the biostratigraphic framework for the development of a paleooceanographic model for the early Oligocene of the Labrador Sea. In addition, the improved stratigraphic control and the stratigraphic correlation between Sites 112 and 647 allows one to refine the age assigned to the regional seismic reflector "R4."

METHODS

Each sample (about 1.5 cm^3 of sediment) was placed in a 400-mL beaker and disaggregated by adding about 10 mL of 30% hydrogen peroxide (H_2O_2). Then, about 30 mL of 37% hydrochloric acid (HCl) was added, and the sample was heated until the carbonate and organic carbon were removed. The sample was neutralized by adding approximately 300 mL of distilled water. After 1½ hr of settling, the water was decanted and the beaker was refilled with distilled water. This procedure was repeated until a pH of about 6 was achieved. Strewn slides were prepared on 22- × 30-mm (No. 1 thickness) cover glasses and mounted in Hyrax on 22- × 75-mm glass slides.

Strewn slides of acid-cleaned material prepared aboard *JOIDES Resolution* were reexamined, together with additional samples processed at shore-based facilities. At least one slide was examined in its entirety at ×770. Species identifications were verified at a magnification of ×1250. Species were recorded as abundant (*A*) if two or more specimens were present in one field of view at ×770, common (*C*) if one specimen occurred in two fields of view, few (*F*) if one specimen was observed in each horizonal transverse, and rare (*R*) if specimens were encountered less frequently. The quality of diatom preservation in samples (good [G], moderate [M], and poor [P]) is based on a semiquantitative estimate of robust forms, such as *Pyxilla* and *Hemiaulus*, to finely silicified forms, such as *Actinocyclus, Actinoptychus*, and *Cestodiscus*.

OLIGOCENE DIATOM ZONATIONS

Diatom zonations representing the Oligocene Epoch were previously established for the low latitudes (Jouse, 1974; Fenner, 1984a, 1984b, and 1985; and Barron, 1985), the high southern latitudes (Gombos and Ciesielski, 1983; and Fenner, 1984a, 1984b, and 1985), and the Norwegian-Greenland Sea (Schrader and Fenner, 1976; and Fenner, 1985; Fig. 2). The stratigraphic marker species used to delineate these zonations are shown in Figure 3. Although these zonations are defined for use in different latitudes, several of the marker species are recognized in both the low and high latitudes. For example, *Rocella vigilans* is recorded from both the low latitudes and the high southern latitudes, *Rhizosolenia oligocaenica* (= *Rhizosolenia gravida*) is recorded from the high southern and high northern latitudes, and *Coscinodiscus excavatus* occurs in both the low latitudes and high northern latitudes. Although such cosmopolitan occurrences allow similar zones to be recognized in both the low and high latitudes, additional studies will be required to document the synchroneity of these biostratigraphic markers among the various regions. Next, previously established Oligocene diatom zonations are discussed briefly.

Low-Latitude Diatom Zonations

Jouse (1974) defined four diatom zones (*Cestodiscus pulchellus* to *Coscinodiscus vigilans* zones) for the Oligocene, based on sediment recovered from the equatorial Pacific (Fig. 2). This zonation was used as a biostratigraphic framework for the more recent zonations defined by Fenner (1984a), based on sediment examined from the low-latitude Atlantic and Pacific oceans, and by Barron (1985), based on core material recovered during DSDP Leg 85 in the eastern equatorial Pacific. Fenner (1984a and 1985) defined five diatom zones for the Oligocene (*Coscinodiscus excavatus* to *Rocella gelida* zones) and Barron (1985) defined four zones (*Coscindiscus excavatus* to *Rocella gelida* zones) for the same interval. The similarities between these two zonations allow them to be discussed together.

[1] Srivastava, S. P., Arthur, M. A., Clement, B., et al., 1989. *Proc. ODP, Sci. Results*, 105: College Station, TX (Ocean Drilling Program).

[2] Ocean Drilling Program, Texas A&M University, College Station, TX 77843.

[3] Université de Bretagne Occidentale, Gis "Océanologie et Géodynamique," 6 Avenue le Gorgeu, 29287 Brest Cedex, France.

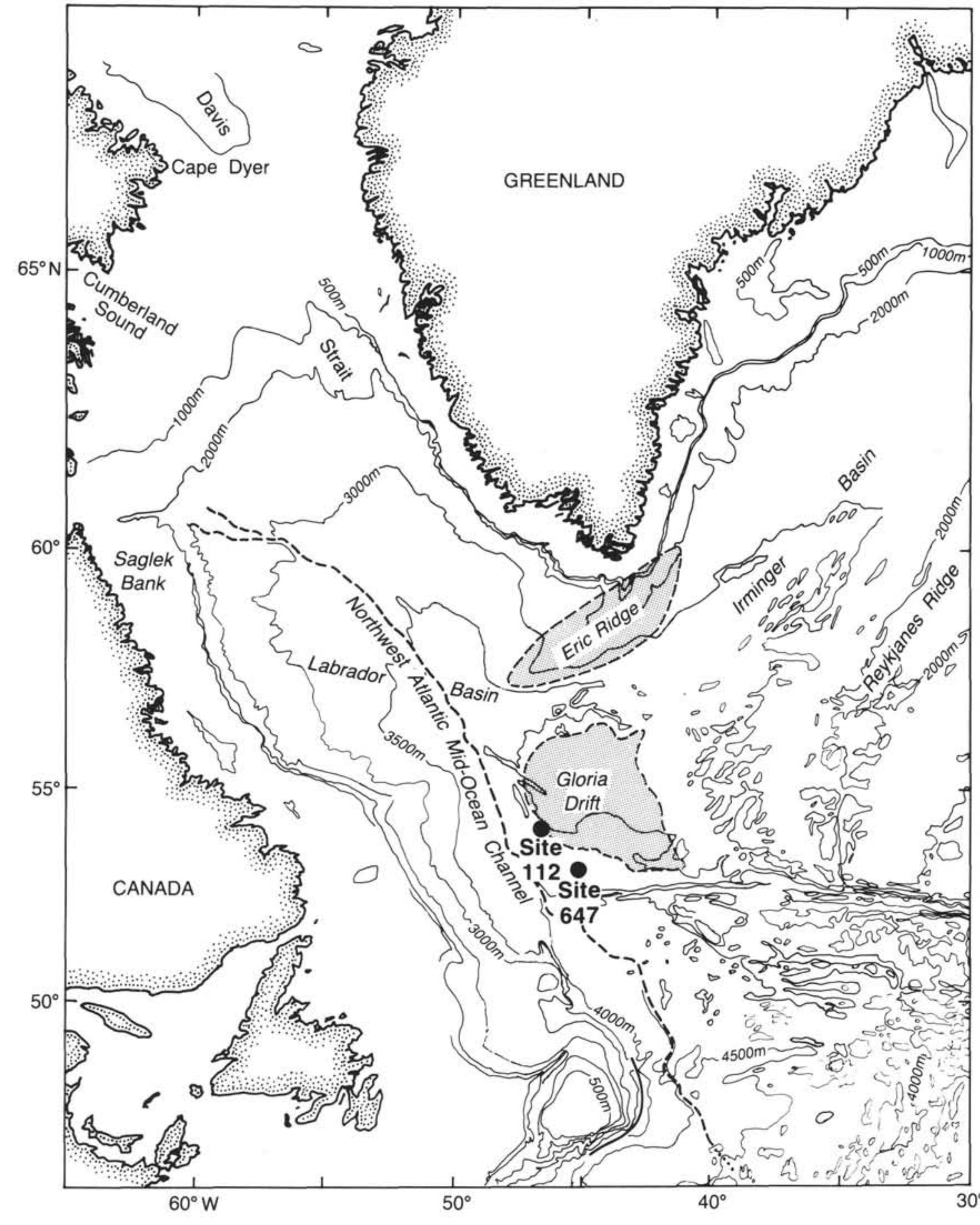

Figure 1. Map of geographic location of DSDP Site 112 and ODP Site 647 in the Labrador Sea.

1. *Coscinodiscus excavatus* Zone (Jouse, 1974 modified by Fenner, 1984a). Fenner (1984a) defined the *Coscinodiscus excavatus* Zone as the interval from the first occurrence of *C. excavatus* to the first occurrence of *Cestodiscus reticulatus* in the equatorial regions. Fenner (1985) recorded a dramatic decrease in the abundance of typical Eocene species near the top of this zone. Barron (1985) also defined a *C. excavatus* Zone, but this zone differs from that of Fenner (1984a) (see below).

2. *Cestodiscus reticulatus* Zone (Fenner, 1984a). This zone occurs directly above the *C. excavatus* Zone of Fenner (1984a) and is defined as the interval from the first occurrence of *C. reticulatus* to the first occurrence of *Rocella vigilans*. Fenner (1985) recorded a marked increase in abundance of *Cestodiscus* species just above the base of this zone in the low latitudes. In addition, she noted that many of the typical late Eocene diatom species are present in the lower part of the zone, but are generally rare or absent in the upper part of the zone.

Barron (1985) combined the *C. excavatus* and *C. reticulatus* Zones of Fenner (1984a) into the *C. excavatus* Zone of Barron (1985) because of the potential taxonomic confusion between specimens of *Cestodiscus robustus* and *C. reticulatus* and the ease in which specimens of *C. excavatus* could be recognized.

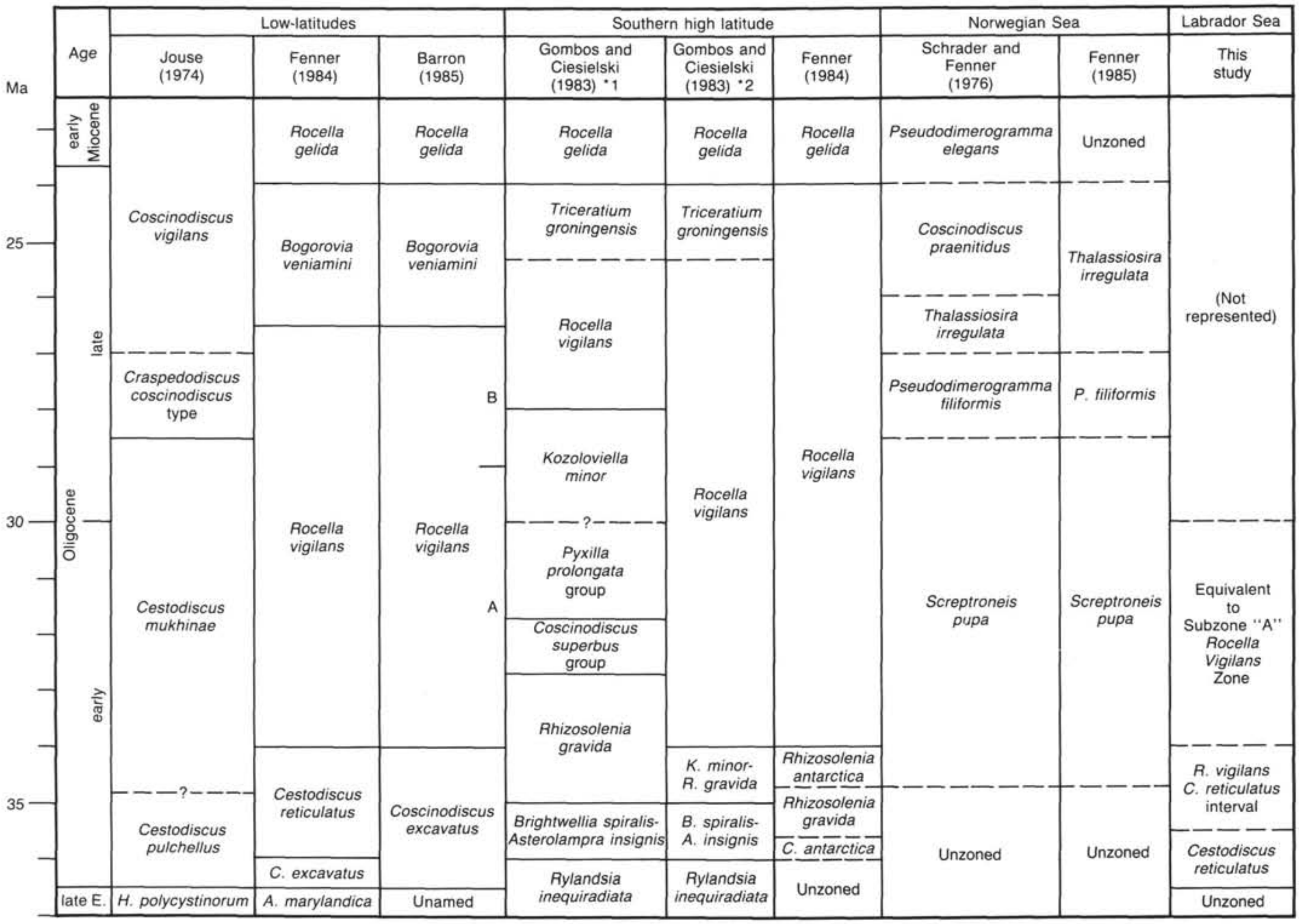

Figure 2. Correlation of the Oligocene diatom zonations previously established for the low latitudes (Jouse, 1974; Fenner, 1984a, 1984b, 1985; and Barron, 1985), the southern high latitudes (Gombos and Ciesielski, 1983; Fenner, 1985), the Norwegian-Greenland Sea (Schrader and Fenner, 1976; Fenner, 1985) with the zonation used during this study for the Labrador Sea sites. *1 indicates correlation of zones following Barron (1985). *2 indicates correlation of the zones following Fenner (1985).

Barron (1985) defined this zone as the total stratigraphic range of *C. excavatus*.

Although intermediate forms of *C. robustus* and *C. reticulatus* were observed during this study, we also observed distinct specimens of *C. reticulatus* consistently. In addition, specimens of *C. excavatus* have a sporadic stratigraphic occurrence at Site 647, which questions the reliability of this marker species. Therefore, here we adhered to the *C. excavatus* and *C. reticulatus* zones of Fenner (1984a).

3. *Rocella vigilans* Zone (Jouse, 1974 modified by Fenner, 1984a). This zone is defined as the interval from the first occurrence of *Rocella vigilans* to the first occurrence of *Bogorovia veniamini*. Barron (1985) modified the base of this zone for use in the equatorial Pacific because poor diatom preservation limited the recognition of the first occurrence of *R. vigilans* at most DSDP Leg 85 sites. He defined the base of this zone as the last occurrence of *C. excavatus*, which at DSDP Site 574 approximates the first occurrence of *R. vigilans*. The *R. vigilans* Zone is subdivided into two subzones separated by either the last occurrence of *Cestodiscus mukhinae* (Barron, 1985) or by the first occurrence of *Rossiella symmetrica* (Fenner, 1985).

4. *Bogorovia veniamini* Zone (Jouse, 1974 modified by Fenner, 1984a). The *Bogorovia veniamini* Zone was orginally defined by Jouse (1974) and later modified by Fenner (1984a) as the interval from the first occurrence of *B. veniamini* to the first occurrence of *Rocella gelida*. This zone is not represented at DSDP Site 112 or ODP Site 647.

5. *Rocella gelida* Zone (Bukry and Foster, 1974, modified by Barron, 1983). The *Rocella gelida* Zone was originally defined by Bukry and Foster (1974) and was later modified by Barron (1983) as the interval from the first occurrence of *Rocella gelida* to the first occurrence of *Rossiella paleacea*. The scarcity of specimens of *R. gelida* in ODP Leg 105 sediments prevented their use as stratigraphic indicators.

High Southern Latitudes

The diatom zonations of Gombos and Ciesielski (1983) and of Fenner (1984a, 1984b, and 1985) are the two primary zonations defined for use in the high southern latitudes (Fig. 2). Whereas Fenner's zonation is somewhat similar to the low-latitude zonations previously discussed, the zonation proposed by Gombos and Ciesielski (1983) is very different. Gombos and Cielsielski (1983) defined 11 diatom zones for the Oligocene (*Rylandsia inaequiradiata* to *Rocella gelida* zones). The majority of these zones are based on species restricted to high lati-

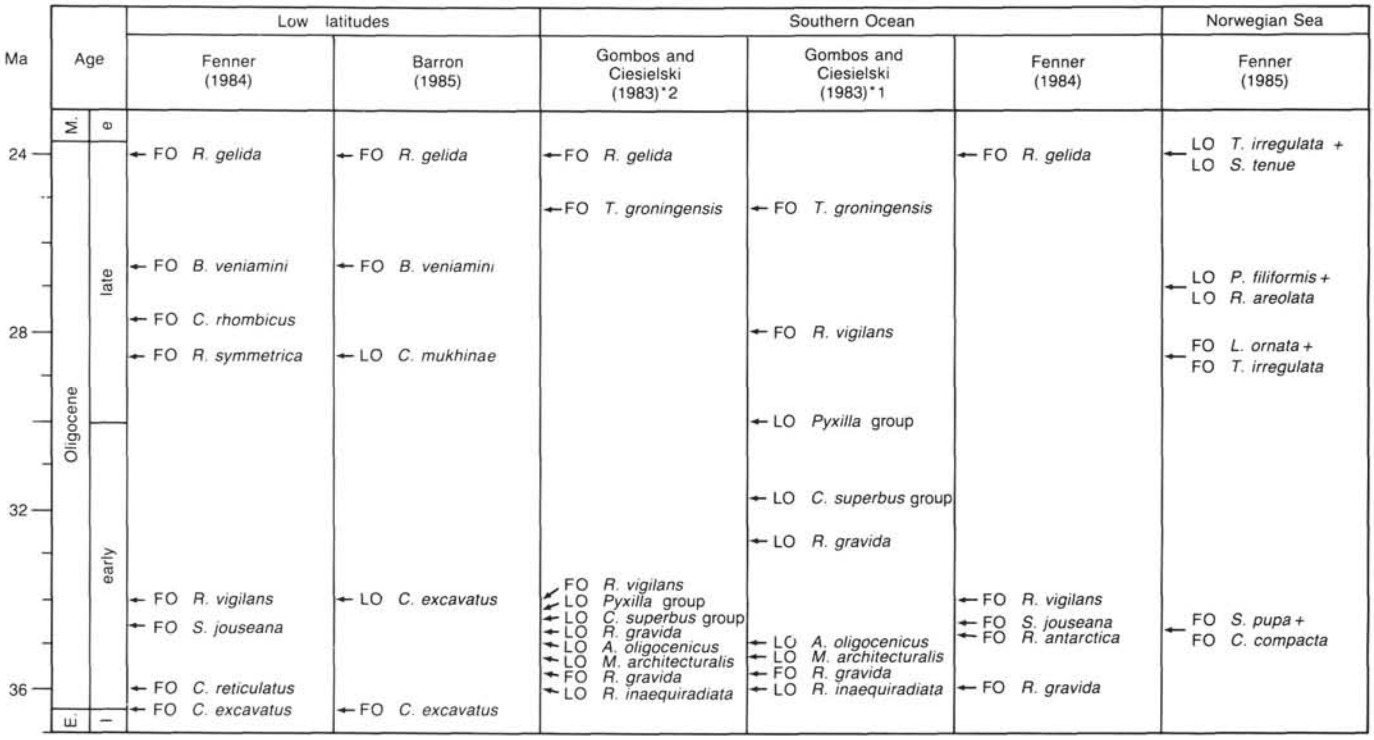

Figure 3. Correlation of the biostratigraphic markers used to define the various diatom zones shown in Figure 2. "FO" represents the first stratigraphic occurrence, "LO" represents the last stratigraphic occurrence of a specific species. *1 indicates correlation of zones following Barron (1985). *2 indicates correlation of the zones following Fenner (1985).

tudes, thereby disallowing direct correlation of these zones to those defined for the low latitudes.

Several of the zonal boundaries defined by Gombos and Ciesielski (1983) are tenuous because there is a difference between the stratigraphic range of several of the marker species reported by Gombos and Ciesielski (1983) and those recorded by Fenner (1984a). For example, the *Brightwellia spiralis* Zone of Gombos and Ciesielski (1983) is defined as the interval from the last occurrence of *Melosira architecturalis* to the first occurrence of *Asteromphalus oligocenicus*. Although Gombos and Ciesielski (1983) indicated that *M. architecturalis* has a last occurrence in the lower Oligocene, Fenner (1984a, 1984b, and 1985) indicated that this species has a last occurrence in the lower Miocene. The high southern latitude zonations of Gombos and Ciesielski (1983) and Fenner (1984a and 1985) are discussed next.

1. *Rylandsia inequiradata* Zone (Gombos and Ciesielski, 1983). This zone is defined by Gombos and Ciesielski (1983) as the interval representing the total stratigraphic range of *Rylandsia inequiradata*. This marker species was not observed at Site 647.

2. *Asterolampra insignis* Zone (Gombos and Ciesielski, 1983). Gombos and Ciesielski (1983) defined this zone as the interval from the last occurrence of *R. inequiradata* to the first occurrence of *Rhizosolenia gravida* (here referred to as *R. oligocaenica*; see Appendix A). Fenner (1984a) combined the *R. inequiradata* and *A. insignis* zones of Gombos and Ciesielski (1983) into the *Cestodiscus antarcticus* Zone for use in the high southern latitudes. She defined this new zone as the interval from the first occurrence of *R. inaquiradata* to the first occurrence of *R. gravida*.

3. *Melosira architecturalis* Zone (Gombos and Ciesielski, 1983). This zone is defined by Gombos and Ciesielski (1983) as the interval from the first occurrence of *R. gravida* to the last occurrence of *Melosira architecturalis*.

4. *Brightwellia spiralis* Zone (Gombos and Ciesielski, 1983). Gombos and Ciesielski defined this zone as the interval from the last occurrence of *Melosira architecturalis* to the first occurrence of *Asteromphalus oligocenicus*. Fenner (1984a and 1985) combined the *M. architecturalis* and *B. spiralis* zones of Gombos and Ciesielski (1983) because of the difference in the stratigraphic range of *M. architecturalis* previously discussed.

5. *Rhizosolenia gravida* Zone (Gombos and Ciesielski, 1983). This zone is defined as the interval from the first occurrence of *A. oligocenicus* to the last occurrence of *R. gravida*.

6. *Coscinodiscus superbus* Group Zone (Gombos and Ciesielski, 1983). Gombos and Ciesielski (1983) defined this zone as the interval from the last occurrence of *R. gravida* to the last occurrence of the *C. superbus* group.

7. *Pyxilla prolongata* Zone (Gombos and Ciesielski, 1983). The *Pyxilla prolongata* Zone is defined by Gombos and Ciesielski (1983) as the interval from the last occurrence of *C. superbus* to the last occurrences of *P. prolongata* and other related *Pyxilla* species. Gombos and Ciesielski suggested that the *Pyxilla* group disappears at an interval equivalent to the lower/upper Oligocene boundary.

8. *Kozloviella minor* Zone (Gombos and Ciesielski, 1983). This zone is defined as the interval from the last occurrences of *P. prolongata* and related *Pyxilla* species to the first occurrence of *Rocella vigilans*. According to Gombos and Ciesielski, *Kozloviella minor* has a stratigraphic occurrence restricted to this zone.

Fenner (1984a) defined three new zones (*Cestodiscus antarctica* to *Rhizosolenia antarctica* zones; Fig. 2) for use in the southern high latitudes for the interval equivalent to the *R. inequiradata* through the *K. minor* zones of Gombos and Ciesielski (1983).

The *Cestodiscus antarctica* Zone of Fenner (1984a) is defined as the interval from the first occurrence of *Rylandsia inequiradata* to the first occurrence of *Rhizosolenia gravida*. This zone is equivalent to the *R. inequiradata* and *A. insignis* zones of Gombos and Ciesielski (1983).

