22. CENOZOIC MARINE PLANKTONIC DIATOM STRATIGRAPHY OF THE TROPICAL INDIAN OCEAN

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CONTENTS

INTRODUCTION

Leg 22 of the Deep Sea Drilling Project, January-March 1972, from Darwin, Australia to Colombo, Ceylon drilled eight sites. Two sites, 213 and 215, contain excellently preserved Cenozoic diatom assemblages. Site 213 is situated east of the Ninetyeast Ridge at lat 10°12.71′S, long 93°53.77′E and was drilled at a water depth of 5611 meters. Site 215 is situated west of the Ninetyeast Ridge at lat 8°07.30′S, long 86°47.50′E and was drilled at a water depth of 5319 meters. Leg 24 of the Deep Sea Drilling Project, May-June 1972, from Djibouti, F.T.A.I. to Port Louis, Mauritius drilled eight sites. Two sites, 236 and 238, were chosen for this investigation. Site 236 is situated northeast of Seychelles Block at lat 01°40.62′S, long 57°38.85′S and was drilled at a water depth of 5404 meters. Site 238 is situated at the extreme northeast end of Argo Fracture Zone at lat 11°09.21′S, long 70°31.56′E and was drilled at an actual water depth of 2844 meters (Figure 1). Sites 236, 238, 215, and 213 today underlie areas where the calculated mean yearly primary production (expressed as $gC/m^2/year$) varies between 100 and 200 $gC/m^2/year$ (Krey, 1971) (Figure 2).

PREPARATION OF SAMPLES

The total amount of the wet samples (approx. 3 ml of original samples) was taken and heated at 100°C for 20 minutes in a beaker with an equal mixture of concentrated acetic acid and hydrogen peroxide. The suspension was then centrifuged in 50 ml centrifuge tubes at a speed of 1300 r.p.m., decanted, and the residue diluted with demineralized water. This procedure of centrifuging-decanting-diluting was repeated for five times to remove most of the clay-sized mineral components. The residue was then carefully shaken in a mixture of 0.5 percent sodium pyrophosphate in water and centrifuged twice at 1300 r.p.m. The residue was then washed three times by repeated centrifuging, decanting, and diluting. Residue, after the

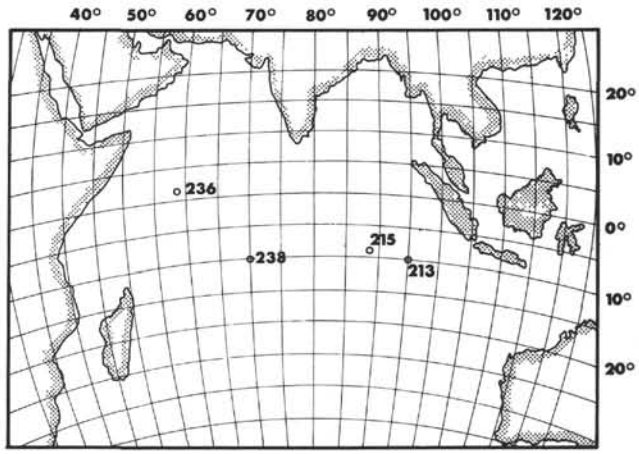


Figure 1. *Index map, showing localities of investigated sites of Leg 22 and Leg 24.*

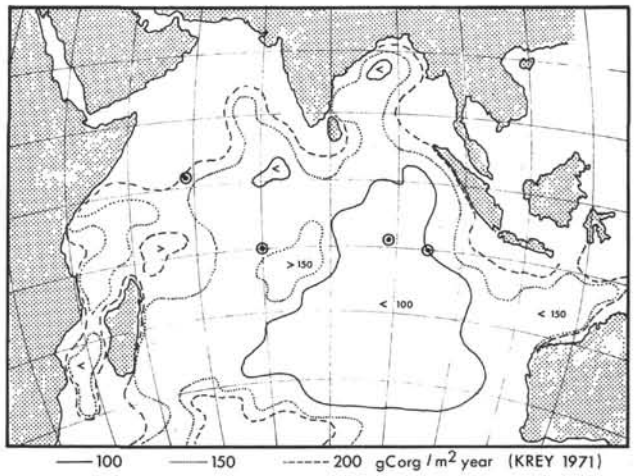


Figure 2. *Mean calculated organic carbon production per year in the Indian Ocean. Dots represent sites (Krey, 1971).*

cleaning procedure, was stored in demineralized water to which a few drops of formaldehyde had been added to prevent bacterial activity (Schrader, in press).

For slide preparation, each sample was carefully shaken and 1 to 3 drops of residue were pipetted from the middle of the bottle (plastic disposable tips, Stradner and Papp, 1961) and placed on a clean 18 X 18 mm cover glass (thickness less than 0.17 mm). After drying, a small amount of Aroclor No. 4465 (nd 1.66; Xylene solvent, Schrader, 1969) was placed on the cover glass and heated at approximately 100°C until the mounting medium became hard upon cooling. The cover glass was then taken up on a heated slide (for more detailed description see Hustedt, 1924; Schrader, 1973a, 1974).

Investigations were made with a Leitz Orthoplan light microscope with apochromatic optics (Objectives FL Oil 54 X/0.95 and Apo Oil 90 X/1.40). Micrographs were made with an automatic Leitz Orthomat camera using a 10X ocular. Most of the illustrated individuals are located on the slides and marked with a diamond microscopical pencil. Individuals on the plates are pictured at 1500X magnification except for a few at 600X magnification.

TIME RANGES OF TAXA AND BIOSTRATIGRAPHIC ZONATION

Planktonic marine diatom zonations of the equatorial Pacific were first established by Kolbe (1954) on sediment cores of the Swedish Deep-Sea Expedition. This zonation has been revised by Kanaya (1969 and 1971) who showed that the Pliocene/Pleistocene boundary of Kolbe (1954) on SDE Core 76 is really an erosional unconformity. Muchina (1963) discussed the diatom stratigraphy on Station 3802 and defined four zones. In a later paper, Muchina (1969) reported on additional cores from the Pacific and constructed a range chart of stratigraphically useful diatoms for the Neogene. Burckle (1972) suggests that a late Miocene-early Pliocene unconformity is present in the core of Muchina (1969). Bukry and Foster (1973) established a diatom zonation from Holocene to middle Miocene using a 44μ fraction. Zonations with high biostratigraphic resolution were presented by Burckle (1972) for the equatorial east Pacific, by Jousé (1971b) for the central north Pacific, by Schrader (1973a) for the northeast Pacific, by Koizumi (1973) for the northwest Pacific, by Kanaya and Koizumi (1970) for the circum-Pacific region. The last range chart presents preliminary data which will be revised in the near future (Koizumi, 1973, personal communication).

The biostratigraphic zonation used in this report incorporates biostratigraphic zones first proposed by Burckle (*in* Hays et al., 1969) and Burckle (1972). The biostratigraphic zonation of Burckle (1972) is related to closely spaced first and last occurrences of species and to the composition of the thanatocoenoses. The diatom zonation applicable to the Leg 22 and Leg 24 sequences is correlatable to the zonation of Burckle (1972) except for the closer distance (in time) (Figure 3) of the new proposed tropical Indian Ocean diatom zones (Figure 4). New "events", morphotypic and evolutionary, were found and defined, and different taxonomic views led to a different evolutionary interpretation and thus different biostratigraphic zonation.

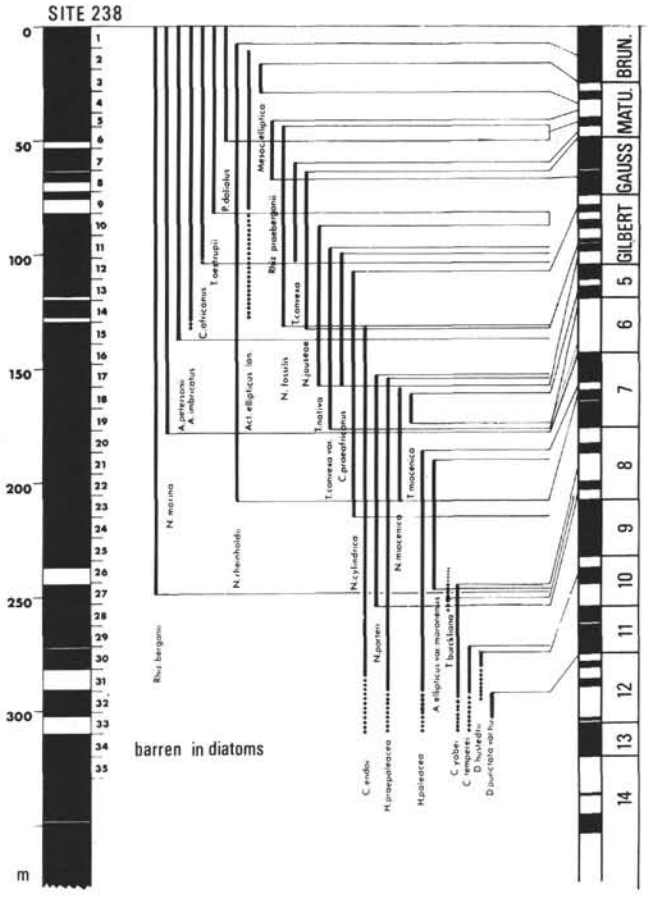


Figure 3. *Species ranges at Site 238. Left: Site 238, recovered interval black, core numbers. Right: species ranges correlated to the paleomagnetic stratigraphic scale. For explanation see text.*

Tropical Indian Ocean Diatom Zone 1

Definition: The base of this zone is defined at the extinction of *Nitzschia reinholdii.*

Discussion: An essentially modern flora is present throughout the zone, it includes *Actinocyclus ehrengergii, Asteromphalus arachne, A. flabellatus, A. imbricatus, A. petersonii, A. robustus, Coscinodiscus africanus, C. curvatulus, C. crenulatus, C. excentricus, C. lineatus, C. lineatus* var. *ellipticus, C. nodulifer, Ethmodiscus rex, Hemidiscus cuneiformis, Nitzschia aequatorialis, N. marina, N. seriata, N. interrupta, Pseudoeunotia doliolus, Roperia tesselata* and varieties, *Rhizosolenia bergonii, Rh. styliformis, Thalassiosira excentrica, Th. oestrupii, Thalassionema nitzschioides, Thalassiothrix frauenfeldii, Th. longissima,* and *Triceratium cinnamomeum.*

Paleomagnetic stratigraphy: The base of this zone falls within the middle part of the Brunhes normal epoch and ranges to the top of the Brunhes normal epoch.

Comparison with the zonation of other workers: Zone 1 correlates to the upper part of the *Pseudoeunotia doliolus* Range Zone of Burckle (1972), and with the upper part of the *Roperia tesselata* Zone of Bukry and Foster (1973).

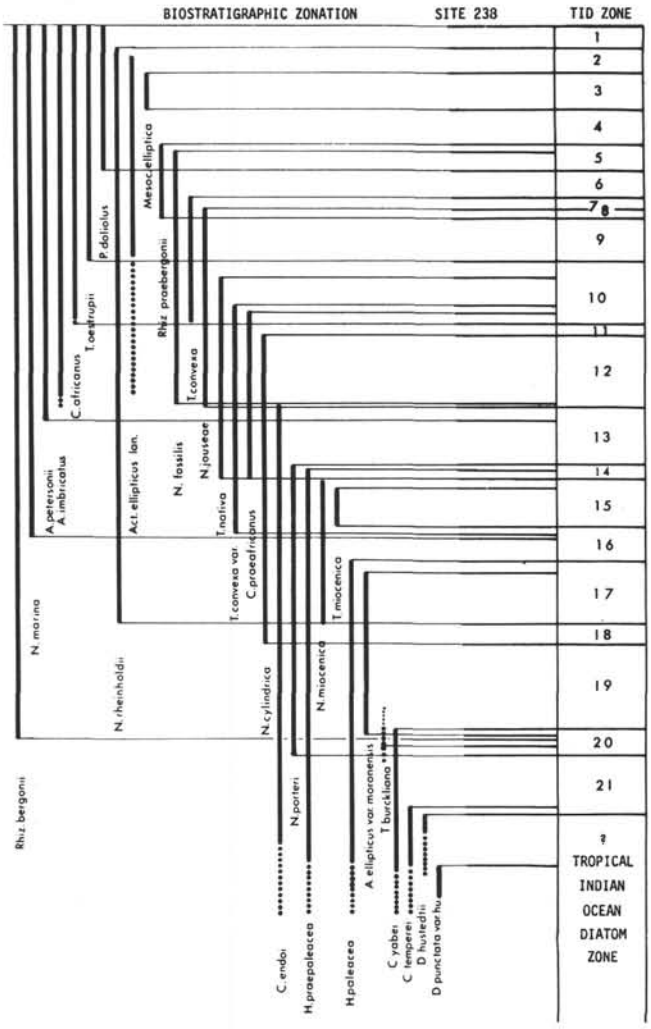


Figure 4. *Species ranges and resulting tropical Indian Ocean diatom zonation.*

Absolute age: 0.3 (?) m.y., the lower age has been interpolated from the data of Kanaya and Koizumi (1970) and Kanaya *in* Kobayashi et al. (1971).

Geographical extent: Found in tropical Indian Ocean sediments.

Type locality: DSDP Leg 24, Site 238, Core 1, Section 1, 60 cm to Core 1, Section 3, 75 cm.

Tropical Indian Ocean Diatom Zone 2

Definition: The base of this zone is placed at the extinction of the silicoflagellate species *Mesocena elliptica* within the Pleistocene; the top at the extinction of *Nitzschia reinholdii.*

Discussion: A modern flora, present throughout the zone includes the same species as Tropical Indian Ocean Diatom Zone 2.

Paleomagnetic stratigraphy: The base of this Zone falls within the uppermost part of the Matuyama reversed epoch; the top within the middle part of the Brunhes normal epoch.

Comparison with the zonation of other workers: Zone 2 correlates to the upper part of the *Pseudoeunotia doliolus* Range Zone of Burckle (1972), with the upper part of the *Roperia tesselata* Zone of Bukry and Foster (1973) and the *Dictyocha epiodon* Zone of Bukry and Foster (1973).

Absolute age: 0.3(?)-0.7 m.y.

Geographical extent: Found in tropical Indian and Pacific Ocean sediments.

Type locality: DSDP Leg 24, Site 238, Core 1, Section 4, 65 cm to Core 2, Section 2, 75 cm.

Tropical Indian Ocean Diatom Zone 3

Definition: The base of this zone is defined at the first evolutionary appearance within the Pleistocene of the silicoflagellate *Mesocena elliptica;* the top at the extinction of the silicoflagellate *Mesocena elliptica* within the Pleistocene.

Discussion: A modern flora is present throughout this zone with a similar species assemblage as Zone 1.

Paleomagnetic stratigraphy: The base of this zone falls just below the Jaramillo event within the Matuyama reversed epoch; the top within the uppermost part of the Matuyama reversed epoch.

Comparison with the zonation of other workers: Zone 3 correlates to the middle part of the *Pseudoeunotia doliolus* Range Zone of Bukry and Foster (1973) and to the *Mesocena elliptica* silicoflagellate zone of Bukry and Foster (1973).

Absolute age: 0.7-0.93 m.y. extrapolated from Burckle *in* Hays et al. (1969) and from Kanaya *in* Kobayashi et al. (1971).

Geographical extent: Found in tropical Indian and Pacific Ocean sediments.

Type locality: DSDP Leg 24, Site 238, Core 2, Section 3, 75 cm to Core 3, Section 6, 75 cm.

Tropical Indian Ocean Diatom Zone 4

Definition: The base of this zone is defined at the evolutionary extinction of *Rhizosolenia praebergonii*; the top at the first evolutionary appearance of the silicoflagellate *Mesocena elliptica* within the Pleistocene.

Discussion: A modern flora in this zone includes *Actinocyclus ehrenbergii, A. divisus, A. ellipticus* forma *lanceolata, Asterolampra affinis, A. marylandica, Asteromphalus arachne, A. flabellatus, A. heptactis, A. imbricatus, Coscinodiscus africanus, C. crenulatus, C. lineatus, C. lineatus* var. *ellipticus, C. nodulifer, C. tabularis* var. *egregius, Ethmodiscus rex, Hemidiscus cuneiformis, Nitzschia marina, N. seriata, N. reinholdii, Pseudoeunotia doliolus, Roperia tesselata, Rhizosolenia bergonii, Pleurosigma* sp., *Thalassiosira excentrica, Th. oestrupii, Th. plicata, Thalassionema nitzschioides, Thalassiothrix frauenfeldii, Thal. longissima.* Within this zone, *Roperia tesselata* var. *ovata* appears as does *Coscinodiscus lineatus* var. *ellipticus.* The first occurrences, which are interpretated as being evolutionary, may help to distinguish this zone from others. The first appearance of *C. lineatus* var. *ellipticus* may be best recognized on coarse fraction slides.

Paleomagnetic stratigraphy: The base of this zone falls within the middle part of the Matuyama reversed epoch; the top just below the Jaramillo event within the Matuyama reversed epoch.

Comparison with the zonation of other workers: Zone 4 correlates to the middle part of the *Pseudoeunotia doliolus* Range Zone of Burckle (1972) to the *Chaetoceros* sp. Zone of Bukry and Foster (1973). *Roperia tesselata* extends well into this zone.

Absolute age: 0.93 m.y.-1.2 m.y. extrapolated from Kanaya *in* Kobayashi et al. (1971, fig. 6).

Geographical extent: Found in tropical Indian and Pacific Ocean sediments.

Type locality: DSDP Leg 24, Site 238, Core 4, Section 1, 75 cm to 4, CC.

Tropical Indian Ocean Diatom Zone 5

Definition: The base of this zone is defined at the first evolutionary appearance of *Pseudoeunotia doliolus;* the top at the extinction of *Rhizosolenia praebergonii.*

Discussion: The extinction of *Rhizosolenia praebergonii* was defined to occur within the middle of the Matuyama reversed epoch by Burckle (1972) and the same range was detected on core KH 68-4-18 by Kanaya *in* Kobayashi et al. (1971). The first evolutionary appearance of *Pseudoeunotia doliolus* from its immediate ancestor was found to occur within the Olduvai event (Burckle, 1972) and at about 5 meters of depth in core KH 68-4-18 (Kanaya *in* Kobayashi et al., 1971). I have followed Burckle's interpretation although I could find overlapping occurrences of *P. doliolus* and *N. fossilis.* A modern flora is present throughout this zone. *Coscinodiscus plicatus* occurs last in this zone but is too rare to be considered a useful stratigraphic marker.

Paleomagnetic stratigraphy: The base of this zone falls within the Olduvai event of the Matuyama reversed epoch; the top within the middle part of the Matuyama reversed epoch.

Comparison with the zonation of other workers: Zone 5 correlates to lower part of the *Pseudoeunotia doliolus* Range Zone of Burckle (1972) and to the North Pacific Diatom Zone IV of Schrader (1973a).

Absolute age: 1.2-1.8 m.y. extrapolated from Burckle (1972), Opdyke (1972), and Berggren (1972).

Geographical extent: Found in tropical Indian Ocean and tropical north Pacific Ocean sediments.

Type locality: DSDP Leg 24, Site 238, Core 5, Section 2, 53 cm to Core 6, Section 4, 75 cm.

Tropical Indian Ocean Diatom Zone 6

Definition: The base of this zone is defined at the extinction of *Thalassiosira convexa;* the top at the first evolutionary appearance of *Pseudoeunotia doliolus.*

Discussion: The extinction of *Thalassiosira convexa* occurred in core KH 68-4-18 at approximately 7.8 meters (Kanaya *in* Kobayashi et al., 1971), which correlates to the lower part of the Matuyama reversed epoch. Burckle (1972) found the same extinction level in equatorial Pacific cores. This species is a warm-water species and does not occur in sediments underlying cold water representing biocoenoses. An essentially modern flora is present comparable to that of Zone 4.

Paleomagnetic stratigraphy: The base of this zone falls within the lower part of the Matuyama reversed epoch, the top within the Olduvai event of the Matuyama reversed epoch.

Comparison with the zonation of other workers: Zone 6 correlates to the upper part of the *Rhizosolenia praebergonii* Partial-range Zone of Burckle (1972), and to the middle to lower Pleistocene of Muchina (1969).

Absolute age: 1.8-2.1 m.y. extrapolated from Kanaya *in* Kobayashi et al. (1971).

Geographical extent: Found in tropical Indian and Pacific Ocean sediments.

Type locality: DSDP Leg 24, Site 238, Core 7, Section 1, 75 cm to Core 7, Section 3, 60 cm.

Tropical Indian Ocean Diatom Zone 7

Definition: The base of this zone has been defined at the extinction of *Nitzschia jouseae,* the top at the extinction of *Thalassiosira convexa.*

Discussion: The extinction of *Nitzschia jouseae* occurs in equatorial Pacific sediments in the uppermost part of the Gauss normal epoch (Burckle, 1972). Other floral elements include *Actinocyclus ellipticus, Asterolampra marylandica, Asteromphalus imbricatus, Coscinodiscus africanus, C. lineatus, C. nodulifer, C. plicatus* group 4, *C. tabularis* var. *egregius, Ethmodiscus rex, Hemidiscus cuneiformis, Nitzschia fossilis, N. interrupta, N. marina, N. seriata, N. reinholdii, Roperia tesselata, Rhizosolenia bergonii, Rhiz. praebergonii, Thalassiosira convexa, Th. excentrica, Th. plicata, Th. symbolophora, Th. oestrupii, Th.* sp. II, *Th.* sp. 7, *Thalassionema nitzschioides, Thalassiothrix longissima,* and *Thal. frauenfeldii.*

Paleomagnetic stratigraphy: The base of this zone falls approximately within the uppermost part of the Gauss normal epoch; the top within the lower part of the Matuyama reversed epoch.

Comparison with the zonation of other workers: Zone 7 correlates to the middle part of the *Rhizosolenia praebergonii* Partial-range Zone of Burckle (1972), Subzone B; with the lower part of the middle Pleistocene of Muchina (1969).

Absolute age: 2.1-2.4 m.y.

Geographical extent: Found in tropical Indian and Pacific Ocean sediments.

Type locality: DSDP Leg 24, Site 238, Core 7, Section 4, 70 cm to Core 7, Section 5, 40 cm.

Tropical Indian Ocean Diatom Zone 8

Definition: The base of this zone is defined at the first evolutionary appearance of *Rhizosolenia praebergonii;* the top at the extinction of *Nitzschia jouseae.*

Discussion: The first appearance of *Rhizosolenia praebergonii* occurred during the middle of the Gauss normal epoch where *Rhiz. praebergonii* evolved from its immediate ancestor *Rhizosolenia bergonii* (Burckle, 1972). Kanaya *in* Kobayashi et al. (1971) found this event occurring at core KH 68-4-20 at 4.5 meters correlative to the middle normal event which falls between Kaena and the Mammoth events. Other floral elements are comparable to those found in Zone 7.

Paleomagnetic stratigraphy: The base of this zone falls within the middle of the Gauss normal epoch; the top within the uppermost part of the Gauss normal epoch.

Comparison with the zonation of other workers: Zone 8 correlates with the lower part of the *Rhizosolenia praebergonii* Partial-range Zone of Burckle (1972),

Subzone A, and with the lower Pleistocene of Muchina (1969).

Absolute age: 2.4-2.85 m.y. extrapolated from Opdyke (1972). Kanaya *in* Kobayashi et al. (1971) and Burckle (1972).

Geographical extent: Found in tropical Indian and Pacific Ocean sediments.

Type locality: DSDP Leg 24, Site 238, Core 7, Section 6, 35 cm to Core 8, Section 2, 32 cm.

Tropical Indian Ocean Diatom Zone 9

Definition: The base of this zone is defined at the first occurrence of *Thalassiosira oestrupii*; the top at the first evolutionary appearance of *Rhizosolenia praebergonii.*

Discussion: The morphological differences used to distinguish between *Thalassiosira oestrupii* and *Thalassiosira nativa* (in the definition of Burckle, 1972) were made using the following criteria:

1) *Thal. oestrupii* possesses separated girdles which are solid rings with a solitary spine (compare Plate 1, Figure 14) which is not present in *Thal. nativa.*

2) The areolae in *Thal. oestrupii* decrease gradually in size towards the margin, whereas there is a sharp boundary in size in *Thal. nativa.*

3) The size of the areolae in the middle of the valves of *Thal. oestrupii* range from 5-8 areolae in 10μ, whereas they range from 9-12 areolae in 10μ in *Thal. nativa.* This species differs from those which I have identified (sensu Sheshukova-Poretzkaya, 1967) which normally did show numerous strutted tubuli in the center of the valve.

Actinocyclus ellipticus forma *lanceolata* (not var. *lanceolata* sensu Burckle, 1972) is present in small numbers throughout most of the Pleistocene and Pliocene section. *Coscinodiscus africanus* ranges in my material well into Zone 10. The range of *Asteromphalus elegans* could not be defined because this species was rare in almost all samples (compare to Burckle, 1972, p. 236). Other floral elements are comparable to those found in Zone 7.

Paleomagnetic stratigraphy: The base of this zone has not been defined on the paleomagnetic stratigraphic scale. The top falls within the middle of the Gauss normal epoch.

Comparison with the zonation of other workers: Zone 9 correlates to the upper part of the *Nitzschia jouseae* Partial-range Zone of Burckle (1972), and to the Pliocene of Muchina (1969).

Absolute age: 2.85-(?) m.y. The base has not been defined and no extrapolation is possible at the moment as the first occurrence of *Thal. oestrupii* has not yet been defined in other sections.

Geographical extent: Found in tropical Indian Ocean sediments.

Type locality: DSDP Leg 24, Site 238, Core 8, Section 3, 35 cm to Core 9, Section 1, 30 cm.

Tropical Indian Ocean Diatom Zone 10

Definition: The base of this zone has been defined at the first evolutionary appearance of *Thalassiosira convexa*; the top at the first occurrence of *Thalassiosira oestrupii.*

Discussion: *Thalassiosira convexa* first appears at the base of this zone from its immediate ancestor *Thal. convexa* var. *aspinosa.* These spines were not broken off (compare to Burckle, 1972, p. 228) in most cases and thus a level could be defined above which spinous forms are common and below which nonspinous forms are common. To determine whether spines are present, high microscopical resolution should be used. Other floral elements are: *Actinocyclus divisus, A. ellipticus, Asterolampra grevillei, Ast. imbricatus* (first appearance in the upper part of this zone), *Coscinodiscus africanus, C. crenulatus, C. lineatus, C. nodulifer, C. plicatus* group 4, *C. tabularis* var. *egregius, C. vetustissimus* (becoming extinct in the lower part of the zone), *Ethmodiscus rex, Hemidiscus cuneiformis, H. simplicissimus, Nitzschia fossilis, N. interrupta, N. marina, N. praereinholdii* (becoming extinct within this zone), *N. reinholdii, Roperia tesselata* (first evolutionary appearance within this zone from its immediate ancestor *Roperia praetesselata*), *Rhizosolenia bergonii, Thalassiosira convexa, Thal. convexa* var. *aspinosa* (becoming extinct in the lower part of the zone), *Thal. antarctica, Thal. excentrica, Thal. plicata* (first occurrence within the middle of this zone from a not yet defined ancestor), *Thal. nativa* (becoming extinct within the middle part of this zone), *Thal.* sp. 7, *Thalassionema nitzschioides, Thalassiothrix frauenfeldii, Thal. longissima,* and *Triceratium cinnamomeum.* Muchina (1969, p. 81) lists a *Thalassiosira marujamica* Sheshuk as being common in her "Pliocene". This species is synonymized with *Thalassiosira decipiens* (Grun.) Jörg.(?) by Sheshukova-Poretzkaya (1967, p. 141). Similar individuals have not been found here; thus a correct interpretation of the range of *Thal. marujamica* is impossible at the moment.

Paleomagnetic stratigraphy: The zone has not been correlated to the paleomagnetic stratigraphic scale.

Comparison with the zonation of other workers: Zone 10 correlates to the upper part of the *Nitzschia jouseae* Partial-range Zone of Burckle (1972), to the Pliocene of Muchina (1969).

Absolute age: No absolute age estimates have been made.

Geographical extent: Found in tropical Indian Ocean sediments.

Type locality: DSDP Leg 24, Site 238, Core 9, CC to Core 11, Section 6, 70 cm.

Tropical Indian Ocean Diatom Zone 11

Definition: The base of this zone has been defined at the extinction of *Nitzschia cylindrica*; the top at the first evolutionary appearance of *Thalassiosira convexa.*

Discussion: *Nitzschia cylindrica* ranges in east equatorial sediments to approximately the middle of the Gilbert reversed epoch. Here a higher range was found, and by comparison with other ranges, an extrapolated range to the "a" event within the Gilbert reversed epoch is postulated. Associated species can be found listed in Table 2

Paleomagnetic stratigraphy: The base of this zone is tentatively placed at the "a" event within the Gilbert reversed epoch; the top has not been defined.

Comparison with the zonation of other workers: Zone 11 correlates with the middle part of the *Nitzschia jouseae* Partial-range Zone of Burckle (1972) and with the "Pliocene" of Muchina (1969).

Absolute age: Top has not been estimated, base approximately 3.8 m.y.

Geographical extent: Found in tropical Indian Ocean sediments.

Type locality: DSDP Leg 24, Site 238, Core 11, CC to Core 12, Section 3, 70 cm.

Tropical Indian Ocean Diatom Zone 12

Definition: The base of this zone has been defined at the first appearance of *Nitzschia jouseae;* the top at the extinction of *Nitzschia cylindrica*.

Discussion: *Nitzschia jouseae* first appears in equatorial east Pacific sediments at the top of the "c" event within the Gilbert reversed epoch (Burckle, 1972). Burckle (1972, p. 228) postulates an evolutionary transition of *Nitzschia jouseae* from its immediate ancestor *Nitzschia cylindrica*. This transition takes place just before, and within, the "c" event of the Gilbert reversed epoch. Associated species are: *Actinocyclus divisus, A. ellipticus* var. *elongatus, Asterolampra affinis* (first occurrence in the middle part of zone 12), *A. marylandica, Asteromphalus arachne, A. heptactis, Coscinodiscus nodulifer, C. plicatus* group 4, *Ethmodiscus rex, Hemidiscus cuneiformis, H. simplicissimus, Nitzschia cylindrica, N. fossilis, N. interrupta, N. jouseae* (first evolutionary appearance at the base of zone 12), *N. marina, N. reinholdii, N.* spec. 13 (extinction in the middle part of this zone), *Roperia praetesselata, Thalassiosira convexa* var. *aspinosa, Thal. excentrica, Thal. gravida* (?), *Thal. nativa, Thal.* spec. 6, *Thalassionema nitzschioides, Thalassiothrix longissima, Th. frauenfeldii, Th. monospina* (upper part of the zone), and *Triceratium cinnamomeum.*

Paleomagnetic stratigraphy: The base of this zone has been placed at the "c_1" event of the Gilbert reversed epoch; the top at the "a" event (Cochiti) within the Gilbert reversed epoch.

Comparison with the zonation of other workers: Zone 12 correlates with the lower part of the *Nitzschia jouseae* Partial-range Zone of Burckle (1972) and the "Pliocene" of Muchina (1969)

Absolute age: 3, 8-4, 3 m.y.

Geographical extent: Found in tropical Indian and Pacific Ocean sediments.

Type locality: DSDP Leg 24, Site 238, Core 12, Section 4, 70 cm to Core 15, Section 1, 40 cm.

Tropical Indian Ocean Diatom Zone 13

Definition: The base of this zone has been defined at the extinction of *Nitzschia porteri;* the top at the first evolutionary appearance of *Nitzschia jouseae.*

Discussion: *Coscinodiscus endoi* appears last in this zone. Kanaya and Koizumi (1970) gave a range for tropical Pacific sediments from about N.9 to N.16. Here it ranges much higher. *Actinocyclus moronensis* was found last. *Asteromphalus petersonii* appeared first in the upper part of the zone as does *Coscinodiscus plicatus* group 4 and *Nitzschia* sp. 13.

Paleomagnetic stratigraphy: The base of this zone has not been defined; the top occurs at the "c_1" event of the Gilbert reversed epoch.

Comparison with the zonation of other workers: Zone 13 correlates to the upper part of the *Thalassiosira convexa* Partial-range Zone of Burckle (1972).

Absolute age; 4, 3- (?). The base has not been estimated.

Geographical extent: Found in tropical Indian Ocean sediments.

Type locality: DSDP Leg 24, Site 238, Core 15, Section 2, 30 cm to Core 17, Section 1, 75 cm.

Tropical Indian Ocean Diatom Zone 14

Definition: The base of this zone is defined by the extinction of *Nitzschia miocenica;* the top at the extinction of *Nitzschia porteri.*

Discussion: *Nitzschia porteri* is interpreted here after the description of Frenguelli (1949). It is not clear if Burckle (1972) used the same identification, as his *N. porteri* (Burckle, 1972, pl. 2, fig. 16) is different in shape and striation; no morphologic description is presented. *Asterolampra acutiloba* becomes extinct at the top of this zone. Other elements are listed in Table 2.

Paleomagnetic stratigraphy: The base of this zone has been defined to occur within the "a" event of normal epoch 5. The top has not been defined.

Comparison with the zonation of other workers: Zone 14 correlates to the middle part of the *Thalassiosira convexa* Partial-range Zone of Burckle (1972), Subzone B.

Absolute age: (?) - 6 m.y. on the Berggren (1972) time scale. The top has not been defined.

Geographical extent: Found in tropical Indian and Pacific Ocean sediments.

Type locality: DSDP Leg 24, Site 238, Core 17, Section 2, 75 cm to Core 17, Section 6, 75 cm.

Tropical Indian Ocean Diatom Zone 15

Definition: The base of this zone has been defined at the first appearance of *Thalassiosira miocenica;* the top at the extinction of *Nitzschia miocenica.*

Discussion: *Thalassiosira miocenica* may be the same species as Burckle.s (1972) *Thalassiosira usatchevii.* The author does not present pictures of *Thal. usatchevii* but notes (1972, p. 228): "*Thalassiosira convexa* (after the interpretation used in this paper *Thal. convexa* var. *aspinosa*) appears just after the first appearance of *Thal. usatchevii*. Throughout the range of this species there is a general, though small, increase in size." "*Thalassiosira usatchevii* appears first and is characterized chiefly by an increase in diameter over its ancestor and an increase in size of the areolae." I have investigated original LDGO material (RC-12-65) from the *Thalassiosira convexa* Partial-range Zone and could not find a species fitting into the morphology of *Thal. usatchevii* (for ref. see Sheshukova-Poretzkaya, 1967, p. 150, 38-50μ in diameter, with bent out margin [5μ wide], 3.5 areolae in 10μ). Therefore, I gave this species a new name. The Indian Ocean individuals are nearly congruent to those found in the Pacific materials. *Thalassiosira miocenica* belongs in the evolutionary line of *Thalassiosira praeconvexa* (not found at either one of the sites, but has been treated in Schrader, 1974) over *Thalassiosira*

convexa var. *aspinosa* to *Thalassiosira convexa. Asteromphalus arachne* appears first at the base of this zone as does *Asteromphalus hookeri* and *Thalassiosira convexa* var. *aspinosa.* Other floral elements are listed on Table 2.

Paleomagnetic stratigraphy: The base of this zone occurs within magnetic reversed epoch 6, the top within the "a" event of magnetic normal epoch 5.

Comparison with the zonation of other workers: Zone 15 is correlative to the lowest part of the *Thalassiosira convexa* Partial-range Zone of Burckle (1972).

Absolute age: 6-6.5 m.y. on the Berggren (1969, 1972) time scale.

Geographical extent: Found in tropical Indian and Pacific Ocean sediments.

Type locality: DSDP Leg 24, Site 238, Core 18, Section 2, 75 cm to Core 19, Section 5, 75 cm.

Tropical Indian Ocean Diatom Zone 16

Definition: The base of this zone has been defined at the extinction of *Cussia paleacea;* the top at the first appearance of *Thalassiosira miocenica.*

Discussion: *Nitzschia miocenica* does range well over the extinction level of *Cussia paleacea* in Indian Ocean sediments. *Thalassiosira* sp. 7 appears first near the top of this zone (this species has been described as *Thalassiosira lineata* by Muchina 1969, but is different). Other floral elements are listed in Table 2. This zone should be investigated in more detail in the near future, as the samples showed a moderately well preserved diatom assemblage. Within this zone and the two following, 17-18 long specimens of *Cussia* sp. were observed (for reference see Burckle, 1972, p. 225).

Paleomagnetic stratigraphy: The base of this zone falls within the "a" event in magnetic normal epoch 7, the top within magnetic reversed epoch 6.

Comparison with the zonation of other workers: Zone 16 is correlative to the upper part of the *Nitzschia miocenica* Partial-range Zone of Burckle (1972).

Absolute age: 6.5-6.9 m.y. on the Berggren (1969, 1972) and Abdel-Monem et al. (1971) time scale.

Geographical extent: Found in tropical Indian Ocean sediments.

Type locality: DSDP Leg 24, Site 238, Core 19, CC to 20, CC.

Tropical Indian Ocean Diatom Zone 17

Definition: The base of this zone has been defined at the first appearance of *Nitzschia miocenica;* the top at the extinction of *Cussia paleacea.*

Discussion: Burckle (1972) assumed an evolutionary transition between *Nitzschia porteri* and *Nitzschia miocenica.* I do not agree and have found some other forms which belong to the evolutionary line *Nitzschia marina, Nitzschia reinholdii*, and *Nitzschia indica*. The event has not yet been well defined and detailed results on the evolution of this whole *Nitzschia* group will be published at a later date. Floral elements are: *Actinocyclus ehrenbergii* var. *tenella, A. ellipticus* var. *elongatus* (first occurrence in this zone), *A. ellipticus* var. *javanica* (becoming extinct in the middle part of this zone), *A. moronensis* (synonym: *A. ellipticus* var. *moronesis*) becomes extinct at the top of this zone and may be useful in defining the upper limit of the zone, *Asterolampra acutiloba* (appears first), *A. grevillei, A. marylandica, Coscinodiscus endoi, C. lineatus, C. nodulifer, C. vetustissimus, Ethmodiscus rex, Cussia paleacea, Cus. praepalacea, Hemidiscus cuneiformis, H. simplicissimus, Nitzschia cylindrica, N. interrupta* (first appearance in this zone), *N. marina* (first appearance in the middle of the zone), *N. miocenica, N. porteri, N. reinholdii, Rouxia moholensis, Thalassiosira excentrica, Thalassionema nitzschioides, Th. lineata, Thalassiothrix longissima, T. monospina,* and *Triceratium cinnamomeum.*

Paleomagnetic stratigraphy: This zone ranges from the middle part of magnetic normal epoch 7 to the "a" event within the magnetic normal epoch 7.

Comparison with the zonation of other workers: Zone 17 is correlative to the lower part of the *Nitzschia miocenica* Partial-range Zone of Burckle (1972).

Absolute age: 6.9-7.2 m.y. on the Berggren (1969, 1972) and Abdel-Monem et al. (1971) time scale.

Geographical extent: Found in tropical Indian and Pacific Ocean sediments.

Type locality: DSDP Leg 24, Site 238, Core 21, Section 2, 100 cm to Core 23, Section 2, 75 cm.

