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LATE MIOCENE AND EARLY PLIOCENE SILICEOUS MICROFOSSILS FROM THE UPPER MONTEREY AND LOWER SISQUOC FORMATIONS, SWEENY ROAD, SANTA BARBARA COUNTY, CALIFORNIA

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ABSTRACT

Radiolaria, diatoms, and silicoflagellates are identified and illustrated from the late Miocene and Early Pliocene beds of the Monterey and Sisquoc Formations that are exposed along Sweeny Road, near Lompoc, California. The greatest number of species recovered belong to the Bacillariophyceae (diatoms). Radiolaria are second in species abundance and silicoflagellates third. Radiolaria were sometimes found to outnumber diatoms in rocks affected by diagenesis or dissolution. In some intervals, diatoms and silicoflagellates were rare or absent, and only three or four species of Radiolaria, predominantly SPUMELLARIA Ehrenberg 1875, were found. In general, the rocks that were least subjected to diagenesis or dissolution yielded the highest species diversity and the most specimens of all three groups of siliceous microfossils.

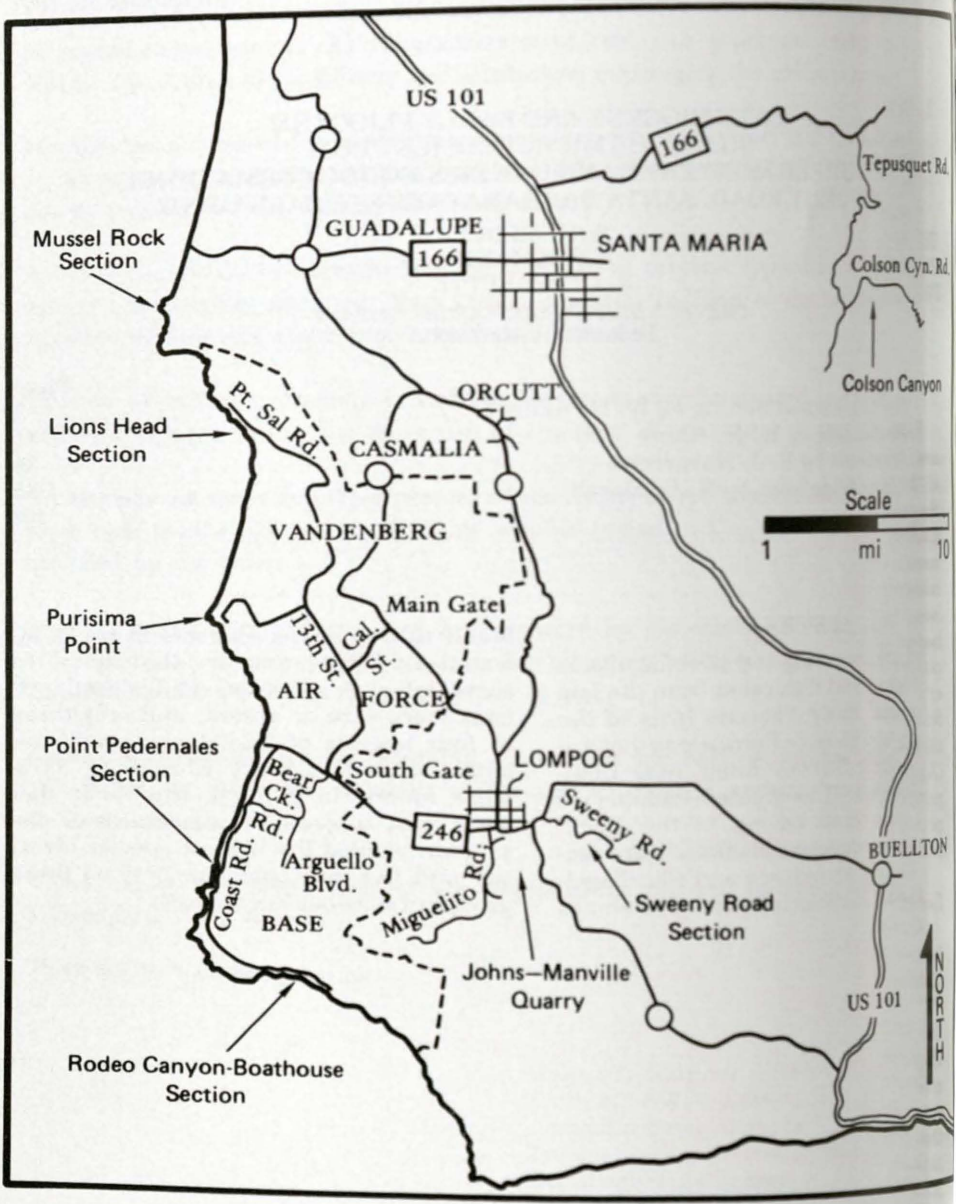

Figure 1. Location map for the Sweeny Road section and other outcrops of the Monterey Formation in the Santa Maria-Lompoc area.

PART I
THE GEOLOGICAL SETTING

W. H. AKERS

CONTENTS

I. INTRODUCTION

Radiolaria, diatoms, and silicoflagellates are conspicuous microscopic constituents of the Monterey and Sisquoc formations at Sweeny Road, Santa Barbara County, California, and offer the only substantial means for subdividing the sequence on a biostratigraphic basis. Other fossils have been noted there, including fish scales, fish bones, sponge spicules, foraminifera, and palynomorphs. Summaries on the recovery of foraminifera, and palynomorphs from the section at Sweeny Road are included in the appendices by K. L. Finger (Appendix A) and S. K. Srivastava (Appendix B). Also included is a note on the processing of rocks for siliceous microfossils by Carlton J. Ford (Appendix C).

Location of Study Area

Access to the Sweeny Road section may be accomplished by proceeding north on California Highway 1 to Lompoc. At the "T" intersection with Ocean Avenue (at the Grefco processing plant), turn right on Highway 246 and drive approximately 0.5 mile to Sweeny Road. Turn right and drive two miles to exposures on the north side of the road (see Fig. 1). The locality is at latitude 34° 39-39.5'N., longitude 120° 35.5'W.