Fenner (1984a) defined the *Rhizosolenia gravida* Zone as the interval from the first occurrence of *R. gravida* to the first occurrence of *Rhizosolenia antarctica*. This zone is equivalent to the *M. architecturalis* Zone to an interval within the *C. superbus* Group Zone of Gombos and Ciesielski (1983).

The *Rhizosolenia antarctica* Zone was defined by Fenner (1984a) as the interval from the first occurrence of *R. antarctica* to the first occurrence of *Rocella vigilans*. This zone is equivalent to an interval within the *Coscinodiscus superbus* Group Zone to the top of the *K. minor* Zone of Gombos and Ciesielski (1983).

9. *Rocella vigilans* Zone (Gombos and Ciesielski, 1983, modified by Fenner, 1984a). Gombos and Ciesielski defined their *Rocella vigilans* Zone as the interval from the first occurrence of *R. vigilans* to the first occurrence of *Triceratium groningensis*. Although they defined the base of this zone at the first occurrence of *R. vigilans*, they suggested that the first common occurrence of *R. vigilans* may eventually prove to be a more reliable stratigraphic marker.

10. *Triceratium groningensis* Zone (Gombos and Ciesielski, 1983). This zone is defined as the interval from the first occurrence of *Triceratium groningensis* to the first occurrence of *Rocella gelida*. Fenner (1984a) combined the *Rocella vigilans* and *Triceratium groningensis* zones of Gombos and Ciesielski into her *Rocella vigilans* Zone for use in the southern high latitudes. Fenner defined this new zone as the interval from the first occurrence of *R. vigilans* to the first occurrence of *Rocella gelida*. The *R. vigilans* Zone as proposed by Fenner (1984a) may allow direct correlation of this high southern latitude zone to the similar zone defined for the low latitudes.

11. *Rocella geilda* Zone (Gombos and Ciesielski, 1983). This zone is defined as the interval from the first occurrence of *R. gelida* to the first occurrence of *Rossiella* sp. In the low latitudes, the top of the *R. gelida* Zone is defined by the first occurrence of *Rossiella paleacea* (Barron, 1983). We correlated the diatom zones of Gombos and Ciesielski (1983) with the low-latitude zonations in two different ways (Fig. 2). Barron (1985) suggested that the *Rhizosolenia gravida* through *Kozolviella minor* zones correlate with the upper part of his *C. excavatus* Zone (*C. reticulatus* Zone of Fenner, 1984a) through the lowermost part of Subzone *b* of the *R. vigilans* Zone.

This correlation was based on the first occurrence of *Synedra jouseana* corresponding with the restricted stratigraphic occurrences of *Kozolovia edita* (in Section 85-574C-26R, CC) and of *K. minor* (in Section 85-574C-21R, CC) in the eastern equatorial Pacific. Barron (1985) indicated that the last occurrence of *Cestodiscus mukhinae* is just below this interval (Section 85-574C-27R, CC) and the first occurrence of *Coscinodiscus rhombicus* is directly above this interval (Section 85-574C-20R, CC), which suggests that this interval is equivalent to Subzone *b* of the *Rocella vigilans* Zone. However, Barron (1985) indicated that diatom preservation in the interval representing the *R. vigilans* Zone is generally poor in the DSDP Leg 85 sediments, especially in the basal part of the zone. The correlation proposed by Barron (1985) suggests that the last occurrence of *Coscinodiscus excavatus* approximates the first occurrence of *Rocella vigilans* and that the first occurrence of *Rocella vigilans* is time transgressive between the low and high southern latitudes (Figs. 2 and 3).

Fenner (1984a, 1984b, and 1985) reexamined sediments from the South Atlantic and suggested that the first occurrence of *R. vigilans* in the high southern latitudes corresponds to its first occurrence in the low latitudes. Fenner (1984a and 1985) correlated the *R. vigilans* Zone as used by Gombos and Ciesielski (1983) to the *R. vigilans* Zone as used by Fenner (1984a and 1985). This caused the *Rhizosolenia gravida* to *Kozlovellia minor* zones of Gombos and Ciesielski (1983) to be restricted to an interval corresponding to the upper part of the *Cestodiscus reticulatus* Zone of Fenner (1984a) and not to the *C. excavatus* to *R. vigilans* zones, as correlated by Barron (1985; see Fig. 2).

Fenner (1984a, 1984b, and 1985) also indicated that the first occurrence of *Synedra jouseana* approximates the upper part of the *C. reticulatus* Zone (Fig. 3). She also suggested that in the lowermost part of its range, *S. jouseana* has a sporadic stratigraphic occurrence and may not be stratigraphically useful. A correlation of the Gombos and Ciesielski (1983) zones to those of the low latitudes, following that of Fenner (1984a), also suggests that the last occurrence of *R. gravida* should correspond to the upper part of the *Cestodiscus reticulatus* Zone and should approximate the first occurrence of *Syndera jouseana*.

NORWEGIAN-GREENLAND SEA

Schrader and Fenner (1976) defined a series of zones (*Screptroneis pupa* through *Coscinodiscus praenitidus* zones) for use in Oligocene sediments of the Norwegian Sea. This zonation was modified by Fenner (1985) because of the endemic nature of several of the marker species and because she noted a possible hiatus at DSDP Site 338, which disallowed the separation of the *Thalassiosira irregulata* and *Coscinodiscus praenitidus* zones defined by Schrader and Fenner (1976). These zonations are discussed next.

1. *Screptroneis pupa* Zone (Schrader and Fenner, 1976 modified by Fenner, 1985). This zone was originally defined as the interval from the first occurrences of *Screptroneis pupa* and *Cymatosira compactata* to the first occurrences of *Triceratium cruciforme* (*Lisitziana ornata*) and *Coscinodiscus praenitidus* (now referred to as *Rocella praenitidus*). Fenner (1985) redefined this zone to represent the interval from the first occurrences of *S. pupa* and *C. compacata* to the first occurrence of *Lisitzinia ornata*.

2. *Pseudodimerogramma filiformis* Zone (Schrader and Fenner, 1976 modified by Fenner, 1985). Schrader and Fenner (1976) defined this zone as the interval from the first occurrences of *T. cruciforme* and *Coscinodiscus praenitidus* to the last occurrences of *Pseudodimerogramma filiformis* and *Rutilaria areolata*. Fenner (1985) modified this zone to represent the interval from the first occurrence of *L. ornata* to the last occurrences of *P. filiformis* and R. *areolata*.

3. *Thalassiosira irregulata* Zone (Schrader and Fenner, 1976 modified by Fenner, 1985). This zone was defined by Schrader and Fenner (1976) as the interval from the last occurrences of *P. filiformis* and *R. areolata* to the last occurrence of *Sceptroneis tenue* and the first occurrence of specimens identified as *Thalassionema hirosakiensis* (but are most likely specimens of *Synedra jouseana*).

4. *Coscinodiscus praenitidus* (Schrader and Fenner, 1976 modified by Fenner, 1985). The base of this zone is defined by Schrader and Fenner (1976) as the last occurrence of *Sceptroneis caducea* and the first occurrence of *T. hirosakiensis*. The top of this zone was defined as the last occurrences of *Actinoptychus thumii, Asteromphalus oligocenicus, A. symmetricus, Cymatosira compactata, Pseudodimerogramma oligocenicus, Pseudotriceartium oligocenica, Pseudotriceratium chenevieri, Rhizosolenia pokrovskaja, Screptroneis humincia, S. propinqua, Coscinodiscus praenitidus* (now referred to as *R. praenitida*), *Synedra miocenica*, and *Thalassiosira irregulata*. The large number of last occurrences present at this specific level of DSDP Hole 338 suggests a possible hiatus at this interval. Reinvestigation of this interval by Fenner (1985) indicated that the last occurrence of *S. tenue* coincides with the last occurrences of *R. praenitida* and *T. irregulata*, thereby inhibiting the separation of

the *T. irregulata* Zone from the *C. praenitidus* Zone. Thus, Fenner combined these two zones into the *T. irregulata* Zone, which she defined as the interval from the last occurrences of *P. filiformis* and *R. areolata* to the last occurrences of *S. tenue* and *T. irregulata*.

BIOSTRATIGRAPHY

Site 647

Well-preserved and common diatoms were observed in samples examined from Cores 105-647A-13R through 105-647A-27R. Diatoms were sporadic and generally rare in samples examined from below Core 105-647A-27R (260.1 meters below seafloor [mbsf]) and virtually absent from samples examined from Cores 105-647A-1R through 105-647A-12R (0–116.0 mbsf). The diatom assemblage observed in Cores 105-647A-13R through 105-647A-27R is composed of species characteristic of the low latitudes, the high southern latitudes, and the Norwegian-Greenland Sea. The occurrence of such a mixture of species allowed us to recognize many of the zones previously discussed. However, the limited stratigraphic occurrence of the primary marker species meant that we often relied on the secondary markers for zonal assignment or stratigraphic correlations.

Secondary stratigraphic indicators are usually useful for determining the stratigraphic relationship of a specific sequence; however, the limited number of Oligocene sequences containing a biogenic silica component required that additional sections be recovered and examined to determine the stratigraphic and chronologic extent of the majority of these secondary markers.

The stratigraphic occurrence and range of selected species are illustrated in Table 1 and Figure 4. The occurrence of *Cestodiscus reticulatus* in Section 105-647A-27R, CC through Sample 105-647A-23R-4, 100–102 cm, suggests that this interval is equivalent to the *C. reticulatus* Zone of Fenner (1984a) and the *Coscinodiscus excavatus* Zone of Barron (1985). The occurrence of *Coscinodiscus excavatus* in Section 105-647A-25R, CC through Sample 105-647A-23R-4, 100–102 cm, supports this zonal assignment. The sporadic stratigraphic occurrence of *Coscinodiscus excavatus* and the sparse occurrence of *Rocella vigilans* inhibited our use of these primary markers for identifying the top of the *Cestodiscus reticulatus* Zone of Fenner (1984a) or the *Coscinodiscus excavatus* Zone of Barron (1985).

Barron (1985) indicated that the last occurrence of *C. excavatus* coincides wih the first occurrence of *R. vigilans* in the equatorial Pacific. If the same stratigraphic relationship holds true in the Labrador Sea, then the last occurrence of *C. excavatus* in Sample 105-647A-23R-4, 100–102 cm, may mark the top of the *C. reticulatus* Zone of Fenner (1984a). Such a stratigraphic placement of this zonal boundary is also suggested by the last occurrence of *C. reticulatus* in the same sample. Fenner (1978, 1984a, and 1984b) indicates that the last occurrence of *C. reticulatus* approximates the first occurrence of *R. vigilans* and the top of the *C. reticulatus* Zone in the low latitudes.

Based on the occurrence of *C. excavatus* and *C. reticulatus*, the top of the *C. reticulatus* Zone should approximate the level of Sample 105-647A-23R-4, 100–102 cm. This also suggests that the interval immediately above Sample 105-647A-23R-4, 100–102 cm should be equivalent to the lowermost part of the *R. vigilans* Zone. The *C. excavatus/R. vigilans* zonal boundary was correlated by Barron et al. (1985) with the lower part of the *Sphenolithus distentus* Calcareous Nannofossil Zone (CP18) in the equatorial Pacific (Fig. 5). Fenner (1984a and 1984b) likewise correlated the *C. reticulatus/R. vigilans* zonal boundary to the *Sphenolithus distentus* Calcareous Nannofossil Zone. In the Leg 105 material, however, the last occurrence of *C. excavatus* and *C. reticulatus* (in Sample 105-647A-23R-4, 100–102 cm) correlates with the upper part of the *Reticulofenestra hillae* Calcareous Nannofossil Zone (NP22, CP16c) determined by Firth (this volume; Fig. 5). Differences in the correlation of the diatom and calcareous nannofossil zones in this study with those previously completed for the low latitudes suggest either that the *C. reticulatus/R. vigilans* boundary should occur stratigraphically higher in Hole 647A or that the species used to identify this boundary in Hole 647A may be diachronous between the low and high latitudes.

Fenner (1984a, 1984b, and 1985) placed the first occurrence of *Synedra jouseana* in the upper part of the *C. reticulatus* Zone. In addition, correlations of the Norwegian Sea diatom zones with the low latitude zones suggest that first occurrence of *Screptroneis pupa* and the last occurrence of *Rhizosolenia gravida* (= *R. oligocaenica*) also can be placed in an interval corresponding to the uppermost part of the *C. reticulatus* Zone.

Screptroneis pupa was observed only in samples from Core 105-647A-23R (see Table 1 and Fig. 4). Although this was a restricted occurrence, its presence suggests that Core 105-647A-23R may be equivalent to the *S. pupa* Zone of Fenner (1984a). Assuming that the stratigraphic occurrence of this species is equivalent to its occurrence in the Norwegian Sea also suggests that Core 105-647A-23R may be equvalent to or younger than the uppermost part of the *C. reticulatus* Zone.

The first occurrence of *Synedra jouseana* was observed in Sample 105-647A-20R-1, 48–50 cm. This first occurrence is sporadic and its usefulness as a primary marker is questionable. Fenner (1985) recorded the first occurrence of *S. jouseana* below the first occurrence of *Rocella vigilans* at a horizon equivalent to the uppermost part of the *C. reticulatus* Zone in the low latitudes. Fenner (1984a and 1984b) correlated this interval with the upper part of the *Sphenolithus distentus* Calcareous Nannofossil Zone (CP18). In DSDP Hole 513A in the South Atlantic, Gombos and Ciesielski (1983) also recorded the first occurrence of *Synedra jouseana* below the first occurrence of *Rocella vigilans* and at an interval equivalent to the base of their *K. minor* Zone. This interval in Hole 513A is also equivalent to the middle part of the *Stephenolithus distentus* Calcareous Nannofossil Zone (CP18), as determined by Wise (1983; Fig. 5). However, Barron (1985) indicated that in the equatorial Pacific the first occurrence of *Synedra jouseana* was observed stratigraphically above the first occurrence of *R. vigilans* and at an interval approximating the *a/b* subzone boundary of the *Rocella vigilans* Zone. This interval is correlated by Barron et al. (1985) with the lower part of the *Sphenolithus ciperoensis* Calcareous Nannofossil Zone (CP19) (Fig. 5). Schrader (1978) also recorded the first occurrence of *S. jouseana* above the first occurrence of *R. vigilans* in DSDP Hole 369A in the equatorial Atlantic and at an interval equivalent to the *Sphenolithus ciperoensis* Zone.

This discussion illustrates that additional stratigraphic studies should be completed to determine the stratigraphic usefulness of the first occurrence of *S. jouseana* between the low and high latitudes. The most likely explanation of the stratigraphic differences that exist when placing the first occurrence of this species is taxonomic confusion and uncertainty of intermediate forms of *S. jouseana* and *S. miocenica*.

If the first occurrence of *S. jouseana* observed during this study is similar to its stratigraphic range recorded by Fenner (1984a, 1984b, and 1985) for the low and high southern latitudes, then the top of the *C. reticulatus* Zone should correlate with a level just above Sample 105-647A-20R-1, 48–50 cm. If the stratigraphic position of *S. jouseana* is similar to that recorded by Barron (1985), then Sample 105-647A-20R-1, 48–50 cm, should correlate with the *Rocella vigilans* Zone.

Asterolampra schmidtii occurs in the majority of samples examined from Cores 105-647A-26R through 105-647A-20R. In the high southern latitudes (DSDP Hole 513A), this species has a consistent stratigraphic occurrence in the interval assigned by Gombos and Ciesielski (1983) to the *Coscinodiscus superbus* Group Zone and the *Pyxilla prolongata* Zone. Both the last occurrence of *A. schmidtii* and the first occurrence of *S. jouseana* are equivalent to the *S. distentus* Calcareous Nannofossil Zone (CP18) as determined by Wise (1983) in Hole 513A (Fig. 5).

The first occurrence of *S. jouseana* and the last occurrence of *A. schmidtii* were recorded in Sample 105-647A-20R-1, 48–50 cm, and correlated with undifferentiated calcareous nannofossil zones CP17 and CP18, based on the calcareous nannofossil stratigraphy of Firth (NP23; this volume; Fig. 5). Differences in stratigraphic correlation of the diatom zonations between the low and high latitudes (as discussed above) and the inability to complete direct correlations with other diatom zonations prevented us from determining the exact zonal placement of this interval (Sections 105-647A-23R-4 to 105-647A-20R-1). Correlations following Barron (1985) suggest that this interval is equivalent to Subzone *a* of the *Rocella vigilans* Zone and correlations following Fenner (1985) suggest that this interval is equivalent to the upper portion of the *C. reticulatus* Zone.

The last occurrence of *R. oligocaenica* (= *R. gravida*) is found in Section 105-647A-17R, CC. This sample correlates with calcareous nannofossil zones CP17 and CP18 (NP23; Firth, this volume; Fig. 5). Gombos and Ciesielski (1983) used the last occurrence of *R. gravida* (= *R. oligocaenica*) to define the top of their *R. gravida* Zone. This zone was calibrated in DSDP Hole 513A to the *Blackites spinosa* Calcareous Nannofossil Zone (correlated with zone CP16c) determined by Wise (1983) (Fig. 5), which indicates that this stratigraphic event occurs later (younger) in the northern high latitudes than in the southern high latitudes.

The above stratigraphic argument suggests that the *Cestodiscus reticulatus* Zone can be recognized in samples from Core 105-647A-27R to Section 105-647A-23R-4 and that the marker species for this zone may be diachronous between the low and high northern latitudes. The above argument also suggests that the interval from Sections 105-647A-23R-4 to 105-647A-20R-1 is equivalent to either the upper portion of the *C. reticulatus* Zone or to Subzone *a* of the *R. vigilans* Zone. Here, we assign Cores 105-647A-23R-4 through 105-647A-20R-1 to an interval referred to as the *Cestodiscus reticulatus/Rocella vigilans* Interval.

Cores 105-647A-19R through 105-647A-15R were not assigned to zones, but are thought to be equivalent to the lower part of the *Rocella vigilans* Zone, assuming continuous sedimentation and relying on stratigraphic correlation between ODP Site 647 and DSDP Site 112 (see below). We suggest that a break in the stratigraphic record (encompassing the upper Oligocene) occurs in Core 105-647A-14R, based on the change from well-preserved diatoms below this interval to diatoms with poor preservation above and by the last occurrences of *S. jouseana, R. praenitida*, and *M. architecturalis* in this core, all of which should range into the lowermost Miocene. Such a break may explain the single specimen of *Rocella gelida* observed in Sample 105-647A-14R-3, 6–8 cm. The occurrence of this specimen may have resulted from winnowing of the sediments by bottom currents.

The occurrence of *Coscinodiscus lewisianus* in Sample 105-647A-13R-5, 109–111 cm, and Section 105-647A-13R, CC and *Rocella gelida* in Sample 105-647A-14-3, 6–8 cm suggest that this interval is equivalent to the uppermost Oligocene or lowermost Miocene. The first occurrence of *C. lewisianus* was placed by Fenner (1985) in an interval equivalent to the upper part of the *R. vigilans* Zone. This species has a sporadic occurrence in the lower part of its stratigraphic range and thus is not stratigraphically useful. No other stratigraphic markers were observed in this interval. Samples examined from the upper part of Core 105-647A-13R contained only rare diatoms that were not age diagnostic.

DSDP Site 112

Deep Sea Drilling Project Site 112 is located at 54°01.00′N, 46°36.24′W, at a water depth of 3657 m and approximately 60 nmi northwest of ODP Site 647. A stratigraphic sequence similar to that recovered from Site 647 also was recovered from Site 112. Whereas a nearly continuous sequence was recovered from Hole 647A, only a partial sequence was recovered from Hole 112. This is a result of time constraints during Leg 12. To reach the deeper stratigraphic objectives at Site 112, the stratigraphic sequence was spot cored (i.e., one core was attempted every 50 m, during which the sediment between any given two cores was washed away without any recovery attempt).

Burckle (in Laughton, Berggren, et al., 1972) completed a preliminary examination of the diatoms recovered from Site 112. His initial findings indicated that the diatom assemblage was dominated by 10 to 15 different species, with *Stephanopyxis turris* noted as being the most common. He further noted a predominance of robust species and considerable breakage on the frustules, which he attributed to transportation of the sediment laterally over some distance. Although the siliceous interval at Site 112 (Cores 12-112-5R through 12-112-11R) was not assigned to a specific diatom zone, Burckle (in Laughton, Berggren, et al., 1972) assigned this interval a late Eocene to early Oligocene age.

Table 2 and Figure 6 show the stratigraphic occurrence and range of selected species in samples from Site 112 examined during this study. Diatoms occur only in samples taken from Cores 12-112-5R through 12-112-11R. The abundance and preservation of the diatom assemblage in this interval is somewhat similar to that described by Burckle (in Laughton, Berggren, et al., 1972).

Primary biostratigraphic markers are rare at Site 112, which required both the use of secondary markers and the stratigraphic results at Site 647 for biostratigraphic control. The overlap in the stratigraphic range of *Asterolampra schmidtii* and *Synedra jouseana* observed in Hole 647A (Sample 105-647A-20R-1, 48–50 cm) can also be seen in Core 12-112-11R (Samples 12-112-11R-1, 108–112 cm, and 12-112-11R-2, 108–112 cm), which suggests that Core 12-112-11R correlates with the upper part of Core 105-647A-20R (Fig. 7). This correlation suggests that Core 12-112-11R can be assigned to the *Cestodiscus reticulatus—Rocella vigilans* Interval, as recognized in Hole 647A. This correlation also suggests that the numerous forms of *Cestodiscus* and the common occurrence of both *Hemiaulus* and *Pyxilla* directly below the *A. schmidtii–S. jouaseana* overlap interval in Hole 647A occur stratigraphically below Core 12-112-11R (Fig. 7).

The last occurrence of *Rhizosolenia oligocaenica* is placed in Sample 12-112-11R-1, 108–112 cm (Fig. 6), equivalent to the interval of stratigraphic overlap of *S. jouseana* and *A. schmidtii.* In Hole 647A the last occurrence of *R. oligocaenica* is placed just above the interval of stratigraphic overlap. This slight difference (about 15 m, assuming equal sedimentation rates between Holes 112 and 647A) results either from the sporadic occurrence of *R. oligocaenica* near the top of its stratigraphic range (see Fig. 4) or from the poor recovery of sediment from Core 12-112-10R (see Fig. 6).

Cores 12-112-9R through 12-112-5R are tentatively correlated with Cores 105-647A-19R through 105-647A-14R, based on the similarity of the overall diatom assemblage between the two holes (Fig. 7). Although this correlation is tentative, it does suggest that Cores 12-112-9R to 12-112-5R are equivalent to the lowermost part of the *R. vigilans* Zone. Specimens of *R. vigi-*

Table 1. Stratigraphic occurrence of selected species from Hole 647A.