Tropical Indian Ocean Diatom Zone 18

Definition: The base of this zone is placed at the first appearance of *Nitzschia cylindrica,* the top at the first appearance of *Nitzschia miocenica.*

Discussion: Although *Nitzschia cylindrica* is rare in zones 18 and 17, it is possible to define its first appearance; it is not yet clear if *Nitzschia cylindrica* evolved from an ancestor. Other floral elements are listed in Table 2.

Paleomagnetic stratigraphy: This zone ranges from the base of the magnetic epoch 7 to the middle part of magnetic normal epoch 7.

Comparison with the zonation of other workers: Zone 18 is correlative to the upper part of the *Nitzschia porteri* Partial-range Zone of Burckle (1972).

Absolute age: 7.2-7.6 m.y. on the Berggren (1969, 1972) and Abdel-Monem et al. (1971) time scale.

Geographical extent: Found in tropical Indian and Pacific Ocean sediments.

Type locality: DSDP Leg 24, Site 238, Core 23, Section 5, 75 cm to 23, CC.

Tropical Indian Ocean Diatom Zone 19

Definition: The base of this zone is placed at the extinction of *Coscinodiscus yabei;* the top at the first appearance of *Nitzschia cylindrica.*

Discussion: Other important floral elements are: *Coscinodiscus endoi, Nitzschia porteri, Cussia paleacea, Cus. praepaleacea, Actinocyclus moronensis, Thalassiosira burckliana* (for more detail see Table 2).

Paleomagnetic stratigraphy: This zone ranges from the base of magnetic epoch 7 to the middle part of magnetic epoch 8.

Comparison with the zonation of other workers: Zone 19 is correlative to the lower part of the *Nitzschia porteri* Partial-range Zone of Burckle (1972).

Absolute age: 7.6-8.2 m.y. on the Berggren (1969, 1972) and Abdel-Monem et al. (1971) time scale.
Geographical extent: Found in tropical Indian Ocean sediments.
Type locality: DSDP Leg 24, Site 238, Core 24, Section 2, 70 cm to 26, CC.

Tropical Indian Ocean Diatom Zone 20

Definition: The base of this zone is placed at the first occurrence of *Nitzschia porteri;* the top at the extinction of *Coscinodiscus yabei.*
Discussion: Floral list is in Table 2.
Paleomagnetic stratigraphy: This zone ranges from the lower part of magnetic epoch 8 to the middle part of magnetic epoch 8.
Comparison with the zonation of other workers: Zone 20 is correlative to the uppermost part of the *Coscinodiscus yabei* Partial-range Zone of Burckle (1972).
Absolute age: 8.2-8.6 m.y. on the Berggren (1969, 1972) and Abdel-Monem et al. (1971) time scale.
Geographical extent: Found in tropical Indian Ocean sediments.
Type locality: DSDP Leg 24, Site 238, Core 27, Section 2, 125 cm to Core 28, Section 5, 75 cm.

Tropical Indian Ocean Diatom Zone 21

Definition: The base of this zone is placed at the last appearance of *Denticula hustedtii* from tropical sediments; the top at the first occurrence of *Nitzschia porteri.*
Discussion: Floral list is in Table 2.
Paleomagnetic stratigraphy: This zone ranges from the lower part of magnetic epoch 8 to the middle part of magnetic epoch 9.
Comparison with the zonation of other workers: Zone 21 is correlative to the *Coscinodiscus yabei* Partial-range Zone of Burckle (1972).
Absolute age: 8.6-10 m.y. (?) on the Berggren (1969, 1972) and Abdel-Monem et al. (1971) time scale.
Geographical extent: Found in tropical Indian and Pacific Ocean sediments.
Type locality: DSDP Leg 24, Site 238, Core 28, CC to 29, CC.

EPOCH AND AGE BOUNDARIES

Burckle (1972) and Opdyke (1972) placed epochal and stage boundaries with respect to the paleomagnetic stratigraphy as follows.

1) The middle/late Miocene boundary (interpreted as the Langhian/Tortonian boundary) occurs in geomagnetic epoch 11. This epoch has been correlated to the *Discoaster hamatus* Zone, which is correlative to the *Globorotalia menardii* foraminiferal zone.

2) The Miocene/Pliocene boundary falls at the end of geomagnetic epoch 5 (interpreted as the beginning of the Tabianian [Mayer-Eymar, 1868]. This epoch has been correlated to the N.17-N.18 foraminiferal standard zone of Blow (1969) using Saito's (1969) foraminiferal criteria.

3) The Pliocene/Pleistocene boundary occurs during the Olduvai event of the Matuyama reversed geomagnetic epoch (Berggren et al., 1967; Saito *in* Hays et al., 1969; Burckle 1969 a.o.).
These boundaries have been proposed also by Berggren (1972) and have been used in this paper (Figures 5 and 6).

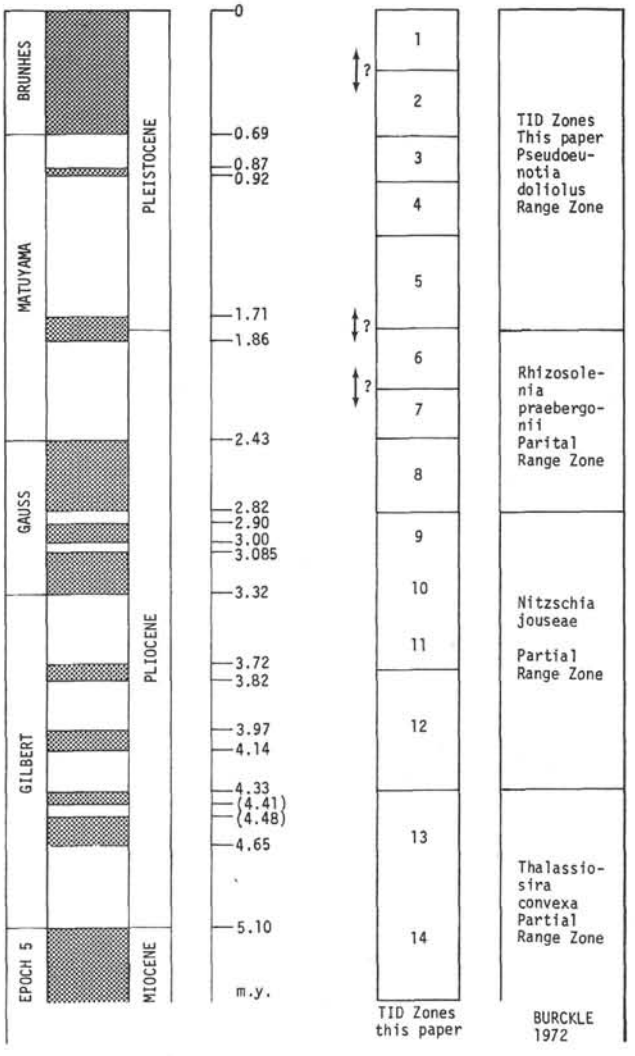


Figure 5. *Correlation of tropical Indian Ocean diatom zones (TID zones) with the paleomagnetic stratigraphy, with the radiometric time scale, ad with the equatorial Pacific diatom zonation of Burckle (1972) for the Pleistocene-Pliocene interval.*

GEOCHRONOLOGICAL TIME SCALE

The biostratigraphy of planktonic diatoms from the equatorial east Pacific (Burckle 1969, 1972) has been correlated to the paleomagnetic stratigraphy. Various authors have since then published correlations of the paleomagnetic stratigraphy to a radiometric time scale. Berggren (1972), Opdyke (1972), Abdel-Monem et al. (1971), Cox (1969) among others have established charts demonstrating the proposed comparisons of the radiometric time scale to the paleomagnetic time scale. In this paper I have used the modified time scales of Opdyke (1972), Abdel-Monem et al. (1971), and Berggren (1972) (Figure 7).

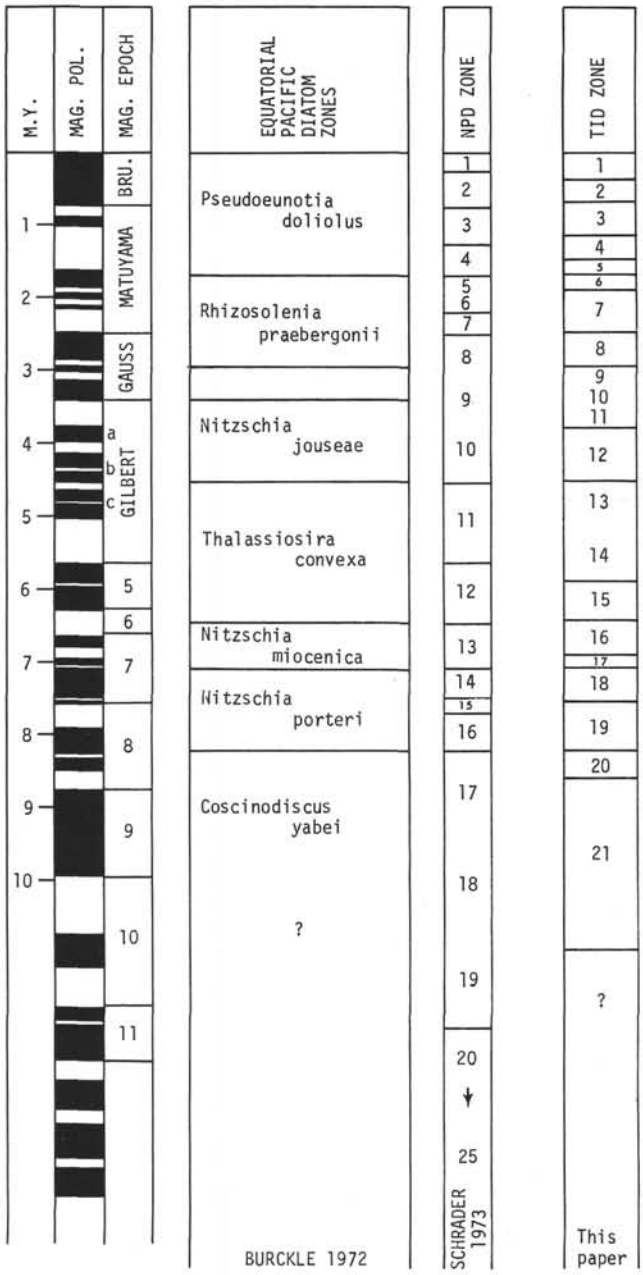


Figure 6. *Correlation of tropical Indian Ocean diatom zones (TID zones) with the paleomagnetic stratigraphy, with the equatorial Pacific diatom zonation of Burckle (1972) with the north Pacific diatom zonation (NPD zones) of Schrader (1973a) for the Pleistocene-late/middle Miocene interval.*

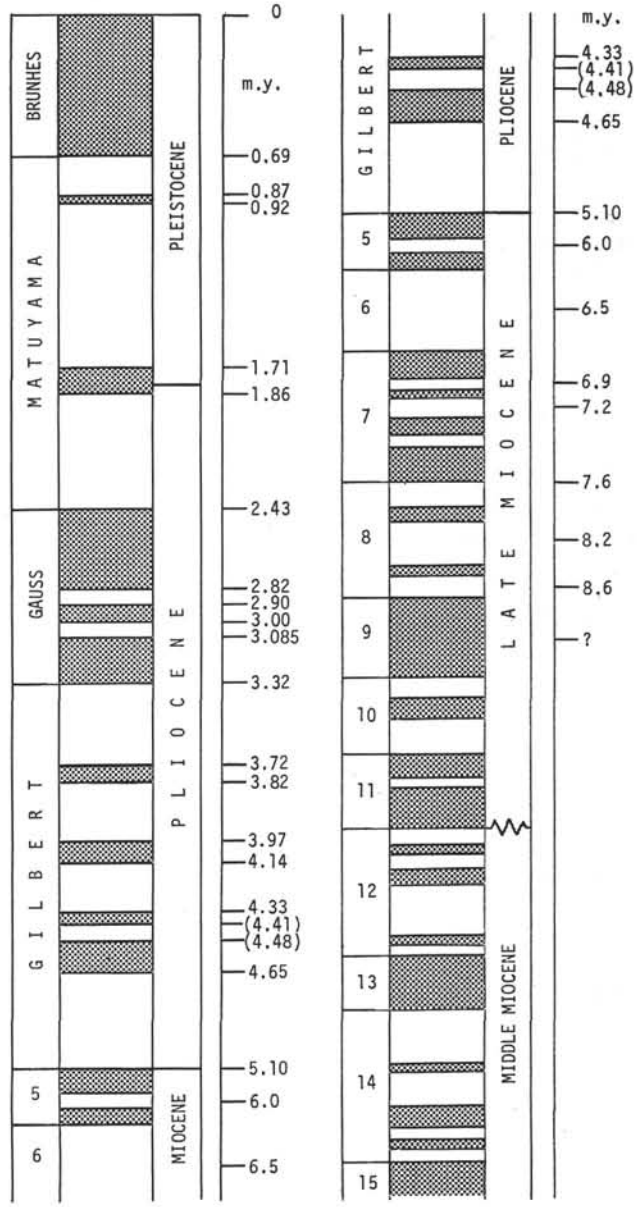


Figure 7. *Paleomagnetic stratigraphy, epoch boundaries, and radiometric time scale used in this paper.*

The Pleistocene-Pliocene boundary, occurring in the Olduvai event, falls within 1.71 to 1.86 m.y.; the Pliocene-Miocene boundary, occurring at the top of geomagnetic epoch 5, falls at 5.10 m.y. (Figure 7). Other data within the late Miocene interval are interpolated from Abdel-Monem et al. (1971) and Berggren (1972). The late-middle Miocene boundary occurs tentatively between geomagnetic epochs 11 and 12 (Burckle, 1972; Opdyke, 1972), defining this boundary on the basis of correlating epoch 11 in equatorial Pacific sediments to the *Discoaster hamatus* Zone which is correlative to the *Globorotalia meyeri* Zone, the highest zone in the middle Miocene. This boundary has an interpolated radiometric age of 10.5 m.y. according to the Berggren (1969, 1972) time scale.

CORRELATION TO OTHER DIATOM SECTIONS

Planktonic marine diatoms have been used to establish the ages and correlations of some other deep-sea drilling sections. They are: the Experimental Mohole Drilling (Schrader, 1974), DSDP Leg 18, Site 173 (Schrader, 1973a), the east equatorial Pacific (Burckle, 1969, 1972), the equatorial Pacific (Buckry and Foster, 1973) and the Pacific and Indian Oceans (Muchina, 1969). Correlations which are tentative and cannot be proven because of the lack of original material and poor descriptions are

connected with a dashed line; others which have been proven by the author and showed good agreement are connected with a solid line (Figure 8).

The correlation between DSDP Leg 22, Sites 213 and 215, and DSDP Leg 24, Site 238 is based exclusively on the floral content and the placement of the tropical Indian Ocean diatom zones. Differences in the stratigraphic interpretation of DSDP Leg 22, Sites 213 and 215 by other microfossils may be resolved by comparing the Leg 22 results.

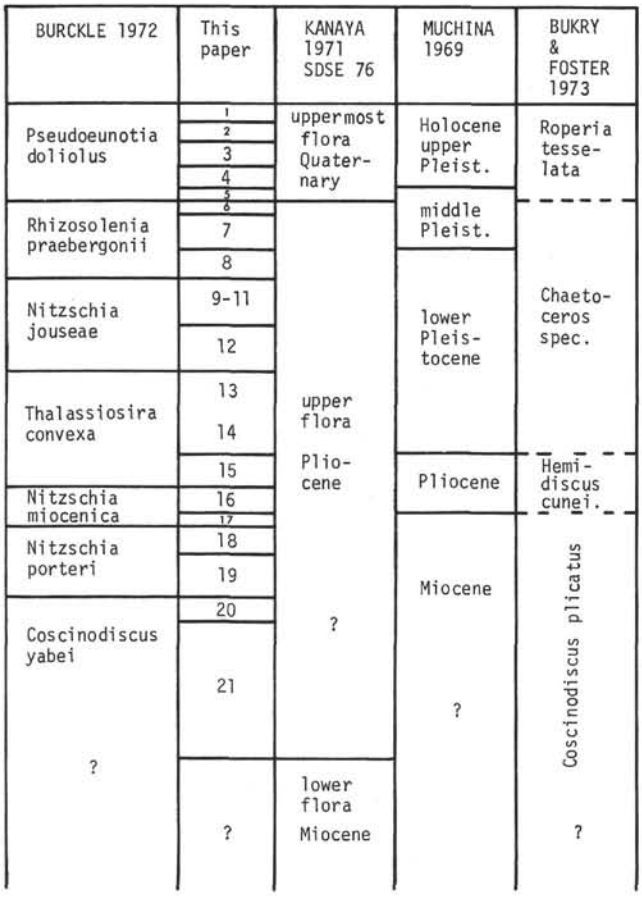


Figure 8. *Correlation of various diatom zonations applied to tropical-subtropical diatom sequencies from the Pacific and Indian oceans.*

DIATOMS AT EACH SITE

Site 236

Diatoms are rare to absent in most samples collected from Site 236. There are a few samples from Cores 1 and 2 which contain a well to moderately preserved diversified diatom assemblage characteristics of a warm-water thanatocoenoses. No *Ethmodiscus* ooze was detected within this interval although a few reworked older fossils (*Nitzschia jouseae* and *Rhizosolenia praebergonii*) were found. A detailed list of the species content is given in Table 1.

The base of TID Zone 3 was recognized at approximately 15 meters below the sea floor. Other younger zones were not present. The interval from approximately 20 to 220 meters below the sea floor was barren of diatoms except for the following samples which contained reworked and/or displaced shallow-water robust species: 3, CC (*Trinacria regina*); 9, CC (*Melosira sulcata*); 11-1, 131 cm (*Coscinodiscus* cf. *radiatus*); 12-5, 108 cm (*Arachnoidiscus spec.*); 13-2, 130 cm (*Ethmodiscus rex*); 17-2, 148 cm (*Melosira sulcata*); 22-4, 116 cm (fragments of *Coscinodiscus*); 23-3, 80 cm (*Grammatophora* sp., *Pyxilla* sp.); and 23, CC (*Grammatophora* sp.).

The interval from about 220 to 255 meters below the sea floor contained a few robust species such as *Pyxilla* sp., *Liostephania* stages of *Asterolampra, Stephanopyxis* sp., *Triceratium* sp., and *Trinacria* sp., proving these samples to be Oligocene to Eocene in age.

The interval from 270 to 320 meters below the sea floor was barren of diatoms.

The interval from 220 to 255 meters below the sea floor contained only rare diatom assemblages which were in part strongly etched and showed corrosion. The diversity of species was very low and therefore no detailed investigation was done.

The abundance of sponge spicules, increased abruptly within the 20-220 meter interval within the following horizons: 4-3, 50 cm; 8-3, 135 cm; 8-5, 59 cm; 9-2, 102 cm to 13, CC; 20-2, 100 cm; and 22-2, 74 cm to 28, CC. This may indicate: (1) the strong dissolution of biogenic opal, and (2) the influx of shallow-water material if other opal skeletons are rare or absent from the assemblage.

Site 238

Diatoms are common to abundant and moderately to well preserved from 0-215 meters below the sea floor; they are moderately to poorly preserved from 215-293 meters. The interval from 293-568.5 meters is barren of diatoms except for a few reworked and/or displaced individuals and poorly preserved assemblages. The typical tropical diatom assemblages yielded various species allowing good floral zonation and will serve as a link between tropical Pacific zonations and Mediterranean diatom zonations being worked out at the moment. The sequence from 0-215 meters represents a continuous record of diatom production from today to the late Miocene. No specific climatic investigations were made, but from the species assemblage, it can be concluded that no real temperature change from tropical to cold occurred. Older reworked microfossil occurrence may be found in Table 2. The abundance of displaced shallow-water diatom species is low throughout this section. A few horizons were found enriched in *Ethmodiscus*. Detailed reference to the systematic composition of diatom floras is given in Table 2.

At this site, the base of the TID zones was observed to occur as follows:

TID Zone 1 at 3.5 meters (1-3, 75 cm)
TID Zone 2 at 13.5 meters (2-3, 75 cm)
TID Zone 3 at 27 meters (3-6, 75 cm)
TID Zone 4 at 38 meters (4, CC)
TID Zone 5 at 49 meters (6-4, 75 cm)
TID Zone 6 at 57 meters (7-3, 60 cm)
TID Zone 7 at 60 meters (7-5, 40 cm)
TID Zone 8 at 64.5 meters (8-2, 32 cm)
TID Zone 9 at 72.5 meters (9-1, 30 cm)
TID Zone 10 at 101 meters (11-6, 70 cm)

TABLE 1
Distribution of Diatoms and Other Siliceous Nannofossils, Site 236

SITE 236

KEY:
- I = Absent
- • = Very rare
- R = Rare
- F = Few
- C = Common
- A = Abundant
- B = Barren
- ○ = Reworked
- ● = *Ethmodiscus* Ooze

	236-1-1, 110 cm 236-1-2, 90 cm 236-1-3, 40 cm 236-1-4, 110 cm 236-1, CC	236-2-1, 136 cm 236-2, CC	236-3-1, 39 cm 236-3-2, 86 cm 236-3-3, 116 cm 236-3, CC
Radiolaria			
Abundance	C C C C C	C F	C R R
Preservation	G G C C C	G M	G P P
Sponge Spicules			
Abundance	C C C G G	C C	C C C
Preservation	G G G R R	G B	G M M
Silicoflagellata			
Abundance	R G G R R	R I	M B B
Preservation	G G G R R	G I	C R B
Diatomacea			
Abundance	C C C C C	R C	C B B
Preservation	G G G G G	M P	M P P
Phytoliths			
Abundance	B B B F F	B R	B B B
Actinocyclus ehrenbergii Ralfs	R R R R R	I I	I I I
A. ehrenbergii var. *tenella* (Breb.) Hustedt	I I I I I	I I	I I I
A. subtilus Hanna and Grant	I I I I I	I I	I I I
A. divisus	I I I I I	I I	I I I
A. ellipticus Grunow	I R R R I	R R	I I I
A. ellipticus forma *lanceolata* Kolbe	I R I I I	R R	I I I
A. ellipticus var. *elongatus* (Grun.) Kolbe	I I I I I	I I	I I I
A. ellipticus var. *javanica*	I I I I I	I I	I I I
A. ellipticus sp. 1 Schrader	I I I I I	I I	I I I
A. ingens _	I I I I I	I I	I I I
A. monomensis Deby	I I I I I	I I	I I I
Asteromphalus boutiobo Frenguelli	I I I I I	I I	I I I
A. affinis Grev.	I I I I I	I I	I I I
A. grevillei (Wall.) Grev.	I I I I R	I I	I I I
A. marylandica Ehr.	I I I I R	I I	I I I
A. liostephania-stage	I I I I I	I I	I I I
Asteromphalus arachne (Breb.) Ralfs	I I I I I	I I	I I I
A. elegans Greville	I I I I I	I I	I I I
A. flabellatus (Breb.) Grev.	I I I I I	I I	I I I
A. heptactis (Ehr.) Ralfs	I I I I I	I I	I I I
A. hilsonianus (Grev.) Ralfs	I I I I I	I I	I I I
A. hookeri Ehr.	I I I I I	I I	I I I
A. imbricatus	I I I R I	I I	I I I
A. monomensis (Grev.) Rattr.	I I I I I	I I	I I I
A. petersonii (Kolbe) n. comb.	I I I I I	I I	I I I
A. robustus Castrac.	I R R R R	I I	I I I
A. rhabdolepsus	I I I I I	I I	I I I
A. liostephania-stage	I I I I F	I I	I I I
Bacteriastrum sp. (various species, unidentified)	I I R R R	I I	I I I
Biddulphia mobiliensis	I I I I I	I I	I I I
Brunia mirabilis	I I I I I	I I	I I I
Coscinodiscus asteromphalus Ehr.	I I I I R	I I	I I I
C. asteromphalus var. *centralis*	I I I I R	I I	I I I
C. centralis	F I I I F	I I	I I I
C. curvatulus	I I I I I	I I	I I I
C. endoi	I I I I I	I I	I I I
C. excentricus	I R R R I	I I	I I I
C. lineatus	I R R R F	I I	I I I
C. lineatus var. *elliptica* Kolbe	I R R R F	I I	I I I
C. nitidus	I R R R R	I I	I I I
C. nodulifer A. Schmidt	C C C C C	I I	I I I
C. obscurus	I I R I I	I I	I I I
C. plicatus Grunow	I I I I I	I I	I I I
C. plicatus Group 1 Schrader	I I I I I	I I	I I I
C. plicatus Group 2 Schrader	I I I I I	I I	I I I
C. plicatus Group 3 Schrader	I I I I I	I I	I I I
C. plicatus Group 4 Schrader	I I I I I	I I	I I I
C. plicatus Group 5 Schrader	I I I I I	I I	I I I
C. plicatus Group 6 Schrader	I I I I I	I I	I I I
C. tabularis var. *egregius* Rattr.	I I I R R	I I	I I I
C. tabularis var. *egregius-liostephania*-stage	I I I R R	I I	I I I
C. radiatus	I R F F R	I R	I I I
C. temperei	I I I I I	I I	I I I
C. vetustissimus Pant.	I I I I I	I I	I I I
C. yabei Kanaya	I I I I I	I I	I I I
Cyclotella striata	I I I I R	I I	I I I
Denticula hustedtii	I I I I I	I I	I I I
D. lauta	I I I I I	I I	I I I
D. nicobarica	I I I I I	I I	I I I
D. punctata var. *hustedtii*	I I I I I	I I	I I I
Ethmodiscus rex	R R F F F	R R	F F F
Grammatophora sp. unidentified (various species)	I I I I I	I I	I I I
Cuasia paleacea	I I I I I	I I	I I I
C. lanceolata	I I I I I	I I	I I I
C. praepalaeacea	I I I I I	I I	I I I
C. tatsunokuchiensis (Kolzumi) Schrader	I I I I I	I I	I I I
C. sp. 1	I I I I I	I I	I I I
Hemidiscus cuneiformis	I I F F F	R I	F F F
H. simplicissimus	I I I I I	I I	I I I
Mastogloia splendida littoral species	I I I I I	I I	I I I
Melosira sulcata	I I F F F	I I	I I I
Neocosma elliptica (Silicoflagellata)	I I R F F	R R	I I I

NOTE: Barren in diatoms below this level. For more detail for the lower part of the section see the text.

TABLE 1 – *Continued*

SITE 236

KEY:
– = Absent
• = Very rare
R = Rare
F = Few
C = Common
A = Abundant
B = Barren
○ = Reworked
● = *Ethmodiscus* Ooze

	Radiolaria		Sponge Spicules		Silicoflagellata		Diatomacea		Phytoliths		
	Abundance	Preservation	Abundance	Preservation	Abundance	Preservation	Abundance	Preservation	Abundance		
236-1-1, 110 cm	C	G	C	G	R	R	C	G	F		
236-1-2, 90 cm	C	G	C	G	R	R	C	G	F		
236-1-3, 40 cm	C	G	C	G	R	R	G	G	F		
236-1-4, 110 cm	C	G	C	G	R	R	G	G	F		
236-1, CC	C	G	C	G	R	R	G	C	M		
236-2-1, 136 cm	C	M	C	G	R	G	C	M	B		
236-2, CC	F	M	C	G	B	I	R	P	R		
236-3-1, 39 cm	C	G	C	G	R	M	C	M	B		
236-3-2, 86 cm	R	P	C	M	B	B	R	P	B		
236-3-3, 116 cm	R	P	C	M	B	B	B	B	B		
236-3, CC	R	P	C	M	B	B	B	B	B		
Nitzschia angustatula Heiden	–	–	–	–	–	–	–	–	–		
N. cylindrica Burckle	–	–	–	–	–	–	–	–	–		
N. cylindrica-fossilis Group	–	–	–	–	–	–	–	–	–		
N. fossilis (Freng.) Kanaya	–	–	–	–	–	–	–	–	–		
N. interrupta Heiden	–	–	R	•	–	–	–	–	–		
N. indica Schrader	–	–	–	–	–	–	–	–	–		
N. jouseae Burckle	–	–	●	I	–	–	–	–	–		
N. marina Grunow	–	–	R	•	–	–	–	–	–		
N. marina-miocenica Group	–	–	–	–	–	–	–	–	–		
N. miocenica Burckle	–	–	–	–	–	–	–	–	–		
N. porteri Frenguelli	–	–	–	–	–	–	–	–	–		
N. praereinholdii Schrader	–	–	–	–	–	–	–	–	–		
N. praereinholdii-fossilis Group	–	–	–	–	–	–	–	–	–		
N. praereinholdii-jouseae Group	–	–	–	–	–	–	–	–	–		
N. serrata	–	–	–	–	–	–	–	–	–		
N. reinholdii	–	–	R	R	–	–	–	–	–		
N. sp. 2 Schrader	–	–	–	–	–	–	–	–	–		
N. sp. 4 Schrader	–	–	–	–	–	–	–	–	–		
N. sp. 13 Schrader	–	–	–	–	–	–	–	–	–		
Pseudoeunotia doliolus●	–	–	F	F	–	–	–	–	–		
Roperia tesselata	–	–	R	R	–	–	–	–	–		
R. tesselata var. *ovata*	–	–	F	R	–	–	–	–	–		
R. praetesselata Schrader	–	–	–	–	–	–	–	–	–		
Rouxia californica M. Perag.	–	–	–	–	–	–	–	–	–		
R. mohleriana Schrader	–	–	–	–	–	–	–	–	–		
R. naviculoides	–	–	–	–	–	–	–	–	–		
Rhizosolenia bergonii	–	–	R	R	–	–	–	–	–		
R. praebergonii	–	–	I	○	–	–	–	–	–		
R. firma	–	–	–	–	–	–	–	–	–		
R. habetata forma *hiemalis*	–	–	–	–	–	–	–	–	–		
R. styliformis	–	–	R	R	–	–	–	–	–		
Planktoniella sol	–	–	–	–	–	–	–	–	–		
Pleurosigma sp. unidentified (various species)	–	–	–	–	–	–	–	–	–		
Thalassiosira cf. *oestrupii* Muchina	–	–	–	–	–	–	–	–	–		
T. convexa var. *aspinosa* Schrader	–	–	–	–	–	–	–	–	–		
T. antarctica Comber	–	–	–	–	–	–	–	–	–		
T. burckliana Schrader	–	–	–	–	–	–	–	–	–		
T. excentrica (Ehr.) Cleve	–	–	R	R	–	–	–	–	–		
T. gravida	–	–	–	–	–	–	–	–	–		
T. plicata Schrader	–	–	R	R	–	–	–	–	–		
T. symbolophora Schrader	–	–	–	–	–	–	–	–	–		
T. nativa Sheshukova	–	–	–	–	–	–	–	–	–		
T. oestrupii (Ost.) Prosk-Lavr.	–	–	F	C	–	–	C	C	C		
T. miocena n. sp.	–	–	–	–	–	–	–	–	–		
T. sp.	–	–	–	–	–	–	–	–	–		
T. sp. Schrader	–	–	–	–	–	–	–	–	–		
T. sp. I Schrader	–	–	–	–	–	–	–	–	–		
T. sp. II Schrader	–	–	–	–	–	–	–	–	–		
T. sp. III Schrader	–	–	–	–	–	–	–	–	–		
T. sp. 7 Schrader	–	–	–	–	–	–	–	–	–		
T. sp. 6 Schrader	–	–	–	–	–	–	R	R	R		
Thalassionema nitzschioides	–	–	C	C	C	C	C	C	C		
T. lineatum	–	–	–	–	–	–	–	–	–		
Thalassiothrix frauenfeldii	–	–	F	F	F	F	F	F	F		
T. longissima	–	–	–	–	F	F	F	F	F		
T. monospina	–	–	–	–	–	–	–	–	–		
Triceratium ehrenbergianum	–	–	–	–	–	–	–	–	–		
T. ehrenbergianum var. *minor* Grunow	–	–	–	–	–	–	–	–	–		
T. ehrenbergianum forma 1 Schrader	–	–	–	–	–	–	–	–	–		
T. ehrenbergianum forma *quadrangulata* Grunow	–	–	–	–	–	–	–	–	–		
Trinacria excavata	–	–	–	–	–	–	–	–	–		
T. regina	–	–	–	–	–	–	–	–	–		
Stephanopyxis turris	–	–	–	–	–	–	R	R	I		
Syndendra jouseana	–	–	–	–	–	–	–	–	–		
										3	T10 Zones
										?	

NOTE: Barren in diatoms below this level. For more detail for the lower part of the section see the text.

TID Zone 11 at 104.5 meters (12-3, 70 cm)
TID Zone 12 at 130 meters (15-1, 75 cm)
TID Zone 13 at 151 meters (17-2, 75 cm)
TID Zone 14 at 156.5 meters (17-6, 75 cm)
TID Zone 15 at 174 meters (19-5, 75 cm)
TID Zone 16 at 186.5 meters (20, CC)
TID Zone 17 at 207.5 meters (23-2, 75 cm)
TID Zone 18 at 215 meters (23, CC)
TID Zone 19 at 243.5 meters (26, CC)
TID Zone 20 at 259.5 meters (28-5, 75 cm)
TID Zone 21 at 272 meters (29, CC)

No breaks in the diatom stratigraphic record were found from 0-272 meters. Based on placement of the bottom of Tropical Indian Ocean Diatom Zone 5 (Pleistocene-Pliocene boundary) at 49 meters, the base of Tropical Indian Ocean Diatom Zone 13 (tentative Miocene-Pliocene boundary) at 151 meters, and other horizons with absolute ages estimated on the basis of Berggren's (1969, 1972), and Opdyke's (1972) correlations with the radiometric-paleomagnetic time scale, indications are that the interval from 0-293 meters below the sea floor (Pleistocene to late Miocene) has a sedimentation rate of 30 m/m.y. (Figure 9). The sequence from 293-568.5 meters contains only a few reworked and/or displaced individuals (*Trinacria regina* [41-2, 72 cm]). *Ethmodiscus* ooze was found at 1-6, 75 cm to 2-2, 75 cm, 5-4, 90 cm to 6-1, 11 cm and at 7-4, 70 cm.

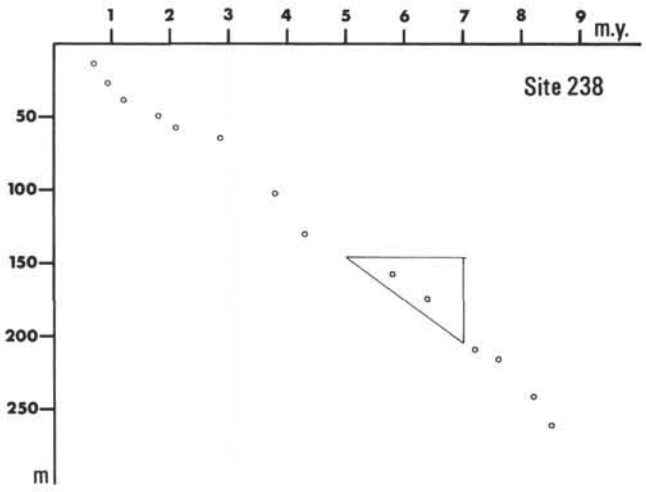


Figure 9. *Sediment accumulation rate at Site 238.*

Site 213 (DSDP Leg 22)

The diatom-radiolarian ooze at this site for the upper sequence from 1-1, 50-51 cm to 8-5, 50-51 cm suggests the onset of high biogenetic productivity with only the siliceous component being preserved below the calcium carbonate compensation depth (CCD) from late Miocene until today. No detailed climatic investigations were made on these excellently preserved diatom assemblages, but from the species composition it can be suggested that no real cool period is represented. Older reworked microfossils occur sporadically. A few horizons were found to represent *Ethmodiscus* ooze (1-1, 50-51 cm; 1-3, 50-51 cm; 2-1, 50-51 cm; 4-1, 50-51 cm; 4-4, 50-51 cm). Detailed reference to the systematic composition of diatom floras is given in Table 3.

At this site, the base of the TID zones was observed to occur as follows:

TID Zones 1 and 2 at 2 meters (1-2, 100-101 cm)
TID Zone 3 at 3.5 meters (1-3, 50-51 cm)
TID Zones 4 and 5 at 9.5 meters (2-1, 50-51 cm)
TID Zone 6 at 22 meters (3-3, 50-51 cm)
TID Zone 7 at 28.5 meters (4-1, 50-51 cm)
TID Zones 8-10 at 39.5 meters (5-2, 50-51 cm)
TID Zone 11 at 50.5 meters (6-3, 50-51 cm)
TID Zone 12 at 58.5 meters (7-2, 50-51 cm)
TID Zones 13 and 14 at 68 meters (8-2, 50-51 cm)
TID Zone 15 the base has not been defined.

No breaks in the diatom stratigraphic record were observed. Recognition of the tropical Indian Ocean diatom zones was in some cases tentative. This a result of widely placed samples, and/or coring disturbance (mixing of soupy material). Based on the placement of the bottom of Tropical Indian Ocean Diatom Zone 5 (Pleistocene-Pliocene boundary) between Samples 2-1, 50-51 cm and 2, CC, the base of Tropical Indian Ocean Diatom Zone 13 (tentative Miocene-Pliocene boundary) between Samples 7, CC and 8-1, 50-51 cm, and other horizons with absolute ages estimated on the basis of Berggren's (1969, 1972), Opdyke's (1972) correlations with the radiometric-paleomagnetic time scale, indications are that the interval from 0-80 meters below the sea floor (Pleistocene to late Miocene) has a sedimentation rate of 26 m/m.y. (Figure 10).