The section was measured and sampled by G. L. Armstrong and W. H. Akers (see Figures 2 and 3) on May 11 and 12, 1982. The 73 samples of rock material collected at that time were prepared for radiolarian, diatom, and silicoflagellate microscopy at the Chevron Oil Field Research Company (COFRC) biostratigraphic laboratory by C. J. Ford and G. L. Armstrong.

Geologic Setting

Approximately 1,575 feet (480 meters) of diatomites, cherts, porcellanites, and occasional dolomites are exposed in the road cut along Sweeny Road (Figure 2). The beds strike WNW with variable dips, and the oldest rocks are exposed toward the east. Terrace deposits at the western end of the section conceal the top of the marine sequence. The uppermost portion of the section, as in other exposed sections in the Santa Maria - Santa Barbara area, is considered to be the Sisquoc Formation (Woodring and Bramlette, 1950). The contact between the Sisquoc Formation and the underlying Monterey Formation in this area has been identified by criteria which are elusive in the field (Isaacs, 1981, p. 52). The section is continuously exposed except for three intervals of slumping or erosion of the road bank. Several east-west trending folds repeat part of the section between samples 31 and 36 (see Figures 5 and 6).

The Neogene section exposed along Sweeny Road is divided into two parts by a sequence of folded beds. The 800 feet (244 meters) of section below this folded interval is composed of flaggy, siliceous mudstones interbedded with laminated porcellanites and cherts (Figures 3, 4). The flaggy, siliceous mudstones are usually thin-bedded to laminated and weathered to a dull, chalky appearance, outwardly resembling somewhat hard, buff diatomite. The lower portion of the section was selectively sampled for the softest rocks. Even these yielded only rare siliceous microfossils due to diagenesis. Calcareous microfossils are absent, but fish scales and bones are locally abundant on bedding

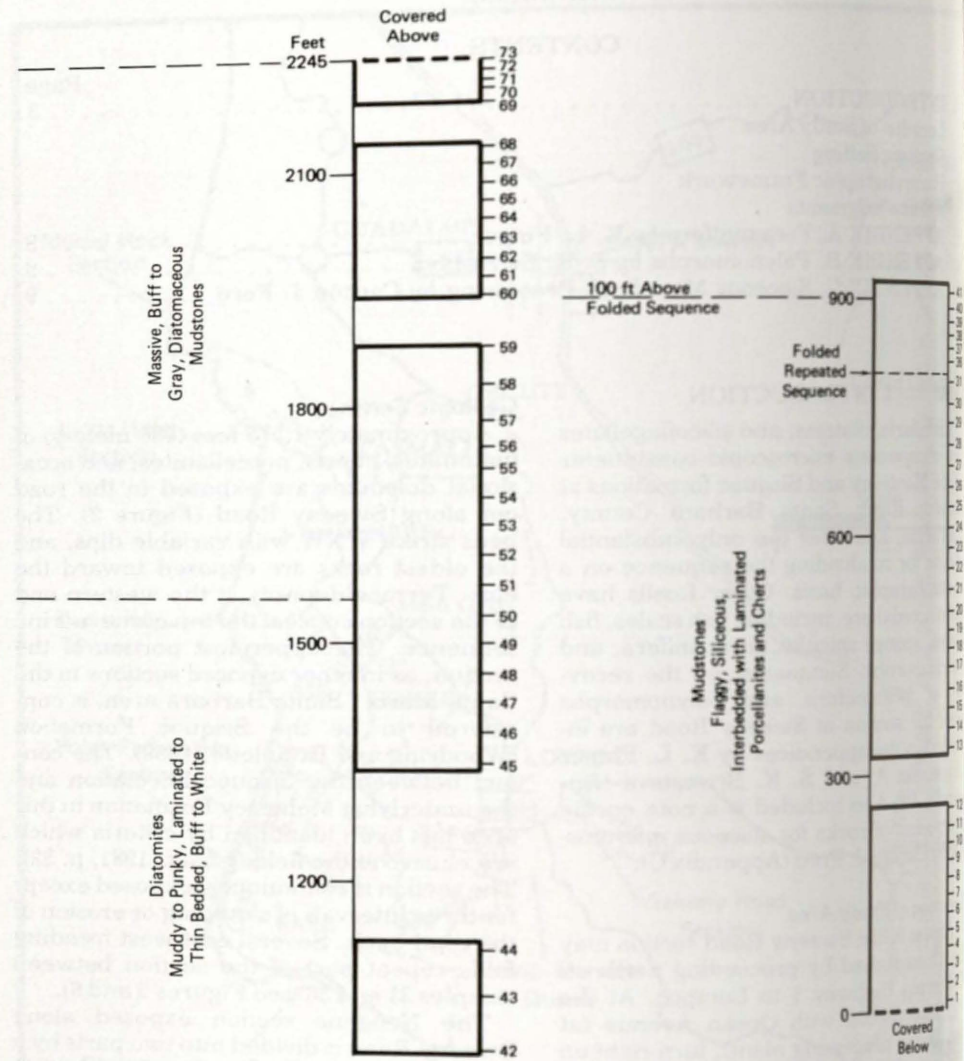

Figure 2. Sweeny Road Section (CRC40396). Relative stratigraphic positions of sampled horizons and major lithologic categories. Covered intervals left blank.

planes. The porcellanites and cherts are thin-bedded to laminated and weathered to a dull, highly fractured and jagged surface. Thin beds of buff-weathering dolomitic porcellanites and dolomites are present but rare.

The 100 feet (30 meters) of beds immediately above the folded and repeated interval are similar to the flaggy, siliceous mudstones, laminated porcellanites, and cherts below the folded zone. Laminated diatomites appear and rapidly increase in abundance to predominate in the sequence from 100 feet (30 meters) above the folded interval to the top of the section. They are muddy to punky and buff to white in color. Diagenetically produced cherts and porcellanites do not occur in the

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Figure 4. View of the exposures along Sweeny Road, looking south from near the top of the section. The oldest beds are near the right-hand margin of the photograph.

interval between 190 feet (58 meters) above the folded beds and the top of the exposure.