Hole 647A	Abundance	Preservation	*Actinocyclus curvatulus*	*A. divisus*	*A. ehrenbergii*	*Actinoptychus senarius*	*A. splendens*	*A. thumii*	*Arachnoidiscus* Group	*Asterolampra marylandica*	*Asterolampra* cf. *praeacutiloba*	*A. punctifera*	*A. schmidtii*	*A. symmetricus*	*Asterolampra* sp. 1	*Asteromphalus oligocenicus*	*Asteromphalus* sp. 1	*Azpeitia oligocenica*	*A. tuberculata* var. *atlantica*	*A. vetusrissima*	*A. voluta*	*Cestodiscus pulchellus*	*C. reticulatus*	*C. robustus*	*Cestodiscus* sp. 2	*Cestodiscus* sp. 3	*Cestodiscus* sp. 4	*Cestodiscus* sp. 5	*Cestodiscus* sp. 6	*Cestodiscus* sp. 7	*Cestodiscus* sp. 8	*Cestodiscus* sp. 9	*Cestodiscus* sp. 10	*Cocconeis vitrea*	*Coscinodiscus argus*	*C. asteromphalus*	*C. asteromphalus* var. *princeps*	*C. excavatus*	*C. lewisianus*
13-1, 119-121 cm	R	M	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
13-2, 109-111 cm	R	M	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
13-3, 111-113 cm	R	M	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
13-4, 109-111 cm	R	M	R	—	R	R	—	—	—	—	—	—	—	—	—	—	—	R	—	—	—	R	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	R
13-5, 109-111 cm	R	P	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
13, CC	R	P	R	—	—	R	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R
14-1, 50-52 cm	F	P	—	—	—	R	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
14-2, 50-52 cm	F	M	R	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
14-3, 6-8 cm	C	M	R	—	R	F	—	—	—	—	—	—	—	—	—	—	—	R	—	—	R	R	—	—	—	—	—	—	—	—	—	R	—	R	—	R	—	—	—
14, CC	F	M	—	—	R	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—
15-1, 124-126 cm	C	M	—	R	—	F	—	—	—	—	—	—	—	—	R	R	—	F	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	F	—	—	—
15-2, 124-126 cm	C	M	—	R	—	F	—	—	—	—	—	—	—	—	—	R	—	F	—	—	—	R	—	—	R	—	—	—	—	—	—	—	—	—	—	F	—	—	—
15-3, 49-51 cm	C	M	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R	—	—	—
15, CC	C	M	—	—	R	F	—	—	—	—	—	—	—	—	—	R	—	F	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	R	R	—	—
16-1, 49-51 cm	F	M	—	R	R	R	—	—	R	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	R	—	—	—	R	—	—	—
16-2, 39-41 cm	C	M	—	R	R	R	—	—	—	R	—	—	—	—	—	R	—	R	R	—	—	—	—	R	—	R	R	—	R	—	—	R	—	—	—	R	—	—	—
16, CC	F	P	—	R	R	R	—	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R	—	—	R	—	—	—	—
17-1, 128-130 cm	C	M	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
17-3, 128-130 cm	C	M	—	—	—	F	—	—	—	—	—	—	—	—	—	—	—	F	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
17-4, 116-118	F	P	—	—	—	F	—	—	—	—	—	—		—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	R	—	—	R	—	—	—	—	—	—	—
17-5, 125-127 cm	C	M	—	—	—	F	—	—	—	—	—	—	—	—	—	—	—	F	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	F	R	—	—
17, CC	C	M	—	R	—	R	—	—	—	—	—	—	—	—	—	—	—	F	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	F	R	—	—
18-1, 50-52 cm	C	M	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	R	—	—	R	—	—	—	—	—	—	—	R	—	—	R	—	—	—	—	—	—	—
18-2, 48-50 cm	C	M	—	R	—	R	—	—	—	—	—	—	—	—	—	—	—	R	—	R	—	—	—	—	—	—	R	R	—	—	—	R	—	—	R	—	R	—	—
18, CC	F	P	—	R	R	R	—	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R	—	—	—	R	—	—	—
19-1, 125-127 cm	A	M	—	—	—	F	—	—	—	—	—	—	—	—	—	R	—	F	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R	—	—
19-3, 125-127 cm	A	M	—	R	—	F	—	—	—	—	—	—	—	—	—	—	—	F	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	R	—	—	—
19-5, 124-126 cm	A	M	—	—	—	C	—	—	—	—	—	—	—	—	—	R	—	F	—	—	—	—	—	—	F	—	—	—	—	—	—	—	—	—	—	—	R	—	—
19, CC	A	M	—	R	—	R	R	—	—	—	—	—	—	—	—	R	—	F	—	—	—	—	—	—	F	—	—	—	—	—	—	—	—	—	—	R	R	—	—
20-1, 48-50 cm	C	M	—	R	R	R	—	—	R	—	R	—	F	—	—	R	R	R	R	R	R	—	—	R	—	—	—	—	—	—	—	R	—	—	—	R	R	—	—
20-3, 52-54 cm	C	M	—	R	—	R	—	—	—	—	R	—	—	R	—	R	—	R	—	—	—	—	—	R	R	—	R	—	—	—	—	—	—	—	—	—	R	—	—
20-5, 50-52 cm	A	M	—	—	—	R	—	—	—	—	R	—	R	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R	—	—	—
20, CC	C	M	—	R	—	R	—	—	—	—	—	—	R	—	—	—	R	R	—	—	—	R	—	—	—	—	—	—	—	—	—	R	—	R	R	—	—	—	—
21-1, 124-126 cm	A	G	—	—	—	F	—	—	—	—	—	—	R	—	—	R	—	F	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—
21-2, 124-126 cm	A	M	—	—	—	F	—	—	—	—	—	—	—	R	—	R	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—
21-3, 124-126 cm	A	G	—	—	—	F	—	—	—	—	—	—	—	—	—	R	—	F	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	R	—	—	—
21, CC	A	G	—	—	—	F	—	—	—	—	—	—	—	—	—	—	—	F	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
22, CC	A	M	—	R	—	R	—	—	R	—	—	—	R	—	—	R	R	F	—	—	R	—	—	—	—	—	—	—	R	R	—	R	—	—	—	R	—	—	—
23-1, 104-106 cm	A	G	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
23-2, 101-103 cm	A	G	—	—	—	R	—	—	—	—	—	R	—	—	—	—	—	R	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	R	—	—	—
23-3, 57-59 cm	A	M	—	—	—	R	—	—	—	R	—	—	—	—	—	—	—	R	—	—	—	R	—	R	—	—	—	—	R	—	R	R	—	—	—	—	—	—	—
23-4, 100-102 cm	A	G	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	R	—	—	—	—	R	R	R	—	—	—	—	—	—	—	—	—	—	—	—	R	—
23-5, 102-104 cm	A	G	—	—	—	F	—	—	—	—	—	R	—	—	—	—	—	R	—	—	—	—	—	R	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—
23, CC	A	G	—	—	—	F	—	—	—	—	—	—	—	—	—	—	—	F	—	—	—	—	F	F	—	—	—	—	—	—	—	—	—	—	—	F	—	—	—
24-2, 83-85 cm	A	M	—	R	—	R	—	—	—	—	—	—	R	—	—	R	R	—	—	—	—	—	—	R	—	—	—	—	R	—	—	R	R	—	R	—	R	—	—
23-3, 86-88 cm	A	M	—	—	—	R	—	—	—	—	—	—	—	R	—	R	R	R	—	—	—	—	—	R	—	—	—	—	R	—	—	—	R	—	—	R	—	—	—
24-4, 86-88 cm	A	M	—	R	R	R	—	—	—	—	R	—	—	R	—	R	—	R	—	—	—	R	R	R	—	—	—	R	R	—	—	—	R	—	R	R	—	—	—
24, CC	A	M	—	R	R	R	—	R	R	R	—	—	—	—	—	—	F	R	—	—	—	R	R	R	R	R	—	—	R	—	—	R	—	—	—	R	—	R	—
25-1, 120-122 cm	C	M	—	—	—	R	—	—	—	R	—	—	—	R	—	—	—	R	—	—	R	R	R	—	—	—	—	—	—	—	—	R	—	—	R	—	—	—	—
25-2, 120-122 cm	A	G	—	—	—	F	—	—	—	—	—	—	—	—	R	—	—	F	—	—	—	—	R	R	—	—	—	—	—	—	R	—	—	—	—	R	—	—	—
25-3, 120-122 cm	C	M	—	—	—	R	—	—	—	—	—	—	—	—	—	R	—	R	—	—	—	R	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—
25-4, 119-120 cm	A	G	—	—	—	R	—	—	—	—	—	R	—	—	R	—	—	F	—	—	—	—	R	R	—	—	—	—	—	—	—	—	—	—	—	F	—	—	—
25-5, 119-120 cm	A	M	—	—	—	R	—	—	—	—	—	—	—	—	—	R	—	F	—	—	R	—	R	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—
25, CC	A	G	—	—	—	F	—	—	—	—	—	—	—	—	—	?	—	C	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R	—	R	—
26, CC	C	M	—	R	—	R	—	—	—	—	—	—	R	R	—	R	—	R	—	R	R	R	—	R	—	—	—	R	—	—	—	—	R	—	R	R	R	R	—
27, CC	C	M	—	—	—	R	—	—	—	—	—	—	—	—	—	?	—	F	—	—	—	—	R	R	—	—	—	—	—	—	—	—	—	—	—	R	—	—	—
28, CC	F	M	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
29, CC	C	M	—	—	—	R	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	R	—	—	—

Species abundance is recorded as abundant (A), common (C), few (F), rare (R), not observed (—). Preservation is recorded as good (G), moderate (M), and poor (P).

lans observed in Core 12-112-5R (Table 2) support such a zonal assignment. The occurrence of *Goniothecium decoratum, Melosira architecuralis*, and *Rocella praenitida* in samples from this interval at Sites 112 and 647 also support this stratigraphic placement.

Micropaleontologic studies for DSDP Leg 12 (Laughton, Berggren, et al., 1972) tentatively placed Cores 12-112-11R to 12-112-7R in the lower Oligocene and Cores 12-112-5R and 12-112-6R in the upper Oligocene. The revised diatom stratigraphy completed during this study suggests a similar stratigraphic placement.

Stratigraphic studies completed for Leg 12 (Laughton, Berggren, et al., 1972) also place an unconformity midway between the base of Core 12-112-4R (209 mbsf) and the top of Core 12-

Table 1 (continued).

C. lineatus	*C. marginatus*	*C. obscurus*	*C. oculis-iridis*	*C. radiatus*	*C. symbolophorous*	*Coscinodiscus* sp. 1	*Coscinodiscus* sp. 2	*Coscinodiscus* sp. 3	*Coscinodiscus* sp. 4	*Coscinodiscus* sp. 5	*Coscinodiscus* sp. 6	*Coscinodiscus* sp. 7	*Craspedodiscus* sp. 1	*Cymatosira biharensis*	*C. compactata*	*Ethmodiscus* sp.	*Goniothecium decoratum*	*G. odontella*	*Goniothecium* sp. 1	*Goniothecium* sp. 2	*Hemiaulus crenulatus*	*H. hostilis*	*H. kittonii*	*Hemiaulus* cf. *malleolus*	*H. polycystinorum*	*H. porteus*	*H. pungens*	*H. subacutis*	*H. taurus*	*Hemiaulus* sp. 1	*Hemiaulus* sp. 2	*Hemiaulus* sp. 3	*Hemiaulus* sp. 4	*Hemiaulus* sp. 5	*Hemiaulus* sp. 6	*Hemiaulus* sp. 7	*Hemiaulus* sp. 8	*Hyalodiscus detatus*	*H. szurdokpuespokiensis*	*Hyalodiscus* sp. 1	*Liradiscus bipolaris*	*Melosira architecturalis*	*M. clavigeria*
—	—	—	—	—	—	—	—	—	—	—	—		—	—	—	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—		—	—	—	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
R	—	—	—	—	—	—	—	—	—	—	—		—	—	—	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
R	R	—	R	—	—	—	—	—	—	—	—		—	—	—	R	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
R	—	—	—	—	—	—	—	—	—	—	—		—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
R	R	—	R	—	—	—	—	—	—	—	—		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
R	—	—	—	—	—	—	—	—	—	—	—		—	—	—	R	—	—	—	R	—	—	—	—	R	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R
R	R	—	—	R	—	—	—	—	—	—	—		—	—	—	F	R	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
F	R	R	R	—	—	—	—	—	—	—	—		—	R	—	C	F	—	—	—	—	—	—	R	R	—	—	—	—	—	R	—	R	—	—	—	—	—	—	—	—	R	—
R	—	—	—	—	—	—	—	R	—	—	—		—	—	—	R	R	R	R	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R	—	R	R
R	—	—	—	R	—	—	R	—	—	—	—		—	—	—	—	F	F	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	R	—	—
—	—	R	—	R	—	—	—	—	—	—	—		—	—	—	—	R	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R	—	—
R	—	R	—	—	—	—	—	—	—	—	—		—	—	—	—	R	R	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R	—
R	—	R	R	—	—	—	—	—	—	—	—		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R	R	—
F	—	R	—	—	—	—	—	—	—	—	—		—	—	—	—	R	—	R	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	R	—	—	R	R	—	—	—	—
R	—	R	—	R	—	—	—	—	R	—	—		—	—	R	—	R	—	R	—	—	—	—	R	R	—	—	—	—	R	—	R	—	—	—	—	—	—	—	—	—	—	—
F	—	—	—	—	—	—	—	—	—	—	—		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
R	—	—	F	R	—	—	—	—	—	—	—		—	—	—	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
R	—	R	—	—	—	—	—	—	—	—	—		—	—	—	—	—	—	—	—	—	—	—	—	R	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	R	R	—
—	R	—	—	R	—	—	R	—	—	—	—		R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R	—
R	R	R	—	—	—	—	—	—	—	—	—		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R	—
R	R	R	—	—	—	—	—	—	—	—	—		—	—	—	—	—	—	—	—	—	—	—	R	F	—	—	—	—	—	—	—	—	—	R	—	—	—	R	—	—	—	R
R	R	R	—	R	—	—	—	—	—	—	—		—	—	—	—	—	—	—	—	—	—	R	R	R	R	—	—	—	—	—	—	R	R	—	—	—	—	—	—	—	R	—
F	—	—	R	—	—	—	—	—	—	—	—		—	—	—	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—	R	—
F	F	R	—	R	—	—	—	—	—	—	—		—	—	—	—	—	—	—	—	—	—	—	—	F	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
R	—	R	—	—	—	—	—	—	—	—	—		—	—	—	—	—	—	—	—	R	R	—	—	F	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R	—
F	F	R	—	R	—	—	—	—	—	—	—		—	—	—	—	—	—	—	—	—	—	—	—	R	—	—	—	R	—	—	R	—	—	—	—	—	—	—	—	—	R	—
—	—	—	R	—	—	—	—	—	—	—	—		—	—	—	—	—	—	—	—	—	R	—	—	F	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R	—
F	—	F	R	R	—	—	—	R	R	R	—		—	—	—	R	—	—	—	—	—	—	R	R	F	—	—	—	—	—	—	—	R	R	—	—	—	—	—	R	—	R	—
R	R	—	—	R	—	—	—	—	R	—	—		—	—	—	—	—	—	—	—	—	—	R	R	C	—	—	—	—	—	—	R	R	R	—	—	R	—	—	—	—	R	—
R	R	R	R	—	—	—	—	—	—	—	—		—	—	—	—	—	—	—	—	—	—	—	—	F	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R	—	—	—
R	—	R	R	—	—	—	—	—	—	—	—		—	—	—	—	—	—	—	—	—	—	R	R	C	—	—	—	—	R	—	—	R	—	R	—	—	R	—	—	—	—	—
F	F	—	C	—	—	R	—	—	—	—	—		—	—	—	—	—	—	—	—	—	—	R	—	C	—	—	—	—	R	R	—	—	—	—	—	—	—	—	—	—	R	—
R	R	—	—	—	—	—	—	—	—	—	—		—	—	—	—	—	—	—	—	—	—	R	—	F	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
F	—	—	F	R	—	—	—	—	—	—	—		—	—	—	—	—	—	—	—	R	—	R	—	C	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R	—
R	—	R	F	—	—	—	—	—	—	—	—		—	—	—	—	—	—	—	—	—	—	—	—	F	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	R	—
R	R	R	R	R	—	—	—	—	R	—	R		—	—	—	—	—	—	—	—	—	—	—	—	F	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	R	—
R	R	R	R	—	—	—	—	—	—	—	—		—	—	—	—	—	—	—	—	R	—	—	—	R	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	R	—	—	—	—	—	—	—		—	—	—	—	—	F	—	—	R	—	R	—	R	—	—	—	—	R	R	—	R	—	—	—	—	—	—	—	—	—	—
R	—	—	—	—	—	—	—	—	—	—	—		—	—	—	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—
R	R	—	F	—	—	—	—	—	—	—	—		—	—	—	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
R	R	F	C	R	—	—	—	—	—	—	—		—	—	—	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R	—	—
F	—	F	F	R	—	—	—	—	—	—	—		—	—	—	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
R	—	—	—	R	—	—	—	R	—	R	—		—	—	—	—	—	R	—	—	R	—	—	R	R	—	—	—	—	—	—	R	R	—	—	—	—	—	—	—	—	R	R
R	R	R	R	R	—	—	—	—	—	R	—		—	—	—	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—
F	—	—	—	R	—	—	—	—	—	—	—		—	—	—	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
C	R	—	R	R	—	—	—	—	—	—	—		—	—	—	—	—	—	—	—	R	—	R	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R	—
R	—	—	—	—	—	—	—	—	—	—	—		—	—	—	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
F	—	—	F	R	—	—	—	—	—	—	—		—	—	—	—	—	R	—	—	—	—	—	—	F	R	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—
R	—	R	—	—	—	—	—	—	—	—	—		—	—	—	—	—	—	—	—	—	—	R	—	R	—	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—	R	—
R	—	F	C	R	—	—	—	—	—	—	—		—	—	—	—	—	—	—	—	R	—	R	—	F	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	R	R	—
F	—	R	—	—	—	—	—	—	—	—	—		—	—	—	—	—	—	—	—	R	—	R	—	C	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
F	F	F	F	—	—	—	—	—	—	—	—		—	—	—	—	—	—	—	—	—	—	R	—	F	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R	—
F	R	R	R	R	—	—	—	—	—	—	—		—	—	—	—	—	—	—	—	R	—	R	—	F	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R	—
R	R	—	F	R	—	—	—	—	—	—	—		—	—	—	—	—	—	—	—	—	—	—	—	F	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
R	—	—	—	R	—	—	—	—	—	—	—		—	—	—	—	—	—	—	—	—	—	—	—	F	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
F	—	R	F	—	—	—	—	—	—	—	—		—	—	—	—	—	—	—	—	—	—	—	—	F	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

112-5R (270 mbsf). Stratigraphic correlation between Sites 112 and 647 suggests that the hiatus at Site 112 corresponds to the major stratigraphic disconformities observed between the Oligocene and Miocene (135 mbsf) and Miocene and Pliocene (125 mbsf) at Site 647.

A prominent regional seismic reflector identified as "R4" occurs at the change from siliceous to calcareous biogenic claystones in the lower Oligocene at about 240 mbsf (about Cores 105-647A-25R to 105-647A-26R) in Hole 647A. This reflector approximates the cored interval equivalent to the lower part of

Table 1 (continued).