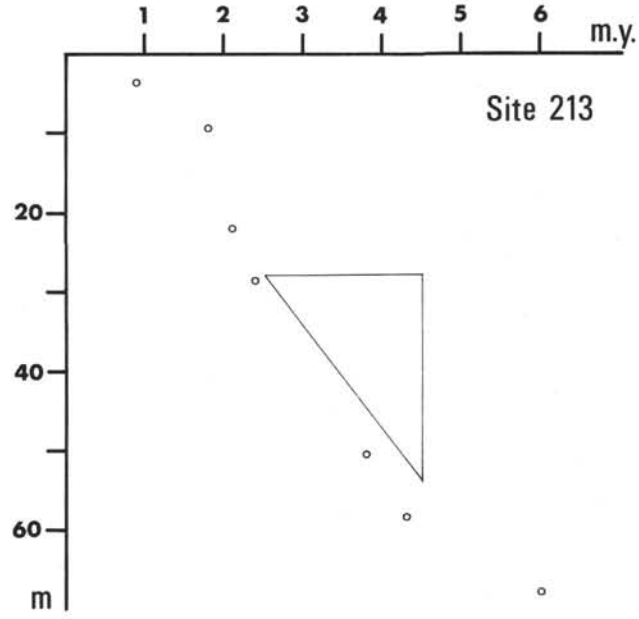


Figure 10. *Sediment accumulation rate at Site 213.*

Site 215 (DSDP Leg 23)

The diatom-radiolarian ooze sequence from 1-1, 50-51 cm to 7, CC resembles Site 213, which was drilled on the opposite site of the Ninetyeast Ridge in 5310 meters of water. The consistent occurrence of abundant siliceous tests suggests a high biogenetic productivity, with only the opaline silica being preserved below the CCD from late Miocene until today. No detailed climatic investigations were made on these excellently preserved diatom

TABLE 2
Distribution of Diatoms and Other Siliceous Nannofossils, Site 238

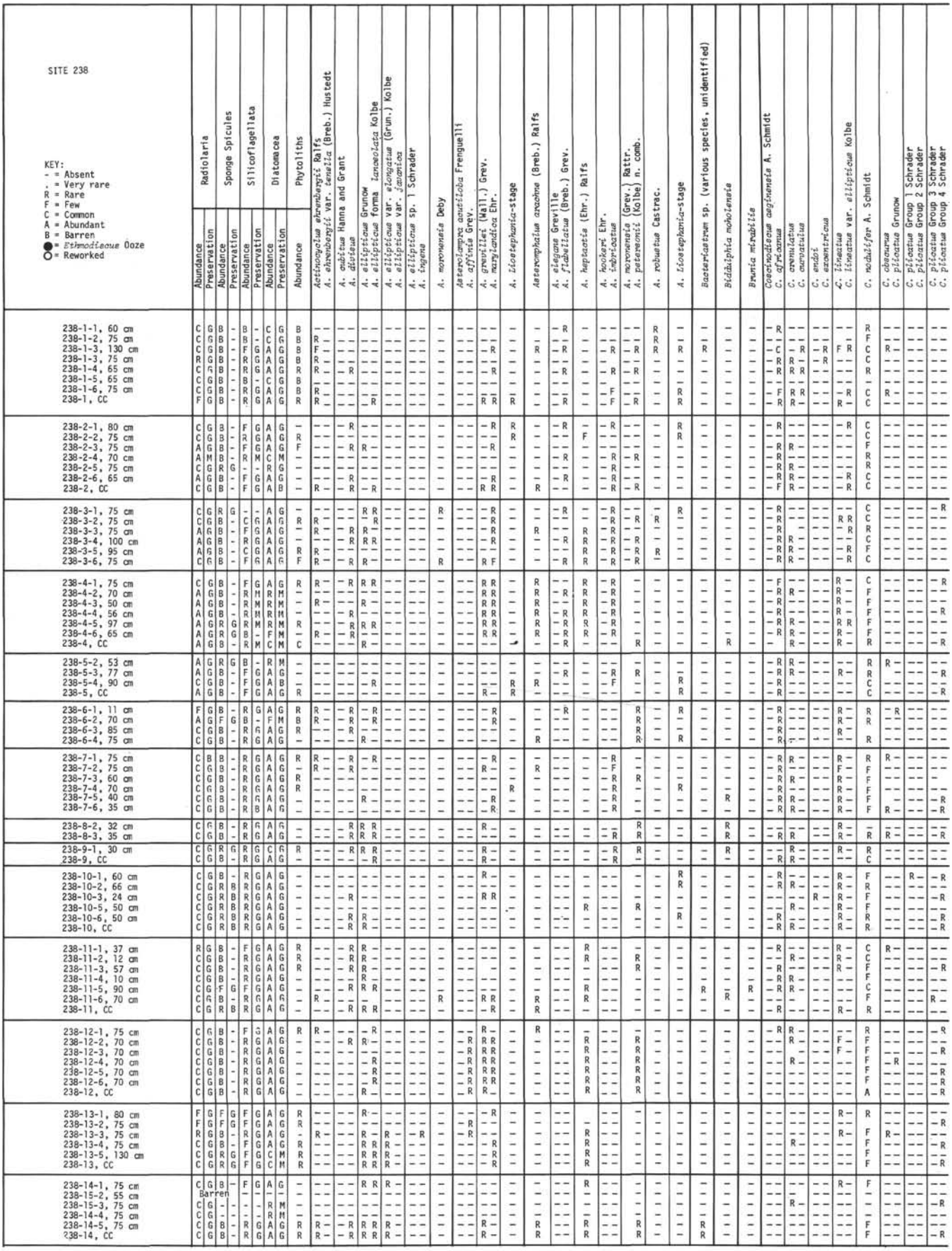


TABLE 2 – *Continued*

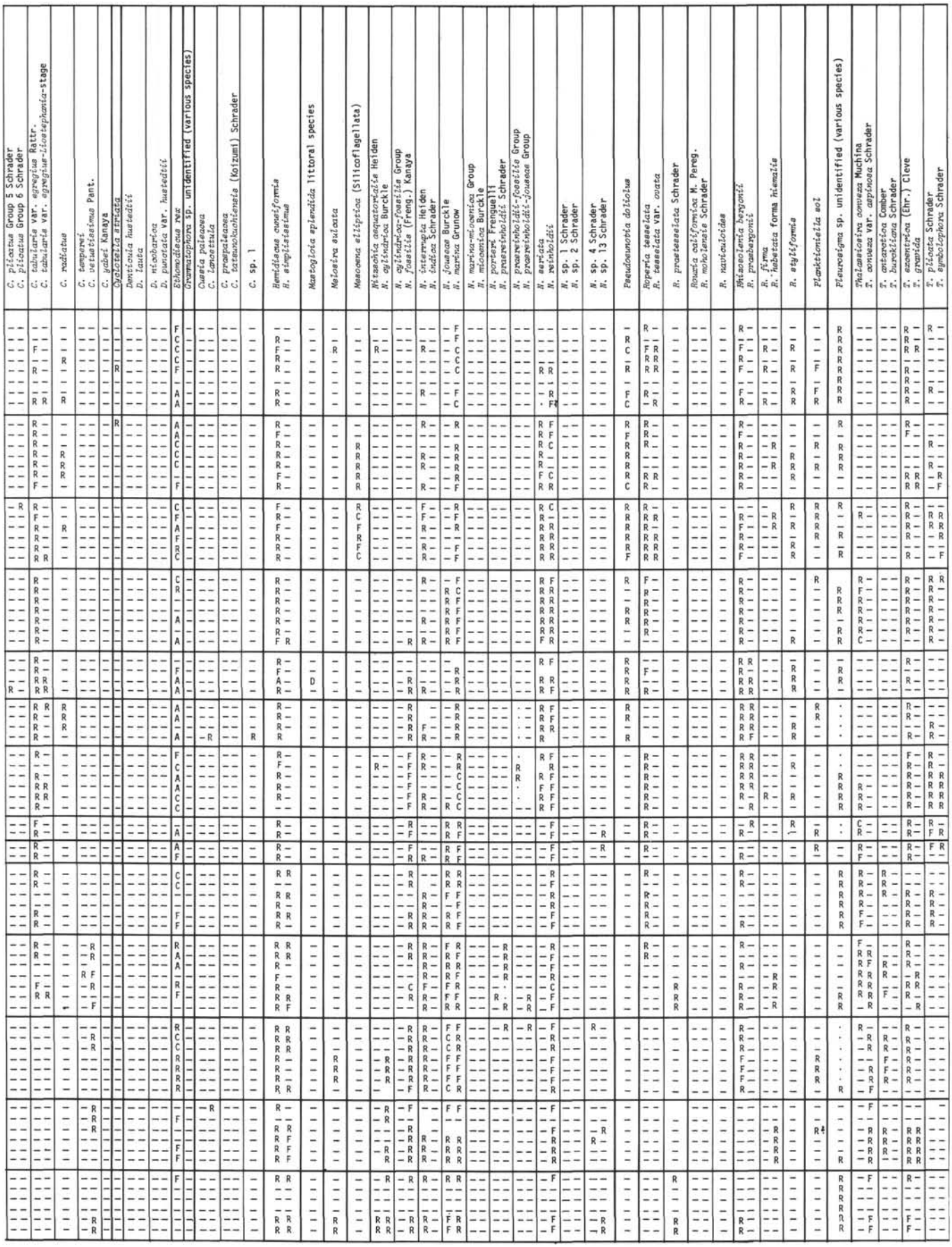


TABLE 2 – *Continued*

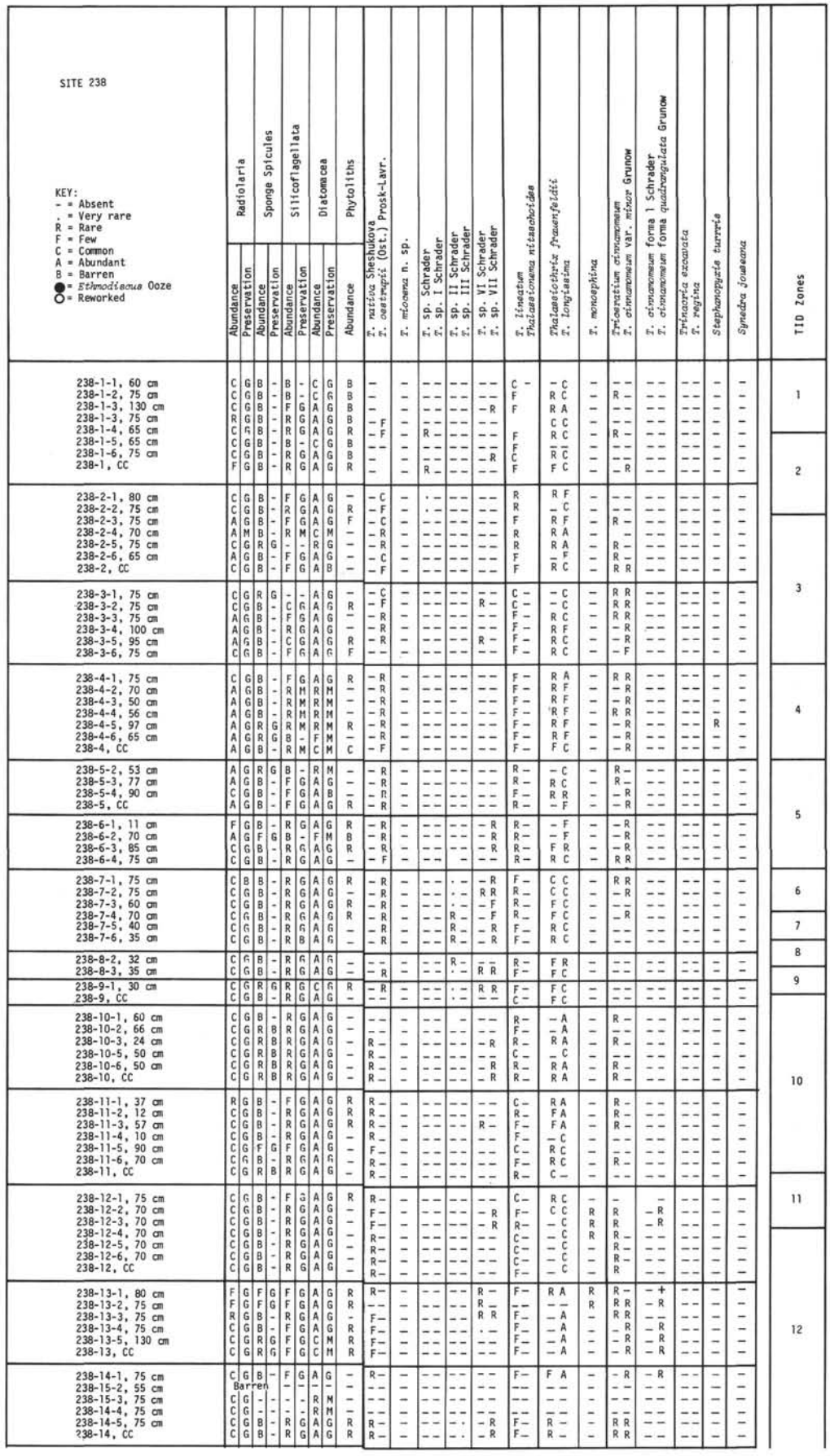
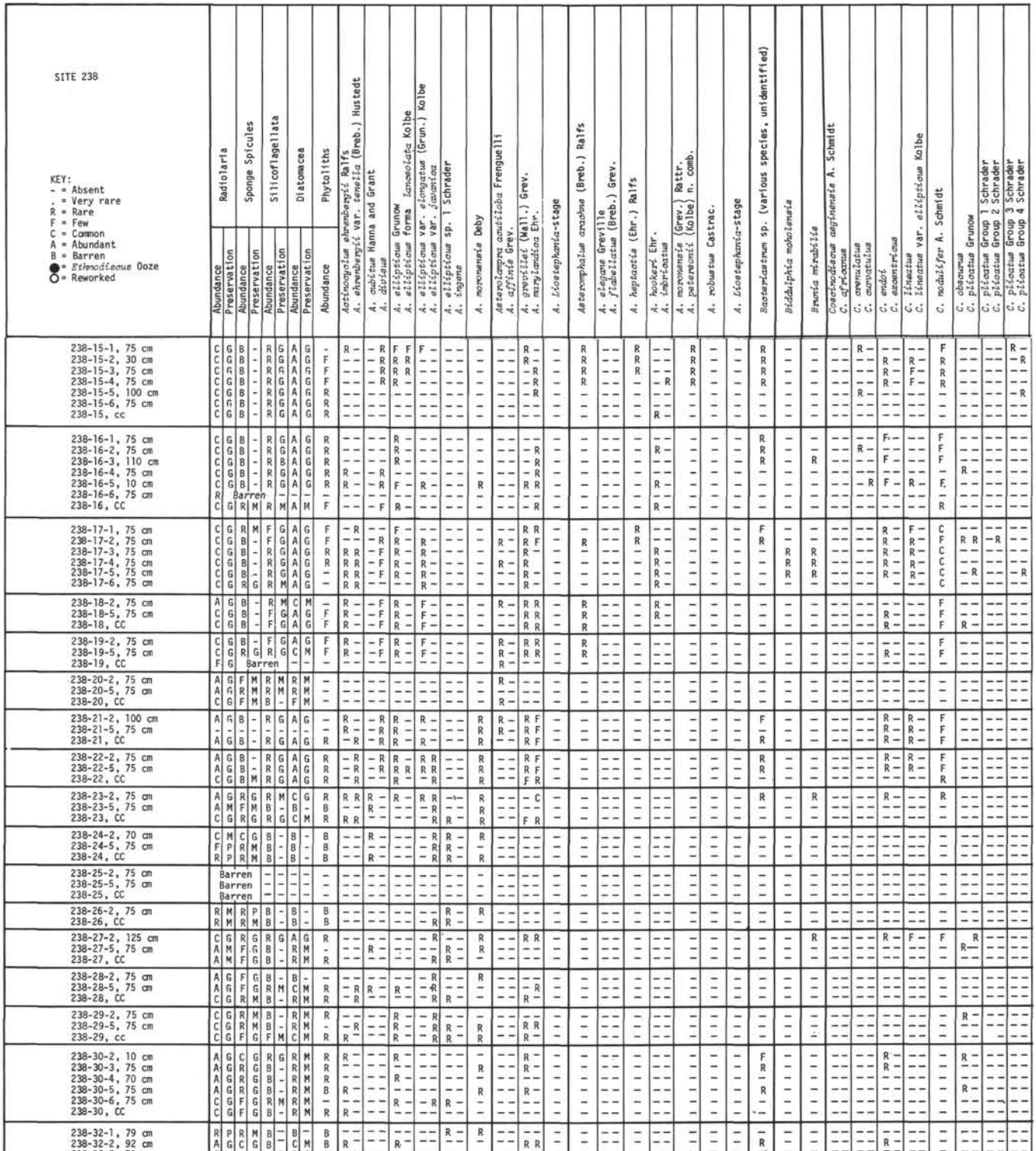


TABLE 2 – *Continued*



Note: Lower part of the section is barren in diatoms.

TABLE 2 – *Continued*

SITE 238

KEY:
- = Absent
. = Very rare
R = Rare
F = Few
C = Common
A = Abundant
B = Barren
● = *Ethmodiscus* Ooze
○ = Reworked

	Radiolaria		Sponge Spicules		Silicoflagellata		Diatomacea		Phytoliths	*C. plicatus* Group 5 Schrader	*C. plicatus* Group 6 Schrader	*C. tabularis* var. *egregius* Rattr.	*C. tabularis* var. *egregius-doroteophania*-stage	*C. radiatus*	*C. temperei*	*C. vetustissimus* Pant.	*C. yabei* Kanaya	*Cyclotella atomata*	*Dentinula hustedtii*	*D. lauta*	*D. nicobarica*	*D. punctata* var. *hustedtii*	*Ethmodiscus rex*	*Grunowiophora* sp. unidentified (various species)	*Chaetoceros paleacea*	*C. lanosettula*	*C. praepalaeacea*	*C. tatsunokuchiensis* (Kolzumi) Schrader	*C.* sp. 1	*Hemidiscus cuneiformis*	*H. triangularissimus*	*Mastogloia splendida* Littoral species	*Melosira sulcata*	*Meosowena elliptica* (Silicoflagellata)	*Nitzschia aequatoriolis* Heiden	*N. cylindrica* Burckle	*N. cylindrica-fossilis* Group	*N. fossilis* (Freng.) Kanaya	*N. interrupta* Heiden	*N. indica* Schrader	*N. jouseae* Burckle	*N. marina* Grunow	*N. marina-miocenica* Group	*N. miocenica* Burckle	*N. porsere* Frenguelli	*N. praeinterhoidii* Schrader	*N. praeinterhoidii-fossilis* Group	*N. praeinterhoidii-jouseae* Group
	Abundance	Preservation	Abundance	Preservation	Abundance	Preservation	Abundance	Preservation	Abundance																																						
238-15-1, 75 cm	C	G	B	-	R	G	A	G	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
238-15-2, 30 cm	C	G	B	-	R	G	A	G	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
238-15-3, 75 cm	C	G	B	-	R	G	A	G	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
238-15-4, 75 cm	C	G	B	-	R	G	A	G	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
238-15-5, 100 cm	C	G	B	-	R	G	A	G	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
238-15-6, 75 cm	C	G	B	-	R	G	A	G	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
238-15, cc	C	G	B	-	R	G	A	G	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
238-16-1, 75 cm	C	G	B	-	R	G	A	G	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
238-16-2, 75 cm	C	G	B	-	R	G	A	G	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
238-16-3, 110 cm	C	G	B	-	R	G	A	G	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
238-16-4, 75 cm	C	G	B	-	R	G	A	G	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
238-16-5, 10 cm	C	G	B	-	R	G	A	G	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
238-16-6, 75 cm	R	Barren																																													
238-16, CC	C	G	R	M	R	M	A	M	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
238-17-1, 75 cm	C	G	R	M	F	G	A	G	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
238-17-2, 75 cm	C	G	B	-	F	G	A	G	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
238-17-3, 75 cm	C	G	B	-	R	G	A	G	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
238-17-4, 75 cm	C	G	B	-	R	G	A	G	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
238-17-5, 75 cm	C	G	B	-	R	G	A	G	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
238-17-6, 75 cm	C	G	R	G	R	M	A	G	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
238-18-2, 75 cm	A	G	B	-	R	M	C	M	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
238-18-5, 75 cm	C	G	B	-	F	G	A	G	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
238-18, CC	C	G	B	-	F	G	A	G	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
238-19-2, 75 cm	C	G	B	-	F	G	A	G	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
238-19-5, 75 cm	C	G	R	G	R	G	C	M	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
238-19, CC	F	G	Barren																																												
238-20-2, 75 cm	A	G	F	M	R	M	R	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
238-20-5, 75 cm	A	G	R	M	R	M	R	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
238-20, CC	C	G	F	M	B	-	F	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
238-21-2, 100 cm	A	G	B	-	R	G	A	G	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
238-21-5, 75 cm	-	-	B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
238-21, CC	A	G	B	-	R	G	A	G	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
238-22-2, 75 cm	A	G	B	-	R	G	A	G	R	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
238-22-5, 75 cm	A	G	B	-	R	G	A	G	R	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
238-22, CC	C	G	B	M	R	G	A	G	R	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
238-23-2, 75 cm	A	G	R	G	R	M	C	G	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
238-23-5, 75 cm	A	M	F	M	B	-	B	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
238-23, CC	C	G	R	G	R	G	C	M	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
238-24-2, 70 cm	C	M	C	G	B	-	B	-	B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
238-24-5, 75 cm	F	P	R	M	B	-	B	-	B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
238-24, CC	R	P	R	M	B	-	B	-	B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
238-25-2, 75 cm	Barren																																													
238-25-5, 75 cm	Barren																																													
238-25, CC	Barren																																													
238-26-2, 75 cm	R	M	R	P	B	-	B	-	B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
238-26, CC	R	M	R	M	B	-	B	-	B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
238-27-2, 125 cm	C	G	R	G	R	G	A	G	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
238-27-5, 75 cm	A	M	F	G	B	-	R	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
238-27, CC	A	M	F	G	B	-	R	M	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
238-28-2, 75 cm	A	G	F	G	B	-	B	-	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
238-28-5, 75 cm	A	G	F	G	R	M	C	M	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
238-28, CC	C	G	R	M	B	-	R	M	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
238-29-2, 75 cm	C	G	R	M	B	-	R	M	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
238-29-5, 75 cm	C	G	R	M	B	-	R	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
238-29, cc	C	G	F	G	F	M	C	M	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
238-30-2, 10 cm	A	G	C	G	R	G	R	M	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
238-30-3, 75 cm	A	G	R	G	B	-	R	M	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
238-30-4, 70 cm	A	G	R	G	B	-	R	M	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
238-30-5, 75 cm	A	G	R	G	B	-	R	M	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
238-30-6, 75 cm	C	G	F	G	R	M	R	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
238-30, CC	C	G	F	G	B	-	R	M	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
238-32-1, 79 cm	R	P	R	M	B	-	B	-	B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
238-32-2, 92 cm	A	G	C	G	B	-	C	M	B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
238-32-5, 70 cm	F	P	C	M	B	-	R	G	B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
238-32, CC	B	-	R	P	B	-	B	-	B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
238-33-1, 90 cm	B	-	R	P	B	-	B	-	B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
238-33, CC	F	P	C	M	B	-	B	-	B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
238-34-2, 50 cm	R	P	C	M	B	-	B	-	B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
238-34-5, 70 cm	Barren																																												
238-34, CC	F	M	A	G	B	-	B	-	B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
238-35-2, 75 cm	Barren																																												
238-35-5, 65 cm	F	M	C	M	B	-	B	-	B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
238-35, CC	F	M	C	M	B	-	B	-	B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Note: Lower part of the section is barren in diatoms.

TABLE 2 – *Continued*

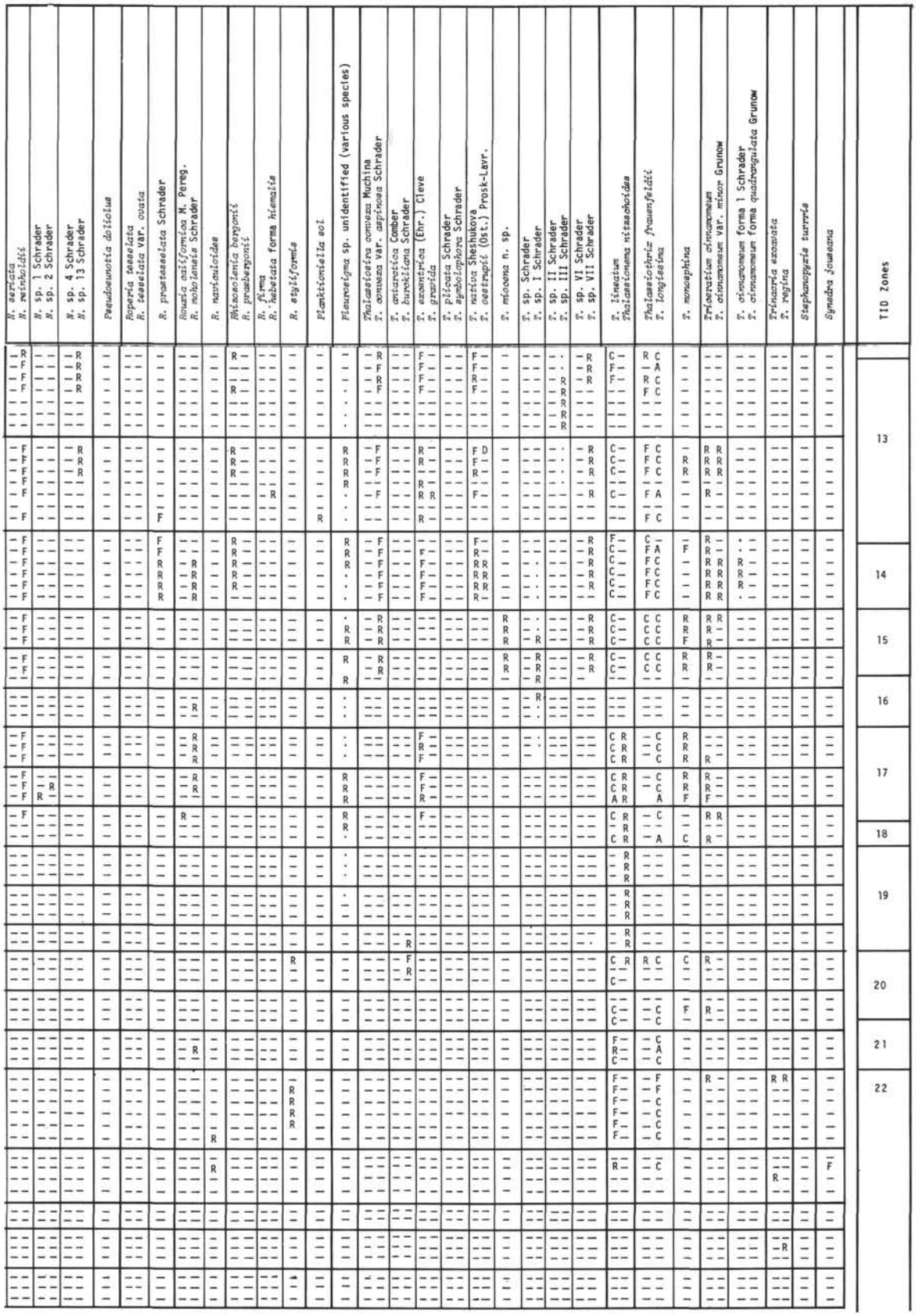


TABLE 3
Distribution of Diatoms and Other Siliceous Nannofossils, Site 213

TABLE 3 – *Continued*

SITE 213

KEY:
– = Absent
• = Very rare
R = Rare
F = Few
C = Common
A = Abundant
B = Barren
○ = Reworked
● = *Ethmodiscus* Ooze

Sample	Ooze	Radiolaria Abundance	Radiolaria Preservation	Sponge Spicules Abundance	Sponge Spicules Preservation	Silicoflagellata Abundance	Silicoflagellata Preservation	Diatomacea Abundance	Diatomacea Preservation	Phytoliths Abundance	*Mesocena elliptica* (Silicoflagellata)	*Nitzschia aequatorialis* Heiden	*N. cylindrica* Burckle	*N. cylindrica-fossilis* Group	*N. fossilis* (Freng.) Kanaya	*N. interrupta* Heiden	*N. indica* Schrader	*N. jouseae* Burckle	*N. marina* Grunow	*N. marina-miocenica* Group	*N. miocenica* Burckle	*N. porteri* Frenguelli	*N. praereinholdii* Schrader	*N. praereinholdii-fossilis* Group	*N. praereinholdii-jouseae* Group	*N. seriata*	*N. reinholdii*	*N.* sp. 2 Schrader	*N.* sp. 4 Schrader	*N.* sp. 13 Schrader
213-1-1, 50-51 cm	●	C	G	B		R	G	A	M	R	–	–	–	–	–	–	–	–	F	–	–	–	–	–	–	–	R	–	–	–
213-1-2, 100-101 cm		C	G	B		R	G	A	G	R	–	–	–	–	–	F	–	–	C	–	–	–	–	–	–	–	R	–	–	–
213-1-3, 50-51 cm	●	C	G	B		R	G	A	M	R	R	R	–	–	–	R	–	–	F	–	–	–	–	–	–	–	R	–	–	–
213-2-1, 50-51 cm	●	R	G	B		R	G	A	M	R	–	–	–	–	–	F	–	–	F	–	–	–	–	–	–	–	–	–	–	–
213-2, CC		A	G	B		R	G	A	M	F	–	–	–	–	F	F	–	–	F	–	–	–	–	–	–	–	R	–	–	–
213-3-1, 50-51 cm		C	G	B		F	G	C	M	R	–	–	–	–	F	R	–	–	R	–	–	–	–	–	–	–	C	–	–	–
213-3-2, 50-51 cm		C	G	B		R	G	A	M	R	–	–	–	–	C	R	–	–	F	–	–	–	–	–	–	–	–	–	–	–
213-3-3, 50-51 cm		C	G	R	G	F	G	A	M	R	–	–	–	–	C	–	–	–	F	–	–	–	–	–	–	–	F	–	–	–
213-3-4, 50-51 cm		C	G	B		R	G	A	G	F	–	–	–	–	F	R	–	–	F	–	–	–	–	–	–	–	F	–	–	–
213-3-5, 100-101 cm		F	G	B		F	G	A	G	R	–	–	–	–	F	R	–	–	F	–	–	–	–	–	–	R	F	–	–	–
213-3, CC		F	G	B		F	G	A	G	R	–	–	–	–	R	–	–	–	–	–	–	–	R	–	–	R	F	–	–	–
213-4-1, 50-51 cm	●	C	G	B		R	G	A	M	F	–	–	–	–	R	R	–	–	F	–	–	–	–	–	–	R	F	–	–	–
213-4-2, 100-101 cm		C	G	B		R	G	A	M	F	–	–	–	–	R	R	–	R	R	–	–	–	–	–	–	R	F	–	–	–
213-4-3, 50-51 cm		C	G	B		F	G	C	M	R	–	–	–	–	R	–	–	R	F	–	–	–	–	–	–	–	R	–	–	–
213-4-4, 50-51 cm	●	R	G	B		F	G	A	M	R	–	R	–	–	–	F	–	F	F	–	–	–	–	–	R	R	–	–	–	–
213-4-5, 50-51 cm		C	G	B		R	G	A	M	R	–	R	–	–	F	R	–	F	R	–	–	–	–	–	R	–	R	–	–	–
213-4, CC		R	G	B		C	G	A	G	R	–	R	–	–	F	F	–	C	F	–	–	–	–	–	–	R	F	–	–	–
213-5-1, 50-51 cm		C	G	B		F	G	A	G	R	–	R	–	–	F	F	–	R	F	–	–	–	–	–	–	–	R	–	–	–
213-5-2, 50-51 cm		C	G	B		R	G	C	M	R	–	–	–	–	–	C	–	F	R	–	–	–	–	–	–	R	–	–	–	–
213-5-3, 50-51 cm		C	G	B		R	G	C	M	R	–	–	–	–	–	C	–	C	R	–	–	–	–	–	–	R	–	–	–	–
213-5-4, 50-51 cm		C	G	B		F	G	A	M	R	–	R	–	–	R	F	–	F	F	–	–	–	–	–	–	R	F	–	–	–
213-5-5, 50-51 cm		C	G	B		F	G	A	M	R	–	R	–	–	R	F	–	F	–	–	–	R	–	–	–	–	F	–	–	–
213-5, CC		C	G	B		F	G	A	M	R	–	R	–	–	F	F	–	C	F	–	–	–	–	–	–	–	F	–	–	–
213-6-1, 50-51 cm		C	G	B		F	G	A	G	R	–	R	–	–	F	F	–	C	F	–	–	R	–	–	–	–	F	–	–	–
213-6-2, 50-51 cm		C	G	B		F	G	A	G	R	–	–	–	–	–	–	–	C	–	–	–	–	–	–	–	–	F	–	–	–
213-6-3, 50-51 cm		C	G	B		F	G	A	G	R	–	–	–	–	C	R	–	C	R	–	–	–	–	–	–	–	F	–	–	–
213-6-4, 50-51 cm		C	G	B		F	G	A	G	R	–	–	R	–	R	F	–	F	F	–	–	–	–	–	–	–	F	–	–	–
213-6-5, 50-51 cm		C	G	B		R	G	A	G	R	–	–	R	–	R	F	–	F	F	–	–	–	–	–	–	–	F	–	–	–
213-6, CC		C	G	B		R	G	A	G	R	–	–	R	–	R	C	–	R	F	–	–	–	–	–	–	–	F	–	–	–
213-7-1, 50-51 cm		C	G	B		R	G	A	G	R	–	–	R	–	R	C	–	R	F	–	–	–	–	–	–	–	–	–	–	–
213-7-2, 50-51 cm		C	G	B		R	G	A	G	R	–	–	R	R	R	F	–	R	F	–	–	–	–	–	–	–	–	–	–	–
213-7-3, 50-51 cm		F	G	B		R	G	C	G	B	–	–	R	F	R	R	–	–	F	–	–	R	–	–	–	–	R	–	–	–
213-7-4, 50-51 cm		C	G	B		F	G	A	G	R	–	–	R	F	F	C	–	–	R	–	–	–	–	–	–	–	R	–	–	–
213-7-5, 50-51 cm		C	G	B		F	G	A	G	R	–	–	R	F	R	R	–	–	F	–	–	–	–	–	–	–	F	–	–	–
213-7, CC		F	G	B		F	G	A	G	R	–	–	R	–	–	F	–	–	R	–	–	–	–	–	–	–	F	–	–	–
213-8-1, 50-51 cm		F	G	B		F	G	A	G	R	–	–	R	R	R	R	R	–	F	–	–	–	–	–	–	–	F	–	–	–
213-8-2, 50-51 cm		C	G	B		R	G	A	M	B	–	–	R	–	F	R	R	–	R	–	–	–	–	–	–	–	F	–	–	–
213-8-3, 50-51 cm		C	G	B		R	G	A	M	B	–	–	–	–	F	F	–	–	F	–	R	–	–	–	–	–	F	–	–	–
213-8-4, 50-51 cm		C	G	R	G	R	M	A	M	R	–	–	–	–	R	R	R	–	R	–	R	–	–	–	–	–	C	–	–	–
213-8-5, 50-51 cm		C	G	B		R	G	A	G	R	–	–	R	–	R	R	–	–	R	–	F	–	–	–	–	–	C	–	–	–
213-8, CC		C	G	B		B		B		R	–	–	R	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Sample	*Pseudoeunotia doliolus*	*Roperia tesselata*	*R. tesselata* var. *ovata*	*R. praetesselata* Schrader	*Rouxia californica* M. Perag.	*R. moholensis* Schrader	*R. naviculoides*	*Rhizosolenia bergonii*	*R. praebergonii*	*R. firma*	*R. hebetata* forma *hiemalis*	*R. styliformis*	*Planktoniella sol*	*Pleurosigma* sp. unidentified (various species)
213-1-1, 50-51 cm	F	R	–	–	–	–	–	R	–	–	–	–	R	–
213-1-2, 100-101 cm	F	F	–	–	–	–	–	F	–	–	–	R	F	–
213-1-3, 50-51 cm	R	R	–	–	–	–	–	F	–	–	–	–	R	–
213-2-1, 50-51 cm	F	F	–	–	–	–	–	R	–	–	–	R	R	–
213-2, CC	–	–	–	–	–	–	–	R	R	–	–	R	–	–
213-3-1, 50-51 cm	–	R	–	–	–	–	–	R	F	–	–	F	–	–
213-3-2, 50-51 cm	–	–	–	–	–	–	–	F	R	–	–	F	R	–
213-3-3, 50-51 cm	–	F	–	–	–	–	–	R	F	–	–	–	–	–
213-3-4, 50-51 cm	–	R	–	–	–	–	–	R	C	–	–	–	R	–
213-3-5, 100-101 cm	–	R	–	–	–	–	–	F	R	–	–	–	R	–
213-3, CC	–	–	–	–	–	–	–	F	R	–	–	R	R	–
213-4-1, 50-51 cm	–	R	–	–	–	–	–	R	R	–	R	R	F	–
213-4-2, 100-101 cm	–	R	–	–	–	–	–	R	R	–	R	R	F	–
213-4-3, 50-51 cm	–	–	–	–	–	–	–	F	–	–	–	–	–	–
213-4-4, 50-51 cm	–	–	–	–	–	–	–	F	–	–	–	R	–	–
213-4-5, 50-51 cm	–	R	–	–	–	–	–	F	–	–	–	R	–	–
213-4, CC	–	R	–	–	–	–	–	F	–	–	–	R	R	–
213-5-1, 50-51 cm	–	R	–	–	–	–	–	R	–	–	–	–	–	–
213-5-2, 50-51 cm	–	–	–	–	–	–	–	F	–	–	–	R	–	–
213-5-3, 50-51 cm	–	–	–	–	–	–	–	F	–	–	–	R	–	–
213-5-4, 50-51 cm	–	–	–	R	–	–	–	F	–	–	–	–	–	–
213-5-5, 50-51 cm	–	R	–	R	–	–	–	R	–	–	–	R	–	–
213-5, CC	–	–	–	–	–	–	–	R	–	–	–	R	–	–
213-6-1, 50-51 cm	–	–	–	–	–	–	–	R	–	–	–	R	–	–
213-6-2, 50-51 cm	–	–	–	–	–	–	–	–	–	–	–	R	–	–
213-6-3, 50-51 cm	–	–	–	R	–	–	–	F	–	–	–	R	–	–
213-6-4, 50-51 cm	–	–	–	R	–	–	–	–	–	–	–	F	–	R
213-6-5, 50-51 cm	–	–	–	R	–	–	–	–	–	–	–	F	–	–
213-6, CC	–	–	–	–	–	–	–	R	–	–	–	R	–	–
213-7-1, 50-51 cm	–	–	–	–	–	–	–	–	–	–	–	R	–	–
213-7-2, 50-51 cm	–	–	–	–	–	–	–	R	–	–	–	R	–	–
213-7-3, 50-51 cm	–	–	–	–	–	–	–	R	–	–	–	R	–	–
213-7-4, 50-51 cm	–	–	–	–	–	–	–	–	–	–	–	R	–	–
213-7-5, 50-51 cm	–	–	–	–	–	–	–	–	–	–	–	R	–	–
213-7, CC	–	–	–	–	–	–	–	–	–	–	–	R	–	–
213-8-1, 50-51 cm	–	–	–	–	–	–	–	–	–	–	–	–	–	–
213-8-2, 50-51 cm	–	–	–	–	–	–	–	–	–	–	–	–	–	–
213-8-3, 50-51 cm	–	–	–	–	–	–	–	–	–	–	R	R	–	–
213-8-4, 50-51 cm	–	–	–	–	–	–	–	–	–	–	R	R	–	–
213-8-5, 50-51 cm	–	–	–	–	–	–	–	–	–	–	–	R	–	–
213-8, CC	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Sample	*Thalassiosira convexa* Muchina	*T. convexa* var. *aspinosa* Schrader	*T. antarctica* Comber	*T. burckliana* Schrader	*T. excentrica* (Ehr.) Cleve	*T. gravida*	*T. plicata* Schrader	*T. symbolophora* Schrader	*T. nativa* Sheshukova	*T. oestrupii* (Ost) Prosk-Lavr.	*T. miocenica* n. spec.	*T.* sp.	*T.* sp. Schrader	*T.* sp. I Schrader	*T.* sp. II Schrader	*T.* sp. III Schrader	*T.* sp. VI Schrader	*T.* sp. VII Schrader	*Thalassionema nitzschioides*	*T. lineatum*	*Thalassiothrix frauenfeldii*	*T. longissima*	*T. monospina*	*Triceratium cinnamomeum*	*T. cinnamomeum* var. *minor* Grunow	*T. cinnamomeum* forma 1 Schrader	*T. cinnamomeum* forma *quadrangulata* Grunow	*Trinacria excavata*	*T. regina*	*Stephanopyxis turris*	*Synedra jouseana*	TID Zones
213-1-1, 50-51 cm	Ⓡ	–	–	–	R	–	R	R	–	C	–	–	–	–	–	–	–	R	F	–	–	R	–	–	–	–	–	–	–	–	–	1
213-1-2, 100-101 cm	–	–	–	–	F	–	R	R	–	C	–	–	–	–	–	–	–	R	A	–	R	R	–	–	–	–	–	–	–	–	–	2
213-1-3, 50-51 cm	–	–	–	–	R	–	–	–	–	R	–	–	–	–	–	–	–	R	C	–	C	C	–	–	–	–	–	–	–	–	–	3
213-2-1, 50-51 cm	–	–	–	–	R	–	–	–	–	C	–	–	–	–	–	–	–	–	C	–	F	C	–	–	–	–	–	–	–	–	–	4,5
213-2, CC	–	–	–	–	–	–	R	–	–	R	–	–	–	–	–	–	–	F	C	–	–	–	–	R	–	–	–	–	–	–	–	
213-3-1, 50-51 cm	–	–	–	–	F	–	–	–	–	F	–	–	–	–	–	–	–	–	C	–	R	R	–	R	–	–	–	–	–	–	–	6
213-3-2, 50-51 cm	–	–	–	–	R	–	R	–	–	F	–	–	–	–	–	–	–	R	–	–	–	–	–	R	–	–	–	–	–	–	–	
213-3-3, 50-51 cm	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	R	A	–	–	–	–	R	–	–	–	–	–	–	–	
213-3-4, 50-51 cm	R	–	–	–	R	–	R	–	–	F	–	–	–	–	–	–	–	R	C	–	–	–	–	R	–	–	–	–	–	–	–	
213-3-5, 100-101 cm	R	–	–	–	R	–	–	–	–	F	–	–	–	–	–	–	–	–	C	–	R	C	–	R	–	–	–	–	–	–	–	7
213-3, CC	–	–	–	–	–	–	–	–	–	F	–	–	–	–	–	–	–	–	C	–	R	C	–	R	–	–	–	–	–	–	–	
213-4-1, 50-51 cm	C	–	R	–	F	–	R	–	–	R	–	–	–	–	–	–	–	R	C	–	F	F	–	R	–	–	–	–	–	–	–	8
213-4-2, 100-101 cm	C	–	R	–	F	–	R	–	–	R	–	–	–	–	–	–	–	R	C	–	–	–	–	R	–	–	–	–	–	–	–	
213-4-3, 50-51 cm	C	–	–	–	F	–	–	–	–	R	–	–	–	–	–	–	–	–	C	–	R	F	–	R	–	R	–	–	–	–	–	
213-4-4, 50-51 cm	C	–	–	–	F	–	R	–	–	R	–	–	–	–	–	–	–	R	C	–	F	–	–	–	–	–	–	–	–	–	–	9
213-4-5, 50-51 cm	C	–	–	–	R	–	R	–	–	R	–	–	–	–	–	–	–	R	F	–	F	–	–	R	–	–	–	–	–	–	–	
213-4, CC	F	–	–	–	R	–	R	–	–	R	–	–	–	–	–	–	–	R	C	–	–	–	–	R	–	–	–	–	–	–	–	
213-5-1, 50-51 cm	C	R	R	–	R	–	–	–	–	R	–	–	–	–	–	–	–	F	F	–	C	F	–	–	R	R	–	–	–	–	–	10
213-5-2, 50-51 cm	R	F	–	–	–	–	–	–	R	–	–	–	–	–	–	–	–	–	C	–	–	C	–	R	–	–	–	–	–	–	–	
213-5-3, 50-51 cm	R	C	–	–	–	–	–	–	R	–	–	–	–	–	–	–	–	–	C	–	–	C	–	R	–	–	–	–	–	–	–	
213-5-4, 50-51 cm	–	R	–	–	–	–	–	–	F	–	–	–	–	–	–	–	–	–	C	–	C	F	–	–	R	–	–	–	–	–	–	
213-5-5, 50-51 cm	–	C	–	–	F	–	–	–	F	–	–	–	–	–	–	–	–	–	C	–	R	C	–	–	R	–	–	–	–	–	–	
213-5, CC	–	C	–	–	F	–	F	–	–	–	–	–	–	–	–	–	–	–	C	–	C	C	–	–	R	–	–	–	–	–	–	11
213-6-1, 50-51 cm	–	C	–	–	F	–	F	–	R	–	–	–	–	–	–	–	–	–	C	–	C	C	–	–	R	–	–	–	–	–	–	
213-6-2, 50-51 cm	–	F	–	–	F	–	R	–	R	–	–	–	–	–	–	–	–	–	C	–	C	C	–	–	R	–	–	–	–	–	–	
213-6-3, 50-51 cm	–	F	–	–	R	–	R	–	R	–	–	–	–	–	–	–	–	F	C	–	C	C	–	R	R	–	–	–	–	–	–	
213-6-4, 50-51 cm	–	C	–	–	R	–	R	R	R	–	–	–	–	–	–	–	–	R	C	–	C	F	R	–	R	–	–	–	–	–	–	
213-6-5, 50-51 cm	–	C	–	–	–	–	R	R	–	–	–	–	–	–	–	–	–	–	C	–	C	F	R	–	R	–	–	–	–	–	–	
213-6, CC	–	F	–	–	–	–	R	F	F	–	–	–	–	–	–	–	–	–	C	–	C	R	–	R	F	–	–	–	–	–	–	12
213-7-1, 50-51 cm	–	F	–	–	–	–	R	–	F	–	–	–	–	–	–	–	–	–	C	–	C	–	–	R	F	–	–	–	–	–	–	
213-7-2, 50-51 cm	–	F	–	–	–	–	–	–	R	–	–	–	–	–	–	–	–	R	C	–	F	–	–	R	R	–	–	–	–	–	–	
213-7-3, 50-51 cm	–	R	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	R	F	–	R	–	–	R	–	–	–	–	–	–	–	
213-7-4, 50-51 cm	–	R	–	–	F	–	–	–	R	–	–	–	–	–	–	–	–	R	C	–	R	F	R	F	–	–	–	–	–	–	–	13
213-7-5, 50-51 cm	–	R	–	–	–	–	–	R	R	–	–	–	–	–	–	–	–	R	–	–	–	–	–	R	R	–	–	–	–	–	–	
213-7, CC	–	F	–	–	–	–	–	R	R	–	–	–	–	–	–	–	–	–	–	–	–	R	–	F	–	–	–	–	–	–	–	
213-8-1, 50-51 cm	–	R	–	–	–	–	–	–	R	–	R	–	–	–	–	–	–	R	F	–	–	C	–	R	–	–	–	–	–	–	–	14
213-8-2, 50-51 cm	–	F	–	–	–	–	–	–	R	–	R	–	–	–	–	–	–	R	C	–	–	–	–	R	–	–	–	–	–	–	–	
213-8-3, 50-51 cm	–	R	–	–	–	–	–	–	–	–	R	–	–	–	–	–	–	–	C	–	R	F	–	R	–	–	–	–	–	–	–	
213-8-4, 50-51 cm	–	R	–	–	–	–	–	–	–	–	R	–	–	–	–	–	–	–	R	–	R	F	R	F	–	–	–	–	–	–	–	
213-8-5, 50-51 cm	–	R	–	–	–	–	–	–	–	–	R	–	–	–	–	–	–	–	R	–	R	F	R	F	–	–	–	–	–	–	–	15
213-8, CC	–	–	–	–	–	–	–	–	–	–	R	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	