The upper portion of the section at Sweeny Road is referable to the Sisquoc Formation. Most of the underlying Monterey Formation fits the lithologic subdivision variously referred to as the "Upper Member" (Arnold and Anderson, 1907; Woodring and Bramlette, 1950) and the "Siliceous Member" (Isaacs, 1981, Fig. 23; Pisciotto, 1978). A thin, lowermost interval is referable to the upper part of the "Lower Member" of Arnold and Anderson (1907), the upper part of the "Middle Member" of Woodring and Bramlette (1950), and the upper part of the "Upper Calcareous Member" of Isaacs (1981). The "Siliceous Facies" of Pisciotto (1978) would include the entire Monterey sequence exposed at Sweeny Road.

Biostratigraphic Framework

The siliceous sequences at Sweeny Road can be correlated with several published sequences. One of these is at Site 173 of DSDP Leg 18 (off Cape Mendocino, California) approximately 449 miles (722 kms) northwest of Sweeny Road. The Newport Bay section, cited below, is approximately 159 miles (256 kms) southeast of the subject locality, and Site 469, DSDP Leg 63, is approximately 145 miles (233 kms) southwest of Sweeny Road.

Mixing of equatorial and high-latitude assemblages were noted at Site 173 by Kling (1973, p. 618), who employed radiolarian zonations proposed for both regions where applicable. He recognized the equatorial Miocene zones of Riedel and Sanfilippo (1970, p. 512, 513; 1971, p. 1549, 1580) but could not determine their boundaries. The nominate species of Kling's composite zones for the Miocene at Site 173, in ascending order, are *Calocyclette costata*, *Dorcadospyris alata*, *Diartus petterssoni*, *Didymocyrtis antepenultima*, and *Stichocorys peregrina* (see Kling, 1973, Fig. 1).

The base of the Pliocene in the Pacific Coast region has been associated with the earliest appearance of *Lamprocyrtis heteroporos* (Hays), and it is on this basis that Kling (1973, p. 618, Fig. 1) recognize

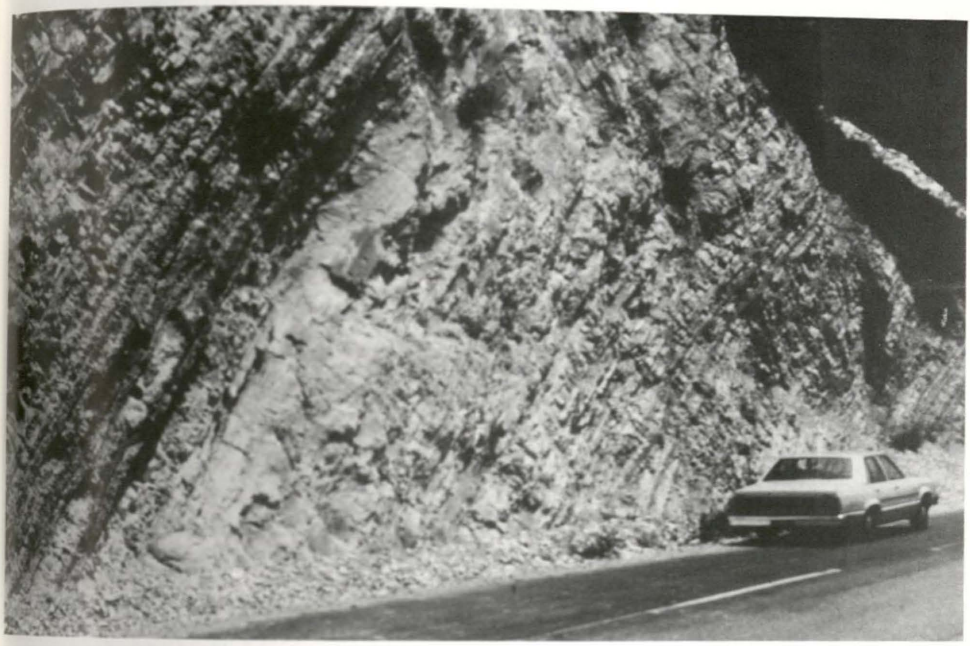


Figure 5. View of interbedded porcellanites, cherts, and diatomaceous mudstones from about the middle of the Sweeny Road section.

Figure 6. Close-up view of laminated diatomites with the first appearance of diagenetic chert nodules.

the Miocene-Pliocene boundary at Site 173. The earliest occurrence of this species in the Newport Bay section approximates the boundary (Weaver *et al.*, 1981, Fig. 2) and dovetails with the interpretation of Ingle (1967, 1972) for the Miocene-Pliocene boundary using foraminifera from the Newport Bay outcrops. This horizon was also identified by Casey *et al.* (1972, p. 226) in the section at Malaga Cove, California. According to Kling (1973, p. 618, Fig. 1), the base of the Upper Pliocene *Lamprocyrtis heteroporos* Zone at Site 173 coincides with the uppermost occurrence of *Stichocorys peregrina* (Riedel), as defined by Hays (1970, p. 195), with a radiometric-paleomagnetic age of 2.8 m.y. Further, Kling adds, "this leaves a segment of time from the Miocene-Pliocene boundary to the base of the *L. heteroporos* Zone representing part of the *Spongaster pentas* Zone of Riedel and Sanfilippo (1970, p. 513) but not recognizable in this region."

The portion of the Sweeny Road section that yielded identifiable diatoms suggests that this fossiliferous sequence includes the North Pacific zones of Schrader (1973) from Zone VII to Zone X and the Northeastern Pacific zones of Barron (1981) from the *Denticulopsis seminae* var. *fossilis-D. kamtschatica* Zone down to the *Nitzschia reinholdii* Zone.

The model, thus constructed for Site 173 and Newport Bay, identifies the Sweeny Road section as Upper Miocene to Pliocene in age. Exactly how much of the Pliocene is represented by the section remains open to question, but it is precisely correlatable with the upper part of the *Stichocorys peregrina* Zone and the lower part of the *Lamprocyrtis heteroporos* Zone as proposed for Site 173 (Kling, 1973, Fig. 1).