Hole 647A	Abundance	Preservation	*M. sulcata*	*Odontella aurita*	*O. tuomeyi*	*Odontella* sp. 1	*Opephora* sp. 1	*Pleurosigma* sp. 1	*Polaria* sp. 1	*Pseudodiomergramma* sp. 1	*Pseudorocella barbadensis*	*Pseudostitodiscus picus*	*Pseudotriceratium chenevieri*	*Pterotheca aculeifera*	*Pyxilla* Group	*Rhaphoneis* sp. 1	*Rhizosolenia hebetata*	*R. interposita*	*R. massiva*	*R. oligocaenica*	*Rhizosolenia* sp. 1	*Riedelia* Group	*Rocella gelida*	*R. praenitida*	*R. vigilans*	*Rouxia obesa*	*Rutilaria areolata*	*Screptroneis grunowii*	*S. humunica*	*S. mayenica*	*S. pupa*	*S. talwanii*	*S. tenue*	*Screptroneis* sp. 1	*Screptroneis* sp. 2	*Stephanogonia* sp. 1	*Stephanogonia* sp. 2	*Stephanogonia* sp. 3	*Stephanopyxis corona*
13-1, 119-121 cm	R	M	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R	—
13-2, 109-111 cm	R	M	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
13-3, 111-113 cm	R	M	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
13-4, 109-111 cm	R	M	R	—	—	—	—	—	—	R	—	—	—	—	R	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R
13-5, 109-111 cm	R	P	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
13, CC	R	P	R	—	—	—	—	—	—	—	—	—	—	—	R	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R	—	—	R
14-1, 50-52 cm	F	P	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
14-2, 50-52 cm	F	M	R	—	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
14-3, 6-8 cm	C	M	F	R	R	—	—	—	—	—	—	—	R	—	R	—	—	—	R	—	—	R	R	R	—	R	—	R	R	—	—	—	R	—	—	R	R	—	—
14, CC	F	M	R	—	—	—	—	—	—	—	—	—	—	F	R	R	R	R	R	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	R	R	—	—
15-1, 124-126 cm	C	M	C	—	—	—	—	R	—	—	—	—	R	—	R	—	—	R	—	—	—	—	—	R	—	R	—	—	—	R	—	—	—	—	—	—	—	—	—
15-2, 124-126 cm	C	M	F	—	—	—	—	—	—	—	—	—	R	—	—	—	—	R	R	—	—	—	—	R	—	R	—	—	—	—	—	—	—	—	—	—	—	—	R
15-3, 49-51 cm	C	M	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R	—	—	R	—	—	—	—	—	—	—	—	—	—	—
15, CC	C	M	F	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	R	—	R	—	R	—	R	—	—	—	—	—	—	—	—	R
16-1, 49-51 cm	F	M	F	—	—	—	—	—	R	—	—	—	—	R	—	—	R	—	—	—	—	—	—	R	—	R	—	R	—	—	—	—	—	—	—	R	—	—	—
16-2, 39-41 cm	C	M	F	—	—	—	—	—	—	—	—	—	R	—	F	—	—	—	F	—	—	R	—	R	—	R	—	—	—	R	—	R	—	—	—	—	—	—	R
16, CC	F	P	—	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	F	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
17-1, 128-130 cm	C	M	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
17-3, 128-130 cm	C	M	—	—	—	—	—	—	—	—	—	—	R	—	R	—	—	—	—	—	—	—	—	F	—	F	—	R	—	—	—	—	—	—	—	—	R	—	R
17-4, 116-118	F	P	F	—	—	—	—	—	—	—	—	—	R	—	R	—	—	—	—	—	—	—	—	R	—	F	—	—	—	—	—	—	—	—	—	—	R	—	—
17-5, 125-127 cm	C	M	R	—	—	—	—	—	—	—	—	—	R	—	R	—	—	—	—	—	R	—	—	R	—	F	—	R	—	—	—	R	—	—	—	—	R	—	R
17, CC	C	M	R	—	—	—	—	—	—	—	—	—	—	—	—	—	F	—	—	—	—	—	—	R	—	F	—	—	—	—	—	—	—	—	—	—	R	—	F
18-1, 50-52 cm	C	M	R	—	—	—	—	—	—	—	—	—	R	—	R	—	R	—	R	R	—	R	—	R	—	R	—	R	R	R	—	—	—	R	R	R	R	—	—
18-2, 48-50 cm	C	M	R	R	R	—	—	—	—	—	—	—	R	—	R	—	—	—	R	—	—	R	—	R	—	F	—	R	R	—	—	—	R	—	R	R	R	—	—
18, CC	F	P	R	—	—	—	R	—	—	—	—	—	R	—	C	—	F	—	F	—	F	—	—	R	—	R	—	—	—	—	—	R	R	—	R	R	—	R	R
19-1, 125-127 cm	A	M	F	—	—	—	—	—	—	—	R	R	—	—	R	R	—	—	—	—	—	—	—	R	—	F	—	R	—	R	—	R	R	—	—	—	R	—	F
19-3, 125-127 cm	A	M	R	—	—	—	—	—	—	—	—	R	R	—	R	—	—	—	—	—	R	—	—	R	—	F	—	R	—	R	—	R	R	—	—	—	F	—	—
19-5, 124-126 cm	A	M	F	—	—	—	—	—	—	—	R	R	—	—	R	—	—	—	—	R	—	—	—	—	—	R	—	—	—	—	—	R	R	—	—	—	R	—	F
19, CC	A	M	R	—	—	—	—	—	—	—	—	R	R	—	R	—	R	—	—	—	—	—	—	R	—	R	—	—	—	R	—	R	—	—	—	—	—	—	R
20-1, 48-50 cm	C	M	F	—	—	—	R	—	—	—	—	—	R	—	—	—	R	R	—	R	—	R	—	R	—	—	R	R	R	R	—	—	R	R	—	—	—	—	—
20-3, 52-54 cm	C	M	R	—	—	—	R	—	—	—	R	—	R	—	—	—	R	R	—	R	—	R	—	R	—	R	—	—	—	R	—	—	—	—	—	—	—	—	R
20-5, 50-52 cm	A	M	R	—	—	—	R	—	—	—	R	—	R	—	—	—	R	—	—	R	—	—	—	R	—	R	R	—	—	R	—	—	—	—	—	—	—	—	—
20, CC	C	M	R	—	—	—	—	—	—	—	R	—	—	R	—	—	R	—	—	R	—	—	—	—	—	R	R	R	—	R	—	—	—	—	—	R	—	R	—
21-1, 124-126 cm	A	G	—	—	—	—	—	—	—	—	—	—	R	—	R	—	R	R	—	R	—	—	—	R	—	—	—	R	—	—	—	R	—	—	—	—	R	—	R
21-2, 124-126 cm	A	M	—	—	—	—	—	—	—	—	R	—	R	—	R	—	R	R	—	R	—	—	—	—	—	R	—	R	—	—	—	—	—	—	—	—	—	—	—
21-3, 124-126 cm	A	G	R	—	—	—	—	—	—	—	R	—	—	—	—	—	R	F	—	R	—	R	—	R	—	R	—	R	—	R	—	—	—	—	—	—	R	—	F
21, CC	A	G	R	—	—	—	—	—	—	—	R	—	—	—	R	—	R	R	—	—	—	—	—	R	—	F	R	—	—	R	—	—	R	—	—	—	R	—	F
22, CC	A	M	R	—	—	—	—	—	—	—	R	R	R	—	F	—	—	—	—	—	—	—	—	—	—	R	—	R	—	—	—	—	—	—	—	—	—	—	R
23-1, 104-106 cm	A	G	R	—	—	—	—	—	—	—	—	R	R	—	C	—	—	—	R	—	R	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	C
23-2, 101-103 cm	A	G	R	—	—	—	—	—	—	—	—	R	—	—	C	—	—	F	—	—	—	—	—	—	—	R	—	—	—	R	—	—	—	—	—	—	—	—	F
23-3, 57-59 cm	A	M	R	—	—	—	—	—	—	—	—	—	—	—	A	—	—	R	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
23-4, 100-102 cm	A	G	—	—	—	—	—	—	—	—	—	—	—	—	A	—	—	R	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	F
23-5, 102-104 cm	A	G	—	—	—	—	—	—	—	—	—	R	—	—	A	—	R	—	—	—	—	—	—	R	—	R	—	—	—	—	—	—	—	—	—	—	—	—	R
23, CC	A	G	—	—	—	—	—	—	—	—	—	R	—	—	A	—	R	R	—	—	—	—	—	—	—	F	—	—	—	—	R	—	—	—	—	—	—	—	F
24-2, 83-85 cm	A	M	R	—	—	—	—	—	—	—	—	R	—	—	R	—	R	R	R	—	—	—	—	R	—	R	—	—	—	R	R	—	—	—	R	—	—	—	—
23-3, 86-88 cm	A	M	R	—	—	R	—	—	—	—	R	R	—	—	—	—	R	R	—	—	—	—	—	R	—	R	R	—	—	—	—	—	—	—	—	—	—	—	—
24-4, 86-88 cm	A	M	R	—	—	R	—	—	—	—	—	R	—	—	R	F	R	R	R	R	—	F	—	R	—	F	—	—	—	—	—	—	—	—	—	—	—	—	—
24, CC	A	M	R	—	—	—	—	—	—	—	R	—	—	R	R	—	R	R	—	R	—	—	—	R	—	R	—	—	—	—	—	—	—	—	—	—	—	—	R
25-1, 120-122 cm	C	M	R	—	—	—	—	—	—	—	—	—	—	—	R	—	R	R	—	—	—	R	—	R	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—
25-2, 120-122 cm	A	G	—	—	—	—	—	—	—	—	—	R	—	—	R	—	R	F	—	—	—	—	—	R	—	F	—	—	—	—	—	—	—	—	—	—	—	—	—
25-3, 120-122 cm	C	M	—	—	—	—	—	—	—	—	—	—	—	—	R	—	R	R	—	—	—	R	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—
25-4, 119-120 cm	A	G	—	—	—	R	—	—	—	—	R	—	—	—	F	R	—	F	—	—	—	—	—	R	—	F	—	—	—	—	—	—	—	—	—	—	—	—	F
25-5, 119-120 cm	A	M	R	—	—	—	—	—	R	—	—	—	—	—	R	R	—	F	—	—	R	R	—	—	—	R	R	—	—	—	—	—	—	—	—	—	—	—	—
25, CC	A	G	—	—	—	—	—	—	—	—	—	—	—	—	R	—	—	F	—	—	—	—	—	—	—	F	—	—	—	—	—	—	—	—	—	—	—	—	F
26, CC	C	M	R	—	—	—	—	—	—	—	—	—	R	—	—	—	R	R	—	R	R	R	—	R	—	—	R	—	—	—	—	R	R	—	—	—	—	—	—
27, CC	C	M	F	—	—	—	—	—	—	—	—	—	R	—	R	—	—	R	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—
28, CC	F	M	R	—	—	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	R	R	—	—	—	—	—	—	—	R	—	—	—
29, CC	C	M	F	—	—	—	—	—	—	—	—	—	R	—	R	—	—	—	—	—	—	—	—	—	—	R	—	—	—	R	—	—	—	—	—	—	—	—	F

the *Cestodiscus reticulatus* Zone and has an early Oligocene age.

At Site 112 a similar seismic reflector was observed, and the shipboard scientific party placed it at an estimated depth of 317 mbsf (equivalent to the upper part of Core 12-112-10R) (Laughton, Berggren, et al., 1972). Because no lithologic change was reported to occur directly above or below the stratigraphic placement at Site 112, the shipboard scientific party suggested that the reflector may correspond to a lithological transition (increased pyrite and recrystalized calcite) from 333 to 384 mbsf.

Table 1 (continued).

S. grunowii	S. hyalomarginata	S. marginata	S. megapora	S. spinossima	S. superba	S. turris	Stephanopyxis sp. 2	Stephanopyxis sp. 3	Stephanopyxis sp. 4	Stephanopyxis sp. 5	Stictodiscus Group	Synedra jouseana	Synedra sp. 1	Thalassionema nitzschioides	Thalassionema sp.	Thalassiosira eccentrica	T. irregulata	Thalassiosira aff. irregulata	T. leptopus	T. media-convexa	Thalassiosira sp. 1	Thalassiosira sp. 2	Thalassiothrix longissima	Thalassiothrix sp. 1	Triceratium condecorum	T. exornatus	T. groningensis	Triceratium cf. macroporum	T. unquiculatum	Triceratium sp. 1	Triceratium sp. 2	Trinacria excavata	Trinacria sp. 1	Trinacria sp. 2	Trinacria sp. 3	Xanthiopyxis panduriformis	Genus and species idet 1	Genus and species idet 2	Genus and species idet 3	Genus and species idet 4	Genus and species idet 5	Genus and species idet 6
—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R	R	—	—	—
—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R	R	—	—	—
R	—	—	—	R	—	R	—	—	—	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
R	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
R	—	—	—	—	—	R	—	—	R	—	—	—	—	R	—	—	—	—	R	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—
R	—	R	R	—	—	—	—	R	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	R
F	—	R	R	—	—	F	R	R	R	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R	—	—	—	R	—	—	—	—	R	—	R
F	—	R	C	R	—	R	—	R	—	R	R	R	R	—	—	—	—	—	—	—	R	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	R	—	—	—	F	—	—	—	—	—	R	—	—	R	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—
R	—	—	—	—	—	R	—	R	—	—	—	—	—	—	R	—	—	—	R	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	R	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
R	—	—	—	—	—	R	—	—	—	—	—	R	—	—	R	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	F	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	R	—	R	—	F	—	R	—	—	—	—	—	—	—	R	—	R	—	—	—	—	R	R	—	—	—	R	—	—	—	—	—	—	—	—	—	—	R	—	—	—
—	—	—	—	R	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
F	—	R	—	—	—	F	—	—	—	—	—	—	—	R	R	R	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
R	—	R	—	—	—	F	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—
F	—	R	—	—	—	F	—	—	—	—	—	—	—	—	R	—	—	—	R	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
F	—	R	—	—	—	F	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R	—	—	R	—	—	R	—	—	—	—	—	—	—
R	—	R	—	—	—	F	—	R	—	—	R	—	—	—	—	—	—	R	—	—	—	—	R	R	—	—	—	—	—	—	—	R	R	—	R	R	—	—	R	—	—	—
—	—	—	—	—	—	F	—	—	—	—	R	R	—	—	—	—	—	—	—	—	—	—	R	—	R	—	—	—	—	—	—	—	R	—	R	—	—	—	R	—	—	—
R	—	—	—	—	—	R	R	R	—	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	R	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—
F	—	—	—	—	—	R	—	R	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	R	—	—	—	—	R	—	—	—	—	—
F	—	—	—	—	—	A	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	R	—	—	R	—	—	—	—	—	—	R	—	R	—	—	—	—	—
—	—	R	—	—	—	F	—	R	—	—	—	—	R	—	R	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R	—	R	—	—	—	—	—	—	—	—
R	—	R	—	R	—	C	—	R	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R	—	R	—	—	—	—	R	—	—	—
R	—	R	—	—	—	R	—	—	—	—	—	R	R	—	—	—	—	—	—	—	—	—	R	R	R	—	—	—	—	—	—	R	—	R	R	—	—	—	R	—	—	—
R	—	R	—	—	—	R	—	R	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	R	—	—	—	—	—	—	R	R	—	—	—	—	—	—	—	—	—	—
R	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R	—	—	R	—	—	—	—	—	—	R	—	R	—	—	—	—	—	R	—	—	—
R	—	—	—	—	—	R	—	R	—	—	—	—	—	—	—	—	—	R	—	—	R	—	—	—	R	—	—	—	—	—	—	R	—	R	—	—	—	—	—	—	—	—
F	—	R	—	—	—	C	R	R	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	R	—	—	R	—	?	—	R	—	R	—	—	—	—	—	—	—	—
F	—	—	—	—	—	F	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R	R	—	—	—	—	—	—	—	—	—	—	—
F	—	F	—	—	—	C	—	F	—	—	—	—	R	—	R	—	—	F	—	—	—	—	R	—	R	—	—	—	—	—	—	R	—	R	—	—	—	—	—	—	—	—
F	—	F	—	—	—	C	F	F	—	—	—	—	R	—	—	—	—	R	—	—	—	—	—	—	—	R	R	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—
R	—	R	—	—	—	F	—	F	—	—	R	—	—	—	—	—	—	R	—	—	—	—	—	—	R	—	R	—	R	—	—	R	—	—	—	—	—	—	—	—	R	—
F	—	R	—	F	R	F	—	C	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	C	—	—	—	—	—	—	—	—	—	—
F	—	R	—	F	—	F	—	F	—	—	—	—	R	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	F	—	F	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R	R	—	—	—	—	—	—	—
—	—	—	—	—	—	F	—	F	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
F	—	—	—	—	—	F	—	F	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
F	—	F	—	—	R	C	—	C	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—
F	R	—	—	—	—	C	—	R	—	—	R	—	—	—	—	—	R	—	—	—	—	—	—	—	R	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—
F	—	—	—	—	—	F	—	R	—	—	R	—	—	—	—	—	—	R	—	R	—	—	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—
F	—	—	—	—	—	C	—	F	—	—	R	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—
R	R	—	—	F	R	R	—	R	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	F	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—
—	—	—	—	F	—	F	—	C	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R	—	—	R	—	—	—	—	—	—	—
R	—	R	—	R	—	C	—	—	—	—	—	—	R	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—
R	—	R	—	F	—	C	—	C	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	R	—	—	R	—	—	—	—	—	—	—
R	—	R	—	R	—	C	—	—	—	—	—	—	R	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R	R	—	—	—	—	—	—	—
F	—	—	—	F	—	C	—	C	—	—	—	—	R	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	R	—	—	R	—	R	—	—	—	—	—
F	—	—	—	R	—	C	—	F	R	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	R	—	—	R	R	—	—	R	R	—	R	—	—	—	—	—	—	—
R	—	R	—	F	—	F	—	F	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R	—	—	—	R	—	—	—
R	—	—	—	R	—	F	—	R	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
F	—	—	—	F	—	F	—	F	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	F	—	—	—	—	—	—	—	—	—	—

This latter interpretation corresponds to the depth assigned to the R4 reflector by Miller and Tucholke (1983).

If the stratigraphic correlation presented here is correct and the seismic reflector at Site 112 results from the lithologic transition from calcareous to siliceous claystone similar to that observed at Site 647, then this reflector should occur between Cores 12-112-11R and 12-112-12R (333–384 mbsf). Assuming similar rates of sedimentation and time equivalency of the reflector at Sites 112 and 647, then the depth of the reflector and the siliceous calcareous transition should be approximately 370 mbsf at Site 112.

PALEOECOLOGY

Similar diatom assemblages were observed at Sites 112 and 647. These assemblages consist of generally moderate to robust silicified species, with finely silicified forms varying in abun-

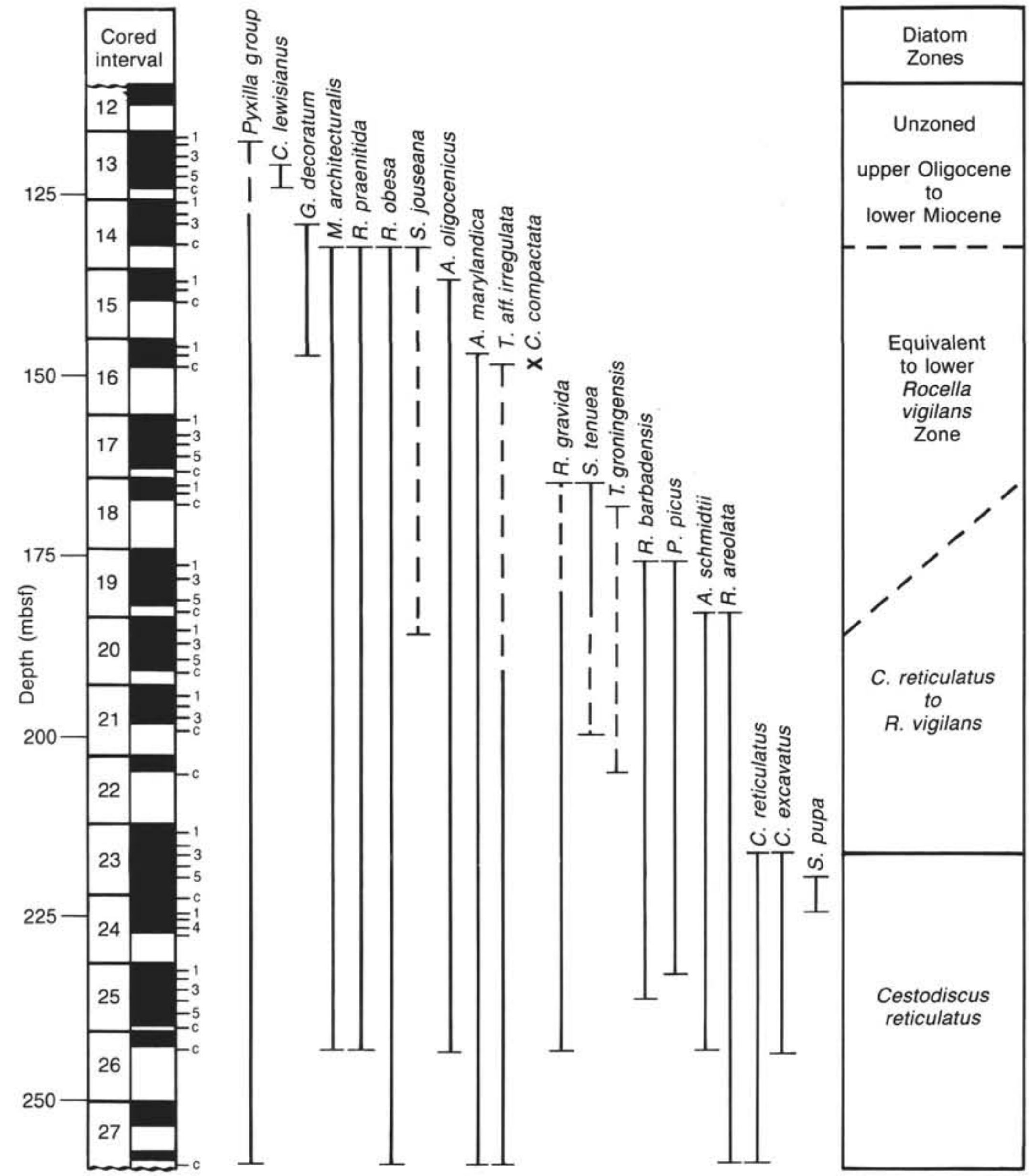

Figure 4. Zonal assignment of samples and the stratigraphic range of selected species from Hole 647A. Shaded area represents core recovery.

dance. These species make up four different groups consisting of species characteristic of the low latitudes, the high southern latitudes, the Norwegian Greenland Sea, and cosmopolitian forms. The first three of these groups are of particular interest because they allude to changing oceanographic conditions in this region during the Oligocene.

Different species dominate the diatom assemblage in specific stratigraphic intervals. For example, specimens of *Cestodiscus* are abundant in the interval from Cores 105-647A-27R to 105-647A-23R; specimens of *Pyxilla* are abundant in the interval from Cores 105-647A-24R to 105-647A-22R, and specimens of *Hemiaulus* dominate Cores 105-647A-20R and 105-647A-21R. Each of these intervals is discussed next.

Cestodiscus reticulatus, Cestodiscus robustus, Coscinodiscus excavatus, and numerous unidentified species of *Cestodiscus* are abundant in the interval from Cores 105-647A-27R to 105-647A-23R. Although several different forms of *Cestodiscus* sp. occur sporadically throughout the Oligocene interval, specimens of various forms of *Cestodiscus* are most consistent and abundant in the samples from Cores 105-647A-27R to 105-647A-23R. The equivalent stratigraphic interval was not recovered at Site 112.

Because *Cestodiscus* is most common and abundant in the warmer low latitudes, the occurrence of such numerous forms in the Labrador Sea suggests that oceanic surface waters in the Labrador Sea were influenced by warm to warm-temperate waters during earliest Oligocene time. The gradual decline in the abundance and diversity of *Cestodiscus* in Core 105-647A-23R suggests a change in paleoceanographic conditions during the early Oligocene. The occurrence of rare specimens of *Screptroneis pupa* in Core 105-647A-23R, several different forms of *Screptroneis* above Core 105-647A-23R, and the common to abundant occurrence of specimens of *Pyxilla* in Cores 105-647A-23R and 105-647A-22R support a dramatic change in paleoceano-

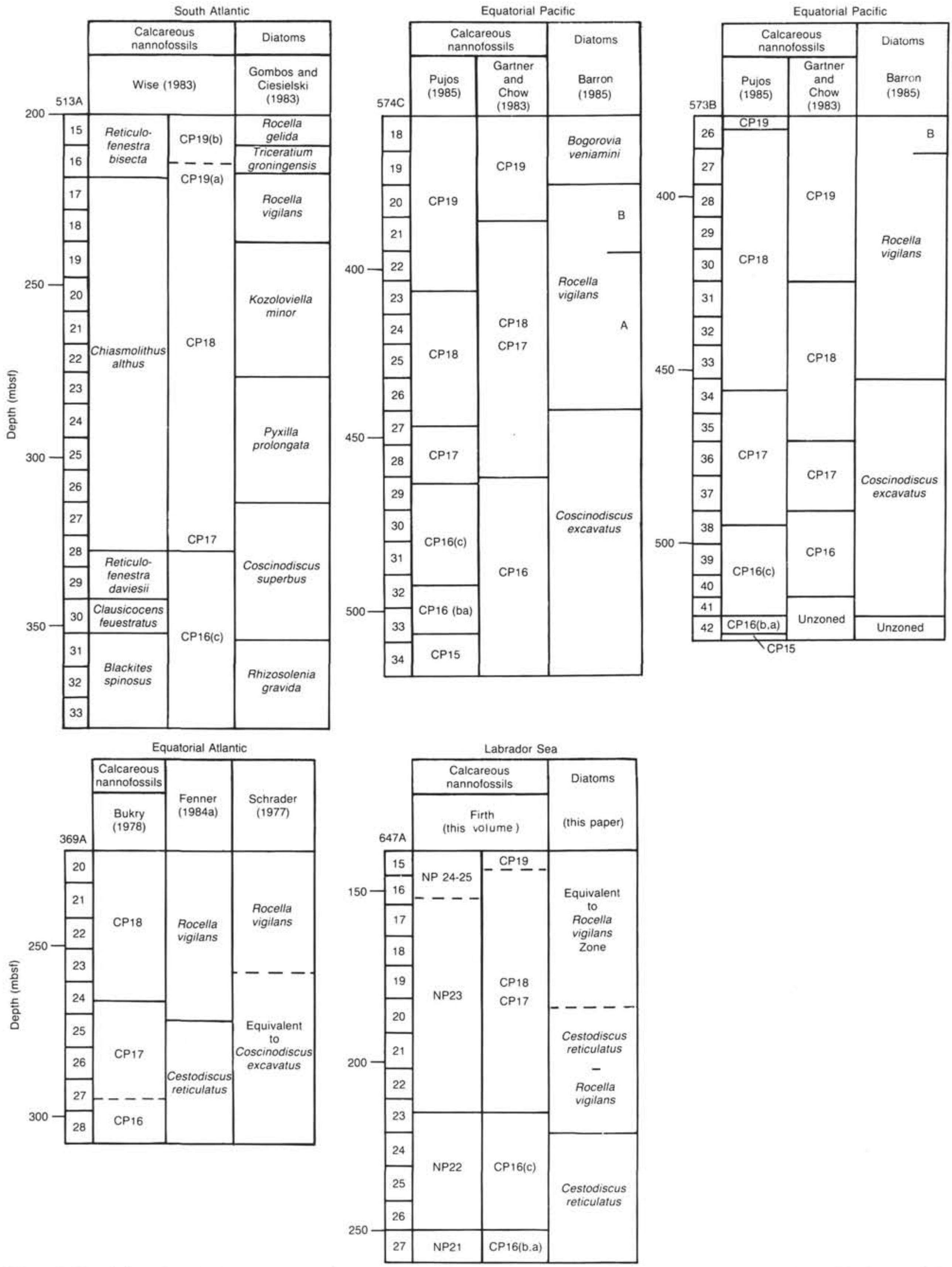

Figure 5. Correlation of the Oligocene diatom zones with the calcareous nannofossil zones from the South Atlantic Ocean (Gombos and Ciesielski, 1983 and Wise (1983), the Equatorial Pacific (Barron, 1985, Barron et al., 1985, Pujos, 1985, and Gartner and Chow, 1985)., and the Labrador Sea (this study and Firth, this volume).

Table 2. Stratigraphic occurrence of selected species from Hole 112.