Note: Lower part of the section is barren in diatoms.

assemblage, but from the species composition, it can be suggested that no real cool period is represented. Reworked older fossils occur (sporadically) only in the upper part of the section. Only one horizon was found to represent *Ethmodiscus* ooze; this was at 2-1, 55-56 cm. Detailed references to the systematic composition of diatom floras are given in Table 4.

At this site, the base of the TID zones was observed to occur as follows:

TID Zone 1-4 at 5 meters (1-4, 50-51 cm)
TID Zone 5 is at 17 meters (2, CC)
TID Zone 6 is at 17.5 meters (3-1, 50-51 cm)
TID Zone 7 is at 19 meters (3-2, 50-51 cm)
TID Zone 8 is at 22 meters (3-4, 50-51 cm)
TID Zone 9 is at 30 meters (4-3, 50-51 cm)
TID Zone 10-11 is at 36.5 meters (5-1, 50-51 cm)
TID Zone 12 is at 39.5 meters (5-3, 50-51 cm)
TID Zone 13-14 is at 47.5 meters (6-2, 100-101 cm)
TID Zone 15 has not been defined.

No breaks in the diatom stratigraphic record were detected. The recognition of tropical Indian Ocean diatom zones is tentative; this is a result of wide sample distance and/or by coring disturbance of soupy material.

Based on the placement of the base of Tropical Indian Ocean Diatom Zone 5 (Pliocene-Pleistocene boundary) between samples 2, CC and 3-1, 50-51 cm and other horizons with absolute age estimates, a sedimentation rate of 16.5 m/m.y. can be calculated (Figure 11).

Correlation of TID zones at Sites 236, 238, 215, and 213 can be found in Figure 12.

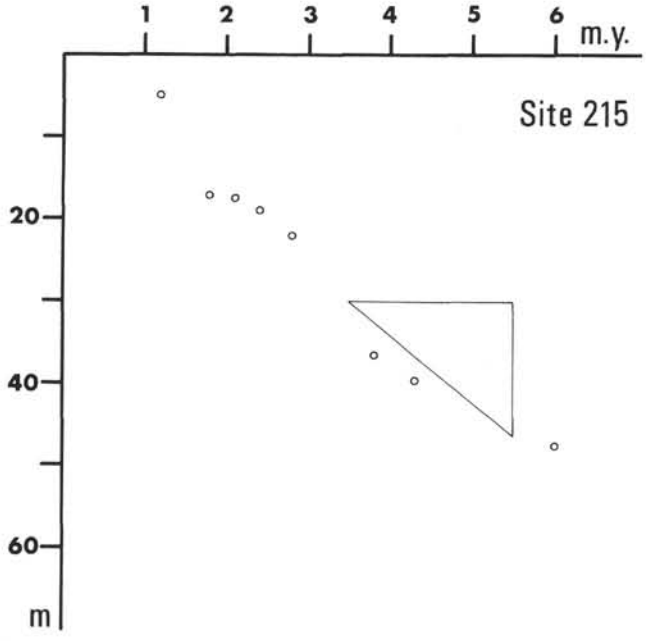


Figure 11. *Sediment accumulation rate at Site 215.*

SYSTEMATIC, FLORAL SEQUENCE

The genera are arranged alphabetically and species alphabetically within each genus. Species and varieties are treated according to the classifications of Hustedt (1929, 1959), Hendey (1937, 1964), Karsten (1907), Kanaya (1957, 1959), Koizumi (1968, 1972), Jousé (1971a), Schrader (1973a, 1973b, 1973c), Van Landingham (1967), Sheshukova-Poretzkaya (1967) and other whose descriptions have been followed strictly in identifying species.

New species have been described and their holotypes and paratypes designated. Holotypes are deposited in the authors type collection. Paratype material has been deposited at the Bundesanstalt für Bodenkunde, Hannover (L. Benda).

Unidentified species are numbered or grouped and illustrated and will be treated in a supplementary paper. An attempt was made to catalogue all diatom species in the samples. Almost all illustrated individuals are marked on the prepared slides with the aid of a diamond scribe (Schrader, 1974). In the synonomies of species that have previously been described, I have included, in most cases, only a reference to the original description and figure. Reference to a new combination is added; if the generic name now used differs; also a reference is added to the paper defining the present concept of the species.

The recently published paper of Bukry and Foster (1973) has not been treated taxonomically within this paper because of the misleading diatom taxonomy and genus concept used. It will be revised at a later date.

Genus ACTINOCYCLUS Ehrenberg (1837)

Actinocyclus cubitus Hanna and Grant (1926)

Description: Hanna and Grant, 1926, p. 118, pl. 11, fig. 3; Schrader, 1973a, pl. 19, fig. 7.

Occurrence: Very rare in the lower part of the section of Site 238 (TID Zone 20).

Actinocyclus divisus (Grun.) Hustedt (1958)

Description: Hustedt, 1958, p. 129-130, pl. 8, fig. 81; Hustedt, 1930, p. 410, fig. 218 (as *Coscinodiscus divisus*). This name was synonymized by Van Landingham (1967) p. 86 and he established a n. comb. *Actinocyclus cholnokyi,* unless the exact taxonomic position of *Act. divisus* Kisselev 1931 is not proven, I shall keep Hustedt's name.

Actinocylus ehrenbergii Ralfs *in* Pritchard (1861)
(Plate 19, Figure 18-19; Plate 21, Figures 16-17)

Description: Hustedt, 1929, p. 525, fig. 298.

Actinocyclus ehrenbergii var. tenella (Breb.) Hustedt (1929)
(Plate 20, Figure 1)

Description: Hustedt, 1929, p. 530, fig. 302.

Actinocyclus ellipticus Grunow *in* Van Heurck (1883)
(Plate 17, Figures 4, 5, 6-8, 16)

Description: Hustedt, 1929, p. 533, fig. 303; Van Heurck, 1883, pl. 124, fig. 10. I have placed all individuals under this name which do not possess a pseudonodulus in the middle of the valve except the marginal one, and which do possess a scattered middle structure.

Actinocyclus ellipticus var. elongatus (Grun.) Kolbe (1954)
(Plate 17, Figure 3)

Description: Kolbe, 1954, p. 20, pl. 3, fig. 28, 31.

Actinocyclus ellipticus var. janvanicus Reinhold (1937)
(Plate 17, Figure 13)

Description: Reinhold, 1937, p. 75, pl. 1, fig. 7-8.

Actinocyclus ellipticus forma lanceolata Kolbe (1954)
(Plate 17, Figure 2)

Description: Kolbe, 1954, p. 20, pl. 3, fig. 27.

Actinocyclus ingens Rattray (1890)

Description: Kanaya, 1971, p. 554, numerous figures; Koizumi, 1968, p. 207-208, pl. 32, fig. 5-6.

Occurrence: Occurs rarely in the lower part of the section of Site 238.

TABLE 4
Distribution of Diatoms and Other Siliceous Nannofossils, Site 215

SITE 215

KEY:
– = Absent
• = Very rare
R = Rare
F = Few
C = Common
A = Abundant
B = Barren
O = Reworked
● = *Ethmodiscus* Ooze

Sample	Radiolaria Abundance	Radiolaria Preservation	Sponge Spicules Abundance	Sponge Spicules Preservation	Silicoflagellata Abundance	Silicoflagellata Preservation	Diatomacea Abundance	Diatomacea Preservation	Phytoliths Abundance	*Actinocyclus ehrenbergii* Ralfs / *A. ehrenbergii* var. *tenella* (Breb.) Hustedt	*A. cubitus* Hanna and Grant / *A. divisus*	*A. ellipticus* Grunow / *A. ellipticus* forma *lanceolata* Kolbe	*A. ellipticus* var. *elongatus* (Grun) Kolbe / *A. ellipticus* var. *javanica*	*A. ellipticus* sp. 1 Schrader / *A. ingens*	*A. moronensis* Deby	*Asterolampra acutiloba* Frenguelli / *A. affinis* Grev.	*A. grevillei* (Wall.) Grev. / *A. marylandica* Ehr.	*A. Liostephania*-stage	*Asteromphalus arachne* (Breb.) Ralfs	*A. elegans* Greville / *A. flabellatus* (Breb.) Grev.	*A. heptactis* (Ehr.) Ralfs / *A. hiltonianus* (Grev.) Ralfs	*A. hookeri* Ehr. / *A. imbricatus*	*A. moronensis* (Grev.) Rattr. / *A. petersonii* (Kolbe) n. comb.	*A. robustus* Castrac. / *A. shadboltianus*	*A. Liostephania*-stage	*Bacteriastrum* sp. (various species, unidentified)	*Biddulphia moholensis*	*Brunia mirabilis*	*Coscinodiscus aeginensis* A. Schmidt / *C. africanus*	*C. crenulatus* / *C. curvatulus*	*C. endoi* / *C. excentricus*	*C. lineatus* / *C. lineatus* var. *ellipticus* Kolbe	*C. nitidus* / *C. nodulifer* A. Schmidt	*C. obscurus* / *C. plicatus* Grunow	*C. plicatus* Group 1 Schrader / *C. plicatus* Group 2 Schrader	*C. plicatus* Group 3 Schrader / *C. plicatus* Group 4 Schrader	*C. plicatus* Group 5 Schrader / *C. plicatus* Group 6 Schrader	*C. tabularis* var. *egregius* Rattr. / *C. tabularis* var. *egregius*-*Liostephania*-stage	*C. radiatus*	*C. temperei* / *C. vetustissimus* Pant.	*C. yabei* Kanaya	*Cyclotella striata*	*Denticula hustedtii* / *D. lauta*	*D. nicobarica* / *D. punctata* var. *hustedtii*	*Ethmodiscus rex*	*Grammatophora* sp. unidentified (various species)	*Cussia paleacea* / *C. lancettula*	*C. praepaleacea* / *C. tuitanouchiensis* (Koizumi) Schrader	*C.* sp. 1	*Hemidiscus cuneiformis* / *H. simplicissimus*	*Mastogloia splendida* (littoral species)	*Melosira sulcata*
215-1-1, 50-51 cm	R	G	B		C	G	A	G	R	– –	– –	F –	– –	– –	–	– –	– R	–	F	R –	– –	R –	– –	– –	–	–	–	–	– F	– F	– F	F R	– F	– –	– –	– –	– –	R R	R	– –	–	–	– –	– –	C	–	– –	– –	–	R –	–	–
215-1-2, 50-51 cm	R	G	B		C	G	A	G	R	– –	– –	F –	– –	– –	–	– –	– R	–	F	R –	– –	R –	– –	– –	–	R	–	–	– F	– F	– F	F R	– F	– –	– –	– –	– –	– R	R	– –	–	–	– –	– –	C	–	– –	– –	–	R –	–	–
215-1-3, 50-51 cm	R	G	B		C	G	A	G	R	– –	– –	F –	– –	– –	–	– –	– R	–	F	R –	– –	R –	– –	– –	–	R	–	–	– F	– F	– F	F R	– F	– –	– –	– –	– –	R R	R	– –	–	–	– –	– –	C	–	– –	– –	–	R –	–	–
215-1-4, 50-51 cm	R	G	B		C	G	A	G	R	– –	– –	F –	– –	– –	–	– –	– R	–	F	R –	– –	R –	– –	– –	–	R	–	–	– F	– R	– R	F R	– F	– –	– –	– –	– –	– R	R	– –	–	–	– –	– –	C	–	– –	– –	–	R –	–	–
215-1-5, 50-51 cm	R	G	B		C	G	A	G	R	– –	– –	R –	– –	– –	–	– –	– R	–	F	– –	– –	– –	– –	R –	R	R	–	–	– R	– R	– R	R –	– F	– –	– –	– R	– –	F R	R	– –	–	–	– –	– –	C	–	– R	– –	–	F –	–	–
215-1, CC	R	G	B		C	G	A	G	R	– –	– –	– –	– –	– –	–	– –	– R	–	R	– –	R –	– –	– –	– –	–	R	–	–	– F	–	– R	F –	– F	– –	– –	– R	– –	R –	–	– –	–	–	– –	– –	C	–	– R	– –	–	F –	–	–
215-2-1, 55-56 cm O	F	G	B		R	G	A		B	– –	– –	R –	– –	– –	–	– –	– –	–	–	– –	R –	– –	– –	– –	–	–	–	–	– –	– –	– –	F –	– C	– –	– –	– F	– –	– F	F	– R	–	–	– –	– –	A	–	– –	– –	–	F –	–	–
215-2, CC	C	G	B		R	G	A	G	R	R –	– –	R –	– –	– –	–	– –	– –	–	F	– –	– –	F –	– –	– –	–	–	–	–	– R	– –	– –	R –	– F	– –	– –	– R	– –	R –	R	– –	–	–	– –	– –	A	–	– –	– –	–	R –	–	–
215-3-1, 50-51 cm	C	G	B		R	G	A	G	R	– –	– –	F –	R –	– –	–	– –	– R	–	R	– –	R –	– –	– –	– –	–	R	–	–	– F	– –	– R	R –	– F	– –	– –	– R	– –	R –	–	– –	–	–	– –	– –	F	–	– –	– –	–	F –	–	–
215-3-2, 50-51 cm	C	G	B		R	G	A	G	R	R –	– –	F –	R –	– –	–	– –	– R	–	R	– –	R –	– –	– –	– –	–	R	–	–	– F	– –	– R	R –	– F	– –	– –	– R	– –	R –	R	– –	–	–	– –	– –	F	–	– –	– –	–	F –	–	–
215-3-3, 50-51 cm	C	G	B		R	G	A	G	R	R –	– –	F –	R –	– –	–	– –	– R	–	R	– –	R –	– –	– –	– –	–	R	–	–	– R	– –	– R	R –	– F	– –	– –	– R	– –	R –	R	– –	–	–	– –	– –	F	–	– –	– –	–	F –	–	–
215-3-4, 50-51 cm	C	G	B		R	G	A	G	R	R –	– –	F –	R –	– –	–	– –	– R	–	R	– –	R –	– –	– –	– –	–	R	–	–	– R	– –	– R	R –	– F	– –	– –	– R	– –	R –	R	– –	–	–	– –	– –	F	–	– –	– –	–	F –	–	–
215-3-5, 50-51 cm	C	G	B		R	G	A	G	R	R –	– –	F –	R –	– –	–	– –	– R	–	R	– –	R –	– –	– –	– –	–	R	R	–	– R	– –	– R	R –	– F	– –	– –	– R	– –	R –	R	– –	–	–	– –	– –	F	–	– –	– –	–	F –	–	–
215-3-6, 50-51 cm	C	G	B		R	G	A	G	R	R –	– –	F –	R –	– –	–	– –	– R	–	R	– –	R –	– –	– –	– –	–	R	R	–	– R	– –	– R	R –	– F	– –	– –	– R	– –	R –	R	– –	–	–	– –	– –	F	–	– –	– R	–	F –	–	–
215-4-1, 50-51 cm	C	G	B		R	G	A	G	R	R –	– –	F –	R –	– –	–	– –	– R	–	R	– –	R –	– –	– –	– –	–	R	R	–	– R	– –	– R	R –	– F	– –	– –	– R	– –	R –	R	– –	–	–	– –	– –	F	–	– –	– R	–	F –	–	–
215-4-2, 50-51 cm	R	G	B		F	G	A	G	R	R –	– –	R –	– –	– –	–	– –	– –	–	R	– –	– –	R –	– –	– –	–	–	R	–	– R	– –	– F	F –	– R	– –	– –	– R	– –	R –	–	– –	–	–	– –	– –	F	–	– –	– –	–	R –	–	–
215-4-3, 50-51 cm	R	G	B		F	G	A	G	R	R –	– –	R –	R –	– –	–	– –	– R	–	R	– –	R –	R –	– –	– –	–	R	R	–	– R	– –	– –	F –	– R	– –	– –	– R	– –	R –	R	– –	–	–	– –	– –	R	–	– –	– –	–	R –	–	–
215-4-4, 50-51 cm	R	G	B		F	G	A	G	R	R –	– –	R –	R –	– –	–	– –	– R	–	R	– –	R –	R –	– –	– –	–	R	R	–	– R	– –	– F	R –	– R	– –	– –	– R	– –	R –	R	– R	–	–	– –	– –	C	–	– –	– –	–	R –	–	–
215-4-5, 50-51 cm	F	G	B		F	G	A	G	R	R –	– –	R –	R –	– –	–	– –	– R	–	R	– –	R –	R –	– –	– –	–	R	R	–	– R	– –	– F	R –	– R	– –	– –	– R	– –	R –	–	– –	–	–	– –	– –	A	–	– –	– –	–	R –	–	–
215-4-6, 50-51 cm	F	G	B		F	G	A	G	R	R –	– –	R –	– –	– –	–	– –	– R	–	R	– –	– –	R –	– –	R –	–	–	–	–	– –	– –	– F	R –	– F	– –	– –	– R	– –	R –	R	– R	–	–	– –	– –	C	–	– –	– –	–	R –	–	–
215-5-1, 50-51 cm	F	G	B		F	G	A	G	R	R R	– –	F –	– –	– –	–	– –	– R	–	R	– –	– –	R –	– –	R –	–	R	R	–	– –	– –	– –	– –	– F	– –	– –	– R	– –	R –	–	– R	–	–	– –	– –	C	–	– –	– –	–	R –	–	–
215-5-2, 100-101 cm	F	G	B		F	G	A	G	B	R R	– –	F –	– –	– –	–	– –	– R	–	R	– –	– –	R –	– –	R –	–	R	R	–	– R	– R	– F	R –	– F	– –	– –	– R	– –	R –	–	– R	–	–	– –	– –	C	–	– –	– –	–	R –	–	–
215-5-3, 50-51 cm	F	G	B		R	G	A	G	R	F –	– –	R –	– –	– –	–	– –	– R	–	R	– –	– –	R –	– –	– –	–	F	R	–	– –	– R	– –	R –	– F	– –	– –	– R	– –	F –	–	– R	–	–	– –	– –	C	–	– –	– –	–	R –	–	–
215-5-4, 50-51 cm	F	G	B		R	G	A	G	R	F –	– –	R –	– –	– –	–	– –	– R	–	R	– –	– –	R –	– –	– –	–	–	R	–	– R	– –	– –	R –	– R	– –	– –	– R	– –	R –	–	–	–	–	– –	– –	C	–	– –	– –	–	F –	–	–
215-5, CC	F	G	B		R	G	A	G	R	F –	– –	R –	R –	– –	–	– –	– R	–	R	– –	– –	R –	– –	R –	–	R	R	–	– R	– R	– –	R –	– F	– –	– –	– R	– –	F –	–	– R	–	–	– –	– –	C	–	– –	– –	–	F –	–	–
215-6-1, 100-101 cm	F	G	B		R	G	A	G	R	F –	– –	F –	R –	– –	–	– –	– R	–	R	– –	– –	R –	– –	R –	–	R	R	–	– R	– R	R –	– –	– F	– –	– –	– R	– –	F –	–	– R	–	–	– –	– –	C	–	– –	– –	–	R –	–	–
215-6-2, 100-101 cm	–	B	A	R	R			•	–	– –	– –	– –	– –	– –	–	– –	– –	–	–	– –	– –	– –	– –	– –	–	–	–	–	– –	– –	– –	– –	– –	– –	– –	– –	– –	– –	–	– –	–	–	– –	– –	–	–	– –	– –	–	– –	–	–
215-6-3, 160-161 cm	C	G	B		R	G	A	G	R	– –	– –	R –	R –	– –	–	– –	– –	–	–	– –	– –	– –	– –	– –	–	R	R	–	– –	– –	– R	R –	– R	– –	– –	– –	– –	– –	–	– R	–	–	– –	– –	–	–	– –	R –	–	R –	–	–
215-6, CC	C	G	B		R	G	A	G	R	– –	– –	– –	– –	– –	–	– –	– –	–	R	– –	– –	– –	– –	– –	–	R	R	–	– R	– –	– R	F –	– R	– –	– –	– –	– –	– –	–	– R	–	–	– –	– –	–	–	– –	– –	–	R –	–	–
215-7-1, 130-131 cm	C	G	B		R	G	A	G	R	R –	– –	R –	R –	– –	R	R –	– R	–	–	– –	– –	– –	– –	– –	–	–	R	–	– R	– R	– –	– –	– R	– –	– –	– –	– –	– –	–	– R	–	–	– –	– –	R	–	– –	R –	–	R –	–	–
215-7-2, 50-51 cm	C	G	B		R	G	A	G	R	– –	– –	R –	– –	– –	R	– –	R R	–	–	– –	– –	– –	– –	– –	–	–	R	–	– –	– –	– –	R –	– R	– –	– –	– –	– –	R –	–	– –	–	–	– –	– –	R	–	– R	– –	–	R –	–	–
215-7, CC	C	G	B		R	G	A	G	R	– R	– –	R –	– –	– –	R	F –	– R	–	R	– –	– –	– –	– –	– –	–	–	R	–	– –	– –	– R	– –	– –	– –	– –	– –	– –	– –	–	– –	–	–	– –	– –	R	–	– F	– –	–	R –	–	–

NOTE: Lower part of section is barren in diatoms.

TABLE 4 – *Continued*

SITE 215

KEY:
– = Absent
• = Very rare
R = Rare
F = Few
C = Common
A = Abundant
B = Barren
O = Reworked
● = *Ethmodiscus* Ooze

	Abundance	Preservation	Abundance	Preservation	Abundance	Preservation	Abundance	Preservation	Abundance	Phytoliths		TID Zones
	Radiolaria		Sponge Spicules		Silicoflagellata		Diatomacea					
215-1-1, 50-51 cm	R	G	B		C	G	A	G	R	*Mesocena elliptica* (Silicoflagellata)	C	3
215-1-2, 50-51 cm	R	G	B		C	G	A	G	R		F	
215-1-3, 50-51 cm	R	G	B		C	G	A	G	R	*Nitzschia aequatorialis* Heiden	–	
215-1-4, 50-51 cm	R	G	B		C	G	A	G	R	*N. cylindrus*	–	
215-1-5, 50-51 cm	R	G	B		C	G	A	G	R	*N. cylindrus-fossilis* Group	–	
215-1, CC	R	G	B		C	G	A	G	R	*N. fossilis* (Freng.) Kanaya	–	
215-2-1, 55-56 cm O	F	G	B		R	G	A		R	*N. interrupta* Heiden	R	4
215-2, CC	C	G	B		R	G	A	G	R	*N. indica* Schrader	–	
215-3-1, 50-51 cm	C	G	B		R	G	A	G	R	*N. jouseae* Burckle	–	
215-3-2, 50-51 cm	C	G	B		R	G	A	G	R	*N. marina* Grunow	F	
215-3-3, 50-51 cm	C	G	B		R	G	A	G	R	*N. marina-miocenica* Grup	F	
215-3-4, 50-51 cm	C	G	B		R	G	A	G	R	*N. miocenica* Burckle	–	
215-3-5, 50-51 cm	C	G	B		R	G	A	G	R	*N. porteri* Frenguelli	–	
215-3-6, 50-51 cm	C	G	B		R	G	A	G	R	*N. praereinholdii* Schrader	–	
215-4-1, 50-51 cm	C	G	B		R	G	A	G	R	*N. praereinholdii-fossilis* Group	–	
215-4-2, 50-51 cm	C	G	B		F	G	A	G	R	*N. praereinholdii-jouseae* Group	–	
215-4-3, 50-51 cm	R	G	B		F	G	A	G	R	*N. seriata*	F	
215-4-4, 50-51 cm	R	G	B		F	G	A	G	R	*N. reinholdii*	C	
215-4-5, 50-51 cm	F	G	B		F	G	A	G	R	*N. sp. 2* Schrader	–	6
215-4-6, 50-51 cm	F	G	B		F	G	A	G	R		–	7
215-5-1, 50-51 cm	F	G	B		F	G	A	G	R	*N. sp. 4* Schrader	–	8
215-5-2, 100-101 cm	F	G	B		F	G	A	G	R	*N. sp. 13* Schrader	–	
215-5-3, 50-51 cm	F	G	B		R	G	A	G	R	*Pseudoeunotia doliolus*	F	9
215-5-4, 50-51 cm	F	G	B		R	G	A	G	R	*Roperia tessellata*	R	
215-5, CC	F	G	B		R	G	A	G	R	*R. tesselata* var. *crenata*	R	
215-6-1, 100-101 cm	F	G	B		R	G	A	G	R	*R. praetesselata* Schrader	–	
215-6-2, 100-101 cm	I	B	A	R	R	G	A	G	R	*Rouxia californica* M. Perg.	–	
215-6-3, 160-161 cm	C	G	B	B	R	G	A	G	R	*R. moholensis* Schrader	–	
215-6, CC	C	G	B	B	R	G	A	G	R	*R. navicula* Ides	–	10
215-7-1, 130-131 cm	C	G	B	B	R	G	A	G	R	*Rhizosolenia bergonii*	F	11
215-7-2, 50-51 cm	C	G	B	B	R	G	A	G	R	*R. praebergonii*	R	
215-7, CC	C	G	B	B	R	G	A	G	R	*R. plana*	R	
										R. hebetata forma *hiemalis*	F	
										R. styliformis	F	12
										Planktoniella sol	R	
										Pleurosigma sp. unidentified (various species)	–	13
										Thalassiosira convexa Muchina	R	
										T. convexa var. *aspinosa* Schrader	F	
										T. antarctica Comber	–	
										T. burckliana Schrader	–	
										T. eccentrica (Ehr.) Cleve	R	
										T. gravida	–	
										T. plicata Schrader	R	
										T. symbolophora Schrader	R	
										T. native Shashukova	–	
										T. oestrupii (Ost) Prosk-Lavr.	C	
										T. miocenica n. spec.	–	14
										T. sp. Schrader	–	
										T. sp. I Schrader	–	
										T. sp. II Schrader	–	
										T. sp. III Schrader	–	
										T. sp. VI Schrader	–	15
										T. sp. VII Schrader	–	
										Thalassionema nitzschioides	C	
										T. lanceolatum	–	?
										Thalassiothrix frauenfeldii	R	
										T. longissima	C	
										T. monocephala	–	
										Triceratium shanghaiense	–	
										T. alnmanomeum	R	
										var. *minor* Grunow	–	
										T. alnmanomeum forma 1 Schrader	–	
										T. alnmanomeum forma *quadrangulata* Grunow	–	
										Trinacria excavata	–	
										T. regina	–	
										Stephanopyxis turris	–	
										Synedra jouseana	–	

NOTE: Lower part of section is barren in diatoms.

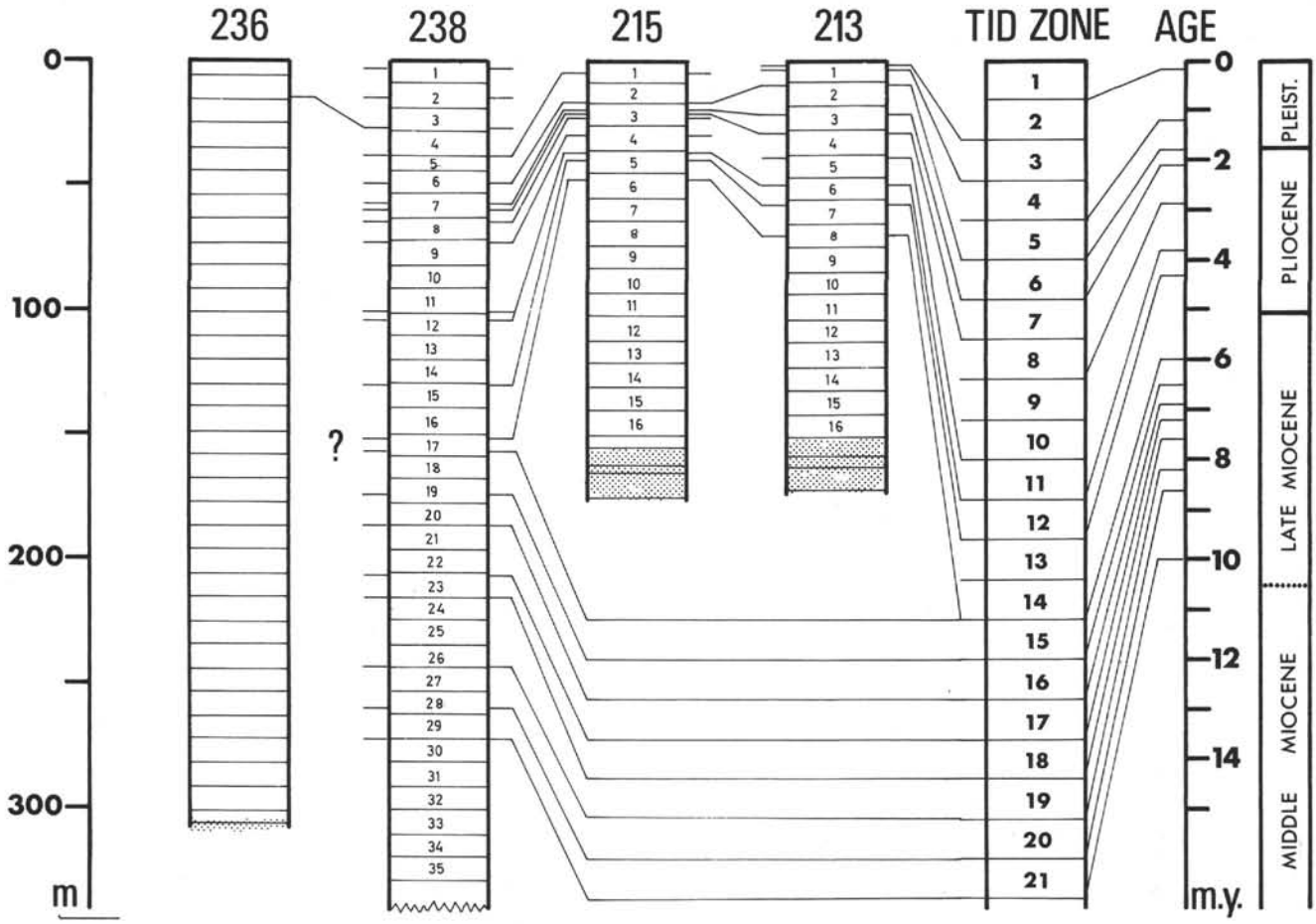


Figure 12. *Correlation of Sites 236, 238, 215, and 213. Small numbers within the site columns are core numbers. Dotted areas at the base of the Site 236, 215 and 213 represent basalt. Site 238 has not been completely drawn.*

Actinocyclus moronensis Deby *in litt.* Rattray (1890)
(Plate 17, Figures 9-12)

Description: Rattray, 1890, p. 195; Kolbe, 1954, p. 21, pl. 3, fig. 29-30 (as *Actinoc. ellipticus* var. *moronensis*). I have kept the original name of Deby because this species is different from *Act. ellipticus* in its characteristic middle structure and the regularly spaced marginal "labiate processes" which are absent from *Act. ellipticus.*

Actinocyclus ellipticus sp. 1 Schrader
(Plate 17, Figures 14-15; Plate 20, Figure 4)

Description: No similar species was observed in the literature. It differs from *Actinocyclus ellipticus* by the presence of a second pseudonodulus which is situated excentrically near the middle of the valve. Central area hyaline. All *Act. ellipticus* species need drastic taxonomic revision along with species being placed into the *Triceratium cinnamomeum* group.

Actinocyclus sp. 1 Schrader
(Plate 21, Figure 18)

Description: No similar species was observed in the literature. This species has a fasciculate structure with a pseudonodulus near the margin and half moon hyaline areas around the margin representing the areas where the labiate processes are inserted.

Occurrence: Rare in the upper part of the sections of Sites 238, 213 and 215.

Genus ANAULUS Ehrenberg (1844)

Anaulus sp. 1
(Plate 19, Figure 1)

Only one specimen was observed. Accurate classification will be done at a later date.