The correlation of sedimentary sequences can be complicated by recycled fossils and hiatuses. The latter phenomenon has been recognized in Pacific regions by several biostratigraphers (Keller, Barron, and Burckle, 1982; Barron and Keller, 1983; and Keller and Barron, 1983) using a multidisciplinary approach. Thus, the apparent first and last appearances of microfossils in the Sweeny Road beds, or in any other section, may not necessarily be the true first and last appearance datums of the respective forms. Correlation of Monterey strata, therefore, should be proposed with consideration of the regional depositional history and as much biostratigraphic detail as available.

Acknowledgments

Chevron Oil Field Research Company (COFRC) fully supported the research for these reports, and we thank our associates, K. L. Finger, S. K. Srivastava, C. J. Ford, G. L. Armstrong and K. N. Kirwan for additional biostratigraphic data, sample collection and processing, and computer generation of occurrence charts. T. C. Mac Kinnon furnished valuable field guidance, lithologic data, and the photographs reproduced for this report. In particular, we thank H. J. Schrader, C. A. Nigrini, W. R. Riedel, and D. Bukry who contributed invaluable literature and expertise within their respective disciplines. The project was conceived and supported by Drew Haman.

II. APPENDIX A
FORAMINIFERA
K. L. FINGER

Twenty-five samples from the Sweeny Road section were examined: CRC40396-1, 5, 9, 13, 17, 21, 25, 29, 36, 40, 44, 48, 52, 56, 60, 64, 65, and 67 through 73. Although diatoms and radiolarians were observed in the washed residues, foraminifera and other calcareous microfauna (*e.g.*, ostracodes) were conspicuously absent throughout the 2,245-foot (685 meters) section, except in Sample 66. This sample, which is from the Sisquoc Formation, yielded only two poorly-preserved specimens similar to *Nonionella* cf. *N. davanaensis* Pierce *sensu* Warren, a form which has been recorded from the Late Mohnian interval of the Monterey Formation at Newport Lagoon. Its full range is unknown.

The highly siliceous nature of these rocks suggests that the overall rarity of foraminifers has not been biased by their disintegration in laboratory processing. Two thin sections of Sample 66 were made, one parallel and one perpendicular to the laminations, but neither contained any foraminifers nor fragments thereof.

III. APPENDIX B

SWEENY ROAD PALYNOMORPHS

S. K. SRIVASTAVA

CRC40396-4: Several vesicles of *Rhizophagites* occurred. Modern fungi similar to *Rhizophagites* grow inside the roots of many plants. These could be modern contamination. No palynomorphs seen.

CRC40396-12: *Pterospermella* (11 specimens), rare occurrence of degraded unidentified chorate dinocysts.

CRC40396-20: Palynomorphs - none.

CRC40396-31: Two damaged specimens of *Pterospermella*.

CRC40396-39: Palynomorphs - none.

CRC40396-48: Palynomorphs - none.

CRC40396-56: *Pterospermella* (10 specimens), abundant brownish-black foraminifer chambers (chitinous linings).

CRC40396-67: *Pterospermella* (6 specimens), several broken *Tytthodiscus*, two bisaccate *Pinus* pollen.

IV. APPENDIX C

SILICEOUS MICROFOSSIL PROCESSING, SWEENY ROAD SECTION, MONTEREY FORMATION

CARLTON J. FORD

The top of the Sweeney Road Section posed no significant problem for processing and recovering siliceous microfossils. Samples 73 through 39 were generally light buff, laminated diatomaceous mudstones. These rocks were processed as described in Procedure #1 (below). Any remaining sample that did not break down was then processed by using the potassium hydroxide method as described in Procedure #2 (below).

Samples 38 through 1 were generally buff, siliceous mudstones with some porcellaneous mudstones present. These samples would not readily break down using the H_2O_2-$Na_4P_2O_7$ method. What material that did break down was still encapsulated in clays. The first procedure was bypassed, and we had great success breaking down the remaining material using Procedure #2.

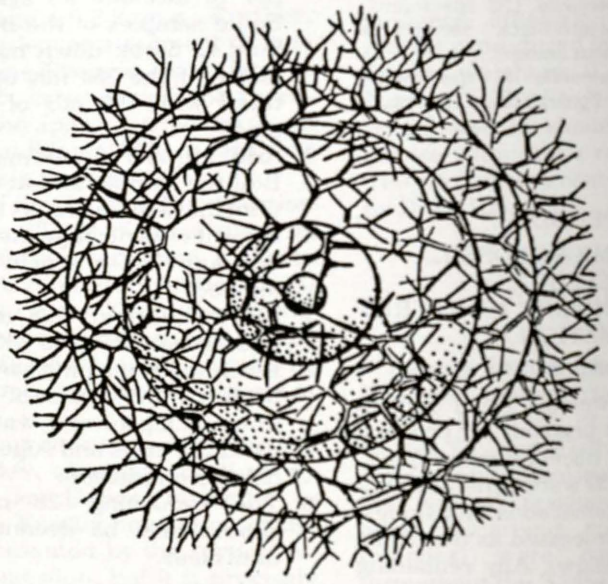
However, one must be very careful while using potassium hydroxide. It is a very harsh basic solution. It is possible that some borderline diagenetic silica can be dissolved by it, including small diatoms and silicoflagellates.

SILICEOUS MICROFOSSIL PROCESSING PROCEDURE #1 FOR DIATOMITES, OOZES, MUDS, SANDSTONES:

1. Boil 5-25 grams of sample in 150 mls of hydrochloric acid for 15 minutes.
2. Rinse the HC1 out of sample by decanting every 30 minutes, or centrifuge the sample until neutral.
3. Place the remaining sample into 250 mls of H_2O and add H_2O_2 with an eyedropper to facilitate an agitating reaction. Some samples of the lithologies above tend to break down more cleanly and faster, if the 250 mls of H_2O is substituted with 100 mls of hydrogen peroxide.
4. Add .5 grams of sodium pyrophosphate.
5. Boil the sample and keep adding H_2O_2 until the sample breaks down.
6. Decant or centrifuge the sample to rinse out any H_2O_2 which may have remained.
7. Sieve +63 and +28 micron fractions and thoroughly rinse with water.
8. Place the remaining sample in a 400 ml beaker with .5 grams of hexameta phosphate (Calgon) and water to help suspend the clays and supernatants for the -28 micron fraction.
9. The remaining -28 micron fraction should then be decanted every hour until clear.