	Abundance	Preservation	*Actinocyclus divisus*	*Actinoptychus senarius*	*Arachnoidiscus* Group	*Asterolampra schmidtii*	*Asterolampra* sp. 1	*Asteromphalus oligocenicus*	*Azpeitia oligocenica*	*A. vetustissima*	*A. voluta*	*Cestodiscus pulchellus*	*Cestodiscus* sp. 2	*Cestodiscus* sp. 4	*Cestodiscus* sp. 5	*Cestodiscus* sp. 6	*Cestodiscus* sp. 7	*Cestodiscus* sp. 9	*Coscinodiscus argus*	*C. asteromphalus*	*C. marginatus*	*C. obscurus*	*C. oculis-iridis*	*C. radiatus*	*C. symbolophorous*	*Coscinodiscus* sp. 1	*Coscinodiscus* sp. 2	*Coscinodiscus* sp. 3	*Coscinodiscus* sp. 4	*Coscinodiscus* sp. 5	*Cymatosira biharensis*	*Ethmodiscus* sp.	*Goniothecium decoratum*	*Hemiaulus* cf. *malleolus*	*H. polycystinorum*	*Hemiaulus* sp. 4	*Melosira architecturalis*
4-2, 119-121 cm	F	P	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R	—	—
5-1, 85-89 cm	M	C	—	F	—	—	—	—	R	—	R	R	R	R	—	R	—	R	—	R	F	R	R	R	R	R	—	R	R	—	—	R	R	—	R	—	R
5-2, 90-94 cm	C	M	—	F	—	—	—	R	R	R	—	R	R	—	—	—	R	—	—	R	F	R	R	R	R	R	—	—	—	—	R	—	R	—	R	—	R
5-3, 116-120 cm	C	P	—	F	—	—	—	—	R	—	—	R	R	—	—	R	—	R	—	—	R	—	—	—	—	—	—	—	—	—	—	—	R	—	R	—	—
5-4, 95-99 cm	C	M	—	R	—	—	—	—	R	R	—	—	R	—	—	R	—	—	—	R	F	R	R	R	R	R	—	—	—	R	—	—	R	—	R	—	R
5-5, 95-99 cm	C	M	—	R	R	—	—	—	R	R	—	R	—	—	R	—	—	—	—	R	R	R	R	R	—	—	—	—	—	—	—	—	R	—	R	—	R
5-6, 89-93 cm	C	M	—	F	—	—	R	—	R	R	—	—	R	—	—	—	R	—	—	R	C	R	R	R	R	—	—	—	—	R	—	—	F	—	F	—	R
6-4, 96-100 cm	F	P	—	—	—	—	—	—	R	—	—	R	—	—	—	—	—	R	—	—	R	R	R	—	—	—	—	—	—	—	—	—	R	—	R	—	—
7-2, 122-126 cm	F	P	—	—	—	—	—	R	R	—	—	R	R	—	—	R	—	—	—	—	R	—	—	—	R	R	R	—	—	—	—	—	R	—	R	—	R
8-1, 107-109 cm	A	M	—	R	—	—	R	R	R	—	—	—	R	—	—	R	R	R	—	R	F	F	R	—	R	F	R	—	R	—	—	—	R	R	R	—	R
9-1, 94-98 cm	F	P	—	R	—	—	—	—	—	—	—	R	—	—	—	R	—	R	—	—	R	—	R	R	—	—	—	—	—	—	—	—	R	—	R	—	R
9-2, 90-94 cm	R	M	—	R	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	R	R	—	R	—	—	—	—	—	—	—	—	R	—	R	—	—
9-3, 94-98 cm	F	M	R	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	R	—	R	—	—	—	—	—	—	—	—	—	—	—	R	—	R
9-4, 94-98 cm	F	M	—	R	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	R	—	R	—	—	—	—	—	—	—	—	—	R	—	R	—	—
9-5, 94-98 cm	F	P	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	R	R	—	—	R	—	—	—	—	—	—	—	—	—	R	—	R
10, CC	F	P	—	R	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	R	R	—	R	—	—	—	—	—	—	—	—	R	—	R	—	R
11-1, 127-131 cm	A	M	—	R	—	R	—	—	R	—	R	—	R	—	—	—	—	—	—	—	R	R	—	R	—	R	—	—	—	—	—	—	—	—	F	—	—
11-2, 102-106 cm	C	M	—	R	—	R	R	—	R	R	—	—	—	—	—	R	—	—	—	—	R	R	—	R	R	R	—	—	—	—	—	—	—	R	F	R	—
11-3, 108-112 cm	C	M	—	R	—	R	—	—	—	R	—	R	R	—	—	—	—	R	R	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	F	—	R
11-4, 69-73 cm	A	M	—	R	—	R	R	—	R	R	—	R	R	—	—	R	—	—	—	—	R	—	R	—	—	—	—	—	—	—	—	—	—	R	F	—	R

Species abundance is recorded as abundant (A), common (C), few (F), rare (R), not observed (—). Preservation is recorded as good (G), moderate (M), and poor (P).

graphic conditions. Because of the the limited data available, we were unable to determine whether surface circulation, bottom circulation, or a combination of both changed.

The occurrence of *Screptroneis pupa* and several other forms of *Screptroneis* at Site 647 suggests that surface waters in the Labrador Sea became cooler during the early Oligocene. This may have resulted from a decreased warm-water influence from the low latitudes (as suggested by the disappearance of most specimens of *Cestodiscus*) and a result of increased influence in this region of cooler surface waters from the Norwegian-Greenland Sea or Baffin Bay (as suggested by the occurrence of several forms of *Screptroneis* that were recorded by Schrader and Fenner [1976] as a typical constituent of the Oligocene diatom assemblage in the Norwegian Sea).

The early Oligocene paleoceanographic change may also have resulted from increased bottom-water circulation, which may be suggested by the common to abundant occurrence of *Pyxilla* specimens in Cores 105-647A-23R and 105-647-22R and the common to abundant occurrence of specimens of *Hemiaulus* in Cores 105-647A-21R and 105-647A-20R. Specimens of *Pyxilla* and *Hemiaulus* are heavily silicified and as a result can easily survive any silica dissolution that would dispose of the less finely silicified forms. Thus, it is possible that specimens of these groups may also be concentrated in these cores by winnowing and redeposition of the sediment that resulted from increased bottom circulation, as suggested by Burckle (1972) for the occurrence of these species at Site 112.

Cores 105-647A-19R and 105-647A-15R contain a diatom assemblage typical for the early-late Oligocene. The lack of one or two dominant species may suggest establishment and stablization of oceanic and climatic conditions. This interval is dominated by species characteristic of the high latitudes (Norwegian Sea and Southern Ocean) or by cosmopolitan species. Although these changes in the diatom assemblage at Site 647 are not as dramatic those at Site 112, there is a slight increase in *H. polyscytinorum* toward the base of Core 12-112-11R, suggesting that the dramatic increase in abundance of *Pyxilla* and *Cestodiscus* occur in the unrecovered interval betweens Core 12-112-11R and 12-112-12R.

CONCLUSIONS

The siliceous interval recovered from Hole 647A (Cores 105-647A-27R to 105-647A-13R) was assigned to the *Cestodiscus reticulatus* Zone, the *C. reticulatus—Rocella vigilans* Interval, and an interval equivalent to Subzone *a* of the *R. vigilans* Zone. Comparing the stratigraphic results from Hole 647A with those from Hole 112 allows the siliceous interval recovered from Hole 112 (Cores 12-112-5R to 12-112-11R) to be assigned to the *C. reticulatus—R. vigilans* Interval and to an interval equivalent to Subzone *a* of the *R. vigilans* Zone. The improved stratigraphic resolution at these sites allows the regional seismic reflector "R4" to be placed at an interval equivalent to the lower portion of the *C. reticulatus* Zone, which gives an estimated age between 34 and 36 Ma.

The change in the composition of the diatom assemblage in this siliceous interval suggests that the early Oligocene was a time of oceanographic reorganization in the Labrador Sea region. The occurrence of specimens of various species of *Cestodiscus* in the lower part of the siliceous interval at Site 647 suggests that surface waters in the Labrador Sea were influenced by warm water from the low latitudes during the earliest Oligocene. The decreased abundance of *Cestodiscus* specimens and the increased abundance of specimens of *Hemiaulus* and *Pyxilla* suggest that a change in oceanographic circulation occurred during the early Oligocene that resulted in a period of cooler surface waters, which influenced the Labrador Sea during the late early Oligocene.

ACKNOWLEDGMENTS

We thank John Barron, Brad Clement, Andrew Gombos, Jr., David Harwood and Shiri Srivastava for reviewing the manuscript; Doris Cooley, Judy Duke, and Amy Russell for typing; and Peggy Myre for photography. Special thanks also to the crew aboard *JOIDES Resolution* for a successful cruise. Samples were supplied by the National Science Foundation. Research funds to complete this study were supplied

Table 2 (continued).

M. sulcata	*Pleurosigma* sp.	*Polaria* sp. 1	*Pseudorocella barbedensis*	*Pseudotriceratium cheneveria*	*Pyxilla* group	*Rhaphoneis* sp. 1	*R. hebetata*	*R. interposita*	*R. massiva*	*Rhizosolenia* sp. 1	*Riedelia* Group	*Rocella praenitida*	*R. vigilans*	*Rouxia obessa*	*Screptroneis grunowii*	*S. humunica*	*S. mayenica*	*S. talwanii*	*Stephanogonia* sp. 1	*Stephanogonia* sp. 2	*Stephanepyxis grunowii*	*S. marginata*	*S. megapora*	*S. superba*	*S. turris*	*Stephanopyxis* sp. 2	*Stephanopyxis* sp. 3	*Stephanopyxis* sp. 5	*Stictodiscus*	*Synedra jouseana*	*Synedra* sp. 1	*Thalassiosira eccentrica*	*T. irregulata*	*Thalassiothrix longissima*	*Triceratium condecorum*	*Trinacria excavata*	*Trinacria* sp. 1	Genus and species idet 1	Genus and species idet 6	Genus and species idet 10
R	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R	—	—	—	R	—	—	—	—	—	—	—	—	—	—	R	—	—	—	—
F	—	—	—	—	R	—	—	—	—	—	R	R	—	—	—	—	—	—	R	—	R	—	—	—	R	—	R	—	R	—	—	—	—	R	—	R	—	R	R	—
F	—	—	R	—	R	—	—	—	R	—	R	F	—	—	R	—	—	—	R	—	R	—	—	—	—	—	R	—	R	—	—	—	—	—	—	—	R	—	R	—
R	—	R	—	—	R	—	—	—	R	—	—	R	—	—	—	—	—	—	—	—	R	—	—	—	R	—	R	—	—	—	—	—	—	—	—	R	—	—	R	—
R	—	R	—	R	—	R	—	—	—	—	R	R	R	R	R	—	—	—	—	R	R	—	—	—	F	F	F	—	R	R	R	—	—	—	—	—	R	R	R	—
R	—	R	—	—	R	—	—	—	—	—	—	R	R	—	R	—	—	R	R	—	R	—	—	—	F	—	—	—	—	R	—	—	—	—	—	—	R	—	—	—
R	—	—	—	R	R	—	—	—	—	—	—	R	—	—	R	—	—	—	R	—	R	—	—	—	F	—	F	—	—	R	—	—	—	—	—	—	F	—	R	—
R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—	R	—	—	—	R	—	R	—	—	R	—	—	—	—	—	—	—	—	R	—
R	—	R	—	R	—	—	—	—	—	—	R	R	—	R	—	—	—	—	—	—	R	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	R	—	R
F	—	—	F	R	R	—	—	—	R	—	R	R	—	R	—	—	—	—	R	R	F	—	—	—	F	R	F	R	—	R	—	—	—	—	—	—	R	R	R	R
—	—	R	—	—	R	—	—	—	—	—	—	R	—	—	R	—	—	—	—	—	R	—	—	—	R	—	R	—	—	—	—	—	—	—	—	R	—	—	—	—
R	—	R	—	—	R	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	R	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
R	—	R	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R	—	—	—	R	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	F	—	—	R	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	R	—	—	—	F	—	—	—	—	—	R	—	—	—	—	—	R	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	R	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
R	—	—	—	—	R	—	—	—	—	—	R	R	—	—	—	—	—	—	—	—	F	—	R	R	R	—	R	R	—	R	—	—	—	—	—	—	—	R	R	—
R	—	—	—	—	R	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	R	—	—	—	C	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—
R	—	—	—	—	R	—	—	—	R	R	R	R	—	—	—	—	—	—	—	—	R	—	—	—	C	—	F	—	—	R	R	—	R	R	—	R	R	—	—	—
R	—	—	R	—	R	—	R	—	—	—	R	R	—	R	—	—	—	—	—	—	R	—	—	R	C	R	—	—	—	R	—	—	—	—	—	R	—	R	—	—
R	R	—	—	—	R	—	F	R	R	—	R	R	—	R	—	—	—	—	—	—	R	—	—	—	C	—	R	—	—	—	R	—	—	—	—	—	—	—	—	—

by USSAC Grant # 76575 P.O. This manuscript is ODP publication ODP/P-87/141.

REFERENCES

Agardh, C. A., 1832. Conspectus Criticus, Diatomacearum. *Lundae*, 4: 48-66. Anissimova, N., 1937. *Diatomoivyye Nizhnetretichnykh Otlozhenii Sredney Volgi*: (VSEGEI Library).

Bailey, J. W., 1842. A sketch of the infusioia of the family Bacillaria. *Am. J. Sci.*, 42:88-105.

Baldauf, J. G., and Barron, J. A., 1982. Diatom biostratigraphy and paleoecology of the type section of the Luisian Stage, central California. *Micropaleontology*, 28(1):59-84.

________, 1856. Notice of microscopic forms in the soundings of the Sea of Kamtschatka. *Am. J. Sci.*, 22(2):1-6.

Barron, J. A., 1983. Latest Oligocene through early Miocene diatom biostratigraphy of the eastern tropical Pacific. *Mar. Micropaleontol.*, 7:487-515.

________, 1985. Late Eocene to Holocene diatom biostratigraphy of the equatorial Pacific Ocean, Deep Sea Drilling Project Leg 85. *In* Mayer, L., Theyer, F., Thomas, E., et al., *Init. Repts.*, *DSDP*, 85: Washington (U.S. Govt. Printing Office), 413-456.

Barron, J. A., Nigrini, C. A., Pujos, A., Saito, T., Theyer, F., Thomas, E., and Weinreich, N., 1985. Synthesis of biostratigraphy, central equatorial Pacific, Deep Sea Drilling Project Leg 85: refinement of Oligocene to Quaternary biochronology. *In* Mayer, L., Theyer, F., Thomas, E., et al., *Init. Repts.*, *DSDP*, 85: Washington (U.S. Govt. Printing Office), 905-934.

de Brébisson, A., 1838. *Consideration sur les diatomées et essai d'une classification des genres et désespèces appartenant à cette famille*: Paris (Brée l'Aine Imprimeur-Libraire Falaise), 1-22.

Brightwell, T., 1853. On the genus Triceratium with description and figures of the species. *Quart. J. Microscop. Sci.*, 1:245-252.

Brun, J., 1891. Diatomées éspeces nouvelles marines, fossiles ou pelagiques. *Soc. Phys. Hist. Nat. Genève Mem.*, 31:1-47.

Bukry, D., 1978. Cenozoic coccolith and silicoflagellate stratigraphy, offshore Northwest Africa, Deep Sea Drilling Project, Leg 41. *In* Lancelot, Y., Seibold, E., et al., *Init. Repts. DSDP*, 41: Washington (U.S. Govt. Printing Office), 689-708.

Bukry, D., and Foster, J. H., 1974. Silicoflagellate zonation for Upper Creataceous to lower Miocene deep-sea sediment. *U.S. Geol. Survey J. Res.*, 2(3):303-310.

Cleve, P. T., 1904. Plankton table for the North Sea. *Bull. Couns. Perman. Int. Explor. Mer., 1903-1904*, 226. Cleve, P. T., and Moller, J. D., 1877-1882. *Diatoms (Exsiccata)*: Upsala.

Ehrenberg, C. G., 1838. Die infusionsthierchen als vollkommenda Organismen. *Ein Blick in das tiefere organische Leben der Natur*: Leipzig (Leopold Voss), 1-548 (Pls. 1-64).

________, 1839. Uber nach jetzt zahlreich lebende Thierarten der Kreidebildung und den Organismus der Polythalamien. *Abh. Akad. Wiss. Berlin*, 81-174.

________, 1841a. Uber Verbreitung und Einfluss des mikroskopischen Lebens in Sudund Nord-Amerika. *Verh. K. Preuss. Akad. Wiss. Berlin*, 139-144.

________, 1841b. Verbreitung und Einfluss des mikroskopischen Lebens in Sud- und Nord-Amerika. *Abh. Akad. Wiss. Berlin*, 1:291-442, 4 Taf. (Sonderabdruck 154S.).

________, 1843. Verbreitung und Einfluss des mikroskopischen Lebens in Sudund Nord-Amerika.. *Abh. Akad. Wiss. Berlin*, 1:291-443.

________, 1844a. Uber Zwei Neue Lager von Gebirgsmassen aus Infusorien als Meeres-Absatz in Nord-Amerika und eine Vergleichung derselben mit den organischen Kreide-Gebiden in Europa und Afrika. *Verh. Akad. Wiss. Berlin*, 1844:57-97.

________, 1844b. Untersuchungen uber die kleinsten Lebensformen im Quellenlande des Euphrats und Araxes, so wie uber eine and neuen Tormen sehr reiche, marine Tripelbildung von den Bermuda-Inseln. *Verh. Akad. Wiss. Berlin*, 1844:253-275.

________, 1844c. Einige vorlaufige Resultate der Untersuchungen der von der Sudpolreise des Capitain Ross, so wie in den Herren Schayer und Darwin Zugekommenen materialien Uber das verhalten des kleinsten Lebens in den Oceanen und den grossten bisher zuganglichen Tiefen des Weltmeers vor. Bericht Uber die zur Bekanntmachung geeigneten. *Verh. Akad. Wiss. Berlin*, 182-207.

________, 1854-1856. *Mikrogeologie Das Erden und felsen schaffende Wirken des unsichtbar kleinenselbststandigen Lebens auf der Erde*: Leipzig (Leopold Voss), 1-374.

Fenner, J., 1978. Cenozoic diatom biostratigraphy of the equatorial and southern Atlantic Ocean. *In* Supko, P. R., Perch-Nielsen, K., et al., *Init. Repts. DSDP*, 38-41, suppl.: Washington (U.S. Govt. Printing Office), 491-623.

________, 1984a. Eocene-Oligocene planktic diatom stratigraphy in the low latitudes and the high southern latitudes. *Micropaleontology*, 30(4):319-342.

________, J., 1984b. Middle Eocene to Oligocene Planktonic diatom stratigraphy from Deep Sea Drilling Project sites in the South Atlantic and Indian oceans. *In* Hay, W. W., Sibuet, J.-C., et al., *Init. Repts. DSDP*, 75(Pt. 2): Washington (U.S. Govt. Printing Office), 1245-1272.

________, 1985. Late Cretaceous to Oligocene planktic diatoms. *In* Bolli, H. M., Saunders, J. B., and Perch-Nielsen, K. (Eds.), *Plankton Stratigraphy*: Cambridge (Cambridge Earth Sci. Ser., Cambridge Univ. Press), 713-762.

Fryxell, G. A., Sims, P. A., and Watkins, T. P., 1986. *Azpeitia* (Bacillariophyceae): Related genera and promorphology. *System. Bot. Mono.*, 13:1-74.

Gartner, S., and Chow, J., 1985. Calcareous nannofossil biostratigraphy, Deep Sea Drilling Project Leg 85, Eastern Equatorial Pacific. *In* Mayer, L., Thayer, F., Thomas, E., et al., *Init. Rept. DSDP*, 85: Washington (U.S. Govt. Printing Office), 609-620.

Gleser, S. I., and Jouse, A. P., 1974. Diatoms and silicoflagellates in the Eocene of the equatorial Atlantic. *In* Jouse, A. P. (Ed.), *Micropaleontology of the Oceans and Seas*: Moscow (Acad., Nauk., USSR) 49-62.

Gombos, A. M., Jr., and Ciesielski, P., 1983. Late Eocene to early Miocene diatoms from the southwest Atlantic. *In* Ludwig, W. J., Krasheninnikov, V. A., et al., *Init. Repts. DSDP*, 71: Washington (U.S. Govt. Printing Office), 583-634.

Greville, R. K., 1865. Descriptions of new and rare diatoms, *Microsc. Soc. London Trans.*, 13:1-37, 43-60, 97-108.

________, 1866. Descriptions of new and rare diatoms, *Microsc. Soc. London Trans.*, 14:1-9, 77-86, 121-130.

Greville, R., and Arnott, G. W., 1857. On new forms of marine Diatomaceae found in the Firth of Clyde and in Loch Fyne. *R. Soc. Edinburgh, Trans.*, 21:473-542.

Grunow, A., 1884. Die Diatomeen von Franz-Josefs-Land. *Denkschr. Math.-Naturw. Classe Kaiserl.* Akad. Wiss., 48:53-112.

Hajos, M., 1968. Die Diatomeen der Miozanen Anlagerungen des Matrazorlandes. *Geol. Hungar. Ser. Paleontol.*, 37:1-104.

________, 1976. Upper Eocene and lower Oligocene diatomaceae, Archaeomaaduzeae, and Silicoflagellate in Southwestern Pacific sediments, DSDP Leg 29. *In* Hollister, C. D., Craddock, C., et al., *Init. Repts. DSDP*, 35: Washington (U.S. Govt. Printing Office), 817-883.

Hajos, M., and Stradner, H., 1975. Late Cretaceous Archaeomaaduzeae, Diatomaceae, and Silicoflagellate from the south Pacific Ocean, Deep Sea Drilling Project, Leg 29, Site 275. *In* Kennett, J. P., Houtz, R. E., et al., *Init. Repts. DSDP*, 29: Washington (U. S. Govt. Printing Office), 913-1009.

Hanna, G. D., 1927a. The lowest known Tertiary diatoms in California. *J. Paleontol.*, 1:103-127.

________, 1927b. Cretaceous diatoms from California. *Occas. Pap. Calif. Acad. Sci.*, 13:1-49.

________, 1932. The diatoms of Sharktooth Hill, Kern County, California. *Calif. Acad. Sci. Proc.*, 20:161-263.

Hanna, G., D., and Brigger, A. L., 1964. Some fossil diatoms from Barbados. *Occas. Pap. Calif. Acad. Sci.*, 45:1-27.

Harwood, D. M., 1982., Oligocene-Miocene diatom biostratigraphy from the equatorial to the Antarctic Pacific [M.S. thesis]. Antarctic Res. Facility, Florida State Univ., Tallahassee, 1-240.

Hasle, G. R., and Fryxell, G., 1977. The genus *Thalassiosira* and some species with a linear aveola array. *Nova Hedwigia Beih.*, 54:15-66.

Heiberg, P.A.C., 1863. *Conspectus Criticus Diatomacearum Danicarum:* Copenhagen (Wilh. Priors Forlag).

Hustedt, F., 1927-1966. Die Kieselalgen Deutschlands, Osterreichs und der Schweiz. Band 7 of Rabenhorst, F. L., Kryptogamenflora. Leipzig: *Akad, Verlagsges.*, Pt. 1:1-920, Figs. 1-542, 1927-1930; Pt. 2: 1-845, Figs. 543-1179, 1931-1959; Pt. 3:1-816, Figs. 1180-1788, 1962-1966.

Jouse (Zhuse), A. P., 1974. Diatoms in the Oligocene-Miocene biostratigraphic zones of the tropical areas of the Pacific Ocean. *Second Symp. Recent Fossil Diatoms, Nova Hedwigia, Beih.*, 45:333-364.