Genus ASTEROLAMPRA Ehrenberg (1844)

Asterolampra acutiloba Frenguelli *in* Tempère and Peragallo, 1912
(Plate 9, Figures 7-8)

Description: Schmidt et al., 1874, pl. 137, fig. 19 (unnamed); Forti *in* Tempère and Peragallo, 1912, p. 337, No. 696-698.

Asterolampra affinis Greville (1862)
(Plate 9, Figure 10)

Description: Schmidt, 1874, pl. 137, fig. 4; Rattray, 1890, p. 649.

Asterolampra greville (Wallich) Greville (1860)
(Plate 8, Figure 5)

Description: Hustedt, 1929, p. 489, fig. 274.

Asterolampra marylandica Ehrenberg (1844)
(Plate 8, Figure 2)

Description: Hustedt, 1929, p. 485, fig. 271.

Asterolampra-Liostephania-Stage
(Plate 12, Figures 22-23)

For reference see Hanna and Brigger, 1970; Kolbe, 1954, p. 39. For more detail see under section "*Ethmodiscus* ooze".

Genus ASTEROMPHALUS Ehrenberg (1845)

Asteromphalus arachne (Breb.) Ralfs *in* Pritchard (1861)
(Plate 9, Figure 11)

Description: Hustedt, 1929, p. 493, fig. 276.

Asteromphalus brookei Bailey (1856)

Description: Rattray, 1890, p. 657; illustration Schmidt et al., 1874, pl. 38, fig. 21-23.
Occurrence: Rare in TID Zones 1-5, Sites 238, 213.

Asteromphalus elegans Greville (1859)
(Plate 8, Figure 4)

Description: Hendey, 1937, p. 269; illustration Schmidt et al., 1874, pl. 38, fig. 1-2.
Occurrence: Rare in TID Zones 1-4, Sites 238, 213, 215.

Asteromphalus flabellatus (Breb.) Greville (1859)
(Plate 8, Figure 3)

Description: Hustedt, 1929, p. 498, fig. 279; Schmidt et al., 1874, pl. 38, fig. 10-12.
Occurrence: Rare in TID Zones 1-4, Site 238.

Asteromphalus heptactis (Breb.)
Ralfs *in* Pritchard (1861)
(Plate 8, Figure 1)

Description: Hustedt, 1929, p. 494, fig. 277.

Asteromphalus hiltonianus (Greville)
Ralfs *in* Pritchard (1861)

Description: Ralfs *in* Pritchard, 1861, p. 837; illustration Greville, 1860, p. 117, pl. 4, fig. 15.

Asteromphalus hookeri Ehrenberg (1844)
(Plate 8, Figure 7)

Description: Hendey, 1937, p. 270; illustration Ehrenberg, 1844, pl. (June), fig. 3.

Asteromphalus imbricatus Wallich (1860)

Description: Ralfs *in* Pritchard, 1861, p. 837.
Occurrence: Rare in TID Zones 1-3, Site 213.

Asteromphalus moronensis (Greville)
A. Schmidt (1876)

Description: Greville, 1863, p. 230, pl. 9, fig. 8; Hanna and Grant, 1926, p. 126, pl. 13, fig. 2 (as *Ast. dubius* Hanna and Grant).
Occurrence: Very rare in the lower part of the section, Site 238 (TID Zones 15-20).

Asteromphalus petersonii (Kolbe) n. comb.
(Plate 12, Figures 10-13)

Synonyms: *Liriogramma petersonii* Kolbe, 1954, p. 40, fig. 9; *Liriogramma hustedtii* Kolbe, 1955, p. 173, fig. 6.
Description: Kolbe, 1954, p. 40, fig. 9; 1955, p. 173, fig. 6. Individuals with complete intact structures were observed and revealed that Kolbe's genus *Liriogramma* has to be synonymized with *Asteromphalus* (compare Plate 12, Figures 10-13). The more the gradiant of ghost shape of original structure the more individuals look like "*Liriogramma hustedtii*" and vice versa.

Asteromphalus robustus Castracane (1875)
(Plate 8, Figure 6)

Description: Hustedt, 1929, p. 496, fig. 278.

Asteromphalus shadboltianus (Greville)
Ralfs *in* Pritchard (1861)

Description: Ralfs *in* Pritchard, 1861, p. 838; illustration Schmidt et al., 1874, pl. 38, fig. 17 and pl. 137, fig. 26.

Asteromphalus Liostephania Stage
(Plate 12, Figures 16-19)

For reference see Hanna and Brigger, 1970; Kolbe, 1954, p. 39. For more detail see under section "*Ethmodiscus* ooze".

Asteromphalus spec. 1
(Plate 9, Figures 12-13)

No similar specimens were found in the literature.

Genus BACTERIASTRUM Shadbolt (1853)

Bacteriastrum species

Various fragments of this genus were found in the Pleistocene to Pliocene sections of Sites 213, 215, 238. Exact identification is only possible if whole chains with middle and end cells are present.

Genus BIDDULPHIA Gray (1821)

Biddulphia moholensis Schrader (1974)
(Plate 19, Figures 2-3)

Description: Schrader, 1974, p. 534, pl. 4, fig. 3-4.

Genus BRUNIA Tèmpère (1890)

Brunia mirabilis (Brun *in* Brun and Tèmpère)
Tèmpère (1890)

Description: Brun *in* Brun and Tèmpère, 1889, p. 27, pl. 8, fig. 1. Schrader, 1973a, pl. 13, fig. 16.
Occurrence: Rare in the lower part of the section of Site 238.

Genus CHAETOCEROS Ehrenberg (1844)

Chaetoceros species

In many samples, representing a well-preserved diatom assemblage, numerous *Chaetoceros* fragments (mainly bristles) were observed. These bristles could be assigned in some cases to the following species: *Chaetoceros peruvianus* Brightwell; *Chaetoceros compressus* Lauder, *Chaetoceros messanensis* Castracane a.o. There are about a dozen other fragments which could not be assigned to a specific *Chaetoceros* species.

Genus COSCINODISCUS Ehrenberg (1838)

Coscinodiscus aeginensis Schmidt (1888) *in*
Schmidt et al. (1874)

Description: Hanna, 1932, p. 178, pl. 5, fig. 9; Schmidt et al., 1874, pl. 113, fig. 13-14.
Occurrence: Rare in samples from Site 238; TID Zones 18-20.

Coscinodiscus africanus Janisch (1878)
***in* Schmidt et al. (1874)**
(Plate 18, Figures 1-2)

Description: Hustedt, 1928, p. 428, fig. 231.

Coscinodiscus crenulatus Grunow (1884)

Description: Hustedt, 1928, p. 411, fig. 219.

Coscinodiscus curvatulus Grunow (1878) *in* Schmidt et al. (1874-)

Description: Hustedt, 1928, p. 406, fig. 214.

Coscinodiscus endoi Kanaya (1959)
(Plate 18, Figures 5-7)

Description: Kanaya, 1959, p. 76, pl. 3, fig. 8-11; Schrader, 1973a, pl. 7, fig. 14, 21; pl. 20, fig. 1-2.

Coscinodiscus excentricus Ehrenberg (1839)
(Plate 11, Figures 5, 9-11;
Plate 14, Figures 1-2, 8)

Description: Hustedt, 1928, p. 388, fig. 201. I have placed all individuals with a typical *Cosc. excentricus* structure and without a central strutted tubulus into *Coscinodiscus* and all with a central strutted tubulus into *Thalassiosira.*

Coscinodiscus gigas var. diorama (Schmidt) Grunow (1884)
((?) Plate 18, Figure 8)

Description: Rattray, 1890, p. 542; Schmidt et al., 1874, pl. 64, fig. 2.

Coscinodiscus lineatus Ehrenberg (1838)
(Plate 11, Figure 6)

Description: Hustedt, 1928, p. 392, fig. 204.

Coscinodiscus lineatus var. ellipticus Kolbe (1954)
(Plate 10, Figures 5-8)

Description: Kolbe, 1954, p. 32, pl. 2, fig. 15.
Occurrence: Rare to few in the upper sections. This species is most characteristic and can easily be recognized by its tangential plication and the fine marginal structure.

Coscinodiscus nitidus Gregory (1857)

Description: Hustedt, 1928, p. 414, fig. 221.
Occurrence: Present in samples with shallow-water material influx. *C. nitidus* is common in nearshore environments, possibly as a benthic marine species.

Coscinodiscus nodulifer Schmidt *in* Schmidt et al. (1874-).

Description: Hustedt, 1930, p. 426, fig. 229.

Coscinodiscus obscurus Schmidt *in* Schmidt et al. (1874-)

Description: Hustedt, 1928, p. 418, fig. 224.
Occurrence: Found in varying numbers at Sites 238, 215, 213.

Coscinodiscus plicatus Grunow (1878) *in* Schmidt et al. (1874-)
(Plate 15, Figures 21-22; Plate 16, Figures 9-15;
Plate 21, Figures 1-2, 5-7)

Description: Grunow, 1884, p. 86, pl. 3, fig. 10, 27; Kolbe, 1954, p. 34-35 (no illustration); Schrader, 1973a, pl. 6, fig. 23.
The following species have been grouped preliminary to *Cosc. plicatus* and are numbered. The whole *Cosc. plicate*-Group will be treated taxonomically in a separate paper.
Coscinodiscus plicatus Group 1
Coscinodiscus plicatus Group 2
Coscinodiscus plicatus Group 3
Coscinodiscus plicatus Group 4
Coscinodiscus plicatus Group 5
Coscinodiscus plicatus Group 6

Coscinodiscus radiatus Ehrenberg (1839)

Description: Hustedt, 1929, p. 420, fig. 225.
Occurrence: Rare to common in most samples.

Coscinodiscus symbolophorus Grunow (1884)

Description: Hustedt, 1919, p. 396-398, fig. 208 (as *Coscinodiscus stellaris* var. *symbolophora* (Grunow) Jörgensen; Schrader, 1973a, pl. 22, fig. 8-9.
Occurrence: Very rare in the lower part of the section of Site 238.

Coscinodiscus tabularis var. Egregius-Liostephania-Stage
(Plate 12, Figures 1-9)

Similar to the *Liostephania*-stage of the genera *Asteromphalus* and *Asterolampra.*

Coscinodiscus tabularis var. egregius (Rattray) Hustedt (1930)
(Plate 12, Figures 1, 9; Plate 18, Figures 3-4, 9;
Plate 19, Figure 10a)

Description: Hustedt, 1930, p. 428, fig. 230b.

Coscinodiscus temperei Brun *in* Brun and Tempere (1889)

Description: Kanaya, 1959, p. 84, pl. 4, fig. 8; Schrader, 1973a, pl. 6, fig. 18-19, pl. 7, fig. 1-5, 8-9.

Coscinodiscus vetustissimus Pantocsek (1886)

Description: Pantocsek, 1886, p. 71, pl. 20, fig. 186; Hustedt, 1929; p. 412, fig. 220.

Coscinodiscus yabei Kanaya (1957)
(Plate 21, Figure 8)

Description: Kanaya, 1957, p. 86, pl. 5, figs. 6-9; Schrader, 1973a, pl. 6, figs. 1-6.

Genus CYCLOTELLA Kützing (1834)

Cyclotella striata (Kützing) Grunow *in* Cleve and Grunow (1880)

Description: Hustedt, 1928, p. 344-347, fig. 176. Littoral marine species. Occurrence as displaced individuals in marine hemipelagic sequences.

Genus DENTICULA Kützing (1884)

Denticula hustedtii Simonsen and Kanaya (1961)
(Plate 18, Figures 10-11)

Description: Simonsen and Kanaya, 1961, p. 501, pl. 1, fig. 19-25; Schrader, 1973a, pl. 2, fig. 28-34, 36-47.

Denticula lauta Bailey (1854)

Description: Simonsen and Kanaya, 1961, p. 500-501, pl. 1, fig. 1-8; Schrader 1973a, pl. 2, fig. 14-25, 35.

Denticula nicobarica Grunow (1868)

Description: Simonsen and Kanaya, 1961, p. 503, pl. 1, fig. 11-13; Schrader, 1973b, p. 419-420, pl. 1, fig. 25-27.

Denticula punctata var. hustedtii Schrader (1973a)

Description: Schrader, 1973a, p. 705, pl. 1, fig. 23-24; Schrader, 1973b, p. 420, pl. 1, fig. 18

Genus ETHMODISCUS Castracane (1886)

Ethmodiscus rex (Rattray) Hendey (1953)
***in* Hendey and Wiseman**

Description: Hendey and Wiseman, 1953, p. 51-57, pl. 1, fig. 1-6, pl. 2, fig. 1-3.

Genus GRAMMATOPHORA Ehrenberg (1839)

Grammatophora species

Species of the genus *Grammatophora* occurred in rare numbers within those intervals bearing other displaced littoral marine benthic species. In most cases, only intercalary bands were found which do not permit a taxonomic treatment (Hendey, 1964).

Genus CUSSIA n. gen.

Synonyms: *Coscinodiscus* e.p. Rattray, 1890, p. 597, fig. 149; *Stoschia* (?) e.p. Grunow in Van Heurck, 1883, pl. 128, fig. 6; *Coscinodiscus* e.p. Schrader, 1973a, (*paleaceus, praepaleaceus*); *Rhaphoneis* e.p. Hajos, 1968, p. 143, pl. XLI, fig. 16-27; *Rhaphoneis* e.p. Koizumi, 1972, p. 349, pl. 42, fig. 3-4.

Description: Cells solitary, free. Valves elliptical lanceolate with a symmetrical and/or asymmetrical transapical axis, flat. Valve surface usually either areolate, areolae round or with transapical costae forming a pennate like surface ornamentation with a zig-zag apical costa forming a "pseudoraphe"-like morphological band, in between the costae hyaline intercostal membranes. Valve center not furnished with a central area. Spines or apiculi absent. Valve margin usually narrow with a coarse striation.

Generotype: *Stoschia* (?) *paleacea* Grunow *in* Van Heurck, 1883, pl. 128, fig. 6.

Distribution: Widely distributed in Neogene marine sediments (Pacific, Mediterranean Sea, Atlantic, Indian Ocean).

Discussion: *Stoschia* Janisch *in litt,* was not validly published by Janisch, but was distributed privately to diatomists by the author (Janisch: C.: The diatoms of the *Gazelle* Expedition, 17 plates with m.s. index, no date). Rattray, 1890, p. 548, combined *Stoschia* with *Coscinodiscus* and combined the species *Stoschia admirabilis* Janisch (ca. 1888) with *Coscinodiscus reniformis* Castracane (1886, p. 160, pl. 12, fig. 12). Grunow (1883 *in* Van Heurck) established the species *Stoschia paleacea;* this species was newly combined by Rattray (1890, p. 597, fig. 149) and named *Coscinodiscus paleaceus* (Grunow) Rattray. As soon as the evolution of the genus under discussion was revealed, the taxonomic position of some other species could be detected which have been described under *Rhaphoneis* by Hajos (1968) and Koizumi (1972).

Derivatio nominis: Dedicated to the scientific vessel *Cuss* I, which drilled the Experimental Mohole Drilling.

Cussia lancettula n. sp.
(Plate 19, Figures 14-16)

Description: Valves elliptical-lanceolate with acute rounded ends. 24-70μ long, 4-7μ wide. Transapical axis symmetrical. Valve surface flat with transapical costae, 12-10 in 10μ slightly curved near the apices. Transapical costae not divided in the middle part, divided towards the apices and here in decussate arrangement, connected in the middle by an apical zig-zag line which simulate a pseudoraphe. Intercostal membranes homogenous even in oblique light. Margin not separated from the valve structure.

Discussion: This species differs from *Cussia praepaleacea* by the margin not being separated, and by the simple transapical structure.

Derivatio nominis: lancea (latin) – lance

Holotype: Plate 1, figures 9-10 *in* Schrader (1974) from EMD-8-15-100/101 cm, a sample from North Pacific Diatom Zone 19. California Academy of Sciences, Geology Catalog (diatom collection) No. 54411.

Paratype: Plate 1, figure 5 *in* Schrader (1974). California Academy of Sciences, Geology Catalog (diatom collection) No. 54412.

Cussia paleacea (Grunow) n. comb.

Basionym: *Stoschia paleacea* Grunow *in* Van Heurck, 1883, pl. 128, fig. 6.

Synonyms: *Coscinodiscus paleaceus* (Grunow) Rattray, 1890, p. 597, fig. 149; *Coscinodiscus paleaceus* (Grunow) Rattray, *in* Schrader, 1973a, p. 703, pl. 3, figs. 10-12.

Description: Kolbe, 1954, p. 34, pl. 3, fig. 32.

Cussia praepaleacea (Schrader) n. comb.

Basionym: *Coscinodiscus praepaleaceus* Schrader, 1973a, p. 703, pl. 3, fig. 1.

Description: Schrader, 1973a, p. 703, pl. 3, figs. 1-9.

Cussia tatsunokuchiensis (Koizumi) n. comb.

Basionym: *Raphoneis tatsunokuchiensis* Koizumi, 1972, p. 349, pl. 42, fig. 3-4.

Description: Koizumi, 1972, p. 349, pl. 42, fig. 3-4.

Cussia sp. 1
(Plate 18, Figure 12)

Description: This species is placed with hesitation into the genus *Cussia* and was found only in one single frustule. It has a lanceolate valve with acute apices. Structure is arranged in transapical lines; no middle structure line is present. Unless more individuals have been found no taxonomic decision will be made.

Genus HEMIDISCUS Wallich (1860)

Hemidiscus cuneiformis Wallich (1860)
(Plate 19, Figures 20-25)

Description: Hustedt, 1930, p. 904-907, fig. 542.

Hemidiscus simplicissimus Hanna and Grant (1926)

Description: Hanna and Grant, 1926, p. 147, pl. 16, fig. 13; Schrader, 1973a, p. 706, pl. 24, fig. 12-13.

Genus MASTOGLOIA Thwaites *in* Smith (1856)

Mastogloia species

Various species of this characteristic genus were found, among others, *M. splendida.* All encountered individuals belong to marine littoral benthic species and are displaced into this depositional environment.

Genus MELOSIRA Agardh (1824)

Melosira sulcata (Ehr.) Kützing (1844)

Description: Hustedt, 1928, p. 276-278, fig. 118-119. Littoral marine species; often found displaced with open ocean plankton.

Genus NITZSCHIA Hassal (1845)

**Nitzschia aequatorialis Heiden *in*
Heiden and Kolbe (1927)**

Description: Heiden and Kolbe, 1927, p. 665, pl. 7, fig. 149; Kolbe 1955, p. 174, pl. 2, fig. 24.

Nitzschia cylindrica Burckle (1972)
(Plate 6, Figures 26-34, 36-38)

Description: Burckle, 1972, p. 239-240, pl. 2, fig. 1-6.

**Nitzschia fossilis (Frenguelli) Kanaya *in*
Kanaya and Koizumi (1970)**
(Plate 6, Figures 8-18, 19-20 (?), 21-22)

Description: Schrader, 1973a, p. 707, pl. 4, fig. 9-11, 24-25.

Nitzschia kolaczeckii Grunow (1967)

Description: Kolbe, 1955, p. 174, pl. 2, fig. 22-23; Hustedt *in* Schmidt et al., 1874, pl. 349, fig. 38-39.

Occurrence: Found in rare numbers in the upper Pliocene to Pleistocene section of Site 238.

Nitzschia indica n. sp.

Description: Valves elliptical with slightly convex margins and acute, broadly rounded apices. 40-70μ long, 8-11μ wide in the middle of the valve. Transapical costae 11-12 in 10μ. Intercostal membrane with two rows of rounded pores in decussate arrangement, approximately 20 pores in 10μ. Transapical costae and intercostal structures straight transapical, slightly curved at the apices. Two inner apical lines parallel to the margin, but approximately 3μ from the margin forming the borders of the inner pore margins. Pore longitudinal in transapical direction approximately 4μ wide in the middle of the valve, becoming gradually smaller towards the apices. Raphe marginal, with bent in (like in *Nitzschia marina*) raphe pols at the apices. Keel strong approximately 1-1,5μ wide, about 12 keel-punctae in 10μ. In the middle of the valve a marginal enlarged and well detectable central nodule, approximately 2μ wide in apical direction. Valve surface almost flat becoming gradually convex near the margins and near the apices.

Discussion: This species is close to *Nitzschia miocenica* and *Nitzschia marina* but differs by the presence of a central nodule and by the central line of broad inner rectangular pores.

Holotype: Plate 5, Figures 16-17 from DSDP Leg 24, 238-23, CC, tropical Indian Ocean. Collection Schrader.

Nitzschia interrupta Heiden
***in* Heiden and Kolbe (1927)**
(Plate 15, Figures 1-7, 8-9 (?) 10-11)

Description: Heiden and Kolbe, 1927, p. 665, pl. 7, fig. 150; Kolbe, 1955, p. 174, pl. 2, fig. 25-27.

Nitzschia jouseae Burckle (1972)
(Plate 7, Figures 14-23)

Description: Burckle, 1972, p. 240, pl. 2, fig. 17-21.

Nitzschia marina Grunow
***in* Cleve and Grunow (1880)**
(Plate 5, Figures 1-2, 5, 14-14 (?))

Description: Grunow *in* Cleve and Grunow, 1880, p. 70.

Nitzschia miocenica Burckle (1972)
(Plate 5, Figures 10-11)

Description: Burckle, 1972, p. 240-241, pl. 2, fig. 10-15.

Nitzschia porteri Frenguelli (1949)
(Plate 15, Figure 14)

Description: Frenguelli, 1949, p. 116, pl. 1, fig. 33-34.

Nitzschia praereinholdii Schrader (1973a)
(Plate 7, Figures 24-26)

Description: Schrader, 1973a, p. 708, pl. 5, fig. 20-26.

Nitzschia reinholdii Kanaya and Koizumi (1970)
(Plate 5, Figures 3-4, 6-9, 12-13, 18-19;
Plate 7, Figures 10-11)

Description: Schrader, 1973a, p. 708, pl. 4, fig. 12-16.

Nitzschia seriata Cleve (1883)

Description: Cleve, 1883, p. 478, pl. 38, fig. 75; Hasle, 1972, p. 176-179, fig. 2.

Occurrences: Found in rare numbers in the upper Pliocene to Pleistocene sections of Sites 238, 215, 213.

Only those *Nitzschia* species which could definitively be determined have been treated taxonomically. All the following forms must be studied in more detail in the near future. They represent, among others, transitional forms between species and are placed into groups representing morphological characters of one or the other of the listed species. Final decision will be published in a comprehensive paper (in preparation) on evolutionary trends and "events", together with a revised taxonomy of marine-fossil *Nitzschia* species.

Nitzschia praereinholdii-jouseae Group
(Plate 7, Figures 29-30)
Nitzschia praereinholdii-fossilis Group
(Plate 7, Figures 27-28)
Nitzschia marina-miocenica Group
(Plate 7, Figures 1-7)
Nitzschia cylindrica-fossilis Group
(Plate 6, Figures 25, 35)
Nitzschia sp. 2
(Plate 7, Figures 12-13)
Nitzschia sp. 4
(Plate 15, Figures 12-13)
Nitzschia sp. 13
(Plate 15, Figure 15)
Nitzschia sp. 8
(Plate 15, Figures 16-20)

Genus PLANKTONIELLA Schütt (1893)

Planktoniella sol (Wallich) Schütt (1893)

Description: Hustedt, 1930, p. 465-467, fig. 259; Gerloff, 1970, p. 203 ff.

Genus PLEUROSIGMA Wm. Smith (1852)

Pleurosigma species

A small number of *Pleurosigma* species were found in the well-preserved diatomaceous samples. It is not possible at the moment to identify these individuals.

Genus PSEUDOEUNOTIA Grunow *in* Van Heurck (1880)

Pseudoeunotia doliolus (Wallich)
Grunow *in* Van Heurck (1880)
(Plate 6, Figures 1-7)

Description: Hustedt, 1959, p. 258-260, fig. 737.

Genus RHIZOSOLENIA Ehrenberg (1841)

Rhizosolenia bergonii Peragallo (1892)
(Plate 9, Figure 4)

Description: Hustedt, 1930, p. 575-577, fig. 327.

Rhizosolenia firma Karsten (1907)
(Plate 9, Figure 6)

Description: Karsten, 1907, p. 377, pl. 41, fig. 2; Hustedt, 1930, p. 574-575, fig. 326; Kolbe, 1957, p. 41, pl. 4, fig. 52.

Rhizosolenia hebetata forma hiemalis Gran (1904)
(Plate 9, Figure 5)

Description: Hustedt, 1930, p. 590-592, fig. 337.

Rhizosolenia praebergonii Muchina (1965)
(Plate 9, Figures 1-3)

Description: Koizumi, 1968, p. 217, pl. 34, fig. 20-21.

Rhizosolenia styliformis Brightwell (1858)

Description: Hustedt, 1930, p. 584-588, fig. 333-335.

Genus ROPERIA Grunow *in* Van Heurck (1881)

Roperia praetesselata n. sp.

Description: Valves circular, surface flat, valve mantle–abrupt. 25-30μ in diameter. Valve surface covered with hexagonal areola-

tions arranged in transverse decussating lines in the middle part of the valve up to about half radius (about 8 areolae in 10 μ), from thence to the margin in radiating fascicles. Areolae decreasing in size gradually near the margin (about 16 areolae in 10 μ). Pseudonodulus absent, one areolae two-thirds between center and margin of the valve situated increased in size. At the corners of the areolae, small dots (characteristic structure of Roperia).

Discussion: This species differs from *Roperia tesselata* and its varieties in the absence of the distinct pseudonodulus and is similar in the type of areolae and areolae orientation. This species is the ancestor of *Roperia tesselata.*

Holotype: Plate 21, Figures 13-14 from DSDP Leg 24, 238-13-3. 75 cm, tropical Indian Ocean. Collection Schrader.

Paratype: Plate 14, Figures 3-4. Collection Schrader.

Roperia tesselata (Roper) Grunow *in* Van Heurck (1881)
(Plate 21, Figures 9-12)

Description: Hustedt, 1930, p. 523-524, fig. 297.

Roperia tesselata var. coscinodiscoides (Mann) Kolbe (1955)

Description: Kolbe, 1955, p. 176-177, pl. 1, fig. 6.

Roperia tesselata var. ovata Mann (1925)

Description: Mann, 1925, p. 143, pl. 31, fig. 3.

Genus ROUXIA Brun and Heribaud (1893)

Rouxia moholensis Schrader (1974)
(Plate 20, Figure 12-15)

Description: Schrader, 1973b, p. 555, pl. 5, fig. 11-12. 11-12.

Rouxia naviculoides Schrader (1973a)

Description: Schrader, 1973a, p. 710, pl. 3, fig. 27-30.

Rouxia californica M. Peragallo *in* Tempère and Peragallo (1910)
(Plate 20, Figure 10)

Description: Hanna, 1930, p. 186-188, pl. 14, fig. 6-7; Schrader, 1973a, p. 710, pl. 3, fig. 18-20, 26

Genus STEPHANOPYXIS Ehrenberg (1844)

Stephanopyxis turris (Grey. and Arn.) Ralfs *in* Pritchard (1861)

Description: Hustedt, 1928, p. 304=307, fig. 140.

Genus SYNEDRA Ehrenberg (1830)

Synedra jouseana Sheshukova-Poretzkaya (1962)

Description: Sheshukova-Poretzkaya, 1967, p. 245; Schrader, 1973a, p. 710, pl. 23, fig. 21-23, 25, 28.

Genus THALASSIONEMA Grunow *in* Van Heurck (1881)

Thalassionema lineatum Jousé (1971)

Description: Jousé, 1971p, 15-16, fig. 3 (in Russian).

Thalassionema nitzschioides Grunow *in* Van Heurck (1881)

Description: Hustedt, 1959, p. 244-246, fig. 725; Hasle and Mendiola, 1967, p. 111, fig. 5, 27-34, 39-44.

Genus THALASSIOSIRA Cleve (1873)

Thalassiosira antarctica Comber (1896)
(Plate 3, Figures 10-11)

Description: Hendey, 1937, p. 237-238; Hustedt, 1958, p. 108-109, pl. 3, fig. 1-3.

Thalassiosira burckliana n. sp.

Synonyms: *Thalassiosira* sp. A. Burckle, 1972, p. 241, pl. 1, fig. 1. *Thalassiosira nativa* Sheshukova-Poretzkaya e.p. in Schrader, 1973a, p. 712, pl. 14, fig. 7

Description: Cells solitary, valves small 9-24 μ in diameter. Valves flat with slightly rounded valve margins. One row of strutted tubuli near the valve margin (compare Plate 1, Figure 23). No labiate process could be observed near the margin with normal light microscopic methods. Numerous very small strutted tubuli are scattered over the center of the valve (5-35), forming a distinct, slightly expressed central region (1-4 μ in diameter). Areolae hexagonal decreasing in size towards the margin (6-8 in 10 μ in the middle of the valve). Areolae arranged in sectors, medium rows parallel to the outer radial rows.

Discussion: This species resembles *Thal. antiqua* (Grun.) Cleve but differs in the irregularly bordered central part with fine strutted tubuli. In *Thal. antiqua*, the central part is clearly defined and exactly bordered by some hexagonal larger aerolae.

Holotype: Plate 1, Figure 22 from DSDP Leg 24, 238-27-2 125 cm, tropical Indian Ocean. Collection Schrader.

Paratype: Plate 1, Figures 21, 23, 24-25, 26. Collection Schrader.

Thalassiosira convexa Muchina (1965)
(Plate 2, Figures 1-5, 10-13)

Description: Donahue, 1970, p. 136-137, pl. 3, fig. a-f; Schrader, 1973a, p. 712, pl. 11, fig. 37-38.

Thalassiosira convexa var. aspinosa n. var.
(Plate 2, Figures 8-9, 13a-21)

Description: This variety differs from the species by the non-spinous margin; other morphological features are identical with *Thal. convexa.* This variety seems to be a link in the evolution of the whole *Thalassiosira convexa* group, starting with *Thalassiosira praeconvexa-Thalassiosira pliocenica-Thalassiosira convexa* var. *aspinosa* and *Thalassiosira convexa.*

Holotype: Plate 2, Figures 13a-15 from DSDP Leg 24, 238-17-3, 75 cm, tropical Indian Ocean. Collection Schrader.

Thalassiosira excentrica (Ehr.) Cleve (1904)
(Plate 11, Figures 7-8, Plate 14, Figures 6-7, 9-10)

Description: Sheshukova-Poretzkaya, 1967, p. 141-142, pl. 14, fig. 4. All individuals with a "*Coscinodiscus excentricus* structure" and with a single strutted tubulus in the center of the valve have been identified as *Thal. excentrica;* others without a central strutted tubulus have been identified as *Cosc. excentricus.*

Thalassiosira gravida Cleve (1896)

Description: Hustedt, 1930, p. 325-326, fig. 161; Sheshukova-Poretzkaya 1967, p. 147-148, pl. 15, fig. 1.

Thalassiosira miocenica n. sp.

Synonym: *Thalassiosira usatchevii* Jousé *in* Burckle 1972, p. 228 (no illustration) ?.

Description: Cells solitary, valves small 16-25 μ in diameter. Valves convex (appr. 7μ in height). One row of spines near the margin. No labiate process could be observed near the margin with normal light microscope methods. Central area flattened with one to three muceous pores (compare Plate 22, Figure 4). Areolae hexagonal forming a complete meshwork over the entire valve, approximately of the same size all over the valve, 7-8 in 10 μ. Areolae arranged in curved rows forming somewhat parallel lines, which are often tangential. Valve margin distinct, approximately 0.5μ wide; hyaline with one row of hexagonal areolae 8 in 10 μ.

Discussion: This species is near to *Thal. praeconvexa* from which it differs by its tangential rows of areolae and the more convex valves, to *Thal. usatchvii* from which it differs by the finer areolation and the smaller margin, to *Thal. convexa* var. *aspinosa* from which it differs in the coarser areolation and the nonradiate rows.

Holotype: Plate 22, Figure 4 from DSDP Leg 22, Site 213-8-3, 50-51 cm, tropical Indian Ocean. Collection Schrader.

Paratype: Plate 22, Figures 1-3, 5, 11-13. Collection Schrader.

Thalassiosira nativa Sheshukova-Poretzkaya (1964)
(Plate 1, Figures 1-2, 12, 17-18)

Description: Sheshukova-Poretzkaya, 1967, p. 145, pl. 14, fig. 7.

Thalassiosira oestrupii (Ostenfeld) Proskina-Lavrenco (1956)
(Plate 1, Figures 3-11, 13-16, 19-20;
Plate 14, Figure 5)

Description: Hustedt, 1930, p. 318, fig. 155 (as *Coscinosira oestrupii*).

Thalassiosira plicata n. sp.

Description: Cells solitary, valves 20-36 μ in diameter, slightly convex with a tangential plication in the center of the valve, one side being convex, the other being concave. One row of strutted tubuli near the well-defined, finely striated valve margin (appr. 1-2 μ broad). One labiate process within this marginal row. In between the center of the valve and the valve margin one concentric row of strutted tubuli, which are easily recognized at specific focus. Areolae hexagonal, decreasing in size gradually from the center to the margin (approximately 10 in 10 μ in the center and approximately in 10 μ near the margin). Areolae arranged in radial fascicles and arranged within each fascicle parallel to the longest radial row. Areolae near the margin also arranged to give the appearance that a secondary series of lines are in weak curves or placed tangentially.

Discussion: No similar *Thalassiosira* species was found in the literature. This species is most characterized by its central plication and the middle row of strutted tubuli.

Holotype: Plate 3, Figures 1-2 from DSDP Leg 24, 238-6-4, 75 cm, tropical Indian Ocean. Collection Schrader.

Paratype: Plate 3, Figures 4-6, 7-9. Collection Schrader.

Thalassiosira symbolophora n. sp.

Description: Cells solitary, valves 26-40μ in diameter, convex with a flat small margin and a flat small central area. One row of strutted labiate process within this row. A second row of labiate processes is located in the middle of the valve between the margin and the center. These processes do possess a labiate interior part (compare Plate 4, Figure 6) and are thus identified as being labiate. Valve margin (appr. 1/2–1 μ broad) hyaline. Areolae hexagonal, decreasing in size gradually towards the margin (appr. 13 in 10 μ in the middle and appr. 17 in 10 μ near the margin). Areolae arranged in the same way as in *Coscinodiscus symbolophorus*: Aerolae in broad radial sectors within which the middle rows are nearly parallel and tangential rows are concave towards the outside.

Discussion: This species is close to *Coscinodiscus stellaris* Roper and *Coscinodiscus symbolophorus* Grunow but differs in the presence of one row of marginal strutted tubuli, one marginal labiate process, and one middle row of labiate processes. No similar species has been found in the literature.

Holotype: Plate 4, Figures 1-2 from DSDP Leg 24, 238-2, CC, tropical Indian Ocean.

Paratype: Plate 4, Figures 4-6, 7-8.

Only those *Thalassiosira* species which could definitively be determined have been treated taxonomically. All the following forms must be studied by transmission and scanning electron-microscope and compared with other *Thalassiosira* species before they can be accurately classified.

Thalassiosira sp.
Thalassiosira sp. I Schrader
Thalassiosira sp. II Schrader
Thalassiosira sp. III Schrader
Thalassiosira sp. 6 Schrader
Thalassiosira sp. 7 Schrader

Genus THALASSIOTHRIX Cleve and Grunow (1880)

Thalassiothrix frauenfeldii (Grun.) Grunow *in* Cleve and Grunow (1880)

Description: Hustedt, 1959, p. 247-248, fig. 727; Hasle and Mendiola, 1967, p. 113-114, fig. 9-10, 21, 38, 47-52.

Thalassiothrix longissima Cleve and Grunow (1880)

Description: Hustedt, 1959, p. 247, fig. 726; Hasle and Mendiola, 1967, p. 114, fig. 35-37, 45, 46, 53.

Thalassiothrix monospina n. sp.

Description: Valves elongated 190μ long and 2-4 μ wide, linear with dissimilar ends, one of them being slightly pointed with a solitary spine which rises on the valve and is slightly bent, and the other one somewhat widened and bluntly rounded. Marginal punctae approximately 10-11 in 10 μ.

Discussion: This species differs from *Thal. longissima* and other allied species in the possession of one solitary spine on one end.

Holotype: Plate 19, Figure 8 from DSDP Leg 24, 238-13-3, 75 cm, equatorial Indian Ocean. Collection Schrader.

Paratype: Plate 19, Figures 9-10. Collection Schrader.

Genus TRICERATIUM Ehrenberg (1839)

Triceratium cinnamomeum Greville (1863)
(Plate 20, Figures 10, 11)

Description: Van Heurck, 1880, pl. 126, fig. 1; Kolbe, 1954, p. 47, pl. 2, fig. 18.

Triceratium cinnamomeum var. minor Grunow *in* Van Heurck (1880)
(Plate 19, Figures 11-13; Plate 20, Figures 5-7)

Description: Kolbe, 1954, p. 47, pl. 2, fig. 20; Grunow *in* Van Heurck, 1880, explanation to pl. 126, fig. 2.

Triceratium cinnamomeum forma quadrangulata Grunow *in* Van Heurck (1880)
(Plate 20, Figure 9)

Description: Grunow *in* Van Heurck, 1880, explanation to pl. 126, fig. 1; Kolbe, 1954, pl. 2, fig. 19.

Triceratium cinnamomeum forma 1

This species differs from other *Triceratium cinnamomeum* species by its broad rounded and protuding edges. Only a few broken specimens were found. Taxonomic position will be clarified at a later date.

Genus TRINACRIA Heiberg (1863)

All species found occur commonly in the Moler Formation of Denmark (lower Eocene) and are reworked into the nondiatomaceous sequences of Site 238 and 236.

Trinacria excavata Heiberg (1863)

Description: Hustedt, 1930, p. 887-888, fig. 532; Benda, 1972, pl. 3, fig. 23-24.

Trinacria regina Heiberg (1863)

Description: Hustedt, 1930, p. 884-885, fig. 528; Benda, 1972, pl. 1, fig. 8.

"EVENTS" FOR ESTABLISHING BIOSTRATIGRAPHIC ZONATION

"Events" as proposed and defined for radiolarians by Riedel and Sanfilippo (1971) have been also used for diatoms. Morphological characters change continuously with time, and a dominant form in an assemblage is accompanied by a few intraspecific variations which resemble its ancestor and its descendant. Morphotypic ranges are long and do overlap one another depending on the sedimentation rate and/or sampling distance.