PROCEDURE #2 FOR DOLOMITIC, SILICEOUS, AND PHOSPHATIC SHALES:

1. Crush 5-25 grams of sample until chips are 3 to 6 mm (1/8 to 1/4 in.) in diameter.
2. Boil the sample in 250 mls of Aqua Regia for 15-30 minutes.
3. Centrifuge the sample until neutral.
4. Place the sample into a hot solution of 50-100 mls of ‹5% Potassium Hydroxide.
5. Boil the sample for not longer than 15-20 minutes and add H_2O_2 slowly, using an eyedropper.
6. Centrifuge the sample until neutral, leaving behind in the beaker the larger granules which did not break down.
7. Follow steps 7 through 9.



PART II
RADIOLARIA

W. H. AKERS

CONTENTS

ILLUSTRATIONS

I. INTRODUCTION

Objectives Of Study

This report is intended as a survey and preliminary inventory of the Radiolaria in the section exposed along Sweeny Road. The identification of many species will be practical only after they are studied as components of lineages within their respective families, after the monographic treatment of families on a world-wide basis. The data contributed herein on faunas from Sweeny Road will merely indicate taxonomic groups that require such massive systematic research for an understanding of radiolarian biostratigraphy. A few of the species identified at Sweeny Road offer useful first and last appearance datums to which paleomagnetic ages and radiometric dates have been assigned by Deep Sea Drilling Project (DSDP) scientists.

Background

Formations of coastal California have been neglected for their radiolarian faunas since the epic report by Campbell and Clark (1944) on assemblages from the Palos Verdes Hills and the Newport Bay area. Recent interest in the Monterey Formation has been stimulated by petroleum discoveries offshore of Point Conception and Point Arguello. The biogenic origin of the reservoir rock, which may also have been the source beds for this new prolific production, has revived an interest in the organisms that were responsible for so much sediment accumulation in the Santa Maria basin. Radiolaria are a conspicuous component of the diatomaceous portions of the Monterey Formation, and in some beds they even outnumber diatoms, due to the greater resistance of their skeletons to diagenesis than provided by the hollow skeletal elements of diatoms. It is not surprising, then, that some biostratigraphers are taking another look at the siliceous microfossils of the California Neogene with particular interest in stratigraphic and paleoceanographic implications (Weaver *et al.*, 1981).

Fortunately for the use of Radiolaria in geochronology and stratal correlation, a few research centers have continued since 1944 to support not only biostratigraphic research, but also multidisciplinary approaches to geochronology. Thereby, the DSDP has produced refinements in the taxonomy of planktic microfossils and a global model for marine stratigraphy. Thus, radiolarian research, as well as studies on other microplankton, although represssed on land, is alive and well in the deep sea. It is largely due to the comprehensive scope of DSDP reports that constituents of our land-based faunas can be identified with species that are variously termed "tropical", "subpolar", or "tropical submergent." Publication of *Cenozoic Radiolarian Stratigraphy* (Sanfilipo *et al.*, in press) and *A Guide to Miocene Radiolaria* (Nigrini and Lombari, 1984) will clarify the potential of Radiolaria for marine geochronology. Nevertheless, problems will continue to exist in the identification of Radiolaria on the species level until additional monographic data for families are available, such as Nigrini (1977) contributed on the tropical genera and species of the Cenozoic Artostrobiidae. The identification of lineages in the fossil record, such as those contained in the above reports, will be particularly useful to stratigraphic paleontologists.

The diversity and number of radiolarian species in the Sweeny Road section are less than half of the concentrations found in the tropics, although some of the species from Sweeny Road are abundant at tropi-

cal Neogene sites. This observation is reconcilable with both (1) the higher species diversity in the tropics than in high latitudes, and (2) a diminution of diversity and numbers of individuals in nearshore waters of all oceans and seas of normal marine salinity (Sanfilippo, Westberg-Smith, and Riedel, in press).

Most faunas from the Sweeny Road section are dominated by Spumellarians. Two factors may have contributed to this relationship. The first one is an assumption that certain spongy Spumellarians (with closely related modern descendants) dominated Neogene water masses near land, as they do today on the shelf of the western part of the Bering Sea (Blueford, 1983, p. 769). The second factor for some of the beds is the greater resistance of the spongy type of skeleton to diagenesis than the more delicate skeletons of most Nassellarians.

The fossil radiolarian faunas in the Sweeny Road section are obviously of different species composition than they were in life. Since these organisms lived mostly in the upper few hundred meters of the water column, the more delicate skeletons originating near the sea surface dissolved during their descent to the sea floor, resulting in a concentration of the more robust forms on the sea bottom. Dissolution continued there until burial somewhere in excess of 10-20 cm. Further destruction occurred by diagenesis with progrressive depth of burial until only the most robust and corrosion resistant types survived, and these, too, are absent in the older portions of subsurface and outcropping sections, except for some of the dolomites, in which diagenesis proceeded at a slower rate than in diatomites. Thus, various aspects of siliceous microfossil assemblages were seen in the Sweeny Road section, from those rich in radiolarian, diatom, and silicoflagellate individuals, to those of lower species diversity but with abundant robust radiolarian and diatom individuals, to those with only a few species of robust radiolarians, and finally to rocks barren of all fossil structures. Fortunately, a stratum near the base of the section at Sweeny Road yielded several species of Radiolaria, including the large, corrosion-resistant *Stichocorys peregrina* by which the maximum age of the Monterey Formation exposed here may be concluded to be Late Miocene.

Illustrations

All illustrations are Polaroid prints from type 667 film. The species designation for each figure is followed by the horizon (sample) number, the magnification, and SEM, if a scanning electron micrograph was used. The +63 micron fraction was used for all slides, except when otherwise noted. The prefix, CRC40396, was assigned to all samples collected from the Sweeny Road section, but most references to horizons and samples in this report are cited without the prefix. For example, sample horizon 39, as shown for some of the figures, is an abbreviation for CRC40396-39.