Kanaya, T., 1957. Eocene diatom assemblages from the Kellogg and "Sidney" shales, Mt. Diablo area, California. *Sci. Repts. Tohoku Univ.*, Sendi, Japan, 2 Ser. Geol., 28:27-224.

Kim, W. H., and Barron, J. A., in 1987. Diatom biostratigraphy of the upper Oligocene to lowermost Miocene San Gregorio Formation, Baja California Sur, Mexico. *Diatom Res.*, 1(2):169-187.

Kutzing, F., 1844. *Die kieselschaligen Bacillarien oder Diatomeen*: (Nordhausen), 1-125.

Laughton, . S., Berggren, W. A., et al., 1972. Initial Site Report 112, *Init. Repts. DSDP*, 12: Washington (U.S. Govt. Printing Office), - .

Loeblich, A. R., Loeblich, L. A., Tappan, H., and Lieblich, A. R., Jr., 1968. Annotated index of fossil and Recent silicoflagellates and Ebridians with descriptions and illustrations of validly proposed tax. *Soc. Arm. Inc. Mem.* 106.

Lohman, K. E., 1948. Middle Miocene diatoms from the Hammond Well. Cretaceous and Tertiam subsurface geology. *Maryland Dept. Mines Geol. Bull.*, 21:151-186.

Mann, A., 1997. Report on the diatoms of the *Albatross* voyages in the Pacific Ocean, 1888-1904. *Contrib. U.S.N.H. Herbarium*, 10(5): 121-419.

McCollum, D., 1975. Diatom stratigraphy of the Southern Ocean. *In* Hayes, D., Frankes, L. A., et al., *Init. Repts. DSDP*, 28: Washington (U. S. Govt. Printing Office), 515-571.

Miller, K. G., and Tycholke, B. E., 1983. Development of Cenozoic abyssal circulation south of the Greenland-Scotland Ridge. *In* Bolt, M. H., Sxou, S. J., Talwain, M., and Thiedai, S. (Eds.), *Structure and Development of the Greenland-Scotland Ridge*: New York (Plenum Press), 549-590.

Pantocsek, J., 1886. *Beitrage zur Kenntniss der Fossilen Bacillarien Ungarns. 1. Marine Bacillarien*: (Nagy-Tapolcsany, Julius Platzko), 1-75.

________, 1889. *Beitrage zur Kenntniss der Fossilen Bacillarien Ungarns.* 2: (Nagy-Tapolcsany, Julius Platzko).

Pritchard, A. (Ed.), 1861. A History of Infusoria, Living and Fossil: London (Whittaker, Edition IV, revised and enlarged by J. R. Arlidge, W. Archer, J. Ralfs, W C. Williamson, and the author).

Pujos, A., 1985. Cenozoicnannofossils from Quaternary deposits in the high-productivity area of the central equatorial Pacific, Deep Sea Drilling Project Leg 85. *In* Mayer, L., Thayer, F., Thomas, E., et al., *Init. Repts. DSDP*, 85: Washington (U.S. Govt. Printing Office), 581-608.

Reinhold, T., 1937. Fossil diatoms from Neogene of Java and their zonal distribution. *Verh. Geol. Mijibouwokd. Genoot, Ned. Kolon, Gel.*, Ser. 19:93-133.

Schmidt, A., et al., 1874-1959. *Atlas der Diatomaceenkunde*: Leipzig (R. Reisland), Heft 1-120, Tafeln 1-460 (Taf. 1-216 A. Schmidt, 213-216 M. Schmidt, 217-240 F. Fricke, 241-244 H. Heiden, 245-246 O. Muller, 247-256 F. Fricke, 257-264 H. Heiden, 265-268 F. Fricke, 269-472 F. Hustedt).

Schrader, H. J., 1973. Cenozoic diatoms from the northeast Pacific, Leg 18. *In* Kulm, L. D., von Huene, R., et al., *Init. Repts. DSDP*, 18: Washington (U.S. Govt. Printing Office), 673-797.

________, 1976. Cenozoic planktonic diatom biostratigraphy of the southern Pacific Ocean. *In* Hollister, C. D., Craddock, C., et al., *Init. Repts. DSDP*, 35: Washington (U.S. Govt. Printing Office), 605-671.

________, 1978. Diatoms in DSDP Leg 41 Sites. *In* Lancelot, Y., Seibold, E., et al., *Init. Repts. DSDP*, 41, Washington (U.S. Govt. Printing Office), 791-812.

Schrader, H. J., and Fenner, J., 1976. Norwegian Sea Cenozoic diatom biostratigraphy and taxonmy: Part 1, Norwegian Sea Cenozoic diatom biostratigraphy. *In* Talwani, M., Udintsev, G., et al., *Init. Repts. DSDP*, 38: Washington (U.S. Govt. Printing Office), 921-1098.

Shadbolt, G., 1954. A short description of some few forms of Diatomceae from Port Natal. *Trans. Microscop. Soc. London*, 2(1):13-18.

Sheshukova-Poretzkaya, V. S., 1962. Novie i redkie Bacillariophyta iz diatomovoi sviti Sakhalin. *Uchenie Zapiski Igu, Ser. Biol. Nauk (Leningrad Univ.)*, 49:203-211. Strelinokova, N. I., 1974. Diatomei pozdneg mela (Late Cretaceous diatoms of western Siberia). *Acad. Nauk. U.S.S.R., Moscow*, 8:202.

Tsumura, K., 1963. Figuraro de Kelke da specimeno de *Pyxilla* Kaj aiaj genrao Konservitaj de mi. *Bull. Yokohama Municipal Univ. Soc.*, 14:68-93.

Van Heurck, H., 1880-1896. *Synopsis des Diatomées de Belgique*. Atlas, pl. 1-30 (1880); pl. 31-77 (1881); pl. 78-103 (1882); pl. 104-132 (1883); pl. A,B,C (1885): Antwerp (Duçaju et Cie). Table Alphabetique: Anvers (J. F. Dieltjens) (1884). Texte: Antwerp (Brouwors & Co.), (1885). 1896, *A Treatise on the Diatomaceae*, Trans. W. E. Baxter.

Wise, S. W., Jr., 1983. Mesozoic and Cenozoic calcareous nannofossils recovered by Deep Sea Drilling Project Leg 71 in the Falkland Plateau region, Southwest Atlantic Ocean. *In* Ludwig, W. J., Krasheninnikov, V. A., et al., *Init. Repts., DSDP.*, 71(2): Washington (U.S., Govt. Printing Office), 481–550.

Date of initial receipt: 24 June 1987
Date of acceptance: 21 December 1987
Ms 105B-129

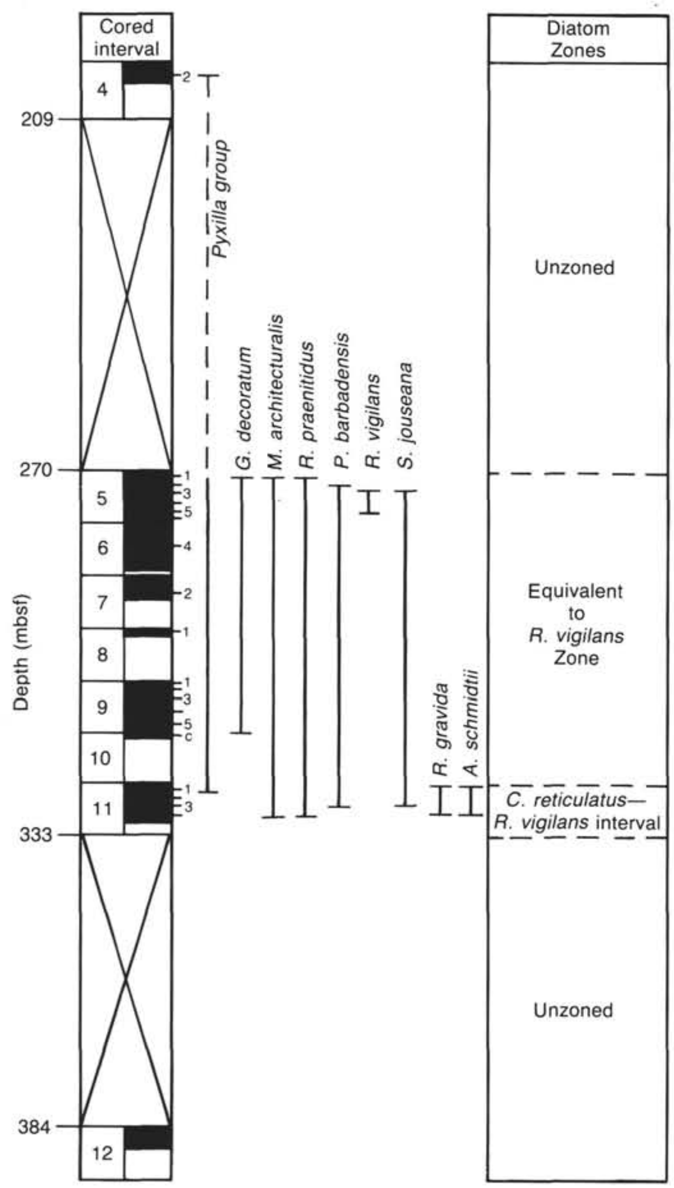

Figure 6. Zonal assignment of samples and the stratigraphic range of selected species from Hole 112.

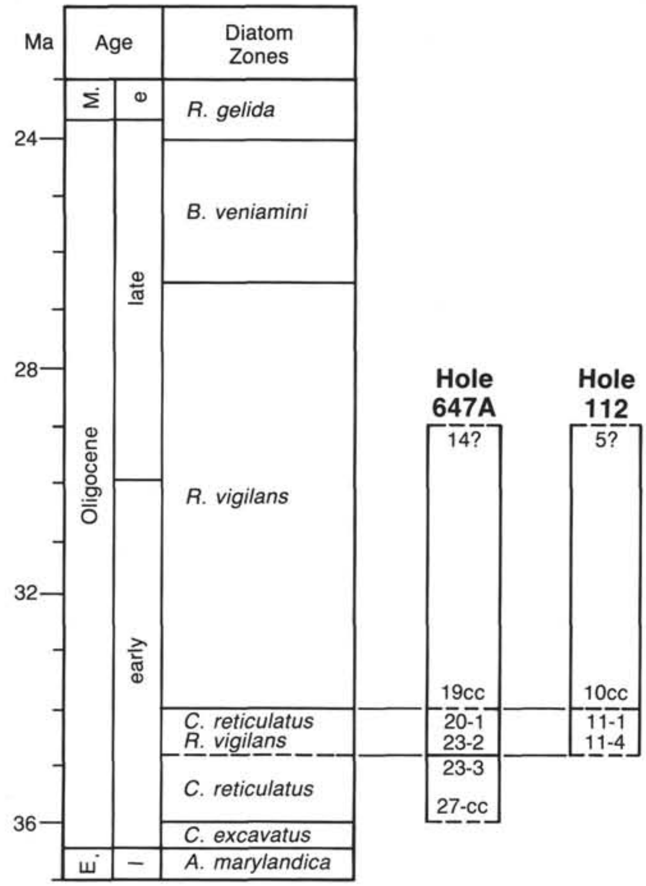

Figure 7. Stratigraphic correlation of Hole 647A with Hole 112, based on the diatom stratigraphy discussed here.

APPENDIX
Floral List

Actinocyclus curvatulus Janisch *in* Schmidt et al., 1874–1959, Pl. 57, Fig. 31; Hustedt, 1958, p. 129–130, Pl. 8, Fig. 81, Pl. 2, Figs. 2, 14 (no illustration).

Actinocyclus divisus (Grunow) Hustedt, 1958, p. 129, Pl. 8, Fig. 81 (no illustration).

Synonym. *Coscinodiscus divisus Grunow 1884, p. 83, Pl. 4, Fig. 16.*

Actinocyclus ehrenbergii Ralfs *in* Pritchard, 1861, p. 834; Hustedt, 1929, p. 525, Fig. 298 (no illustration).

Actinoptychus senarius (Ehrenberg) Ehrenberg, 1843, Pl. 1, Fig. 27 (Plate 1, Fig. 7).

Synonym. *Actinocyclus senarius* Ehrenberg, 1838, p. 172, Pl. 21, Fig. 6; *Actinocyclus undulatus* Bailey, 1842, Pl. 2, Fig. 11; *Actinoptychus undulatus* (Bailey) Ralfs *in* Pritchard, 1861, p. 839, Pl. 5, Fig. 88.

Actinoptychus splendens (Shadbolt) Ralfs in Pritchard, 1861, p. 840 (no illustration).

Synonym. *Actinosphaenia splendens* Shadbolt, 1854, p. 16.

Actinoptychus thumii (Schmidt) Hanna, 1932, p. 171, Pl. 4, Figs. 3, 4 (No illustrations).

Synonym. *Actinoptychus stella* var. *thumii* Schmidt *in* Schmidt et al., 1874–1959, p. 90, Fig. 3.

Arachnoidiscus group (no illustration).

Remarks. Because of the sparse number of specimens, all observed specimens of this genus were grouped under this category.

Asterolampra marylandica Ehrenberg, 1844, p. 76, Fig. 10 (no illustration).

Asterolampra cf. *praeacutiloba* Fenner *in* Schrader and Fenner, 1976, p. 965, Pl. 21, Figs. 8, 13, 14; Pl. 28, Fig. 1 (no illustration).

Asterolampra punctifera (Grove) Hanna, 1927, p. 109, Pl. 17, Fig. 3; Gombos and Ciesielski, 1983, p. 600, Pl. 2, Figs. 4–8; Pl. 5, Figs. 8–10 (no illustration).

Synonym. *Asterolampras affinis* var. *punctifera* Grove *in* Schmidt et al., 1874–1959, Pl. 202, Fig. 18.

Asterolampra schmidtii Hajos, 1976, p. 827, Pl. 21, Fig. 6 (Plate 3, Fig. 3).

Stratigraphic range. Early Oligocene at DSDP Site 280 (Hajos, 1976); early Oligocene at DSDP Sites 511 and 513A (Gombos and Ciesielski, 1983); and early Oligocene at DSDP Site 112 and ODP Site 647 (this study).

Asterolampra symmetricus Schrader and Fenner, 1976, p. 966, Pl. 21, Figs. 7, 10–12 (no illustration). *Asterolampra* sp. 1 (no illustration).

Remarks: Five-rayed *Asterolampra* species with a central hyaline region composing about one-half of the valve face. Valve diameter is 78 m. One hyaline ray is slightly narrower in width than the others. Ribs are connected at the midway point between the outer rays and meet at the center of the valve face. The valve mantle is finely punctuated. Specimens of this species are extremely rare in the material examined.

Asteromphalus oligocenicus Schrader and Fenner, 1976, p. 965, Pl. 21, Figs. 8, 13, 14; Pl. 28, Fig. 1 (no illustration).

Stratigraphic range. Late Oligocene of the Norwegian-Greenland Sea (Schrader and Fenner, 1976), early Oligocene of equatorial and South Atlantic (Fenner, 1978); and the early Oligocene at DSDP Sites 511 and 513 (Gombos and Ciesielski, 1983).

Asteromphalus sp. 1 (no illustration).

Remarks: Observed specimens are similar to *Asteromphalus grevilleianus*, "working name," illustrated by Harwood (1982). Harwood (1982) indicated that this species is similar to *Asterolampra grevillei* in morphology, but is placed in *Asteromphalus* based on the presence of a median ray.

Stratigraphic range. Middle Eocene to early Miocene of DSDP Site 206and the early Miocene of DSDP Site 65 (Harwood, 1982).

Azpeitia oligocenica (Jouse) Sims in Fryxell et al., 1986, p. 16 (Plate 2, Figs. 2, 13).

Synonym. *Coscinodiscus oligocenicus* Jouse, 1974, p. 348, Pl. 1, Figs. 6–8, 16; Fenner, 1978, Pl. 4, Figs. 5–10.

Remarks. Jouse (1974) distinguished this species by the regular radial rows of areolae (4–5 in 10 m) extending from near the center to the margin and additional short rows of areolae near the margin. The margin is very narrow and has a double row of pores. The central area is surrounded by a grove and often a hyaline (thin) band. Specimens of *Coscinodiscus oligocenicus* var. *nodosus* also are recorded under this category in this study.

Stratigraphic range. Eocene (Gleser and Jouse, 1974), Oligocene (Jouse, 1974), Eocene–Oligocene equatorial regions and South Atlantic (Fenner, 1978); Oligocene of the Norwegian-Greenland Sea (Schrader and Fenner, 1976); Oligocene–early Miocene of the equatorial Pacific (Barron, 1983).

Azpeitia tuberculata var. *atlantica* (Gleser and Jouse) Sims in Fryxell et al., 1986, p. 16 (Plate 2, Fig. 18).

Synonym. *Coscinodiscus turberculatus* var. *atlanticus* Gleser and Jouse, 1974, p. 56, Pl. 1, Figs. 14–18; Pl. 2, Fig. 1.

Azpeitia vetustissima (Pantocsek) Sims in Fryxell et al., 1986, p. 16 (no illustration).

Synonym. *Coscinodiscus vestustissimus* Pantocsek, 1886, p. 71, Pl. 20, Fig. 186.

Azpeitia voluta (Baldauf) Sims in Fryxell et al., 1986, p. 14, Figs. XIII-1A and 2A (Plate 2, Fig. 12).

Synonym. *Coscinodiscus volutus* Baldauf in Baldauf and Barron, 1982, p. 66, Pl. 2, Figs. 1–4; Pl. 3, Fig. 2.

Cestodiscus pulchellus Greville, 1866, p. 123, Pl. 11, Fig. 5 (Plate 2, Fig. 6).

Remarks. Greville defined *C. pulchellus* as "Disc circular, very convex, with minute remote radiating puncta, becoming irregular, crowded and slightly less in size towards the margin, processes numerous, margin, as well as the space between it and the granules, striated." Jouse (1974) indicated (1) that this species is very polymorphic, (2) that there may or may not be a central hyaline area, and (3) that the areolae may be remote or very close and arranged radially or spirally. The Leg 105 material contains specimens of *C. pulchellus* that exhibit a range of morphologies similar to those described by Jouse.

Cestodiscus reticulatus Fenner, 1984a, Pl. 1, Fig. 10 (no illustration).

Synonym. *Coscinodiscus superbus* Hardman sensu Fenner, 1978, Pl. 14, Figs. 2-3.

Remarks. This species is distinguished from *Cestodiscus robustus* Jouse by having hyaline ribs in the central part of the frustule, but no small pores.

Cestodiscus robustus Jouse, 1974, p. 345, Pl. 1, Figs. 14, 15 (Plate 1, Fig. 2).

Description. Valve circular with the central region slightly convexed; 42–59 m in diameter. Margin is distinct, has a width of about 5 m, and is finely striated (12 in 10 m). Distinct processes occur about 15 m apart along the margin. The valve center is characterized by subrounded areolae that are arranged in spiral rows starting near the center and continuing until about two-thirds of the distance toward the margin. Outer one-third of valve consists of subrounded areolae (4 in 10 m) radially arranged and decreasing (to 8 in 10 m) in size toward the margin. One or two rows of small areolae separate the margin from the valve proper.

Remarks. This species is characterized by the spiral arrangement of the central areolae and the distinct margin.

Cestodiscus sp. 2 (no illustration).

Description. Valve circular and flat, but may have a slightly depressed center; diameter is 24–57 m. Areolae arranged in radial rows, with primary rows that extend from the center to the margin and bisect secondary rows. Distinct marginal processes occur along the margin at the end of each primary row. The number of primary rows and processes varies. Areolae increase in number about one-half the distance from valve center and are denser toward the margin. Areolation along the margin region also exhibits an eccentric pattern.

Cestodiscus sp. 3 (Plate 1, Fig. 4).

Description. Valve is circular and has slightly depressed margin; valve diameter is between 30–65 m. Has a center hyaline and contains one distinct nodule. Areolae are uniform in size (5 in 10 m) and are arranged radially, with primary rows that extend from the center to the margin and bisect secondary rows. Areolae separated by hyaline region and are denser toward margin. Processes are present along the margin, but are not well developed and do not occur at the ends of primary rows. The margin is finely striated and is separate from the rest of the value mantle by one row of small areolae.

Remarks. This species differs from *Cestodiscus* sp. 2 by the distinct hyaline central region and the nondistinct marginal processes. *Cestodiscus* sp. 3 differs from *Cestodiscus* sp. 5 by the uniform size of the areolae and by the secondary rows of areolae extending farther toward the center of the valve face. *Cestodiscus* sp. 3 and *Cestodiscus* sp. 5 may be varieties of the same species, but are separated until further specimens can be documented.

Cestodiscus sp. 4 (no illustration).

Description. Valve is circular, 38 m in diameter, and slightly convexed. Margin is striated; nondistinct processes occur along margin approximately 14 m apart. Areolae are round, 6 in 10 m, near center, decreasing toward the margin. Approximately 5 m from the margin, areolae extremely fine and abruptly decrease in size. Areolae radially arranged with primary rows cutting secondary rows.

Remarks. This species is distinguished by the abrupt size change in the areolae near the margin.

Cestodiscus sp. 5 (no illustration).

Description. Valve is circular, 35–60 m in diameter, with slightly depressed center. Subrounded areolae are radially arranged and decrease in size from the center (4–5 in 10 m) to the margin (5–6 in 10 m). Areolae within central one-third of valve are surrounded by hyaline regions. Primary rows extend from the valve center to margin; secondary rows extend from midvalve to the margin. Areolae are closely spaced near the margin and have a secondary eccentric pattern. Margin is finely striated, with processes uniformly spaced (located along inner part of margin).

Remarks. This species differs from *Cestodiscus* sp. 3 by having shorter secondary rows that extend from the margin to about the middle of the valve.

Cestodiscus sp. 6 (no illustration).

Description. Valve is circular, flat, 28–55 m in diameter. Areolae are small, round to subrounded, and arranged in subvasicular pattern. Central region is chracterized by widely spaced areolae surrounded by hyaline regions. Four linearly arranged areolae occur in the central region. Outer one-third of valve is characterized by closely spaced areolae that are smaller in size (7 in 10 m) then those in the central region (4–5 in 10 m). Margin is moderately striated.

Cestodiscus sp. 7 (no illustration).

Description. Circular, flat with slight concave nature toward center, about 30–47 m in diameter. Center region of valve contains subrounded areolae spirally arranged from the center toward the margin. Areolae are surrounded and separated by hyaline area. Areolae become closely spaced toward the margin region. Margin is coarsely striated with no observed processes.

Cestodiscus sp. 8 (Plate 2, Fig. 7).

Description. Valve is circular and slightly concave, 27–40 m in diameter. Central region is slightly depressed. Specimens are characterized by subrounded areolae spirally arranged from the center toward the margin. Areolae decrease in size toward the margin, with a major size change occuring at about three-fourths the distance from the center to the margin (from 4–5 in 10 m to 7–8 in 10 m); margin is nondistinct.

Cestodiscus sp. 9 (Plate 1, Figs. 2 and 5; Plate 2, Fig. 9).

Remarks. Valve is circular, 39–80 m in diameter. Areolae are arranged in a fasciculated pattern; about every 10th row extends from the center to the margin. Distinct processes occur along the margin at the end of each primary row. Number of primary rows and processes varies; four, five, seven, eight, and 10 processes were observed. Areolae decrease in size along the margin (8 in 10 m) and exhibit a secondary eccentric pattern. Margin varies from finely to moderately well-striated. Areolae may or may not be separated by hyaline regions. Species is similar to *Cestodiscus* sp. 2, but differs from this species by its distinct primary rows and marginal processes.