In Table 5, I have made distinctions between "evolutionary" and "morphotypic" limits of species and have indicated the two samples between which the event

TABLE 5
Diatom Events, Sites 213, 215, 238

	Events		SITE 213		SITE 215		SITE 238	
T	*Nitzschia reinholdii*	m	1-1, 50-51 cm	M	?		1-3, 75 cm 1-4, 65 cm	G
T	*Actinocyclus ellipticus* forma *lanceolata kurslv*	m	3-4, 50-51 cm 3-5, 100-101 cm	G	?		1-6, 75 cm 1, CC	G
T	*Mesocena elliptica*	m	1-2, 100-101 cm 1-3, 50-51 cm	G M	1-1, 50-51 cm	G	2-2, 75 cm 2-3, 75 cm	G
B	*M. elliptica*	m	1-3, 50-51 cm 2-1, 50-51 cm	M	1-4, 50-51 cm 1-5, 50-51 cm	G	3-6, 75 cm 4-1, 75 cm	G
T	*Rhizosolenia praebergonii*	m	2-1, 50-51 cm 2, CC	M	1-4, 50-51 cm 1-5, 50-51 cm	G	4, CC 5-2, 53 cm	M
→	*Pseudoeunotia doliolus* *Nitzschia fossilis*	e	2-1, 50-51 cm 2, CC	M	1-5, 50-51 cm 1, CC	G	5, CC 6-1, 11 cm	G
T	*Thalassiosira convexa*	m	3-3, 50-51 cm 3-4, 50-51 cm	M G	1, CC 2-1, 55-56 cm	G M	7-3, 60 cm 7-4, 70 cm	G
T	*Nitzschia jouseae*	m	4-1, 50-51 cm 4-2, 100-101 cm	M	3-2, 50-51 cm 3-3, 50-51 cm	G	7-5, 40 cm 7-6, 35 cm	G
→	*Rhizosolenia praegergonii* *R. bergonii*	e	2, CC 3-1, 50-51 cm	M	1, CC 2-1, 55-56 cm	G M	5-3, 77 cm 5-4, 90 cm	G
B	*Thalassiosira oestrupii*	m	5-1, 50-51 cm 5-2, 50-51 cm	G M	4-3, 50-55 cm 4-4, 50-55 cm	G	9-1, 30 cm 9, CC	G
T	*T. natira*	m	5-1, 50-51 cm 5-2, 50-51 cm	G M	4-5, 50-51 cm 4-6, 50-51 cm	G	10-2, 66 cm 10-3, 24 cm	G
→	*T. convexa* *T. convexa* var. *aspinosa*	e	5-2, 50-51 cm 5-3, 50-51 cm	M M	3-3, 50-51 cm 3-4, 50-51 cm	G	11-4, 10 cm 11-5, 90 cm	G
B	*Coscinodiscus africanus*	m	?		7-1, 130-131 cm 7-2, 50-51 cm	G	12-1, 75 cm 12-2, 70 cm	G
T	*Nitzschia cylindrica*	m	6-3, 50-51 cm 6-4, 50-51 cm	G	5-1, 50-51 cm 5-2, 100-101 cm	G	12-3, 70 cm 12-4, 70 cm	G
→	*N. jouseae* *N. cylindrica*	e	7-2, 50-51 cm	G	5-3, 50-51 cm 5-4, 50-51 cm	G	13-4, 75 cm 13-5, 130 cm	G
B	*N. jouseae*	m	7-2, 50-51 cm 7-3, 50-51 cm	G	5-3, 50-51 cm 5-4, 50-51 cm	G	15-1, 75 cm 15-2, 30 cm	G
B	*Asteromphalus petersonii*	m	? 5-5, 50-51 cm 5, CC	M	?		15-4, 75 cm 15-5, 100 cm	G
T	*Nitzschia porteri*	m	?		7-1, 130-131 cm 7-2, 50-51 cm	G	17-2, 75 cm 17-3, 75 cm	G
T	*Cussia praepaleacea*	m	?		6-2, 100-101 cm 6-3, 160-161 cm	B G	17-2, 75 cm 17-3, 75 cm	G
B	*Thalassiosira nativa*	m	8-2, 50-51 cm 8-3, 50-51 cm	M	4-5, 50-51 cm 4-6, 50-51 cm	G	17-6, 75 cm 18-2, 75 cm	G M
T	*Nitzschia miocenica*	m	8-2, 50-51 cm 8-3, 50-51 cm	M	6-2, 100-101 cm 6-3, 160-161 cm	B G	17-6, 75 cm 18-2, 75 cm	G M
T	*Thalassiosira miocenica*	m	7-5, 50-51 cm 7, CC	G	6-2, 100-101 cm 6-3, 160-161 cm	B G	17-6, 75 cm 18-2, 75 cm	G M
→	*T. convexa* var. *aspinosa* *T. miocenica*	e	8-2, 50-51 cm 8-3, 50-51 cm	M	?		18-2, 75 cm 18-5, 75 cm	M G
B	*T. miocenica*	m	? not reached		? not reached		19-5, 75 cm 19, CC	M B
B	*T. convexa* var. *aspinosa*	m	? not reached		? not reached		19-5, 75 cm 19, CC	M B
T	*Cussua paleacea*	m	? not reached		? not reached		20, CC 21-2, 100 cm	M G
T	*Actinocyclus moronensis*	m	? not reached		? not reached		20, CC 21-2, 100 cm	M G
B	*Nitzschia miocenica*	m	? not reached		? not reached		23-2, 75 cm 23-5, 75 cm	G B
B	*N. cylindrica*	m	? not reached		? not reached		23, CC 24-2, 70 cm	M B
T	*Coscinodiscus yabei*	m	? not reached		? not reached		27-2, 125 cm 27-5, 75 cm	G M
B	*Nitzschia porteri*	m	? not reached		? not reached		28-5, 75 cm 28, CC	M
→	*Coscinodiscus lineatus* *C. lineatus* var. *ellipticus*	e	? 5, CC 6-1, 50-51 cm	M G	1-3, 50-51 cm 1-4, 50-51 cm	G	4-4, 56 cm 4-5, 97 cm	M
T	*Biddulphia moholensis*	m	3-2, 50-51 cm 3-3, 50-51 cm	M M	3-4, 50-51 cm 3-5, 50-51 cm	G	4-6, 65 cm 4, CC	M
B	*B. moholensis*	m	? not reached		? not reached		17-5, 75 cm 17-6, 75 cm	G
T	*Cussia tatsunokuchiensis*	m	4-2, 100-101 cm 4-3, 50-51 cm	M	?		?	
B	*C. tatsunokuchiensis*	m	? not reached		?		?	
B	*Roperia tesselata*	m	5-5, 50-51 cm 5, CC	M M	4-1, 50-51 cm 4-2, 50-51 cm		11-2, 12 cm 11-3, 57 cm	G
→	*R. tesselata* *R. praetesselata*	e	? 5-2, 50-51 cm 5-4, 50-51 cm	M M	?		11-2, 12 cm 11-5, 90 cm	G
B	*Thalassiosira plicata*	m	7-2, 50-51 cm	G	4-2, 50-51 cm 4-3, 50-51 cm	G	10, CC 11-1, 37 cm	G
B	*T. symbolophora*	m	7, CC 8-1, 50-51 cm	G	7-1, 130-131 cm 7-2, 50-51 cm	G	9-1, 30 cm 9, CC	G

LEGEND: T = top of the range of a species; B = bottom of the range of a species.
m = morphotypic limits of a species; e = evolutionary limits of a species.
G = good preservation; M = moderate preservation.
? = events have not been defined or are uncertain.

occurred, the top and the bottom of the range of a species, and the preservation of the diatom assemblage (M = moderate, G = good). Events which have not been defined and or which are uncertain have been marked with a question mark.

ETHMODISCUS OOZE INTERPRETATION

Ethmodiscus ooze has been found at the following levels:

Site 238	Site 213	Site 215
1-6, 75cm	1-1, 50-51cm	2-1, 55-56cm
2-2, 75cm	1-3, 50-51cm	
3-1, 75cm	2-1, 50-51cm	
4, CC	4-1, 50-51cm	
5-4, 90cm	4-4, 50-51cm	
5, CC		
6-1, 11cm		
7-4, 70cm		
7-5, 40cm		
10-1, 60cm		
10-2, 66cm		
10-6, 50cm		

The *Ethmodiscus* ooze is defined as a diatomaceous sediment of which 80 percent of the diatom individuals and fragments are *Ethmodiscus.* An enrichment of *Liostephania* stages of various diatom species was found to occur within these oozes (Figure 13), whereas in the overlying and underlying sediment samples, only a very few *Liostephania* individuals were found.

The occurrence and accumulation of *Ethmodiscus* in deep-sea sediments has been interpreted to reflect high production of *Ethmodiscus* in the overlying euphotic zone (Wiseman and Hendey, 1953), and represents a biocoenosis characteristic of low dissolved phosphate (Belyaeva, 1970).

Riedel (1954) interpreted the accumulation of *Ethmodiscus rex* as a result of erosion of older fossil material.

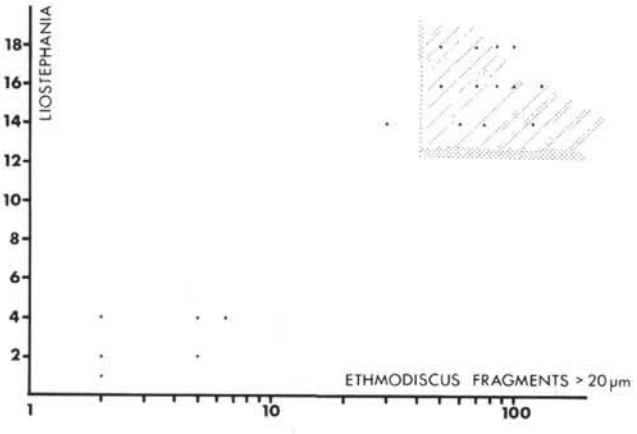


Figure 13. *Plot of number of* Ethmodiscus *fragments coarser 20 µ and number of* Liostephania *individuals. Dotted area characterizes* Ethmodiscus *ooze.*

Belyaeva (1970) found in plankton counts (Juday net, 180µ mesh, 0-100 m water depth) over a traverse in the equatorial Pacific (160° east longitude and 176°, 154°, and 140°), *Ethmodiscus rex* occurring at about 69.6% of all investigated stations. Unfortunately no counts are presented, and the occurrence of a species in a sample does not reflect its abundance. Traverse at 140° east longitude of Belyaeva (1970) corresponds to water sample stations which have been investigated by Hasle (1959). Hasle did not find any *Ethmodiscus* in water samples of 2-250 ml. The phosphate content of surface water ranged from 0.51 µg-atoms P/1 to 0.17 µg-atoms P/1. The surface phosphate content (in µg-atoms P/1) of water overlying DSDP Leg 22 and 24 Sites are (Wyrtke, 1971) as follows:

	Summer May-October	Winter November-April
Site 238	0.2	>0.2
Site 213	0.2	0.2
Site 215	0.2	0.2

The accumulation of *Ethmodiscus* in deep-sea sediments can be controlled by the following parameters: (1) High production of *Ethmodiscus* in the biocoenosis, (2) High settling rates in the water column, (3) Low dissolution rates during settling, and (4) Low dissolution within the sediment and or sediment water interface. These are discussed below.

1) High production of *Ethmodiscus* in the euphotic zone has not been reported by planktologists (Wood, 1967).

2) *Ethmodiscus* ranges in size from 100 to 2000µ. Smayda (1970) shows the sinking rate of *Ethmodiscus rex* (1500-1750µ diameter) to be 465-510 meters per day, and for *Ethmodiscus* fragments to be 28-864 meters per day. Only 5-12 days (Smayda, 1970) would thus be required by an *Ethmodiscus* to reach the depth range reported in the Pacific of areas with high *Ethmodiscus* content in the sediment (4200 m, Wiseman and Hendey, 1953).

3) Dissolution rate of *Ethmodiscus* will be low due to a short exposure period of the frustrule in the water column. The chemical reactive surface of *Ethmodiscus* is about ten times lower than a *Chaetoceros* cell (relatively thick, compact membranes 0.2-0.4µ in diameter). The polysaccharid cell-wall content may also be important to the low dissolution rate during descent (Hecky et al., 1973).

4) A small surface area and coatings of iron, magnesium and calcium alumino-silicates (Hurd, 1972) are responsible for the low dissolution of *Ethmodiscus* opal tests within the sediment-water interface and within the sediment.

The accumulation of *Ethmodiscus* in sediments is caused by the presence of *Ethmodiscus* individuals in the biocoenosis, by the accelerate sinking rate of these frustules through the water column (where other species of the living assemblage are mostly being dissolved [Berger, 1968; Schrader, 1971]), and by the small reactive surface which prevents tests from being dissolved within the sediment.

Liostephania individuals, representing solution stages of diatom frustules, are enriched within the *Ethmodiscus* oozes (Figure 13).

The intermittent occurrence of *Ethmodiscus* ooze within well-diversified siliceous test bearing pelagic sediments at Sites 238, 213, and 215 is related to the sediment

producing biocoenosis: Low phytoplankton production = enrichment of *Ethmodiscus* fragments, high phytoplankton production = well-preserved siliceous assemblage.

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PLATE 1

(Magnification 1500X)

Figures 1, 2 — *Thalassiosira nativa* Sheshukova sensu Burckle; DSDP 238-11-6, 70 cm.

Figures 3-11 — *Thalassiosira oestrupii* (Ostf.) Proskina-Lavrenko
3. DSDP 238-2-2, 75 cm.
4, 5 DSDP 238-2-2, 75 cm.
6-8. DSDP 238-6-4, 75 cm.
9. DSDP 238-7-5, 40 cm.
10. DSDP 238-7-5, 40 cm.
11. DSDP 238-2-2, 75 cm.

Figure 12 — *Thalassiosira nativa* Sheshukova sensu Burckle; DSDP 238-11-4, 10 cm.

Figures 13-16 — *Thalassiosira oestrupii* (Ostf.) Proskina-Lavrenko
13. DSDP 238-3-1, 75 cm.
14. DSDP 238-2-2, 75 cm (girdle).
15, 16. DSDP 238-1-2, 75 cm.

Figures 17, 18 — *Thalassiosira nativa* Sheshukova sensu Burckle; DSDP 238-13-4, 75 cm.

Figures 19, 20 — *Thalassiosira oestrupii* (Ostf.) Proskina-Lavrenko; DSDP 238-7-5, 40 cm.

Figures 21-26 — *Thalassiosira burckliana* n. sp.; DSDP 238-27-2, 125 cm.

PLATE 1

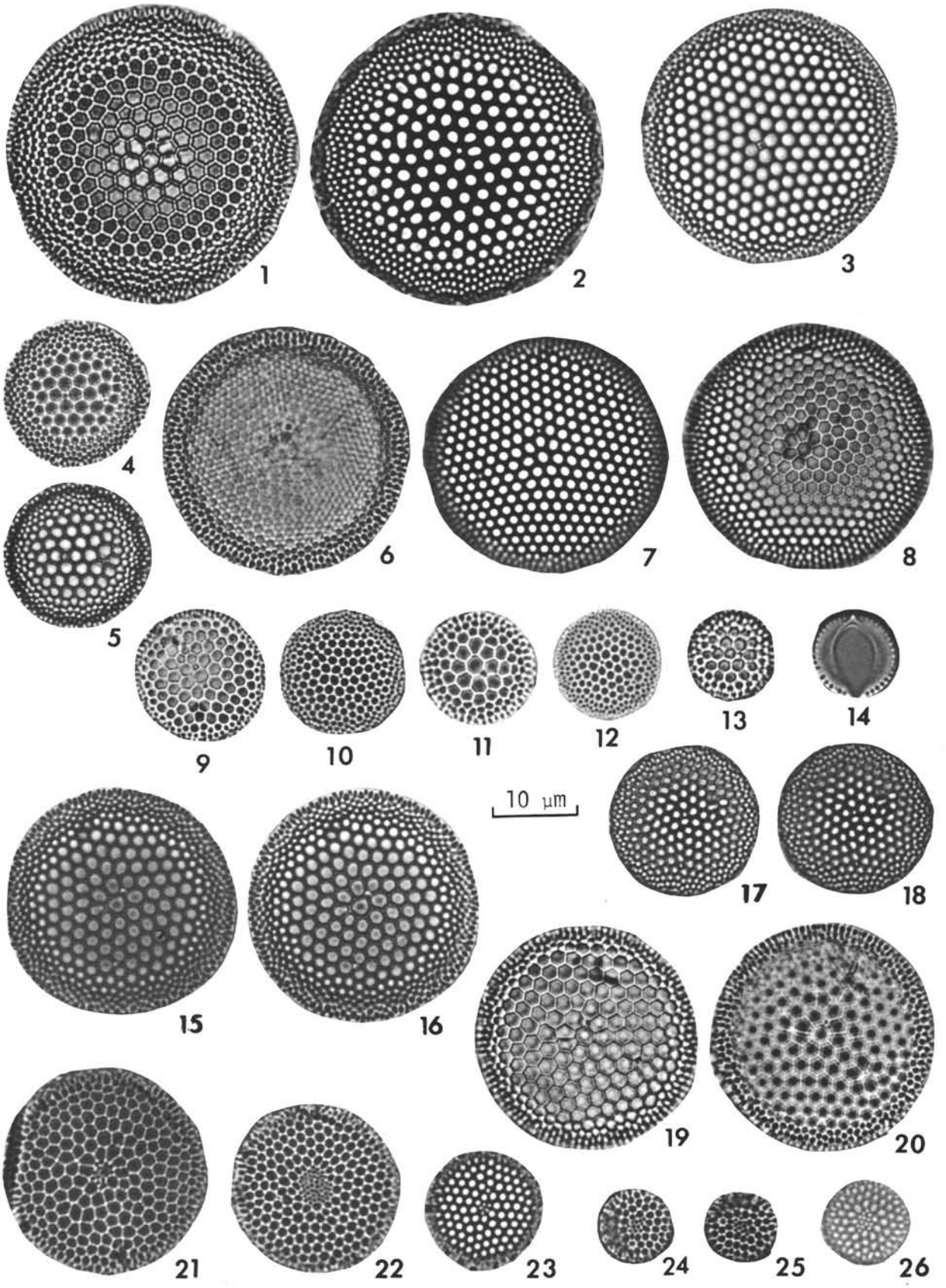

PLATE 2

(Magnification 1500X)

Figures 1-5 *Thalassiosira convexa* Muchina
1-3. DSDP 238-7-4, 70 cm.
4, 5. DSDP 238-7-4, 70 cm.

Figures 6, 7 *Thalassiosira praeconvexa* Burckle; DSDP 238-19-2, 75 cm.

Figures 8, 9 *Thalassiosira convexa* var. *aspinosa* n. var.; DSDP 238-20-2, 100 cm.

Figures 10-13 *Thalassiosira convexa* Muchina; DSDP 238-7-5, 40 cm.

Figures 13a-21 *Thalassiosira convexa* var. *aspinosa* n. var.
13a-15. DSDP 238-17-3, 75 cm (type).
16-18. DSDP 238-17-3, 75 cm.
19-21. DSDP 238-17-3, 75 cm.

PLATE 2

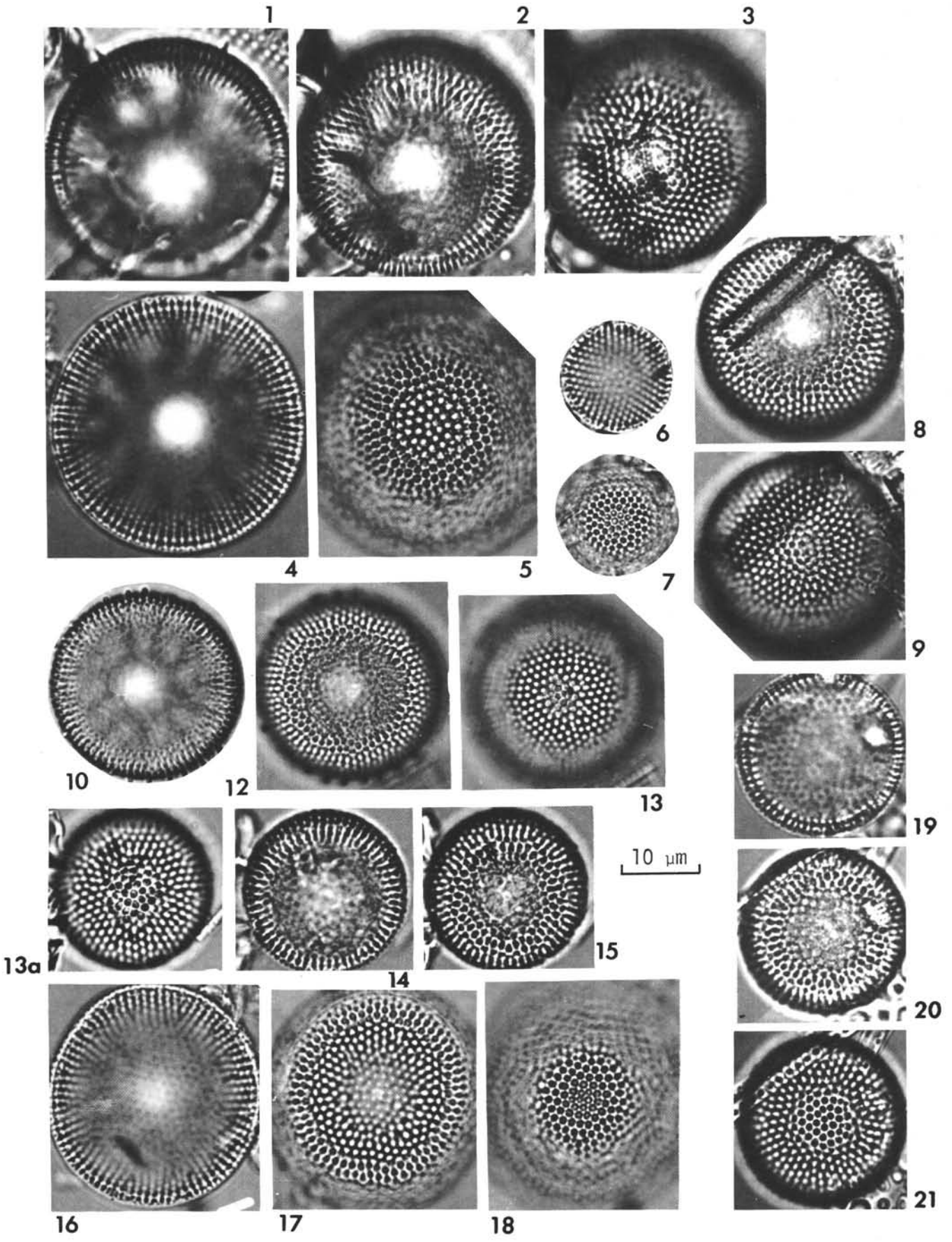

PLATE 3

(Magnification 1500X)

Figures 1, 2 — *Thalassiosira plicata* n. sp. (type); DSDP 238-6-4, 75 cm.

Figure 3 — *Actinocyclus* cf. *curvatulus* Janisch, with plicate central area. DSDP 238-6-3, 75 cm.

Figures 4-6 — *Thalassiosira plicata* n. sp. with slightly plicate central area; DSDP 238-3-2,75 cm.

Figures 7-9 — *Thalassiosira plicata* n. sp. with plicate and hyaline central area; DSDP 238-7-4, 70 cm.

Figures 10, 11 — *Thalassiosira antarctica* Comber; DSDP 238-10-1, 60 cm.

Figures 12, 13 — *Thalassiosira antarctica* Comber; DSDP 238-11-6, 70 cm.

PLATE 3

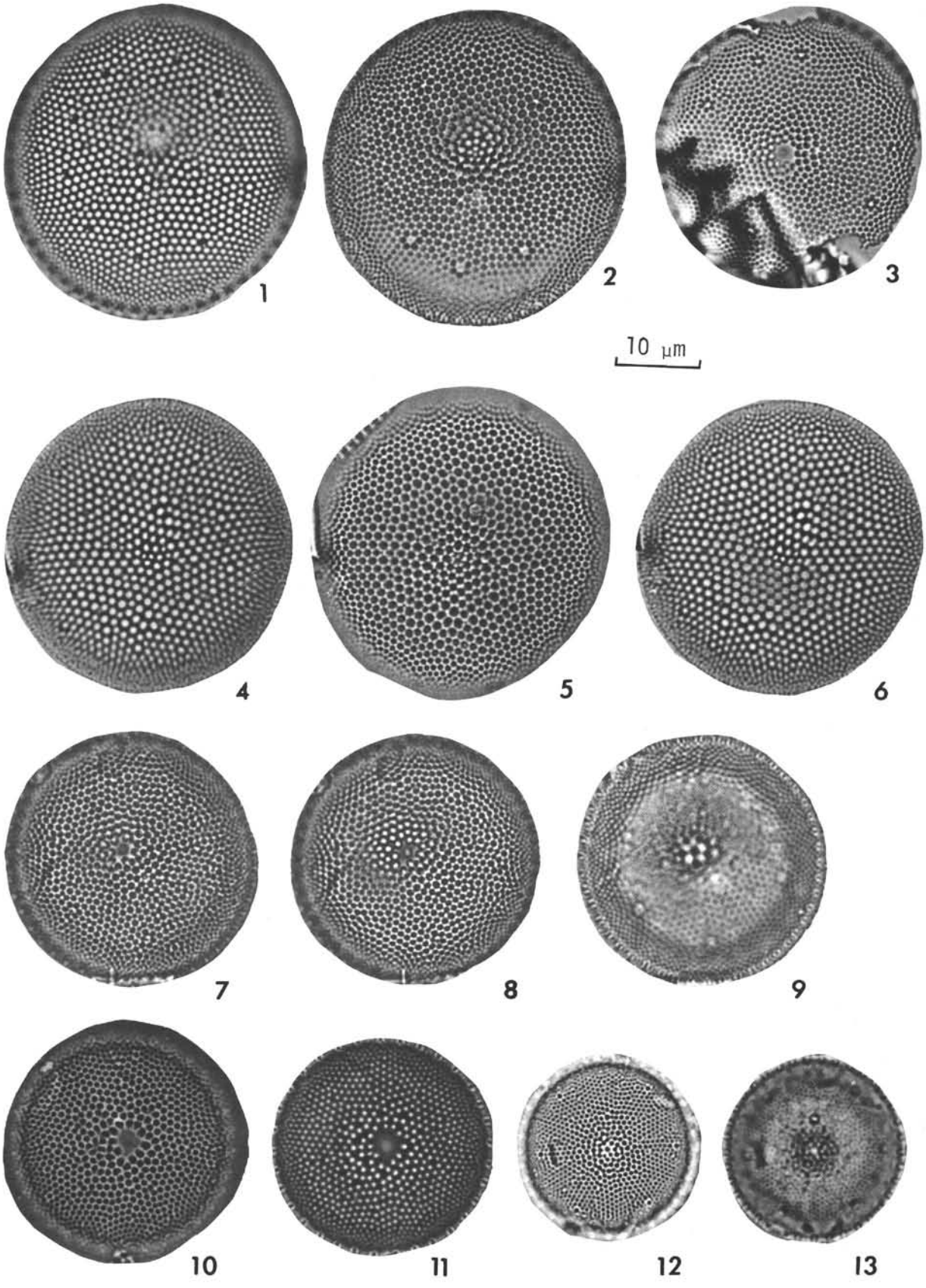

PLATE 4

(Magnification 1500×)

Figures 1-8 *Thalassiosira symbolophora* n. sp.
1-3. DSDP 238-2, CC (type)
4-6. DSDP 238-2, CC.
7, 8. DSDP 238-3-2, 75 cm.

Figures 9, 10 *Thalassiosira* sp. I Schrader; DSDP 238-19-2, 75 cm.

Figures 11-13 *Coscinodiscus* cf. *lineatus* Ehr.; DSDP 238-16-1, 75 cm.

Figures 14-16 *Thalassiosira* sp. II Schrader; DSDP 238-7-5, 40 cm.

Figures 17-19 *Thalassiosira* sp. III Schrader; DSDP 238-15-4, 75 cm.

PLATE 4

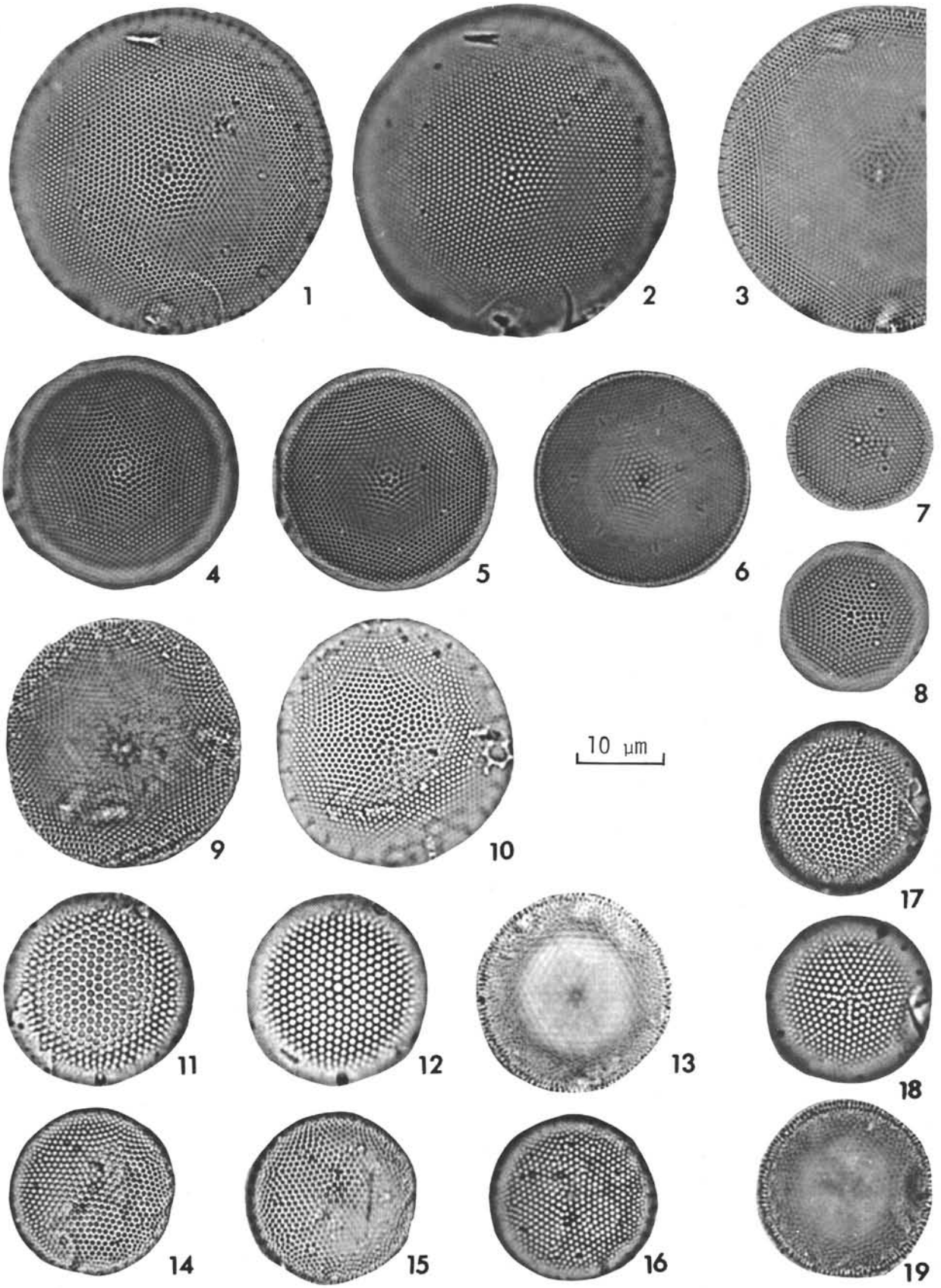

PLATE 5

(Magnification 1500X, unless differently listed)

Figures 1, 2 — *Nitzschia marina* Grunow; DSDP 238-12-2, 70 cm.

Figures 3, 4 — *Nitzschia reinholdii* Kanaya and Koizumi; DSDP 238-2-6, 65 cm.

Figure 5 — *Nitzschia marina* Grunow (600X), DSDP 238-12-2, 70 cm.

Figures 6-9 — *Nitzschia reinholdii* Kanaya and Koizumi
6, 7. DSDP 238-5, CC.
8, 9. DSDP 238-7-4, 70 cm.

Figures 10, 11 — *Nitzschia miocenica* Burckle; DSDP 238-19-2, 75 cm.

Figures 12, 13 — *Nitzschia reinholdii* Kanaya and Koizumi; DSDP 238-14-1, 75 cm.

Figures 14, 15 — *Nitzschia* cf. *marina* Grunow; DSDP 238-17-1, 75 cm.

Figures 16, 17 — *Nitzschia indica* n. sp. (type); DSDP 238-23, CC.

Figures 18, 19 — *Nitzschia reinholdii* Kanaya and Koizumi; DSDP 238-7-5, 40 cm.

PLATE 5

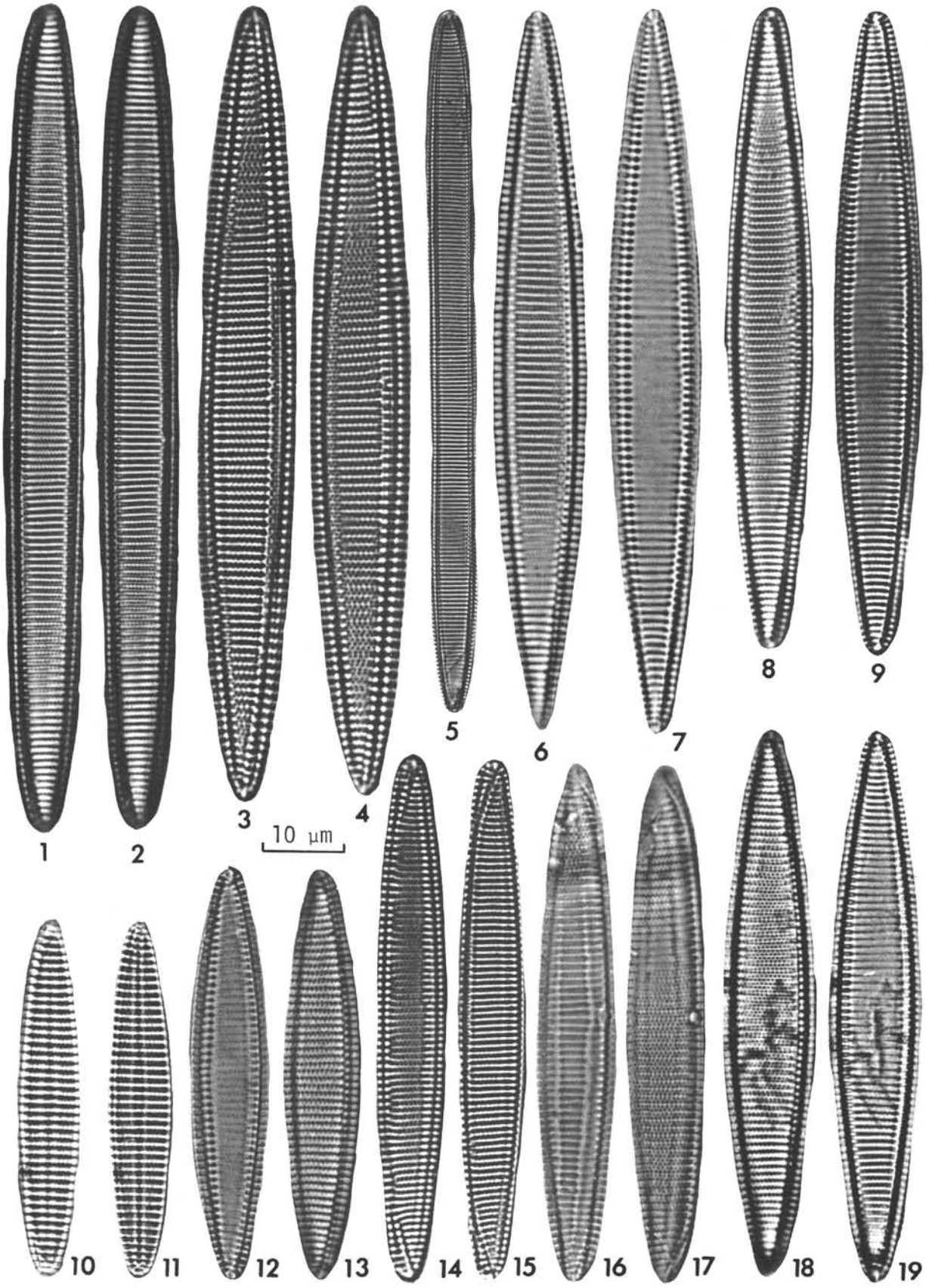

PLATE 6

(Magnification 1500X)

Figures 1-7 *Pseudoeunotia doliolus* Grunow
1. DSDP 238-1, CC.
2, 3. DSDP 238-3-1, 75 cm.
4. DSDP 238-1-2, 75 cm.
5. DSDP 238-6-1, 11 cm.
6, 7. DSDP 238-6-4, 75 cm.

Figures 8-18 *Nitzschia fossilis* (Freng.) emend. Kanaya
8, 9. DSDP 238-6-4, 75 cm.
10, 11. DSDP 238-9-1, 75 cm.
12, 13. DSDP 238-3-2, 75 cm.
14, 15. DSDP 238-10-2, 66 cm.
16-18. DSDP 238-8-2, 32 cm.

Figures 19, 20 *Nitzschia* cf. *fossilis* (Freng.) emend. Kanaya; DSDP 238-7-3, 60 cm.

Figures 21, 22 *Nitzschia fossilis* (Freng.) emend. Kanaya; DSDP 238-3-6, 75 cm.

Figures 23, 24 *Nitzschia* sp. 1 Schrader; DSDP 238-22, CC.

Figure 25 *Nitzschia cylindrica-fossilis* (?) transitional form; DSDP 238-21-2, 100 cm.

Figures 26-34 *Nitzschia cylindrica* Burckle
26. DSDP 238-16-1, 75 cm.
27. DSDP 238-21-2, 100 cm.
28. DSDP 238-16-1, 75 cm.
29, 30. DSDP 238-17-2, 75 cm.
31, 32. DSDP 238-17-2, 75 cm.
33. DSDP 238-17-1, 75 cm.
34. DSDP 238-21-2, 100 cm.

Figure 35 *Nitzschia cylindrica-fossilis* (?) transitional form; DSDP 238-21-2, 100 cm.

Figures 36-38 *Nitzschia cylindrica* Burckle
36, 37. DSDP 238-28-5, 75 cm.
38. DSDP 238-28-5, 75 cm.