II. SYSTEMATIC PALEONTOLOGY

Since the objective of this paper is to inventory the radiolarians in the Sweeny Road section, my first concept of the taxonomic section was as an informal catalog of species under alphabetical genera without regard to supergeneric categories. This format is followed in the organization of the check charts, but the systematics are primarily that of Nigrini and Lombari (1984).

Subclass RADIOLARIA Müller, 1858
Order POLYCYSTINA Ehrenberg, 1838, emend. Riedel, 1967b
Suborder SPUMELLARIA Ehrenberg, 1875
Family ACTINOMMIDAE Haeckel, 1862, emend. Sanfilippo and Riedel, 1980

Genus ACTINOMMA Haeckel, 1860, emend. Nigrini, 1967, emend. Bjorklund, 1977

ACTINOMMA spp.
Pl. 1, fig. 1

Actinomma spp., NIGRINI and LOMBARI 1984, p. S13-S14, pl. 2, fig. 1a-d.

Specimens referable to the "species group" described by Nigrini and Lombari (1984) were observed throughout the fossiliferous portions of the section. The group occurs throughout Miocene sections in both tropical and temperate latitudes but it is more common in temperate than in tropical latitudes, according to these au-

thors. The group may be comprised of several species that do not have stratigraphic utility within the late Neogene.

Genus AXOPRUNUM Haeckel, 1887

AXOPRUNUM ANGELINUM (Campbell and Clark)
Pl. 1, fig. 5, 6

Stylosphaera angelina CAMPBELL and CLARK, 1944, p. 12, pl. 1, fig. 14-20.
Stylatractus universus HAYS, 1970, p. 215, pl. 1, fig. 1, 2; KLING, 1971, p. 1086, pl. 1, fig. 7.
Stylatractus sp. HAYS, 1965, p. 167, pl. 1, fig. 6.
Axoprunum angelinum (Campbell and Clark), KLING, 1973, p. 634, pl. 6, fig. 16, 18; WEAVER *et al.*, 1981, pl. 3, fig. 3, 4.

See Nigrini and Lombari (1984, p. S27-S30, pl. 4, fig. 3a-b) for a discussion of the *Stylatractus universus-Axoprunum angelinum* problem. At Site 173, Leg 18, specimens assigned to this group were identified in Early Miocene to Early Pleistocene sediments.

Genus CROMYDRUPPOCARPUS Campbell and Clark, 1944

CROMYDRUPPOCARPUS ESTERAE
Campbell and Clark
Pl. 1, fig. 7, 8

Cromydruppocarpus esterae CAMPBELL and CLARK, 1944, p. 20, pl. 2, fig. 26-28; WEAVER *et al.*, 1981, p. 73, pl. 2, fig. 3.

This is one of five characteristic species of the *Theocorys redondoensis* assemblage, according to Weaver *et al.* (1981, p. 73).

Genus HEXACONTIUM Haeckel, 1781

HEXACONTIUM spp.
Pl. 1, fig. 2, 3

Hexacontium spp. NIGRINI and LOMBARI, 1984, p. S19-S20, pl. 3, fig. 2a-d.

Nigrini and Lombari (1984, p. S20) found specimens assignable to this group throughout most of their Miocene sections from both tropical and temperate latitudes. More than a single species may have been included in the statistical notations on the check charts, but the group does not have stratigraphic utility in the Miocene-Pliocene sequence at Sweeny Road.

Genus LITHATRACTUS Haeckel, 1887

LITHATRACTUS TIMMSI Campbell and Clark
Pl. 1, fig. 4a-b

Lithatractus timmsi CAMPBELL and CLARK, 1944, p. 18, pl. 2, fig. 18, 19; WEAVER *et al.*, 1981, pl. 4, fig. 3, 4.

The uppermost occurrence of this species in the Newport Bay section is in the Upper Miocene at approximately 6.0 Ma (Weaver *et al.*, 1981, fig. 2).

Family SPONGURIDAE Haeckel, 1862, emend. Petrushevskaya, 1975

Genus SPONGURUS Haeckel, 1860

SPONGURUS (?) sp.
Pl. 1, fig. 9

The shell is elliptical in outline as in *Larnacantha polyacantha*, but concentric layers are clearly visible. The species does not appear to have stratigraphic utility.

Family SPONGODISCIDAE Haeckel, 1862, emend. Riedel, 1967b

Genus CIRCODISCUS Kozlova, 1972

CIRCODISCUS MICROPORUS (Stohr)
Pl. 1, fig. 10

Trematodiscus microporus STOHR, 1880, p. 108, pl. 4, fig. 17.
Porodiscus microporus (Stohr). HAECKEL, 1887, p. 493.
Circodiscus microporus (Stohr). PETRUSHEVSKAYA and KOZLOVA, 1972, p. 526, pl. 19, fig. 1-7.
Xiphospira sp. cf. *X. circularis* (Clark and Campbell) *sensu* KLING, 1973, p. 635, pl. 7, fig. 17 (only).
Circodiscus microporus (Stohr) group. NIGRINI and LOMBARI, 1984, p. S73-S74, pl. 10, fig. 3.

Sweeny Road specimens are typical. They are not as abundant as most other Spongodiscidae.

Genus HYMENIASTRUM Ehrenberg, 1847

HYMENIASTRUM spp.
Pl. 2, fig. 1, 2

Hymeniastrum spp. NIGRINI and LOMBARI, 1984, p. S61-S62, Pl. 8, fig. 2a-b.

Whether specimens from Sweeny Road belong to several species or to a single variable species is not clear.

Genus SPONGOCORE Haeckel, 1887

SPONGOCORE PUER Campbell and Clark
Pl. 2, fig. 4, 5

Spongocore puer CAMPBELL and CLARK, 1944, p. 22, pl. 3, fig. 7.
Spongurus smithi CAMPBELL and CLARK, 1944, p. 21, pl. 3, fig. 4.

The two forms of Campbell and Clark will not be differentiated, unless further study indicates morphologic or stratigraphic justification. Study of *Spongocore puella* Haeckel from the Neogene of the South Pacific may show that both species of Campbell and Clark fall within the range of variation for Haeckel's species.