Cestodiscus sp. 10 (Plate 4, Fig. 1).

Remarks. Valve is flat, with possible slight sloping from center to the margin. Diameter is 50 to 65 m. Specimens are characterized by the distinct arrangement of areolae, which are arranged in fasciculated pattern of primary rows that extend from the center to the margin, cutting shorter rows that are parallel to each other and extend from about one-fourth of the distance from the center to the margin and then extend to the margin. Areolae increase in size abruptly about one-third the distance from valve center (4 in 10 m) and then decrease within the margin region (7 in 10 m). Margin characterized by secondary, eccentric pattern of areolae. Processes are present along margin but poorly developed. Margin is moderately striated.

Cocconeis vitrea Brun, 1891, p. 19, Pl. 18, Fig. 2 (no illustration).

Coscinodiscus argus Ehrenberg, 1838, p. 129 (Plate 2, Fig. 5).

Coscinodiscus asteromphalus Ehrenberg, 1844a, p. 77 (no illustration).

Coscinodiscus asteromphalus var. *princeps* Grunow *in* Van Heurck, 1883, Pl. 128, Figs. 1–3 (no illustration).

Coscinodiscus excavatus Ralfs *in* Pritchard, 1861, p. 829, Pl. 8, Fig. 26 (no illustration).

Synonym. *Coscinodiscus excavatus* var. *tuberosa* Fenner, 1978, p. 514, Pl. 10, Figs. 11–12; Pl. 11, Figs. 1–3.

Stratigraphic range. Lower Oligocene at DSDP Site 354 (Fenner, 1978) and lower Oligocene at DSDP Site 511 (Gombos and Ciesielski, 1983).

Coscinodiscus lewisianus Greville, 1866, p. 78, Pl. 8, Figs. 8–10 (Plate 1, Fig. 11).

Coscinodiscus marginatus Ehrenberg, 1841a, p. 142: Ehrenberg, 1854, Pl. 18, Fig. 44 (Plate 2, Fig. 3).

Coscinodiscus obscurus Schmidt *in* Schmidt et al., 1874–1959, Pl. 61, Fig. 6; Hustedt, 1928, p. 418, Fig. 224; Baldauf and Barron, 1982, p. 69, Pl. 3, Fig. 1 (Plate 3, Fig. 2).

Coscinodiscus oculusiridis Ehrenberg, 1839, p. 147; Ehrenberg, 1854, Pl. 18, Fig. 42; Pl. 19, Fig. 2 (no illustration).

Coscinodiscus radiatus Ehrenberg, 1839, p. 148, Pl. 3, Figs. 1a–2 (no illustration).

Coscinodiscus sp. 1 (no illustration).

Remarks. Diameter, 50–63 m; valve, round and flat with central region slightly depressed. Areolation is hexagonal to subrounded, arranged in fasciculated pattern with a distinct secondary spiral. Very slight increase in size of areolae about halfway from center. Distinct nodule with central region of valve; margin generally striated or absent. Tubulus process, 10–15 m at end of primary rows.

Coscinodiscus sp. 2 (no illustration).

Remarks. Valve is round; flat with a slightly depressed hyaline margin. Areolae are slightly vasiculated, nonregular, and hexagonal, varying in size. Subrounded nodule near center. Small hyaline area occurs near the nodule.

Coscinodiscus sp. 3 (Plate 2, Fig. 8).

Remarks. Diameter, 43 m; valve surface is domed, concaved with a slightly depressed center, characterized by three areolae that form a central cluster and has inner pores with irregular shape and a centric outer pore. Areolae are arranged on remaining valve surface, which forms a circle around a central cluster and continues to the margin. All areolae contain outer pores of similar size. Margin distinct, very finely striated. On margin focus, dark band on inner margin and separated striated margin from irridescent pattern.

Coscinodiscus sp. 4 (no illustration).

Remarks. This species is equivalent to *Coscinodiscus* cf. *symbolophora* (Grunow) Jorgenson, as illustrated by Harwood, 1982.

Coscinodiscus sp. 5 (no illustration).

Coscinodiscus sp. 6 (no illustration).

Coscinodiscus sp. 7 (no illustration).

Craspedodiscus sp. 1 (Plate 1, Fig. 6).

Remarks. Valve is round, diameter of 36 m, depressed central region one-half to two-thirds of diameter from center to margin. Areolae are subrounded to almost square. Central five areolae are grouped with inner pore position toward center and outer pore toward margin; other areolae do not contain outer pores. Coarser areolae are arranged radially from the valve center to margin and separated by a hyaline area. Areolae are arranged in circular arrangement that extends from the central cluster to the margin. Margin nondistinct.

Cymatosira biharensis Pantocsek, 1889, p. 66, Pl. 3, Fig. 42 (no illustration).

Cymatosira compacata Schrader and Fenner, 1976, p. 976, Pl. 8, Figs. 22, 25; Pl. 25, Figs. 30–32 (no illustration).

Ethmodiscus sp. (no illustration).

Remarks. Only fragments were observed.

Goniothecium decoratum Brun, 1891, p. 28, Pl. 12, Fig. 6 (no illustration).

Stratigraphic range. Eocene–Oligocene of the Norwegian Sea (Schrader and Fenner, 1976).

Goniothecium odontella Ehrenberg, 1844 (no illustration).

Goniothecium sp. 1 (no illustration).

Goniothecium sp. 2 (no illustration).

Hemiaulus crenatus Greville, 1865, p. 101, Pl. 8, Fig. 12 (Plate 4, Fig. 4)

Hemiaulus hostilis Heiberg, 1863, p. 48, Pl. 1, Fig. 11 (no illustration).

Hemiaulus kittonii Grunow *in* Van Heurck, 1883, Pl. 106, Figs. 6–9; Schrader and Fenner, 1976, p. 984, Pl. 10, Fig. 19 (Plate 4, Fig. 12).

Stratigraphic range. Middle Eocene at DSDP Site 356 (Fenner, 1978), lower Oligocene at DSDP Site 354 (Fenner, 1978), Upper Cretaceous of western Siberia (Strelnikova, 1974), and lower Eocene of Mors Jutland (Grunow, 1884; Schmidt et al., 1874–1959).

Hemiaulus cf. *malleolus* Pantocsek, 1886, p. 48, Pl. 8, Fig. 66 (no illustration).

Hemiaulus polycystinorum Ehrenberg, 1854; Fenner, 1978, p. 521, Pl. 21, Figs. 13, 14; Pl. 22, Figs. 4, 5, 7–10; Pl. 23, Figs. 1–4 (Plate 2, Figs. 14–17).

Hemiaulus porteus Heiberg, 1863, p. 47, Pl. 1, Figs. 1–11; Fenner, 1978, p. 522, Pl. 21, Figs. 3, 4, 2? (Plate 4, Fig. 7).

Hemiaulus pungens Grunow, 1884, p. 63, Pl. 5, Figs. 56; Fenner, 1978. p. 522 (no illustration).

Hemiaulus subacutis Grunow, 1884, p. 61, Pl. 5. Figs. 55: Fenner, 1978. p. 522, Pl. 24, Figs. 8, 14 (no illustration).

Hemiaulus taurus Gombos and Ciesielski, 1983, p. 606, Pl. 19, Figs. 1–8 (Plate 3, Fig. 13).

Hemiaulus sp. 1 (Plate 3, Fig. 12; Plate 4, Fig. 14).

Remarks. Similar to *Hemiaulus* sp. 1 of Harwood (1982).

Hemiaulus sp. 2 (Plate 4, Fig. 13).

Remarks. Horns similar length, narrow and areolated, linkage spines present on inner side, central region distinct and separated from horn by furrow, central region domed and contains irregular areolae as well as hyaline region. Areolae are larger then those on the remaining part of the base. Areolae are subrounded, areolae on valve surface also subrounded and radially arranged.

Hemiaulus sp. 3 (Plate 3, Fig. 11).

Remarks. Horns are similar length, moderately wide and areolated, decreasing in size toward the apices. Linkage spines are present and are located in center of horn. Areolae on base decrease in size from the margin to the slightly inflated center, areolae are subrounded and arranged radially from the inflated center. Small pores occur between the areolae and are randomly distributed.

Hemiaulus sp. 4 (Plate 4, Fig. 3).

Remarks. Horns same length, but become narrow about one-third length, linkage spines are located in middle of horn (spine is elongated and finely silicified). Areolae are subrounded and linear in upper part of horn. Areolae are irregular in size and arranged in lower part of horn. Central region is very distinct and has subrounded to rectangular areolae that are arranged in rows parallel to the base. Central region strongly domed and separated from the horns by furrows.

Hemiaulus sp. 5 (no illustration).

Remarks. Similar shape and size to *Hemiaulus weissiii* Grunow, 1884; however, solitary process in inflated central region was not observed and areolae on valve surface are much larger (3 to 6 m in 10), compared with

5 to 8 in 10 m, as observed on specimens by Fenner (1978).

Hemiaulus sp. 6 (no illustration).

Hemiaulus sp. 7 (no illustration).

Hemiaulus sp. 8 (no illustration).

Hemiaulus sp. 9 (no illustration).

Hyalodiscus dentatus Korotkevicz, 1964, p. 104, Pl. 1, Figs. 1-4 (no illustration).

Hylodiscus szurdokpuespoekiensis Hajos, 1968, p. 83, Pl. 9, Fig. 9; Schrader and Fenner, 1976, p. 984, Pl. 40, Figs. 18, 19 (no illustration).

Hyalodiscus sp. 1 (no illustration).

Liradisucs bipolaris Lohman, 1948, p. 165, Pl. 8, Fig. 5; Fenner, 1978, p. 524, Pl. 35, Figs. 23, 24 (no illustration).

Melosira architecturalis Brun *in* Schmidt et al., 1874-1959, Pl. 177, Figs. 45-50; Fenner, 1978, p. 524, Pl. 16, Figs. 7-12; Schrader and Fenner, 1976, p. 989, Pl. 14, Fig. 13; Pl. 29, Figs, 7, 8; Pl. 35, Figs. 1-4; Gombos, 1977, p. 595, Pl. 26, Figs. 5-7 (no illustration).

Synonym. *Cyclotella hannae* Kanaya, 1957, p. 82-84, Pl. 3, Figs. 10-14.

Stratigraphic range. Eocene-Oligocene (Schrader and Fenner, 1976); last occurrence reported to coincide with Eocene/Oligocene boundary in the South Atlantic (Gombos and Ciesielski, 1983).

Melosira clavigera Grunow *in* Van Heurck, 1882, Pl. 91, Fig. 1 (no illustration).

Melosira sulcata (Ehrenberg) Kutzing, 1844, p. 55, Pl. 2, Fig. 7 (no illustration).

Synonym. *Gallionolla sulcata* Ehrenberg, 1838, p. 170, Pl. 21, Fig. 5. *Odontella aurita* Agardh, 1832, p. 56 (no illustration).

Synonym. *Biddulphia aurita* (Lyngbye) Brebissor, 1838, p. 12. *Odontella touemyi* (no illustration).

Synonym. *Biddulphia toumeyi* (Bailey) Roper, 1859, p. 8.

Odontella sp. 1 (no illustration).

Pleurosigma sp. 1 (no illustration).

Polaria sp. 1 (no illustration).

Pseudodimerogramma sp. 1 (no illustration).

Remarks. Species is similar to *Pseudodimerogramma elliptica* Schrader *in* Schrader and Fenner (1976) but is distinguished from this species by having a series of centrally situated processes arranged so as to divide the hyaline region of the footpole into two equal sections. *Pseudodimerogramma elliptica* is recorded to contain a solitary process in this hyaline region.

Pseudorocella barbadensis Deflandre, 1938 *in* Loeblich et al. ,1968, p. 207; Fenner, 1978, p. 537, Pl. 23, Figs. 13-16; Pl. 22, Figs. 1-3 (Pl. 2, Fig. 10).

Pseudostictodiscus picus Hanna, 1927, p. 28, Pl. 3. Figs. 1-4; Fenner, 1978, p. 527, Pl. 1, Fig. 10 (no illustration).

Synonym. *Pseudostictodiscus angulatus* Grunow *in* Schmidt et al., 1874-1959, Pl. 74, Fig. 24.

Stratigraphic range. Late Eocene of the Norwegian Sea (Schrader and Fenner, 1976) and Barbados (Schmidt et al., 1874-1959), middle Eocene at DSDP Site 356 (Fenner, 1978).

Pseudotriceratium chenevieri (Meister) Gleser; Schrader and Fenner, 1976, p. 994, Pl. 11, Figs, 7-9; Pl. 26, Fig. 5 (Pl. 4, Fig. 6).

Pterotheca aculeifera Grunow *in* Van Heurck, 1882; Fenner, 1978, p. 527, Pl. 17, Figs. 8-21 (no illustration).

Stratigraphic range. Middle Eocene at DSDP Site 356 (Fenner, 1978); Upper Cretaceous of west Siberia (Strelnikova, 1974); Upper Cretaceous of the southwest Pacific Ocean (Hajos and Stradner, 1975); Eocene of California (Kanaya, 1957); lower Eocene of Mors (Denmark) (Tsumura, 1963); and lower Oligocene of the southwest Pacific (Hajos, 1976).

Pyxilla group (Pl. 4, Figs. 9 and 10).

Remarks. Because the high number of fragments often disallowed distinguishing specimens of *Pyilla gracilis* Tempere and Forti from specimens of *Pyxilla reticulatus* Grove and Sturt, specimens of the two species are grouped together under this category.

Stratigraphic range. Middle Eocene Site 356 (Fenner, 1978); Eocene of DSDP Site 13 (Gleser and Jouse, 1974) and Barbados (Hanna and Brigger, 1964); and late Eocene-early Oligocene of the Southwest Pacific (Hajos, 1976); early Eocene of the Southern Ocean (McCollum, 1975).

Rhaphoneis sp. 1 (no illustration).

Rhizosolenia hebetata Bailey, 1856, p. 5, Pl. 1, Figs. 18, 19 (no illustration).

Remarks. Specimens of *Rhizosolenia hebetata* f. *hiemalis* Gran and *Rhizosolenia hebetata* var. *subacuta* Grunow are grouped in this category.

Rhizosolenia interposita Hajos (no illustration).

Rhizosolenia massiva Schrader *in* Schrader and Fenner, 1976, p. 996, Pl. 41, Fig. 19 (no illustration).

Rhizosolenia oligocaenica Schrader, 1976, p. 635, Pl. 9, Fig. 7 (Pl. 4, Fig. 11).

Synonym. *Rhizosolenia gravida* Gombos and Ciesielski, 1983, p. 606, Pl. 11, Figs. 1-7.

Remarks. Fenner (1985) indicated that smaller specimens of *Rhizosolenia gravida* are identical to those described by Schrader as *Rhizosolenia oligocaenica*; similar results were observed during this study. Botanical nomenclature, therefore, indicates that *R. oligocaenica* has priority over *R. gravida*.

Rhizosolenia sp. 1 (no illustration).

Remarks. Nondiagnostic partial specimen characterized by a narrowing of the central canel toward one apice.

Riedelia group (no illustration).

Remarks. Only fragmented specimens were observed.

Rocella gelida (Mann) Bukry, 1978, p. 788, Pl. 5, Figs. 1-13; Gombos and Ciesielski, 1983, p. 604, Pl. 6, Figs. 1-16; Pl. 26. Fig. 1.

Synonym. *Stictodicus gelidus* Mann, 1907, p. 268, Pl. 50, Fig. 5 (no illustration).

Rocella praenitida (Fenner) Fenner *in* Kim and Barron, 1986, Pl. 4, Fig. 3 (no illustration).

Synonym. *Coscinodiscus praenitidus* Fenner *in* Schrader and Fenner, 1976, p. 972, Pl. 14, Figs. 7-9; Pl. 27, Fig. 8; Pl. 35, Fig. 24; Pl. 36, Fig. 5; Fenner, 1978, p. 516, Pl. 1, Figs. 6, 9, 15; Pl. 3, Fig. 3.

Stratigraphic range. Upper Oligocene at DSDP Site 338 in the Norwegian Sea (Schrader and Fenner, 1976); middle Eocene at DSDP Site 356 (Fenner, 1978); and upper Oligocene of Site 513A (Gombos and Ciesielski, 1983).

Rocella vigilans (Kolbe) Fenner, 1984a; Gombos and Ciesielski, 1983, p. 604, Pl. 6, Figs. 7-10; Pl. 26, Fig. 2 (no illustration).

Stratigraphic range. Common throughout the Oligocene (Gombos and Ciesielski, 1983).

Rouxia obesa Schrader *in* Schrader and Fenner, 1976, p. 997, Pl. 24, Figs. 5, and 6 (no illustration).

Rutilaria areolata Sheshukova *in* Gleser et al., 1974, Pl. 33, Figs. 3a, 3b (no illustration).

Sceptroneis grunowii Anissimova, 1937 (Pl. 3, Fig. 4).

Sceptroneis humunica Schrader and Fenner, 1976, p. 998, Pl. 2, Figs. 5-7; Pl. 24, Figs. 17, 26 (Pl. 3, Fig. 8).

Sceptroneis mayenica Fenner *in* Schrader and Fenner, 1976, p. 998, Pl. 22, Figs. 22-25; Pl. 23, Figs. 1-4; Pl. 25, Figs. 6, 8 (no illustration).

Sceptroneis pupa Schrader and Fenner, 1976, p. 999, Pl. 22, Figs. 17-21; Pl. 24, Figs. 11-13 (no illustration).

Sceptroneis talwanii Schrader and Fenner, 1976, p. 999, Pl. 24, Figs. 28-30 (no illustration).

Sceptroneis tenue Schrader and Fenner, 1976, p. 999, Pl. 3, Figs. 1-4; Pl. 24, Fig. 14-16?; Pl. 25, Figs. 12, 22, 24 (Pl. 4, Fig. 8).

Sceptroneis sp. 1 (no illustration).

Sceptroneis sp. 2 (no illustration).

Stellarima microtroas Hasle and Sinus, 1986, p. 111, Figs. 18-27.

Stephanogonia sp. 1 (Pl. 2, Fig. 1).

Stephanogonia sp. 2 (Pl. 1, Fig. 13; Pl. 3, Fig. 7).

Remarks. Valve circular, 45-50 μm in diameter, center domed and coarsely punctuated; around the center, the valve is flat and hyaline, 6 to 10 ribs are irregularly connected together in the center and reach radially to the margin. Similar to *Stephanogonia* sp. Schrader and Fenner, 1976, Pl. 45, Figs. 2, 3.

Stephanogonia sp. 3 (no illustration).

Stephanopyxis corona (Ehrenberg) Grunow *in* Van Heurck, 1884, p. 90, Pl. 83c, Figs. 10, 11 (no illustration).

Stephanopyxis grunowii Grove and Stuart *in* Schmidt et al., 1874-1959, Pl. 130, Figs. 1-5; Fenner, 1978, p. 532, Pl. 12, Figs. 10, 13; Gombos, 1977, p. 596, Pl. 28, Figs. 3-5; Pl. 31, Figs. 1, 7; Pl. 32, Figs. 1-3 (Pl. 3, Fig. 9).

Stratigraphic range. Middle Eocene at DSDP Site 356 (Fenner, 1978); late Eocene of Oamaru (Schmidt et al., 1874-1959); and late Oligocene of the Norwegian Sea (Schrader and Fenner, 1976).

Stephanopyxis hyalomarginata Hajos, 1976, p. 824, Pl. 19, Figs. 11, 12 (no illustration).
Stephanopyxsis marginata Grunow, 1884, p. 90, Pl. 5, Fig. 17 (Pl. 3, Fig. 5).

Stratigraphic range. Upper Oligocene at DSDP Site 338 (Schrader and Fenner, 1976) and middle Eocene at DSDP Site 356 (Fenner, 1978).
Stephanopyxis megapora Grunow, 1884, p. 89, Pl. 5, Fig. 24 (no illustration).
Stephanopyxis spinosissima Grunow, 1884, p. 90–91; Schrader and Fenner, 1976, Pl. 31, Fig. 5 (no illustration).
Stephanopxis superba (Greville) Grunow, 1884, p. 39, Fig. 91 (Pl. 2, Fig. 4).

Synonym. *Cresswellia superba* Greville, 1861, p. 68, Pl. 8, Figs. 3–5.
Stephanopyxis turris (Greville and Arnott) Ralfs *in* Pritchard, 1861, p. 826, Pl. 5, Fig. 74 (Pl. 2, Fig. 5; Pl. 11).

Synonym. *Cresswellia turris* Greville and Arnott, 1857, p. 538.

Remarks. Specimens of *Stephanopyxis turris* var. *cylindrus* are recorded in this category.
Stephanopyxis sp. 2 (no illustration).
Stephanopyxis sp. 3 (Pl. 3, Fig. 10).

Remarks. Valve circular, strongly convexed, 55–81 μm in diameter. Areolae hexagonally arranged and tangental to center; areolae are uniform in size (3 in 10 μm). Margin varies from prominent to almost indistinct, generally is 10 μm wide and can be heavily striated or ribbed (5 in 10 μm). Margin focus is characterized by an irridescent "star" pattern having five to six rays.
Stephanopyxis sp. 4 (no illustration).
Stephanopyxis sp. 5 (no illustration).
Stictodiscus group (no illustration).

Remarks. Nondiagnostic fragments of the genus were placed in this category.
Synedra jouseana Sheshukova-Poretzkaya, 1962, p. 208, Fig. 4 (no illustration).
Synedra miocenica Schrader, 1976, p. 636, Pl. 1, Fig. 1 (no illustration).
Synedra sp. 1 (no illustration).

Remarks. Specimens of this species are characterized by having one margin straight and the other bowed, similar to those observed in *Pseudoeunotia dolilus*.
Thalassionema nitzschioides Grunow *in* Van Heurck, 1881, p. 319, Fig. 75 (no illustration).
Thalassiosira eccentrica Cleve, 1904, p. 216; Fryxell and Hasle, 1972, p. 302 (no illustration).
Thalassiosira irregulata Schrader *in* Schrader and Fenner, 1976, p. 1001, Pl. 20, Figs. 10–12 (no illustration).

Stratigraphic range. Late Oligocene (Schrader and Fenner, 1976).
Thalassiosira aff. *irregulata* Schrader and Fenner, 1976, p. 1002, Pl. 20, Fig. 13 (Pl. 3, Fig. 2).
Thalassiosira leptopus (Grunow) Hasle and Fryxell, 1977, Figs. 1–14, 94–96 (Pl. 3, Fig. 14).

Synonym. *Coscinodiscus lineatus* Ehrenberg.
Thalassiosira media-convexa Schrader *in* Schrader and Fenner, 1976, p. 1002, Pl. 36, Fig. 1 (no illustration).
Thalassiosira sp. 1 (no illustration).
Thalassiosira sp. 2 (no illustration).
Thalassiosira sp. 3 (no illustration).
Thalassiothrix longissima Cleve and Grunow *in* Cleve and Moller, 1878, no. 118; no. 207 (no illustration).
Triceratium condecorum Brightwell, 1853, p. 250, Pl. 4, Fig. 12; Fenner, 1978, p. 534, Pl. 28, Fig. 7; Pl. 29, Fig. 1 (Pl. 3, Fig. 6).