PLATE 6

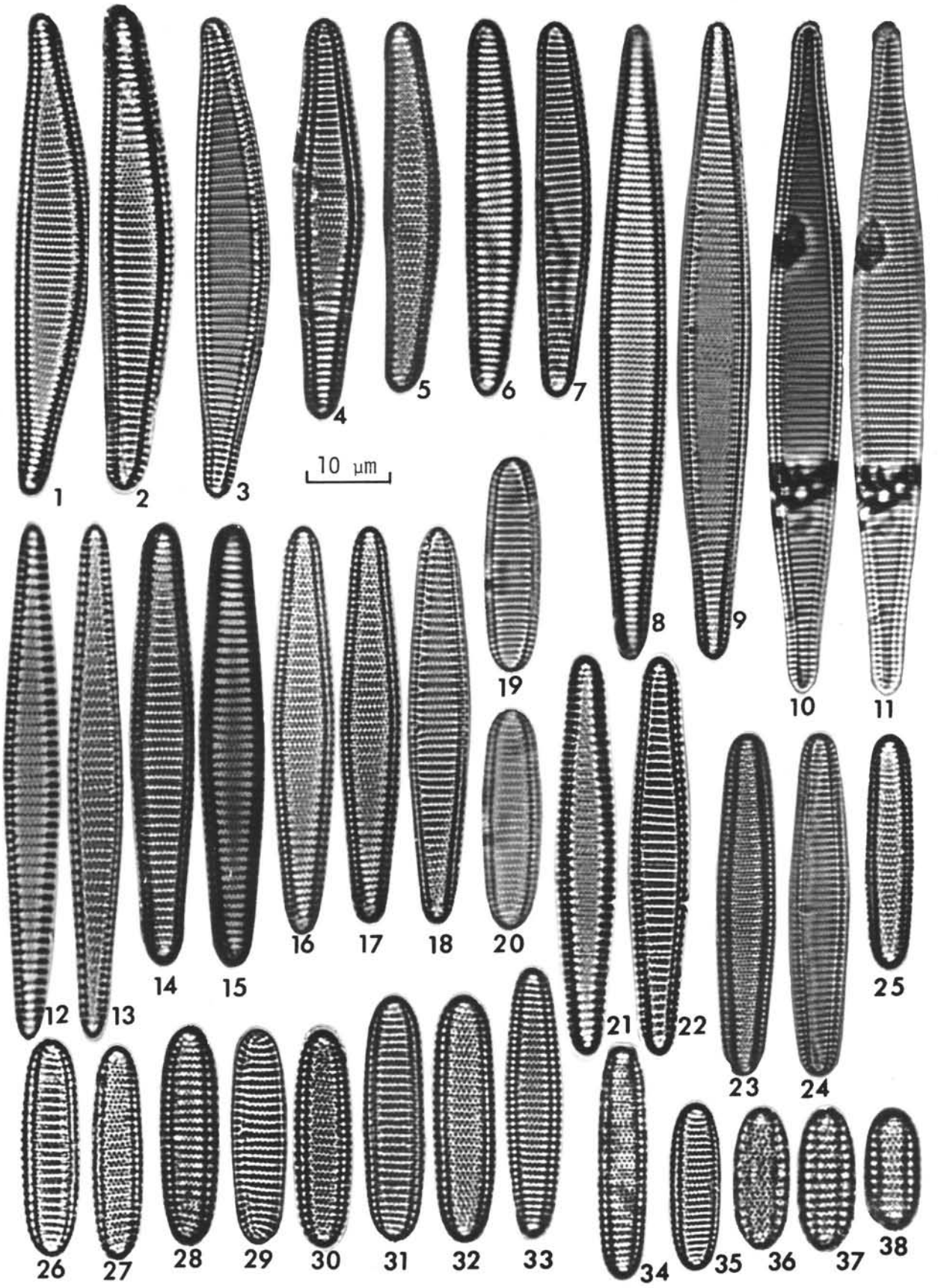
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PLATE 7

(Magnification 1500X)

Figures 1-7 *Nitzschia marina-miocenica* Group, transitional forms.
1, 2. DSDP 238-23, CC
3, 4. DSDP 238-22, CC.
5-7. DSDP 238-22, CC.

Figures 8, 9 *Nitzschia* cf. *marina* Grunow; DSDP 238-19-2, 75 cm.

Figures 10, 11 *Nitzschia reinholdii* Kanaya and Koizumi; DSDP 238-12-1, 75 cm.

Figures 12, 13 *Nitzschia* sp. 2 Schrader; DSDP 238-22-5, 75 cm.

Figures 14-23 *Nitzschia jouseae* Burckle
14, 15. DSDP 238-4, CC.
16. DSDP 238-12-2, 75 cm.
17, 18. DSDP 238-10, CC.
19. DSDP 238-12-1, 75 cm.
20. DSDP 238-13-3, 75 cm.
21. DSDP 238-17-3, 75 cm.
22, 23. DSDP 238-15-5, 100 cm.

Figures 24-26 *Nitzschia praereinholdii* Schrader
24. DSDP 238-11-1, 37 cm.
25, 26. DSDP 238-11, CC.

Figures 27, 28 *Nitzschia praereinholdii-fossilis* Group; DSDP 238-7-2, 75 cm.

Figures 29, 30 *Nitzschia praereinholdii-jouseae* Group; DSDP 238-11, CC.

PLATE 7

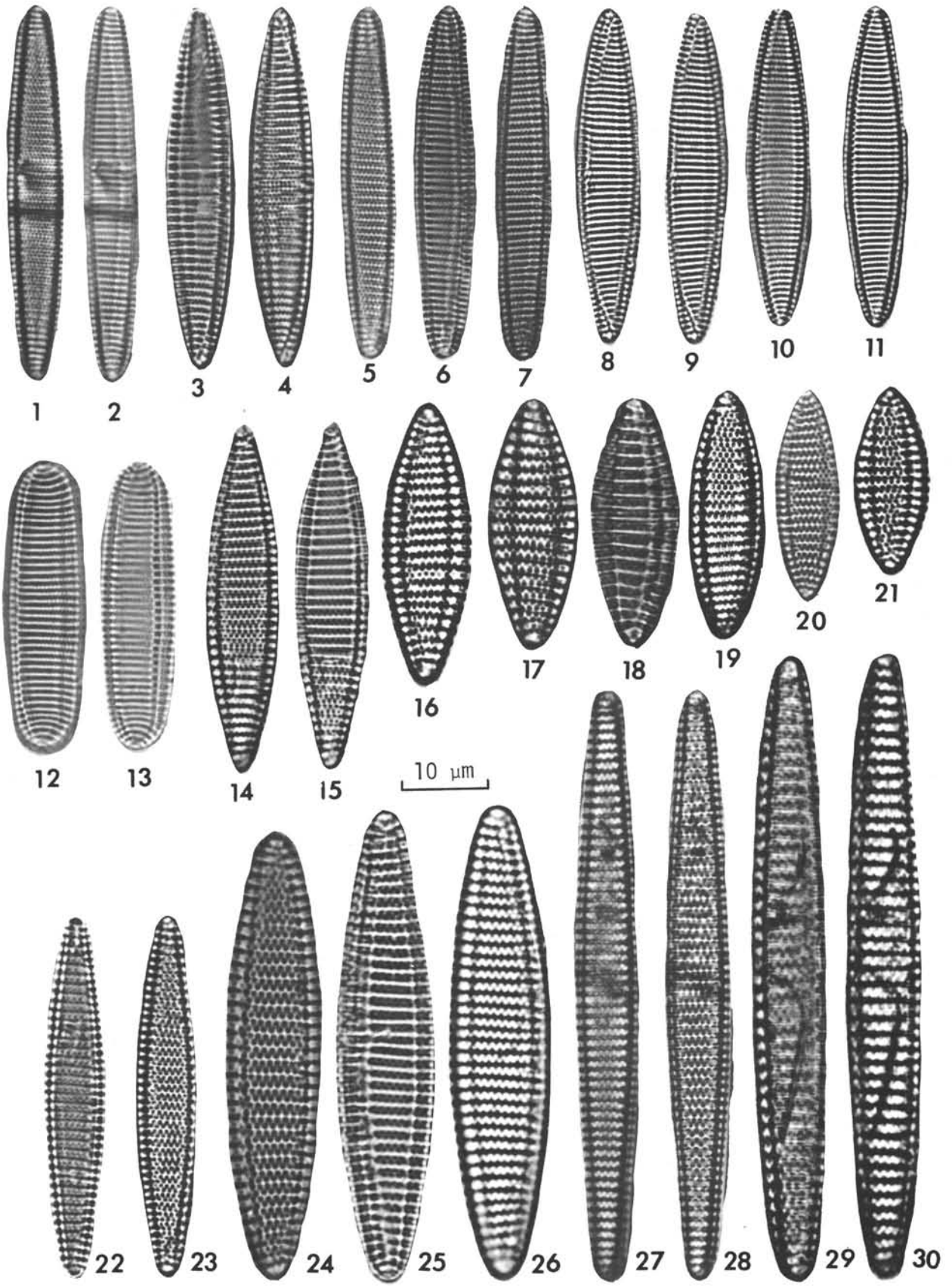
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PLATE 8

(Magnification 1500X)

Figure 1 — *Asteromphalus heptactis* (Breb.) Ralfs; DSDP 238-11-5, 90 cm.

Figure 2 — *Asterolampra marylandica* Ehr.; DSDP 238-7-2, 75 cm.

Figure 3 — *Asteromphalus flabellatus* (Breb.) Greville; DSDP 238-3-2, 75 cm.

Figure 4 — *Asteromphalus elegans* Greville; DSDP 238-1-5, 65 cm.

Figure 5 — *Asterolampra grevillei* (Wall.) Greville; DSDP 238-11-5, 90 cm.

Figure 6 — *Asteromphalus robustus* Castracane; DSDP 238-2-6, 65 cm.

Figure 7 — *Asteromphalus hookerii* Ehr. (?); DSDP 238-3-6, 75 cm.

PLATE 8

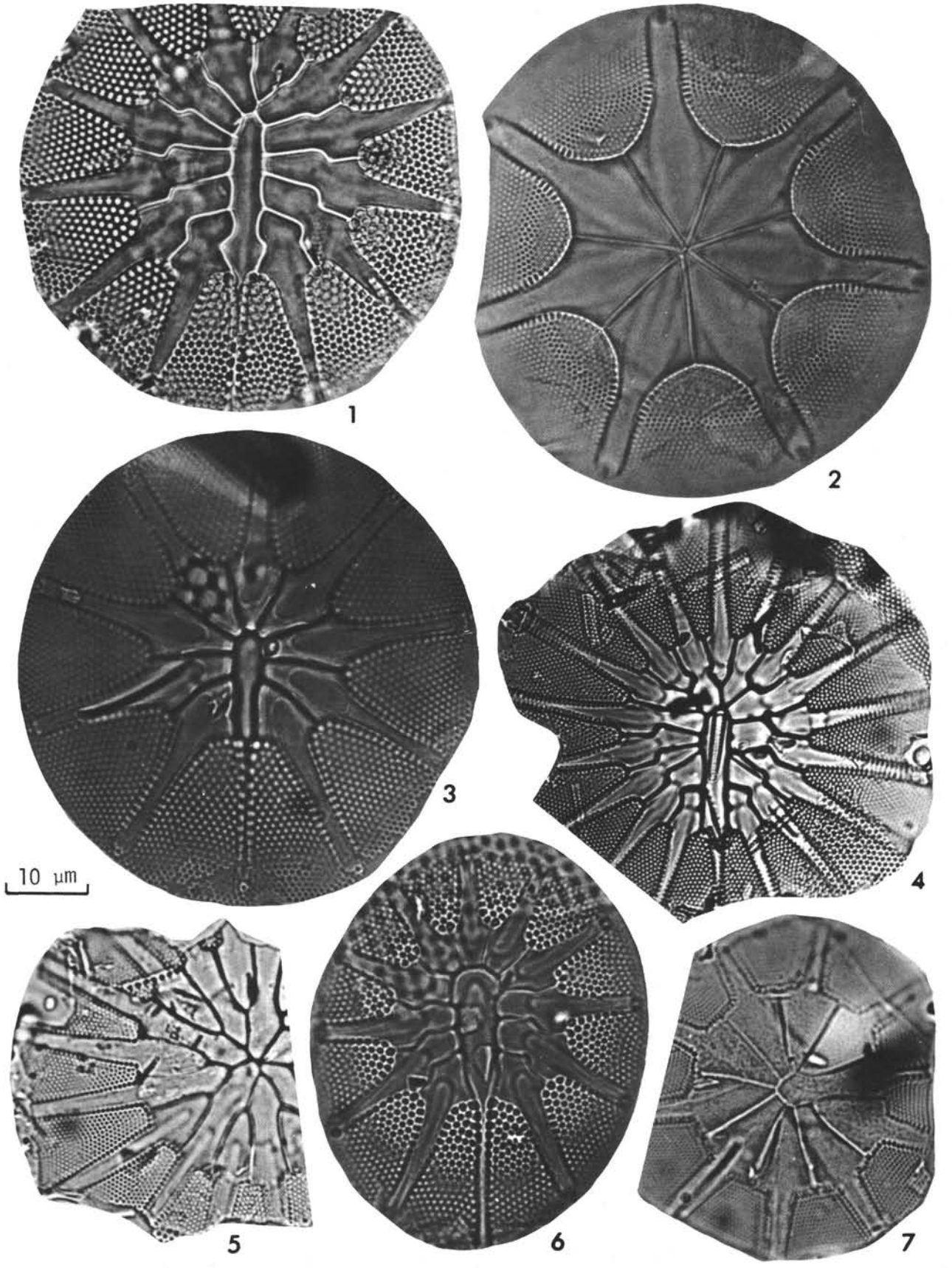

PLATE 9

(Magnification 1500X)

Figures 1-3 *Rhizosolenia praebergonii* Muchina
1. DSDP 238-7-4, 70 cm.
2. DSDP 238-7-4, 70 cm.
3. DSDP 238-7-4, 70 cm.

Figure 4 *Rhizosolenia bergonii* Peragallo; DSDP 238-1-5, 65 cm.

Figure 5 *Rhizosolenia hebetata* forma *hiemalis* Gran; DSDP 238-17-5, 75 cm.

Figure 6 *Rhizosolenia firma* Karsten; DSDP 238-1, CC.

Figures 7, 8 *Asterolampra acutiloba* Frenguelli; DSDP 238-19-2, 75 cm.

Figure 9 *Asteromphalus heptactis* (Breb.) Ralfs; DSDP 238-17-1, 75 cm.

Figure 10 *Asterolampra affinis* Greville; DSDP 238-12-2, 70 cm.

Figure 11 *Asteromphalus arachne* (Breb.) Ralfs; DSDP 238-5-4, 90 cm.

Figures 12, 13 *Asteromphalus* sp. 1 Schrader; DSDP 238-7-5, 40 cm.

PLATE 9

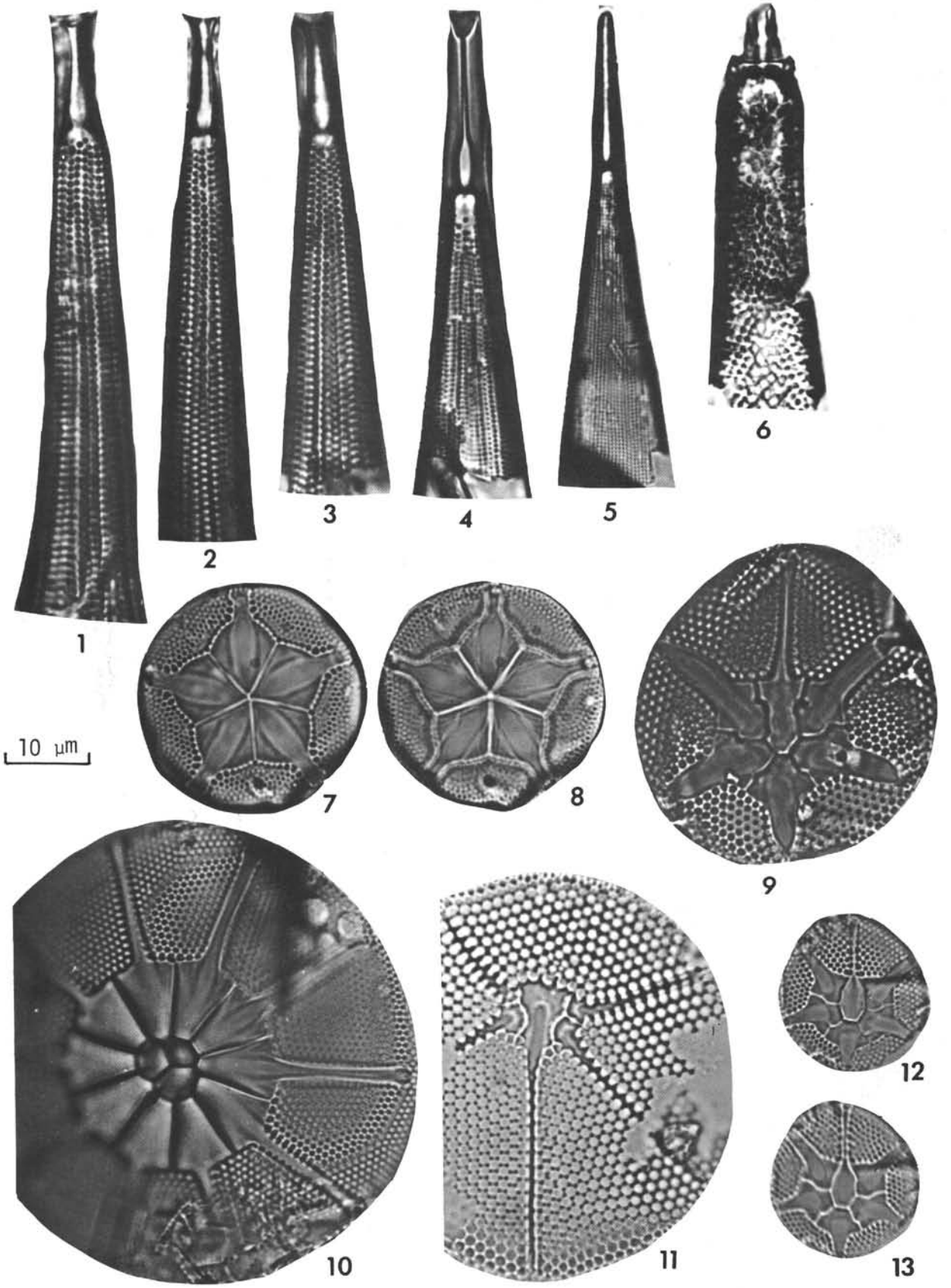

PLATE 10

(Magnification 1500X)

Figures 1-4 *Thalassiosira* sp. 7 Schrader (*Thalassiosira lineata* jouse)
1, 2. DSDP 238-3-2, 75 cm (type).
3, 4. DSDP 238-7-2, 75 cm.

Figures 5-8 *Coscinodiscus lineatus* Ehr. var. *ellipticus* Kolbe
5, 6. DSDP 238-2, CC.
7, 8. DSDP 238-3-6, 75 cm.

Figure 9 *Thalassiosira* sp. Schrader; DSDP 238-1-4, 65 cm.

Figures 10-11 *Thalassiosira* sp. 6 Schrader; DSDP 238-1-4, 65 cm.

PLATE 10

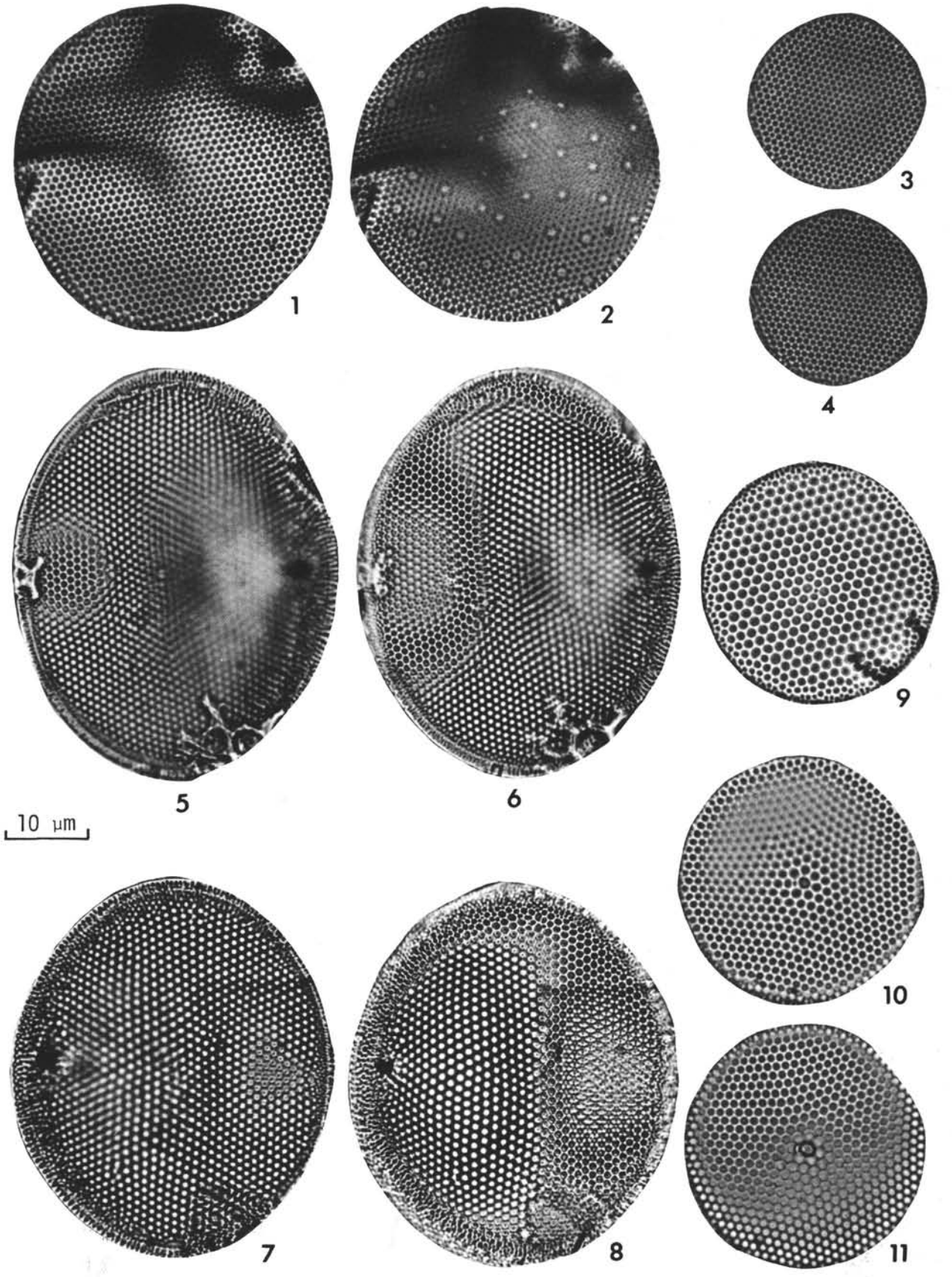

PLATE 11

(Magnification 1500X)

Figures 1, 2 — *Actinocyclus curvatulus* Janisch
1. DSDP 238-11-4, 10 cm.
2. DSDP 238-13-3, 75 cm.

Figures 3, 4 — *Coscinodiscus* cf. *lineatus* Ehr.; DSDP 238-7-5, 40 cm.

Figure 5 — *Coscinodiscus excentricus* Ehr.; DSDP 238-11-4, 10 cm.

Figure 6 — *Coscinodiscus lineatus* Ehr.; DSDP 238-4, CC.

Figures 7, 8 — *Thalassiosira excentrica* (Ehr.) Cleve; DSDP 238-2, CC.

Figures 9-11 — *Coscinodiscus excentricus* Ehr.; DSDP 238-5, CC.

PLATE 11

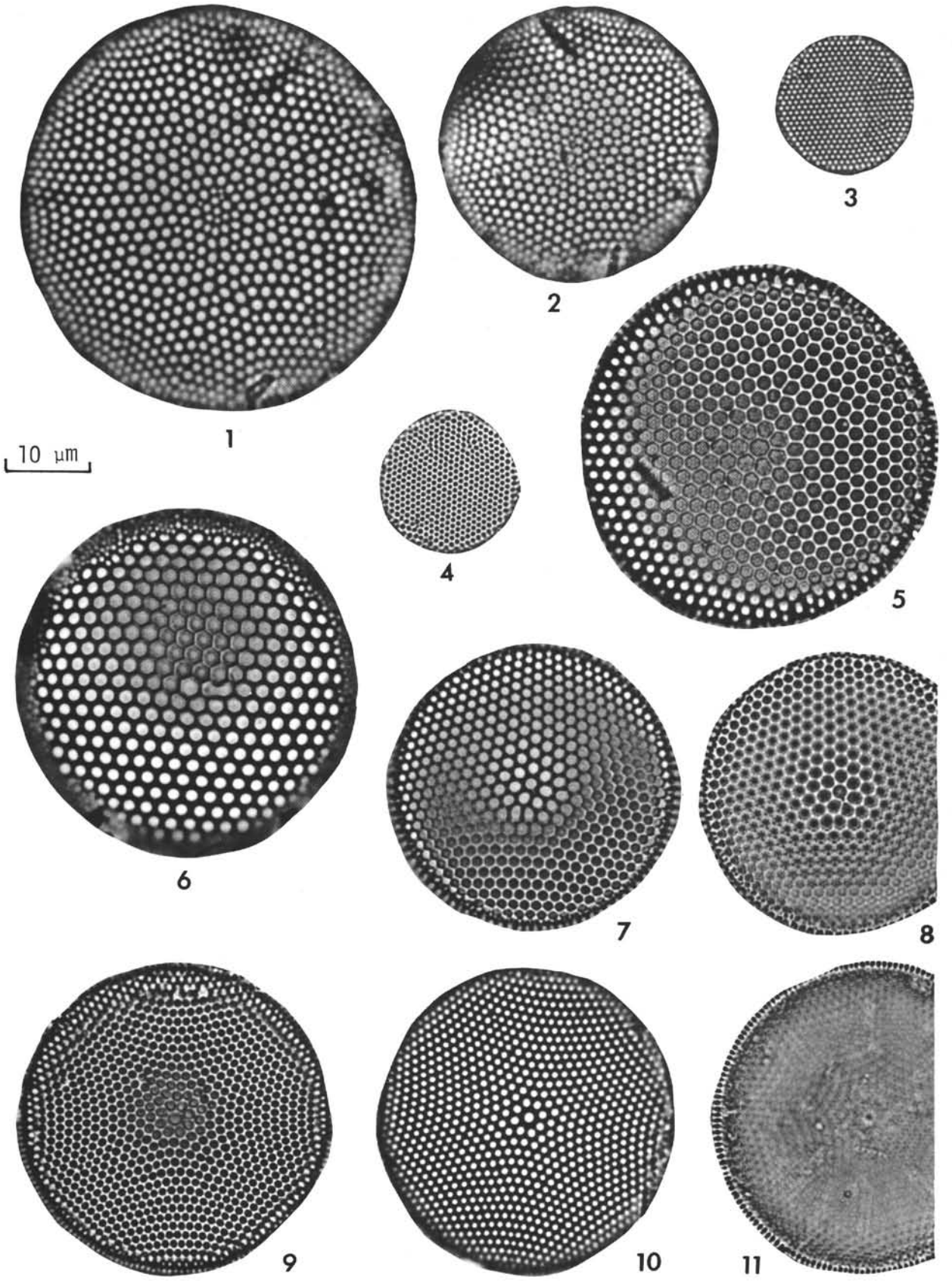

PLATE 12

Preservation of diatom valves in various *Ethmodiscus rex* oozes.
(Magnification 1500X)

Figures 1-9 *Coscinodiscus tabularis* GRUNOW var. *egregius* (Rattray) Hustedt
1. Well-preserved DSDP 238-2, CC.
2. Moderately well preserved DSDP 238-5, CC.
3. Moderately preserved DSDP 238-11-6, 70 cm.
4. Badly corroded DSDP 238-2-2, 75 cm.
5. Badly corroded DSDP 238-7-5, 40 cm.
6. Badly corroded DSDP 238-2-2, 75 cm.
7. Moderately preserved DSDP 238-3-6, 75 cm.
8. Moderately well preserved DSDP 238-3-6, 75 cm.
9. Well-preserved DSDP 238-1, CC.

Figures 10-13 *Asteromphalus peterssonii* (Kolbe) n. comb.
10. Well-preserved DSDP 238-1-2, 75 cm.
11. Moderately well preserved DSDP 238-1, CC.
12. Moderately preserved DSDP 238-2-2,75 cm.
13. Badly corroded DSDP 238-3-1, 75 cm (*Liostephania*-stage).

Figures 14, 15 *Asteromphalus* sp. 1 Schrader
14. Well-preserved DSDP 238-3-1, 75 cm.
15. Badly corroded DSDP 238-7-5, 40 cm (*Liostephania*-stage).

Figures 16-19 *Asteromphalus* various species
16. Moderately preserved DSDP 238-6-4, 75 cm (*Liostephania*-stage).
17. Badly corroded DSDP 238-5-4, 90 cm (*Liostephania*-stage).
18. Badly corroded DSDP 238-5, CC (*Liostephania*-stage).
19. Badly corroded DSDP 238-10-2, 66 cm (*Liostephania*-stage).

Figures 20, 21 *Thalassionema nitzschioides* Grunow
20. Moderately well preserved DSDP 238-4-1, 75 cm.
21. Badly corroded DSDP 238-2-2, 75 cm.

Figures 22, 23 *Asterolampra*
22. Badly corroded DSDP 238-10-1, 60 cm (*Liostephania*-stage).
23. Badly corroded DSDP 238-10-6, 50 cm (*Liostephania* -stage).

Figure 24 *Asteromphalus* sp. Badly corroded DSDP 238-5-4, 60 cm (*Liostephania*-stage).

PLATE 12

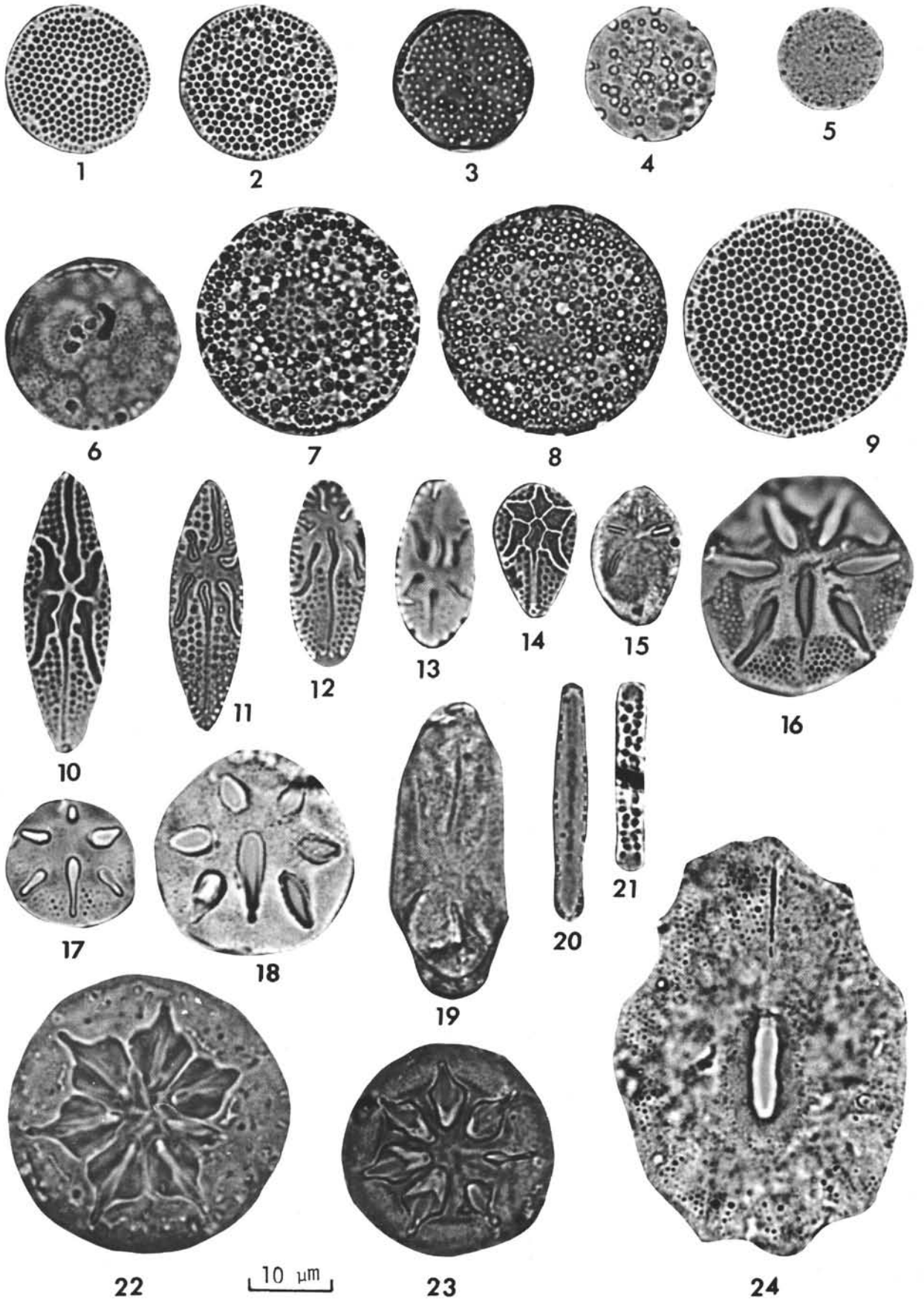

PLATE 13

(Magnification 1500×)

Chert formation (?), piece of about 1 mm diameter flat chert from DSDP 238-4, CC showing preservation and mobilization of opaline silica. Upper part with well-preserved (partly broken: *Ethmodiscus rex, Nitzschia reinholdii, Thalassionema nitzschioides,* radiolarians and sponge spicules); middle part with compacted frustules (mostly broken: *Thalassionema nitzschioides, Thalassiothrix longissima*); lower part with few recognizable diatom fragments. Balsam mount; plain transmitted light.

PLATE 13

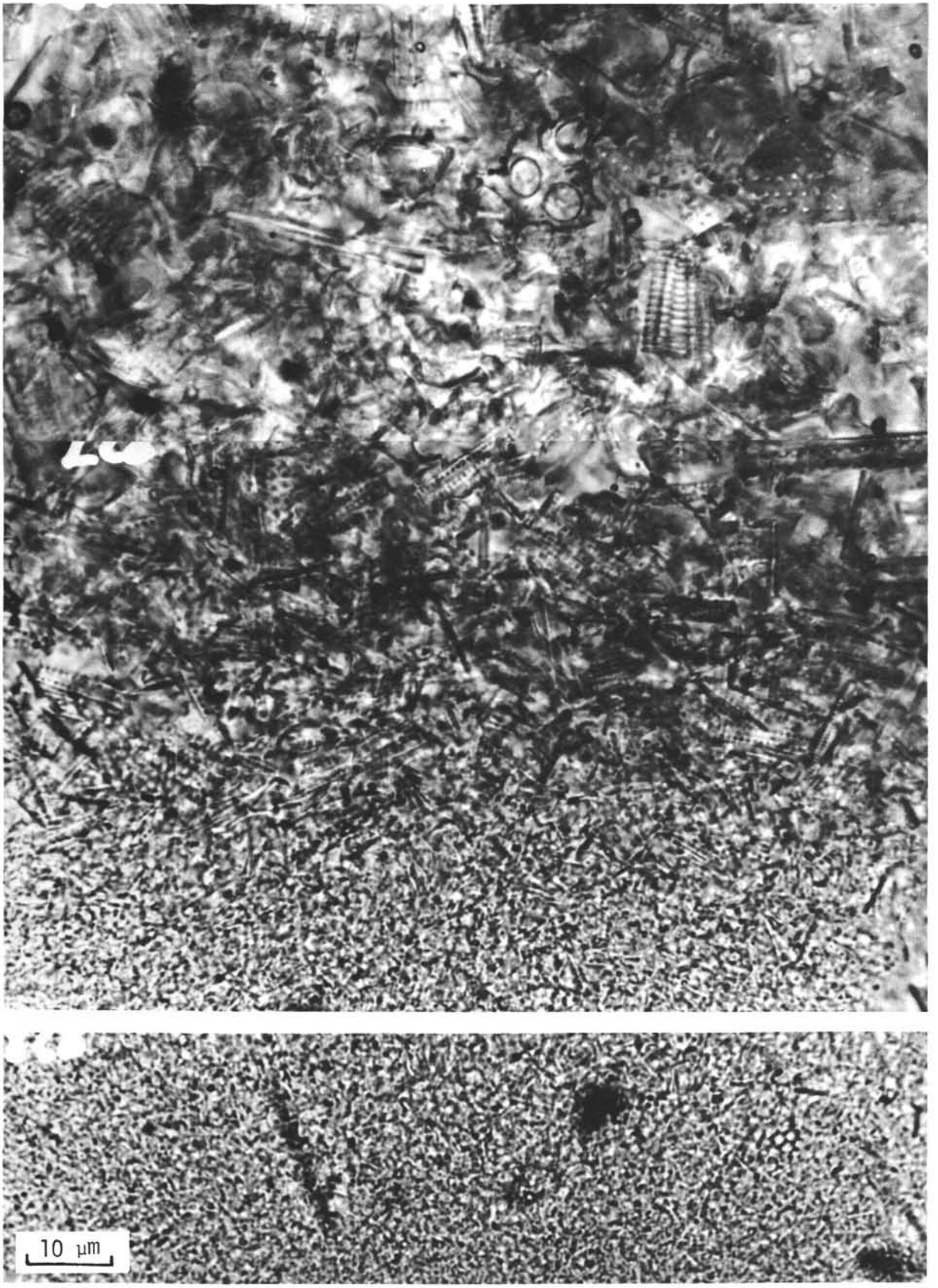

PLATE 14

(Magnification 1500X)

Figures 1, 2	*Coscinodiscus excentricus* Ehr.; DSDP 238-7-5, 40 cm.
Figures 3, 4	*Roperia praetesselata* n. sp.; DSDP 238-12-1, 75 cm.
Figure 5	*Thalassiosira oestrupii* (Ostenf.) Proskina-Lavrenko; DSDP 238-11-2, 12 cm.
Figures 6, 7	*Thalassiosira* cf. *excentrica* (Ehr.) Cleve; DSDP 238-12, CC.
Figure 8	*Coscinodiscus excentricus* Ehr.; DSDP 238-1, CC (no central strutted tubulus).
Figures 9, 10	*Thalassiosira excentrica* (Ehr.) Cleve; DSDP 238-7-5, 40 cm (central strutted tubulus present).