Genus SPONGOPYLE Dreyer, 1889

SPONGOPYLE OSCULOSA Dreyer
Pl. 2, fig. 3, 7

Spongopyle osculosa DREYER, 1889, p. 42, pl. 11, fig. 99, 100; RIEDEL, 1958, p. 226, pl. 1, fig. 12; NIGRINI and MOORE, 1979, p. S115, pl. 16, fig. 1; NIGRINI and LOMBARI, 1984, p. S77-S78, pl. 11, fig. 1a-b.
Spongodiscus(?) *osculosus* (Dreyer). PETRUSHEVSKAYA, 1967, p. 42, fig. 20-22.

Spongopyle osculosa has been reported throughout the Miocene in both tropical and temperate latitudes (Nigrini and Lombari, 1984, p. S78). Nigrini and Moore (1979, p. S116) discussed Holocene distribution.

Genus SPONGOTROCHUS Haeckel, 1860

SPONGOTROCHUS GLACIALIS Popofsky group
Pl. 2, fig. 6, 8

Spongotrochus glacialis POPOFSKY, 1908, p. 228, pl. 26, fig. 8; pl. 27, fig. 1; pl. 28, fig. 1; RIEDEL, 1958, p. 227, pl. 2, fig. 1, 2, text-fig. 1.
Spongotrochus glacialis Popofsky group. PETRUSHEVSKAYA, 1975, p. 575, pl. 5, fig. 8; pl. 35, fig. 1-6 (with synonymy); NIGRINI and MOORE, 1979, p. S117, pl. 15, fig. 2a-d.
Spongodiscus gigas CAMPBELL and CLARK, 1944, p. 27, pl. 4, fig. 1, 3.
Stylotrochus sol CAMPBELL and CLARK, 1944, p. 28, pl. 4, fig. 7, 9, 10, 11.

The two species of Campbell and Clark are gradational, long ranging (Miocene to Holocene), and there is no morphologic or stratigraphic basis for differentiating them.

SPONGOTROCHUS(?) VENUSTUM (Bailey)
Pl. 3, fig. 1

Perichlamydium venustum BAILEY, 1856, p. 3; pl. 1, fig. 16, 17.
Stylochlamydium venustum (Bailey). HAECKEL, 1887, p. 515.
Perichlamydium scutaeforme CAMPBELL and CLARK, 1944, p. 24, pl. 3, fig. 14-16.
Spongotrochus(?) *venustum* (Bailey). NIGRINI and MOORE, 1979, p. S119, pl. 15, fig. 3a-b.

This form ranges thrughout the Monterey Formation and varies in shell outline form elliptical to circular; the edge is sometimes entire but may have spines extending from the central part slightly beyond the periphery.

Genus STYLODICTYA Ehrenberg, 1847, emend. Kozlova, 1972

STYLODICTYA VALIDISPINA Jørgensen
Pl. 3, fig. 4, 7

Stylodictya validispina JØRGENSEN, 1905, p. 119, pl. 10, fig. 40; PETRUSHEVSKAYA, 1967, p. 33, fig. 17, IV-V; NIGRINI and MOORE, 1979, p. S103, pl. 13, fig. 5a-b; NIG-

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PLATE 1

1. *Actinomma* sp. 67, x320.
2. *Hexacontium* sp. 39, x275.
3. *Hexacontium* sp. 39, x275.
4a-b. *Lithatractus timmsi* Campbell and Clark. 43, x320, the same specimen at different levels of focus.
5. *Axoprunum angelinum* (Campbell and Clark). 39, x200.
6. *Axoprunum angelinum* (Campbell and Clark). 39, x250.
7. *Cromydruppocarpus esterae* (Campbell and Clark). 39, x250.
8. *Cromydruppocarpus esterae* (Campbell and Clark). 69, x565, SEM.
9. *Sponguras*(?) sp. 71, x400.
10. *Circodiscus microporus* (Stohr). 54, x320.