Stratigraphic range. Middle Eocene of DSDP Site 356 and early Oligocene of Site 354 (Fenner, 1978); middle-late Miocene of the northeast Pacific (Schrader, 1973).
Triceratium exornatum Greville, 1856, p. 7, Pl. 1, Fig. 25 (no illustration).
Triceratium groningensis Reinhold, 1937, p. 126, Pl. 20, Fig. 9 (Pl. 1, Fig. 3).
Triceratium cf. *macroporum* Hajos, 1968, Pl. 35, Figs. 1–10; Jouse, 1974, p. 349, Pl. 2, Fig. 12 (Pl. 1, Fig. 9).
Triceratium unguiculatum Greville, 1864, p. 85, Pl. 11, Fig. 9; Gombos, 1977, p. 598–599, Pl. 33, Figs. 1, 3; Pl. 34, Figs. 1–4; Gombos and Ciesielski, 1983, p. 605, Pl. 14, Figs. 9–12; Pl. 16, Figs. 1–4 (Pl. 3, Fig. 1).
Triceratium sp. 1 (Pl. 1, Fig. 12).

Remarks. Somewhat similar to *Triceratium* sp. 1 of Fenner, 1978 (p. 535, Pl. 28, Fig. 11).
Triceratium sp. 2 (Pl. 1, Fig. 8).
Trinacria excavata Heiberg, 1863, p. 51, Pl. 4, Fig. 9 (Pl. 1, Fig. 14).

Stratigraphic range. Middle Eocene at DSDP Site 356 (Fenner, 1978); early Oligocene–early Pliocene of the Southern Ocean (McCollum, 1975); Miocene–early Pliocene of the Southwest Pacific (Schrader, 1976); late Eocene to early Oligocene of the Southwest Pacific (Hajos, 1976); late Eocene to late Oligocene of the Southwest Atlantic (Gombos, 1977); Late Cretaceous of California (Hanna, 1927).

Remarks. Specimens of *Trinacria excavata* f. *tetragona* Schmidt are recorded under this category.
Trinacria excavata var. ? (no illustration).
Trinacria sp. 1 (Pl. 1, Fig. 10).
Trinacria sp. 2 (no illustration).
Trinacria sp. 3 (no illustration).
Genus and species indet 1 (no illustration).
Genus and species indet 2 (no illustration).
Genus and species indet 3 (no illustration).
Genus and species indet 4 (no illustration).
Genus and species indet 5 (no illustration).
Genus and species indet 6 (no illustration).
Genus and species indet 7 (no illustration).
Genus and species indet 8 (no illustration).
Genus and species indet 9 (no illustration).
Genus and species indet 10 (Pl. 4, Fig. 5).

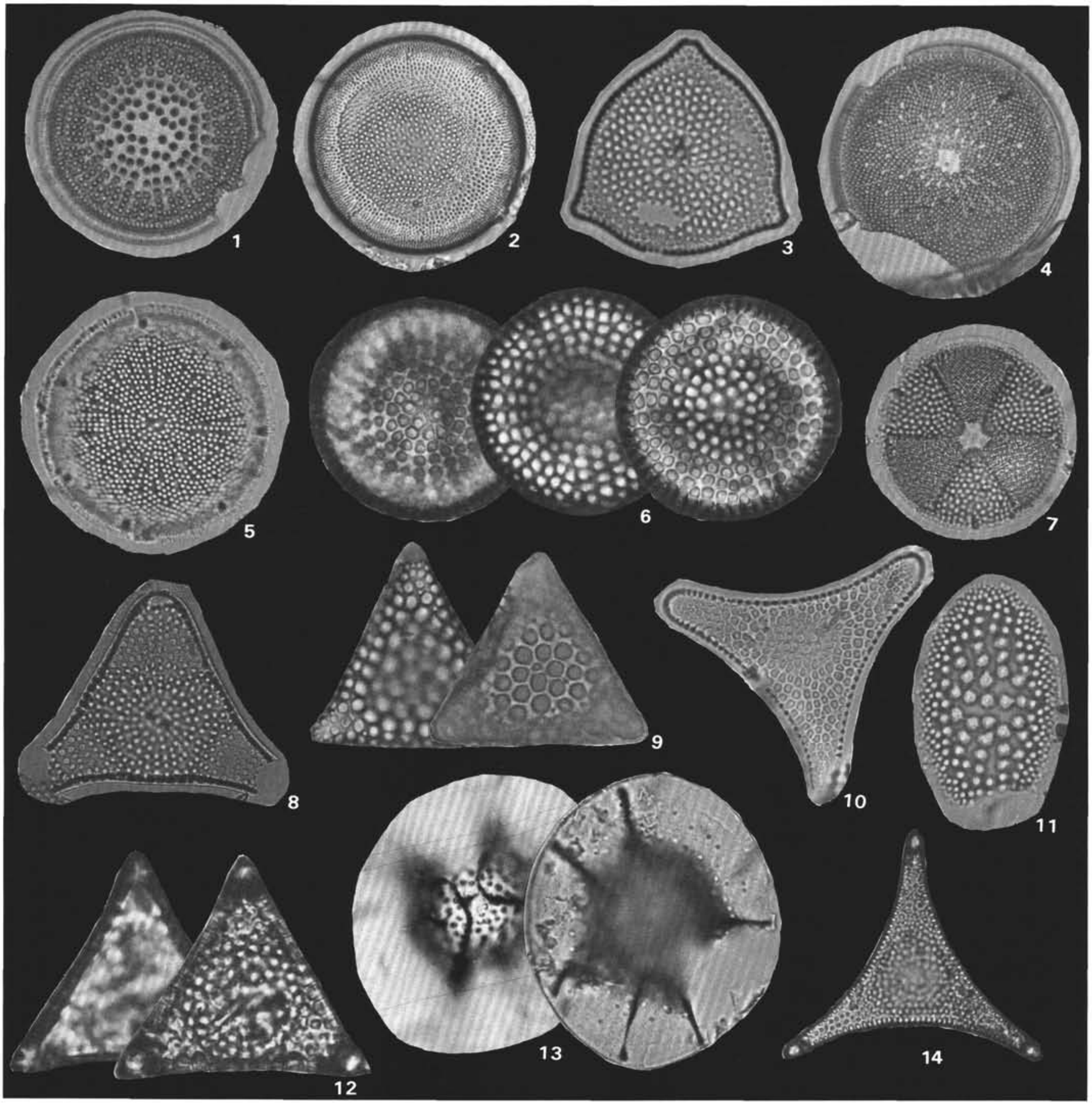

Plate 1. **1.** *Cestodiscus robustus* Jousé. Sample 647A-24R, CC (48 um); **2, 5.** *Cestodiscus* sp. 9. (2) Sample 19R-5, 124–126 cm (43 um), (5) Sample 647A-21R-1, 124–126 cm (67 um); **3.** *Triceratium groningensis* Reinhold. Sample 647A-21R, CC (38 um length); **4.** *Cestodiscus* sp. 3. Sample 647A-24R, CC (65 um); **6.** *Craspedodiscus* sp. 1. Sample 647A-17R-5, 125–127 cm (36 um); **7.** *Actinoptychus senarius* (Ehrenberg) Ehrenberg. Sample 647A-21R-1, 124–126 cm (88 um); **8.** *Triceratium* sp. 2. Sample 647A-18R, CC (65 um length); **9.** *Triceratium* cf. *megapora* Hajos. Sample 647A-21R-1, 124–126 cm (30 um length); **10.** *Trincarica* sp 1. Sample 647A-21R-1, 124–126 cm (125 um length); **11.** *Coscinodiscus lewisianus*, Sample 647A-13R-4, 109–111 cm (32 um length); **12.** *Triceratium* sp. 1. Sample 647A-21R-1, 124–126 cm (36 um length); **13.** *Stephanogonia* sp. 2, Sample 647A-17R-5, 125–127 cm (47 um); **14.** *Trinacraia excavata* Heiberg. Sample 647A-23R-1, 104–106 cm (70 um length).

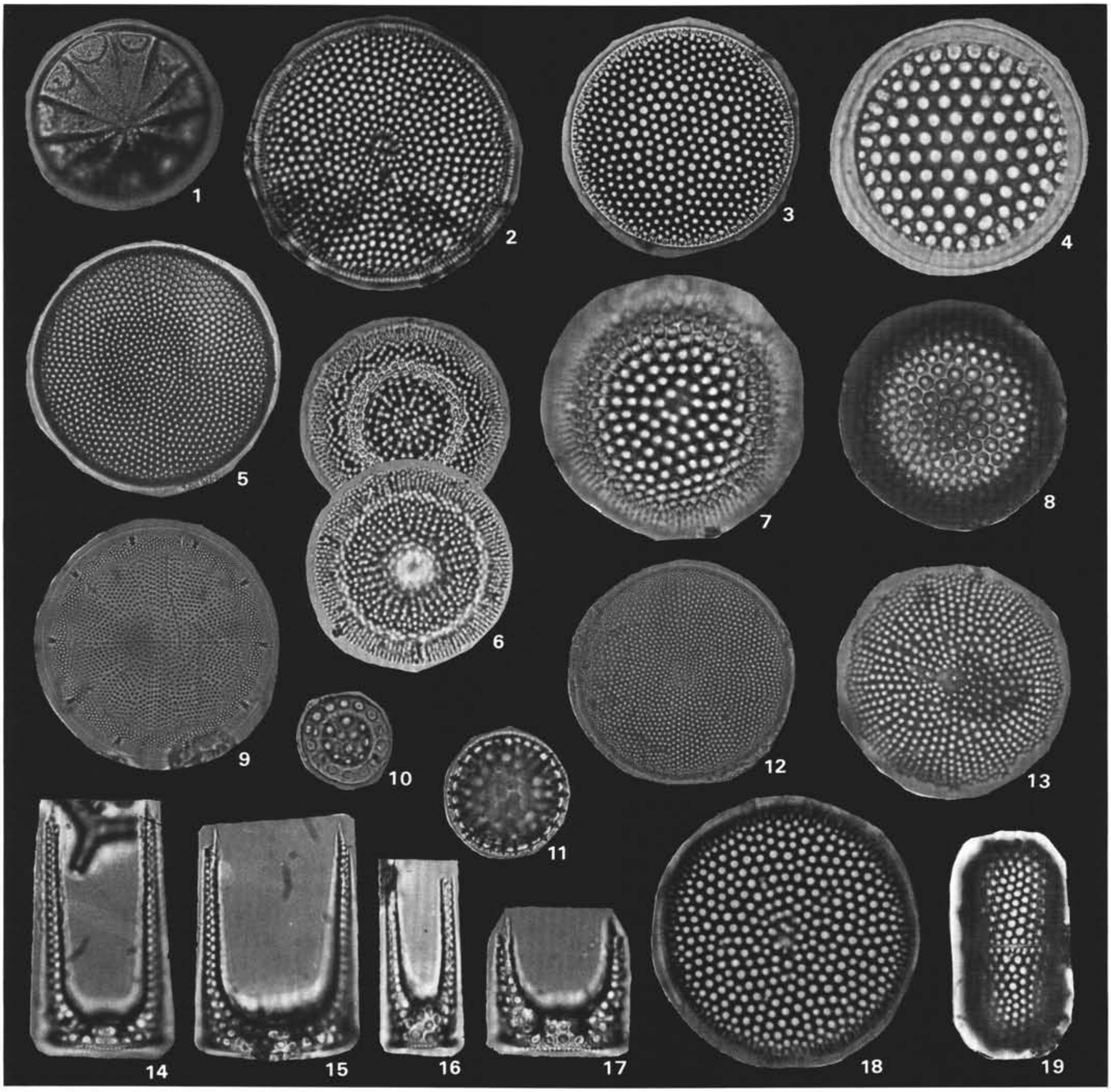

Plate 2 **1.** *Stephanogonia* sp. 1. Sample 647A-13R, CC (37 um); **2, 13.** *Azpeitia oligocenica* (Jousé) Sims. (2) Sample 647A-15R-1, 125–127 cm (38 um), (13) Sample 647A-17R-5, 125–127 cm (35 um); **3.** *Coscinodiscus marginatus* Ehrenberg. Sample 647A-21R-1, 124–126 cm (50 um); **4.** *Stephanopyxis* cf. *superba* (Greville) Grunow. Sample 647A-24R, CC (69 um); **5.** *Coscinodiscus argus*. Sample 647A-15R-1, 125–127 cm (71 um); **6.** *Cestodiscus pulchellus* Greville. Sample 647A-13R-4, 109–111 cm (44 um); **7.** *Cestodiscus* sp. 8. Sample 647A-25R-2, 120–122 cm (30 um); **8.** *Coscinodiscus* sp 3. Sample 647A-15R-1, 125–127 cm (42 um); **9.** *Cestodiscus* sp. 9. Sample 647A-15R-3, 125–127 cm (56 um); **10.** *Pseudorocella barbadensis* Deflandre. Sample 647A-25R-4, 119–121 cm (21); **11, 19.** *Stephanopyxis turris* Group. (11) Sample 647A 21R-1, 124–126 cm (28 um), (19) Sample 647A-21R-1, 124–126 cm (50 um length); **12.** *Azpeitia voluta* (Baldauf) Sims. Sample 647A-23R-1, 104–106 cm (47 um); **14-17.** *Hemiaulus polycystinorium* Ehrenberg. Sample 647A-21R-1, 124–126 cm, 14) (70 um length), 15) (37 um length), 16) (35 um length), 17) (24 um length); **18.** *Azpeitia tuberculata* var. *atlantica* (Gleser and Jousé) Sims. Sample 647A-19R-4, 124–126 cm (38 um).

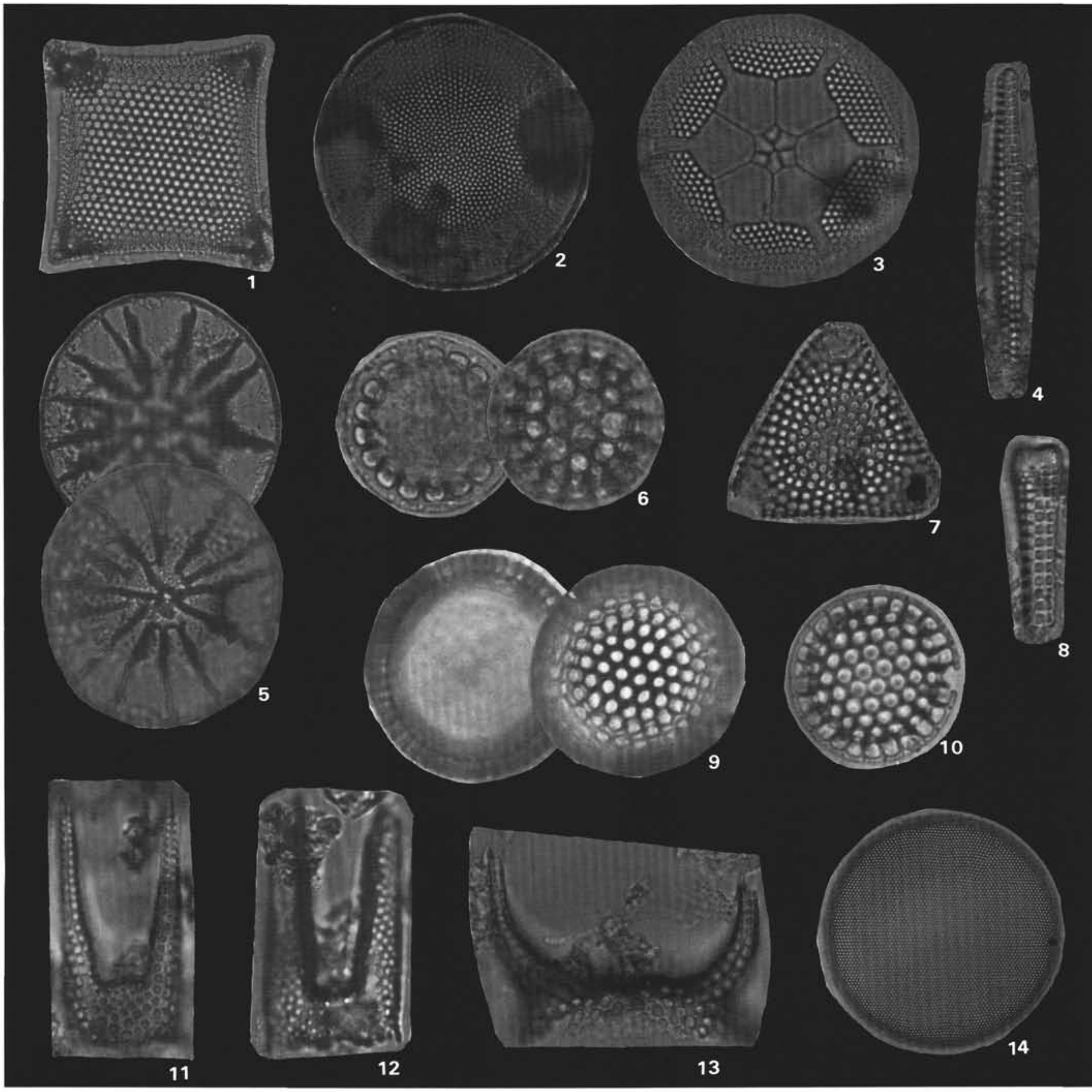

Plate 3 **1.** *Triceratium unguiulatum* Greville. Sample 647A-23R-1, 104–106 cm (93 um); **2.** *Coscinodiscus obscurus* Schmidt. Sample 647A-21R-1, 124–126 cm (152 um); **3.** *Asterolampra schmidtii* Hajos. Sample 647A-21R-1, 124–126 cm (145 um); **4.** *Screptroneis grunowii* Anissimova. Sample 647A-17R-5, 125–127 cm (59 um length); **5.** *Stephanopyxis marginata* Grunow. Sample 647A-14-2, 50–52 cm (44 um); **6.** *Triceratium* cf. *condecorum* Brightwell. Sample 647A-21R-1, 124–126 cm (30 um); **7.** *Stephanogonia* sp. 2. Sample 647A-18R, CC (39 um); **8.** *Sceptroneis humunica* Schrader and Fenner. Sample 647A-19R-5, 124–126 cm (30 um length); **9.** *Stephanopyxis grunowii* Grove and Sturt. Sample 647A- 22R, CC (47 um); **10.** *Stephanopyxis* sp. 3. Sample 647A-25R, CC (62 um); **11.** *Hemiaulus* sp. 3. Sample 647A- 15-1, 125–127 cm (41 um length); **12.** *Hemiaulus* sp. 1. Sample 647A-21R-1, 124–126 cm (120 um length); **13.** *Hemiaulus taurus* Gombos and Ciesielski. Sample 647A-19R-5, 124–126 cm (32 um length); **14.** *Thalassiosira leptopus* (Grunow) Hasle and Fryxell. Sample 647A-17R-3, 128–130 cm (143 um).

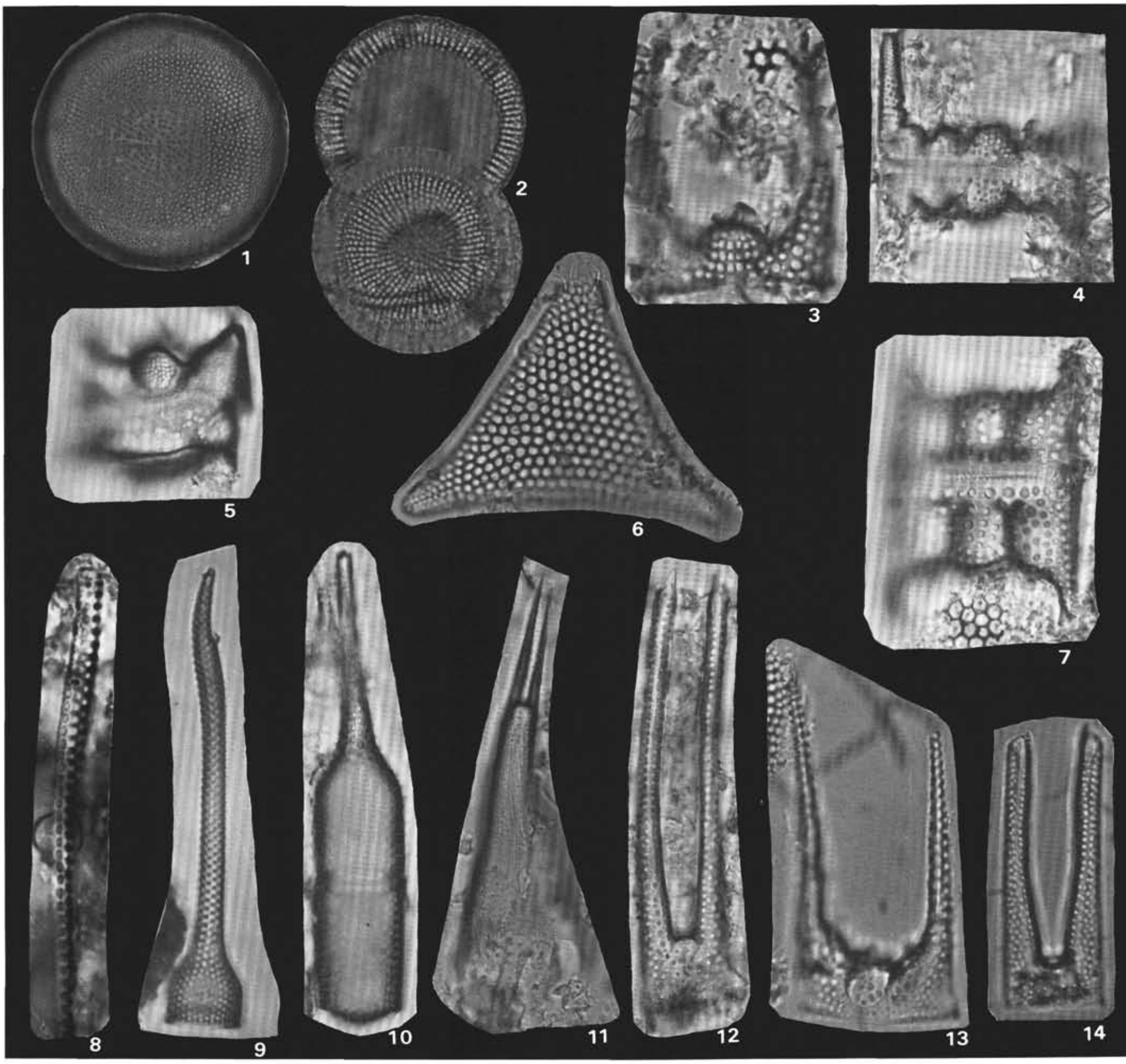

Plate 4 **1.** *Cestodiscus* sp. 10. Sample 647A-15R-1, 125–127 cm (63 um); **2.** *Thalassiosira* aff. *irregulata* Schrader and Fenner. Sample 647A-21R-1, 124–126 cm (38 um); **3.** *Hemiaulus* sp. 4. Sample 647A-25R-2, 120–122 (32 um length); **4.** *Hemiaulus crenulatus* Greville. Sample 647A- 15R-3, 125–127 cm (29 um length); **5.** Genus and Species indet. 10. Sample 647A-19R-5, 124–126 cm (27 um width); **6.** *Pseudotriceratium chenevieri* (Meister) Gleser. Sample 647A-17R-3, 128–130 cm (41 um length); **7.** *Hemiaulus porteus* Heiberg. Sample 647A-25R-2, 120–122 cm (36 um length); **8.** *Sceptroneis tenue* Schrader and Fenner. Sample 647A-15R-3, 125–127 cm (110 um length); **9, 10.** *Pyxilla gracilis* Tempere and Forti. (9) Sample 647A-25R-2, 120–122 cm (90 um length), (10) Sample 647A-24R, CC (103 um length); **11.** *Rhizosolenia oligocaenica* Schrader. Sample 647A-19R-5, 124–126 cm (86 um length); **12.** *Hemiaulus kittonii* Grunow. Sample 647A-21R-1, 124–126 cm (85 um length); **13.** *Hemiaulus* sp. 2. Sample 647A-21R-1, 124–126 cm (100 um length); **14.** *Hemiaulus* sp. 1. Sample 647A-21R-1, 124–126 cm (160 um length).