PLATE 14

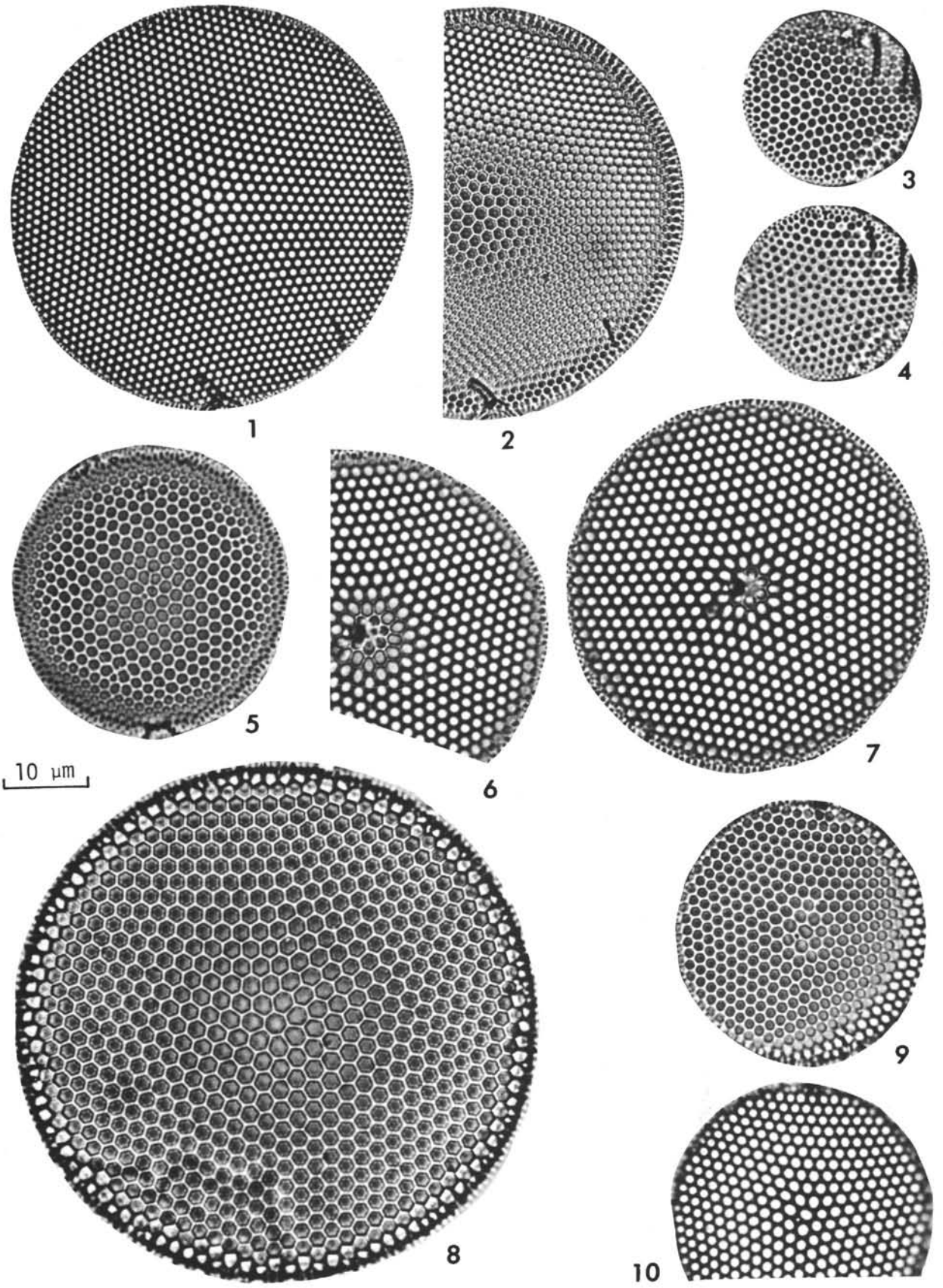

PLATE 15,
(Magnification 1500×)

Figures 1-7 *Nitzschia interrupta* Heiden
1,2. DSDP 238-5, CC.
3,4. DSDP 238-12, CC.
5-7. DSDP 238-7-5, 40 cm.

Figures 8, 9 *Nitzschia* cf. *interrupta* Heiden; DSDP 238-24, CC.

Figures 10, 11 *Nitzschia interrupta* Heiden; DSDP 238-11, CC.

Figures 12, 13 *Nitzschia* sp. 4 Schrader; DSDP 238-15-4, 75 cm.

Figure 14 *Nitzschia porteri* Frenguelli; DSDP 238-22-5, 75 cm.

Figure 15 *Nitzschia* sp. 13 Schrader; DSDP 238-13-3, 75 cm.

Figures 16-20 *Nitzschia* sp. 8 Schrader
16, 17. DSDP 238-16-1, 75 cm.
18-20. DSDP 238-14-5, 75 cm.

Figures 21, 22 *Coscinodiscus plicatus* Grunow; DSDP 238-17-2, 75 cm.

Figures 23, 24 *Coscinodiscus plicatus* Group 1; DSDP 238-10-1, 60 cm.

Figures 25, 26 *Coscinodiscus plicatus* Grunow
25. DSDP 238-15-5, 75 cm.
26. DSDP 238-15-5, 100 cm.

Figures 27, 28 *Coscinodiscus plicatus* Group 2; DSDP 238-17-2, 75 cm.

Figures 29-32 *Coscinodiscus plicatus* Group 3
29, 30. DSDP 238-15-1, 75 cm.
31, 32. DSDP 238-11-6, 70 cm.

PLATE 15

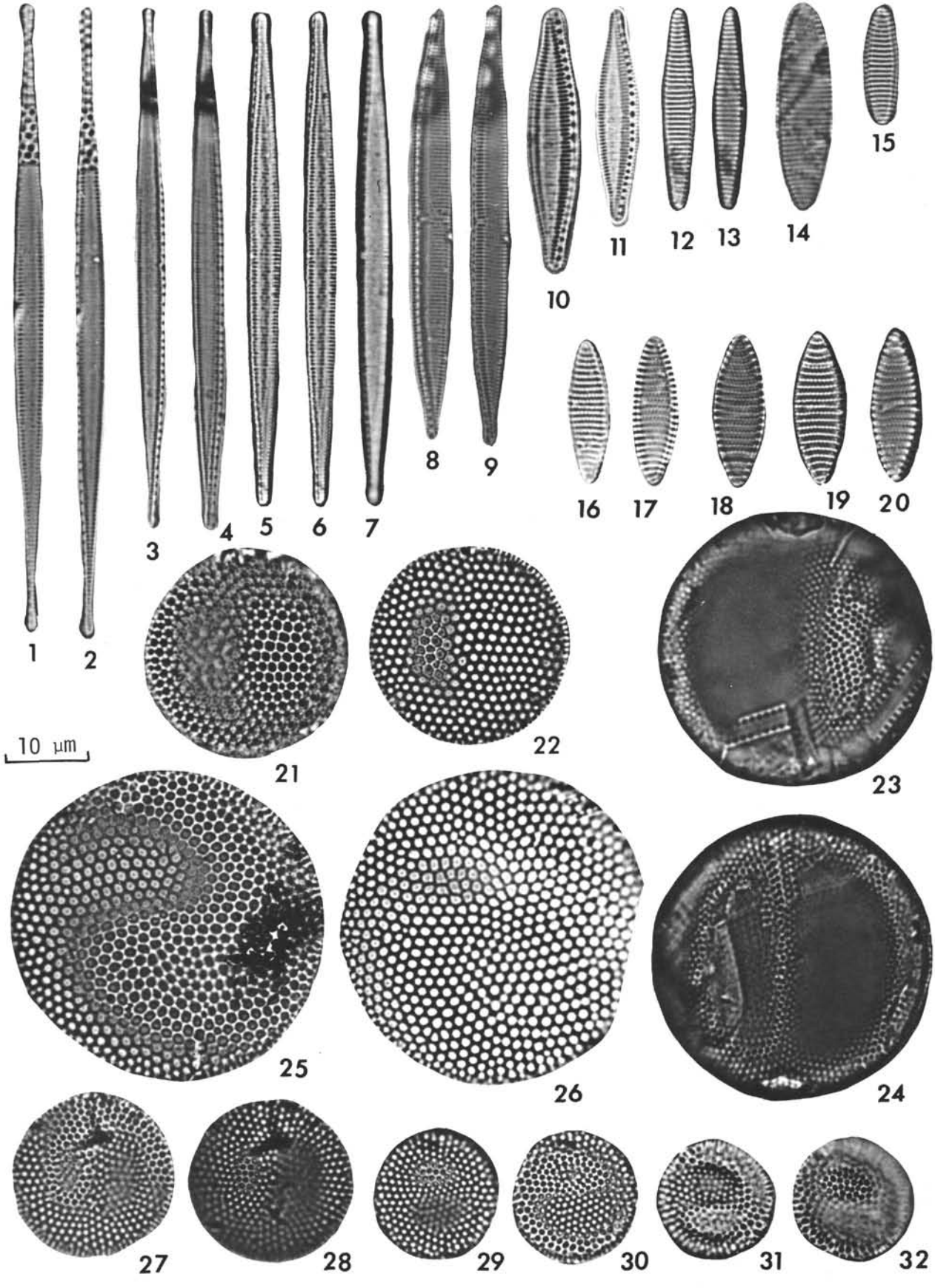
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PLATE 16

(Magnification 1500X)

Figures 1-4 *Coscinodiscus plicatus* Group 4
1,2. DSDP 238-3-1, 75 cm.
3, 4. DSDP 238-15-5, 100 cm.

Figures 5, 6 *Coscinodiscus plicatus* Group 5; DSDP 238-5, CC.

Figures 7, 8 *Coscinodiscus plicatus* Group 6; DSDP 238-3-1, 75 cm.

Figures 9-15 *Coscinodiscus plicatus* Grunow
9, 10. DSDP 238-17-5, 75 cm.
11, 12. DSDP 238-27-2, 125 cm.
13-15. DSDP 238-12-4, 70 cm.

PLATE 16

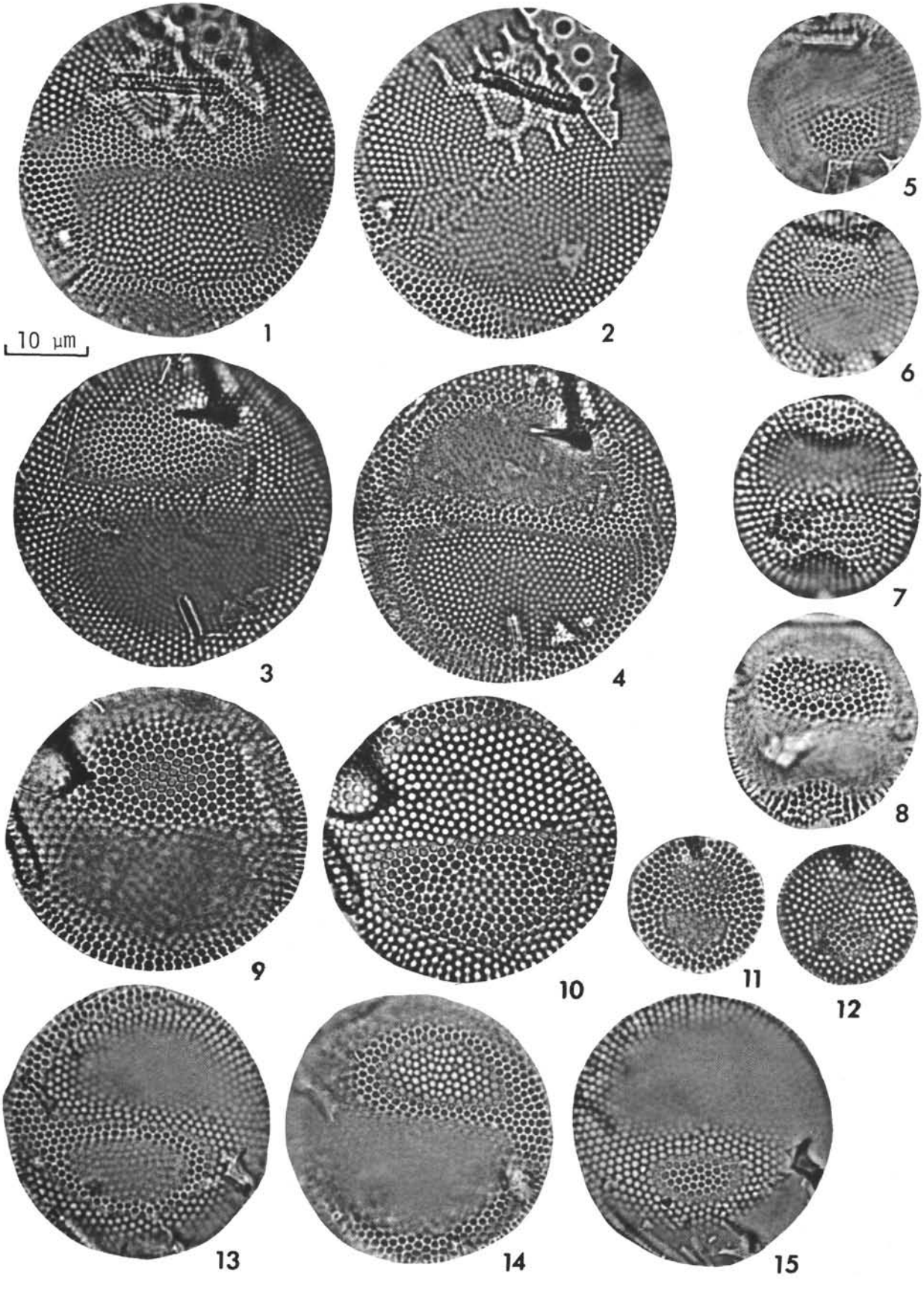

PLATE 17

(Magnification 1500X, unless differently listed)

Figure 1 — *Astinocyclus ellipticus* Grunow var. *elongatus* (Grun.) Kolbe; DSDP 238-3-2, 75 cm.

Figure 2 — *Actinocyclus ellipticus* Grunow forma *lanceolata* Kolbe; DSDP 238-21-2, 100 cm.

Figure 3 — *Actinocyclus ellipticus* Grunow var. *elongatus* (Grun.) Kolbe; DSDP 238-14-1, 75 cm; magnification 600X.

Figure 4 — *Actinocyclus ellipticus* Grunow; DSDP 238-1, CC.

Figure 5 — *Actinocyclus ellipticus* Grunow; DSDP 238-28-5, 75 cm.

Figures 6-8 — *Actinocyclus ellipticus* Grunow forma
6. DSDP 238-11-6, 70 cm.
7. DSDP 238-17-3, 75 cm.
8. DSDP 238-5, CC.

Figures 9-12 — *Actinocyclus moronensis* Deby
9. DSDP 238-11-6, 70 cm.
10. DSDP 238-3-6, 75 cm.
11. DSDP 238-3-1, 75 cm.
12. DSDP 238-16-5, 10 cm.

Figure 13 — *Actinocyclus ellipticus* Grunow var. *javanicus* Reinhold; DSDP 238-23, CC.

Figures 14, 15 — *Actinocyclus ellipticus* spec. 1 Schrader; DSDP 238-23, CC.

Figure 16 — *Actinocyclus ellipticus* Grunow; DSDP 238-27-2, 125 cm.

PLATE 17

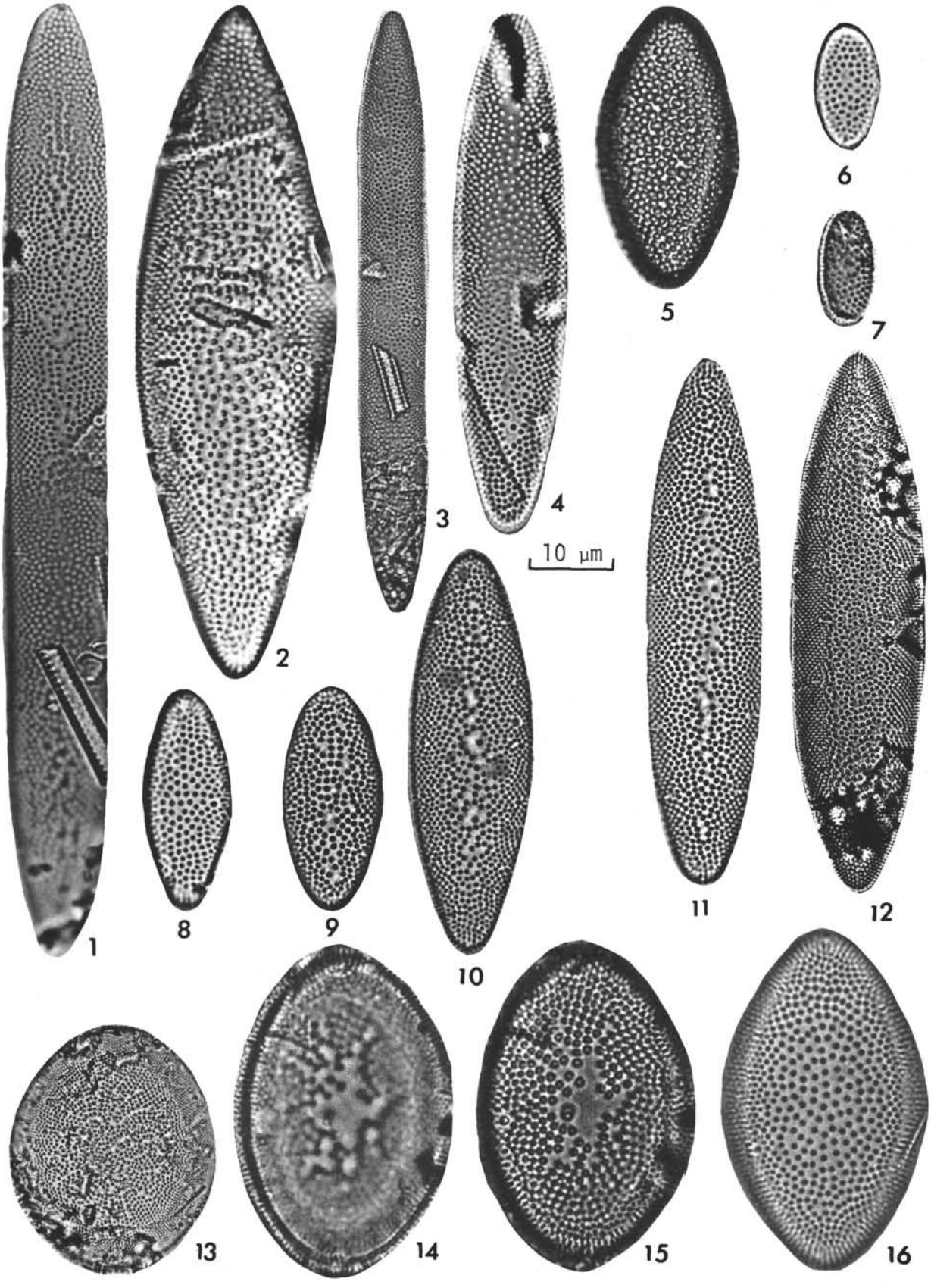

PLATE 18

(Magnification 1500×)

Figures 1, 2 — *Coscinodiscus africanus* Janisch
1. DSDP 238-11, CC.
2. DSDP 238-3-1, 75 cm.

Figures 3, 4 — *Coscinodiscus tabularis* Grunow var. *egregius* Rattray; DSDP 238-8-2, 32 cm.

Figures 5-7 — *Coscinodiscus endoi* Kanaya
5. DSDP 238-17-2, 75 cm.
6. DSDP 238-16-3, 110 cm.
7. DSDP 238-21-4, 100 cm.

Figure 8 — *Coscinodiscus* cf. *gigas* var. *diorama* (Schmidt) Grunow; DSDP 238-2, CC.

Figure 9 — *Coscinodiscus tabularis* Grunow var. *egregius* (Rattray) Hustedt; DSDP 238-17-3, 75 cm.

Figures 10, 11 — *Denticula hustedtii* Simonsen and Kanaya; DSDP 238-30, CC.

Figure 12 — *Cussia* sp. 1 Schrader; DSDP 238-6-4, 75 cm.

PLATE 18

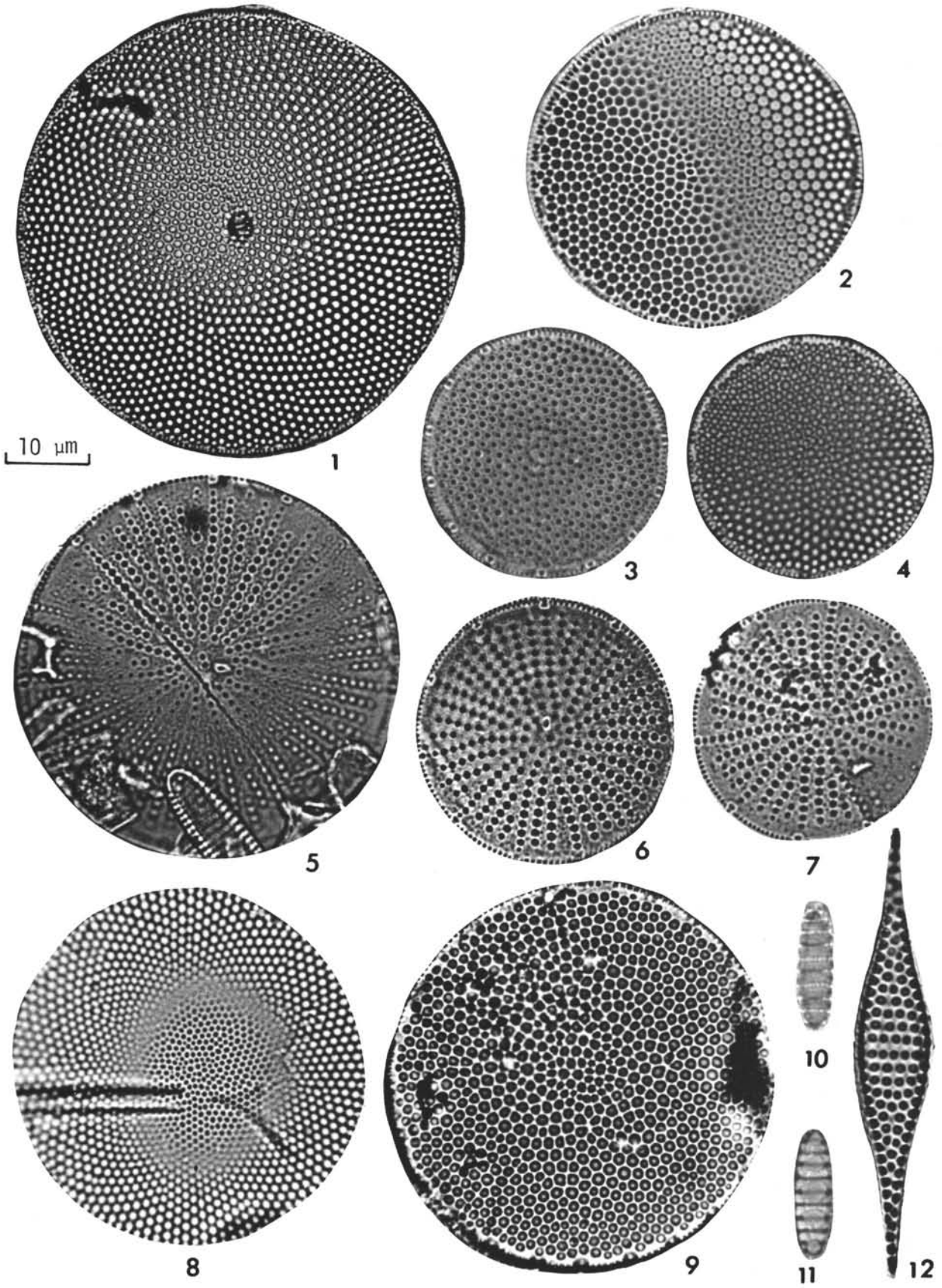

PLATE 19

(Magnification 1500×)

Figure 1 — *Anaulus* sp. 1 Schrader; DSDP 238-23-2, 75 cm.

Figures 2, 3 — *Biddulphia moholensis* Schrader
2. DSDP 238-24, CC.
3. DSDP 238-7-5, 40 cm.

Figures 4, 5 — *Thalassionema lineata* Jouse
4. DSDP 238-21-2, 100 cm.
5. DSDP 238-27-2, 125 cm.

Figure 6 — *Thalassionema nitzschioides* Grunow; DSDP 238-23, CC.

Figures 6a, 7 — *Thalassiothrix longissima* Cleve and Grunow; DSDP 238-13-3, 75 cm.

Figures 8-10 — *Thalassiothrix monospina* n. sp.
8. DSDP 238-13-3, 75 cm.
9. DSDP 238-22, CC.
10. DSDP 238-19-2, 75 cm.

Figure 10a — *Coscinodiscus tabularis* Grunow var. *egregius* (Rattray) Hustedt; DSDP 238-27-2, 125 cm.

Figures 11-13 — *Triceratium cinnamomeum* Grev. var. *minor* Grunow
11. DSDP 238-3-1, 75 cm.
12, 13. DSDP 238-3-1, 75 cm.

Figures 14-16 — *Cussia lancettula* Schrader
14, 15. DSDP 238-12, CC.
16. DSDP 238-23-2, 75 cm.

Figure 17 — Gen. indet. species indet.; DSDP 238-7-5, 40 cm.

Figures 18, 19 — *Actinocyclus ehrenbergii* Ralfs
18. DSDP 238-28-5, 75 cm.
19. DSDP 238-23, CC.

Figures 20-25 — *Hemidiscus cuneiformis* Wallich
20. DSDP 238-8-2, 32 cm.
21. DSDP 238-8-2, 32 cm.
22. DSDP 238-7-5, 40 cm.
23. DSDP 238-13-4, 75 cm.
24. DSDP 238-7-5, 40 cm.
25. DSDP 238-4, CC.

PLATE 19

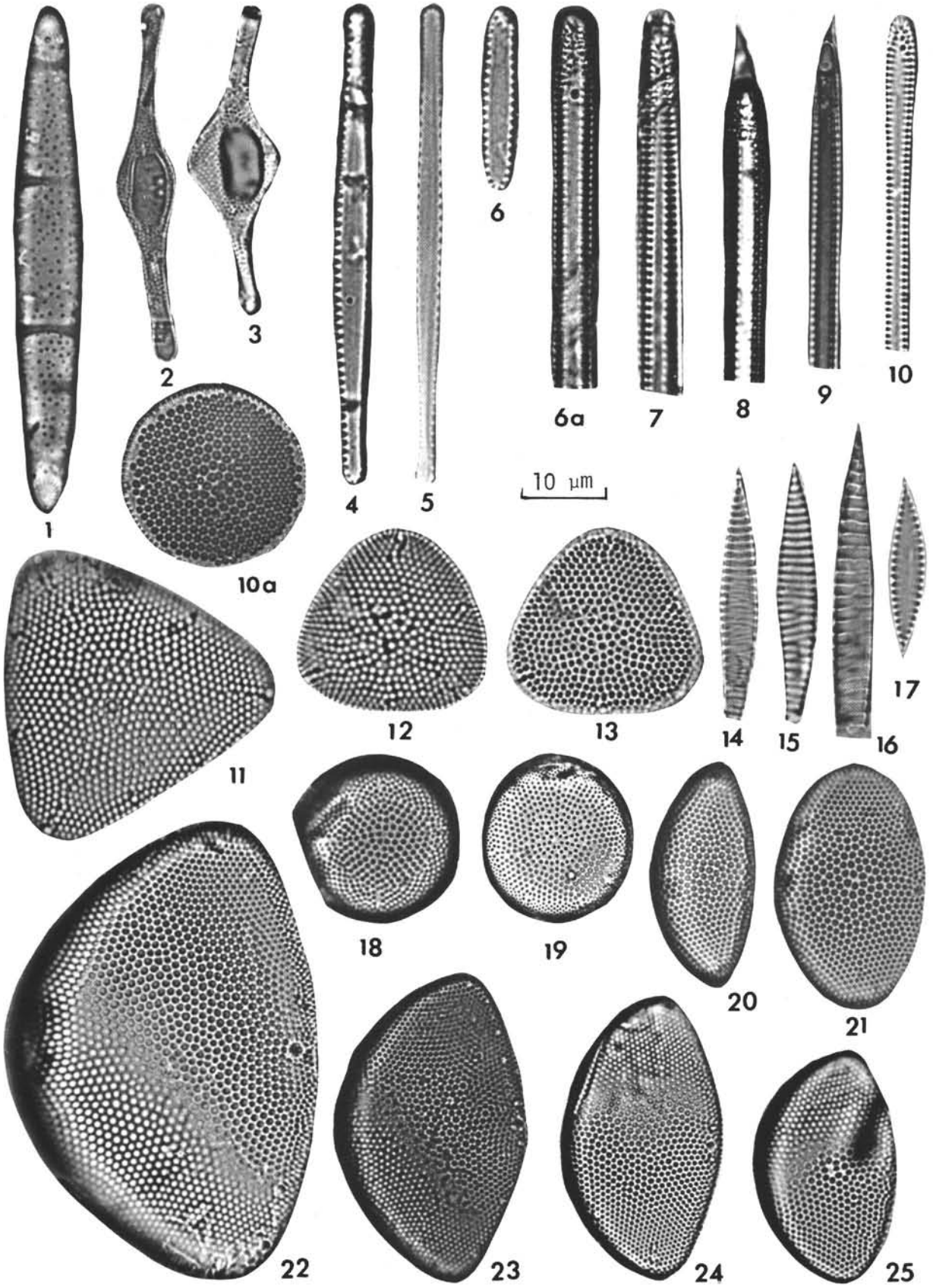
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PLATE 20

(Magnification 1500X)

Figure 1 — *Actinocyclus ehrenbergii* Ralfs var. *tenella* (Breb.) Hustedt; DSDP 238-1, CC.

Figure 2 — *Actinocyclus ehrenbergii* Ralfs; DSDP 238-2-2, 75 cm.

Figure 3 — *Actinocyclus ehrenbergii* Ralfs var. *tenella* (Breb.) Hustedt; DSDP 238-1-4, 65 cm.

Figure 4 — *Actinocyclus* spec. 1 Schrader; DSDP 238-22, CC.

Figures 5-7 — *Triceratium cinnamomeum* Grev. var. *minor* Grunow
5, 6. DSDP 238-3-2, 75 cm.
7. DSDP 238-6-4, 75 cm.

Figure 8 — *Triceratium cinnamomeum* Grev.; DSDP 238-19-2, 75 cm.

Figure 9 — *Triceratium cinnamomeum* Grev. forma *quadrangulata* Grun.; DSDP 238-13-4, 75 cm.

Figure 10 — *Triceratium cinnamomeum* Grev. forma; DSDP 238-17-5, 75 cm.

Figure 11 — *Triceratium cinnamomeum* Grev.; DSDP 238-1-4, 65 cm.

Figures 12-15 — *Rouxia moholensis* Schrader
12, 13. DSDP 238-29-5, 75 cm.
14. DSDP 238-17-5, 75 cm.
15. DSDP 238-17-5, 75 cm.

Figure 16 — *Rouxia californica* M. Peragallo; DSDP 238-23-2, 75 cm.

PLATE 20

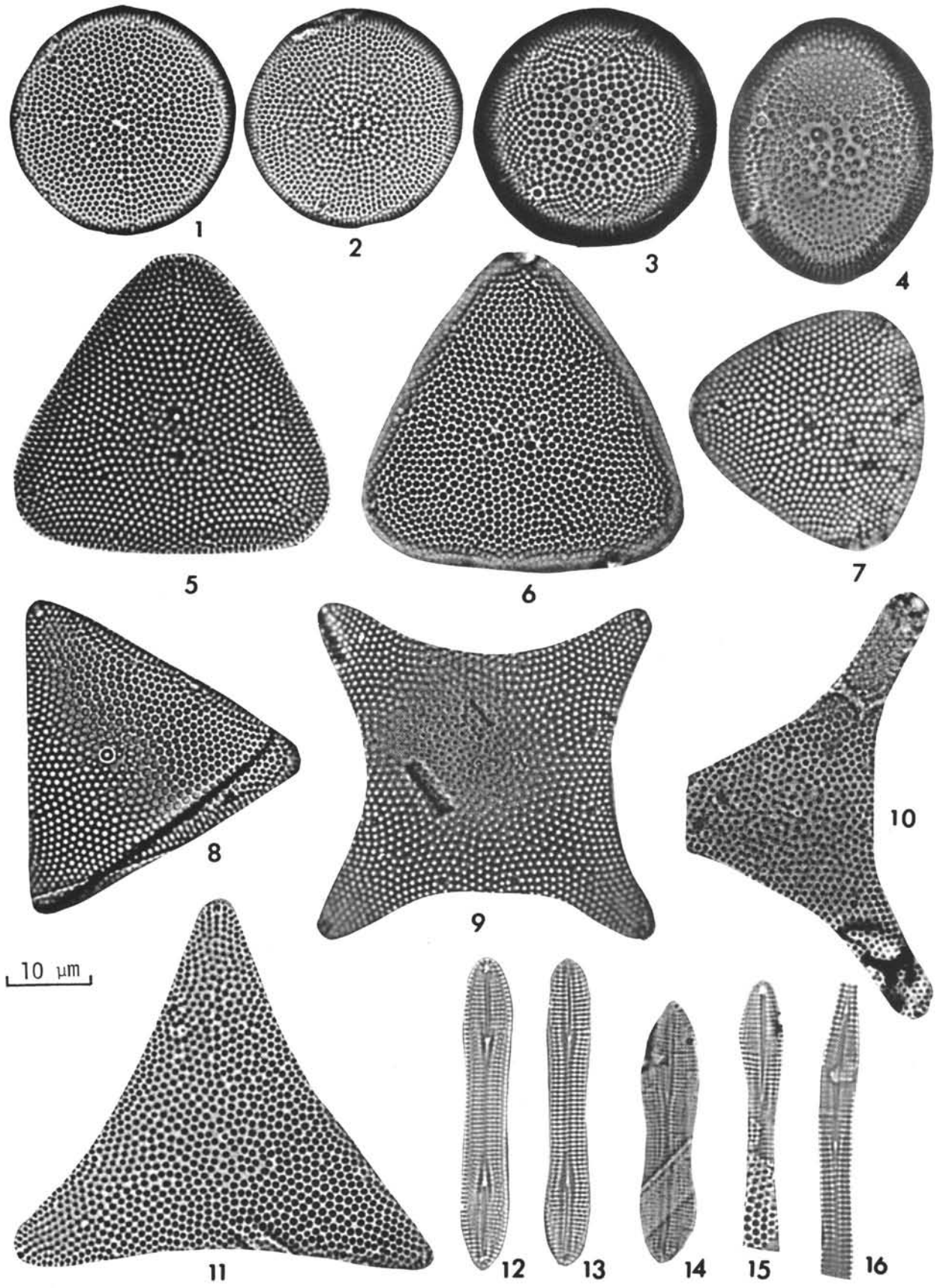

PLATE 21

(Magnification 1500×)

Figures 1, 2 — *Coscinodiscus plicatus* Grunow; DSDP 238-6-1, 11 cm.

Figures 3, 4 — *Coscinodiscus plicatus* Group 4; DSDP 238-17-5, 75 cm.

Figures 5-7 — *Coscinodiscus plicatus* Grunow; DSDP 238-17-5, 75 cm.

Figure 8 — *Coscinodiscus yabei* Kanaya; DSDP 238-27-2, 125 cm.

Figures 9-12 — *Roperia tesselata* (Roper) Grunow
9. DSDP 238-3-1, 75 cm.
10, 11. DSDP 238-1, CC.
12. DSDP 238-3-6, 75 cm.

Figures 13, 14 — *Roperia praetesselata* n. sp.; DSDP 238-13-3, 75 cm.

Figure 15 — *Roperia tesselata* (Roper) Grunow; DSDP 238-4-5, 97 cm.

Figures 16, 17 — *Actinocyclus ehrenbergii* Ralfs
16. DSDP 238-13-3, 75 cm.
17. DSDP 238-17-3, 75 cm.

Figure 18 — *Actinocyclus* sp. 1 Schrader; DSDP 238-5-4, 90 cm.

PLATE 21

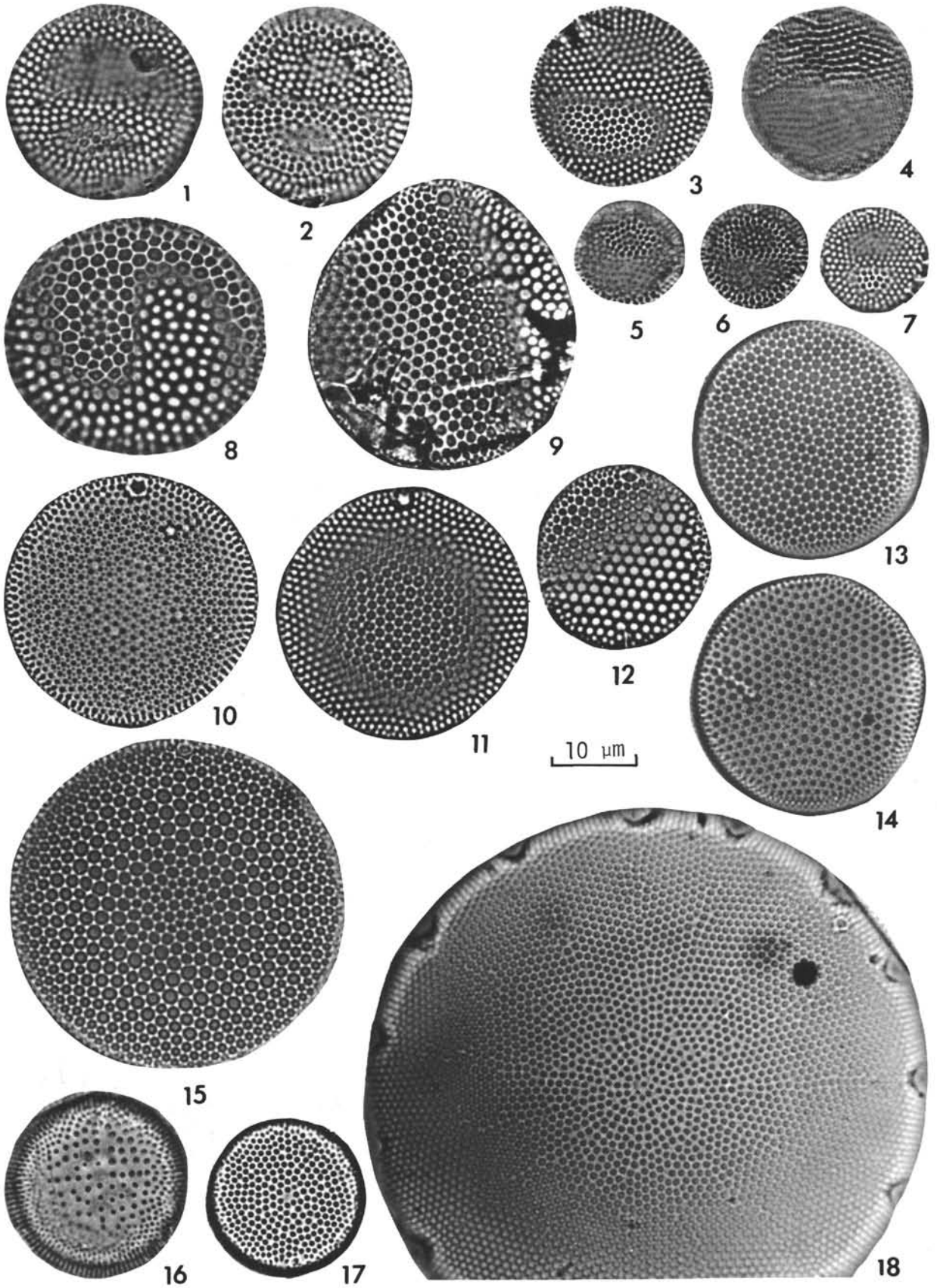

PLATE 22

(Magnification 1500X)

Figures 1-5 *Thalassiosira miocenica* n. sp.
1-3. DSDP 238-19-2, 75 cm.
4. DSDP 213-8-3, 50-51 cm (type).
5. DSDP 213-8-3, 50-51 cm (girdle).

Figures 6, 7 *Nitzschia miocenica* Burckle; DSDP 213-8-3, 50-51 cm.

Figures 8-10 *Nitzschia porteri* Frenguelli; DSDP 213-8-3, 50-51 cm.

Figures 11-13 *Thalassiosira miocenica* n. sp.; DSDP 213-8-3, 50-51 cm.

Figure 14 *Pleurosigma* spec.; DSDP 238-23-4, 75 cm.

Figures 15, 16 *Coscinodiscus nodulifer;* DSDP 213-8-3, 50-51 cm.

Figure 17 *Asteromphalus arachne;* DSDP 213-8-3, 50-51 cm.

Figure 18 *Trinacria regina* Heib.; DSDP 238-34-4, 70 cm.

Figure 19 *Trinacria excavata* Heib.; DSDP 238-34-4, 70 cm.

Figure 20 *Stephanopyxis turris* (Grev. and Arn.) Ralfs.; DSDP 238-32-5, 70 cm.

PLATE 22