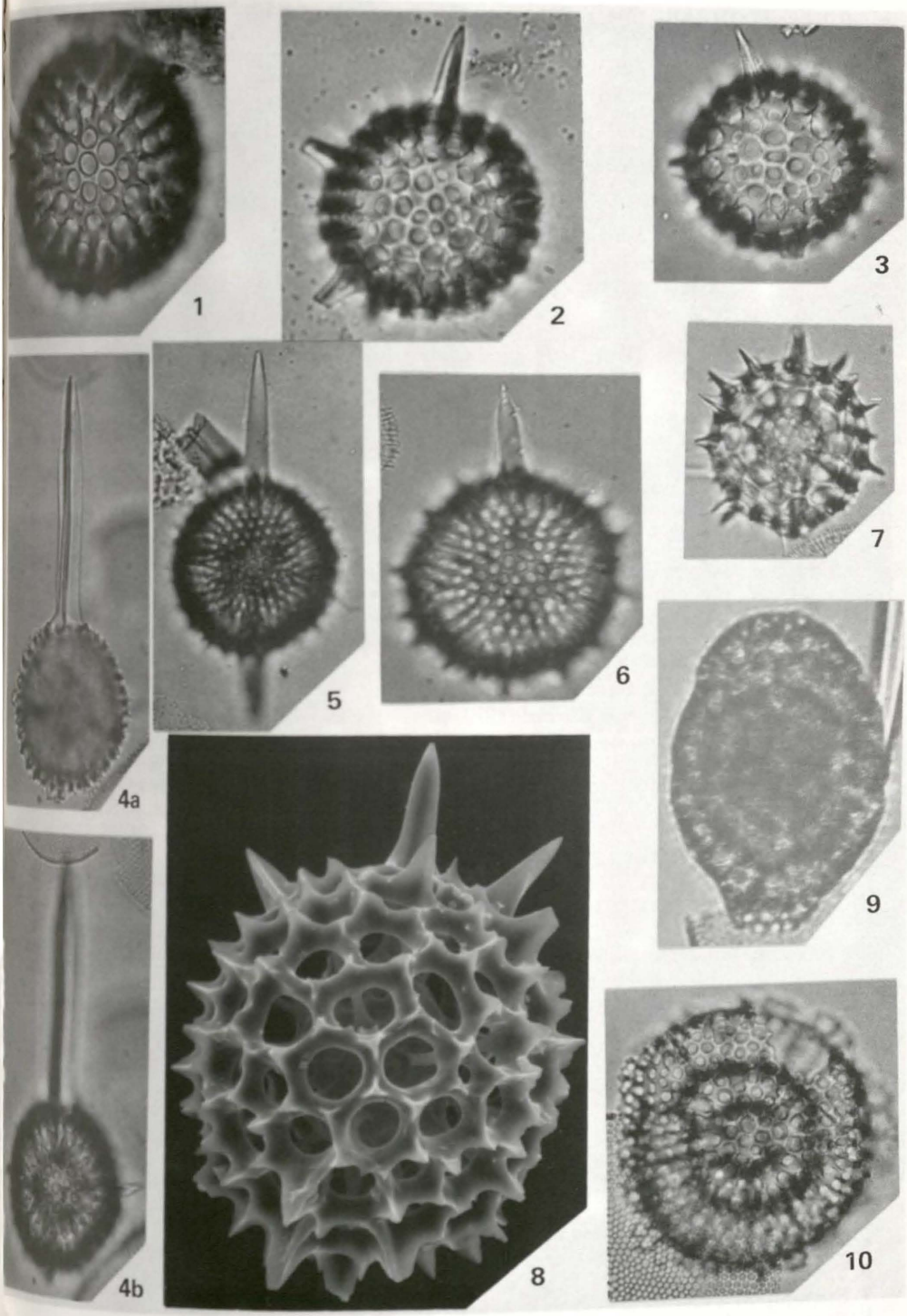


PLATE 1

RINI and LOMBARI, 1984, p. S71, pl. 10, fig. 2 (with morphologic and distribution notes).

Early Miocene to Holocene in both tropical and temperate latitudes (Nigrini and Lombari, 1984, p. S72).

Genus XIPHOSPIRA Haeckel, 1887

XIPHOSPIRA sp. cf. X. CIRCULARIS (Clark and Campbell)
Pl. 3, fig. 2, 3

Porodiscus circularis CLARK and CAMPBELL, 1942, p. 42, pl. 2, fig. 2, 6, 10.
Xiphospira circularis (Clark and Campbell). SANFILIPPO and RIEDEL, 1973, p. 526, pl. 14, fig. 5-12; pl. 31, fig. 4-7.
Xiphospira sp. cf. *X. circularis* (Clark and Campbell). KLING, 1973, p. 635, pl. 2, fig. 1-3; pl. 7, fig. 11-17.
Xiphodictya amphixiphos CLARK and CAMPBELL, 1942, p. 43, pl. 2, fig. 4.
(?)*Stylodictya heliozoides* CAMPBELL and CLARK, 1944, p. 25, pl. 3, fig. 17.
(?)*Stylodictya camerina* CAMPBELL and CLARK, 1944, p. 26, pl. 3, fig. 18, 19, 21.
(?)*Stylodictya ornata* CAMPBELL and CLARK, 1944, p. 26, pl. 3, fig. 20.
(?)*Stylodictya cornuspira* CAMPBELL and CLARK, 1944, p. 27, pl. 3, fig. 22.

The broad concept of this species adopted by Sanfilippo and Riedel (1973, p. 526) is employed here. As so interpreted, the group ranges throughout the Monterey Formation.

Family PYLONIIDAE Haeckel, 1881

Genus PHORTICIUM Haeckel, 1881

PHORTICIUM POLYCLADUM Tan and Tchang
Pl. 3, fig. 9, 11

Phorticium polycladum TAN and TCHANG, 1976, p. 267, text-fig. 39-a-b; NIGRINI and LOMBARI, 1984, p. S83, pl. 12, fig. 1a-b.

This species has been reported common to abundant in Miocene sections from both tropical to temperate latitudes (Nigrini and Lombari, 1984, p. S84). If occurrences in the East China Sea (Tan and Tchang, 1976, p. 267) are Holocene, the range is at least as far back as Early Miocene to Holocene.

Family LITHELIIDAE Haeckel, 1862

Genus LARCOSPIRA Haeckel, 1887

LARCOSPIRA QUADRANGULA Haeckel
Pl. 3, fig. 8

Larcospira quadrangula HAECKEL, 1887, p. 696, pl. 49, fig. 3; BENSON, 1966, p. 266, pl. 13, fig. 7-8; NIGRINI and MOORE, 1979, p. S133, pl. 17, fig. 2.
Larcospira quadrangula Haeckel group. NIGRINI and LOMBARI, 1984, p. S93-S94, pl. 13, fig. 3a-c.

The species group was recorded by Nigrini and Lombari (1984, p. S94) from both tropical (common to abundant) and temperate (rare) latitudes. It has also been found in Holocene material (Nigrini and Moore, 1979, p. S134).

Genus LITHELIUS Haeckel, 1862

LITHELIUS MINOR Jørgensen
Pl. 3, fig. 10

Lithelius minor JØRGENSEN, 1900, p. 65, pl. 5, fig. 24; BENSON, 1966, p. 262, pl. 17, fig. 10 (only); NIGRINI and MOORE, 1979, p. S135, pl. 17, fig. 3, 4a-b.
Larcospira minor (Jørgensen). JØRGENSEN, 1905, p. 121.

See remarks under *L. nautiloides*.

LITHELIUS NAUTILOIDES Popofsky
Pl. 3, fig. 5, 12

Lithelius nautiloides POPOFSKY, 1908, p. 230, pl. 27, fig. 4 (only); RIEDEL, 1958, p. 228, p.

PLATE 2

1. *Hymeniastrum* sp. 73, x320.
2. *Hymeniastrum* sp. 42, x240.
3. *Spongopyle osculosa* Dreyer. 62, x320.
4. *Spongocore puer* Campbell and Clark. 48, x250.
5. *Spongocore puer* Campbell and Clark. 43, x250.
6. *Spongotrochus glacialis* Popofsky Group. 39, x250.
7. *Spongopyle osculosa* Dreyer. 42, x320.
8. *Spongotrochus glacialis* Popofsky Group. 60, x276, SEM.

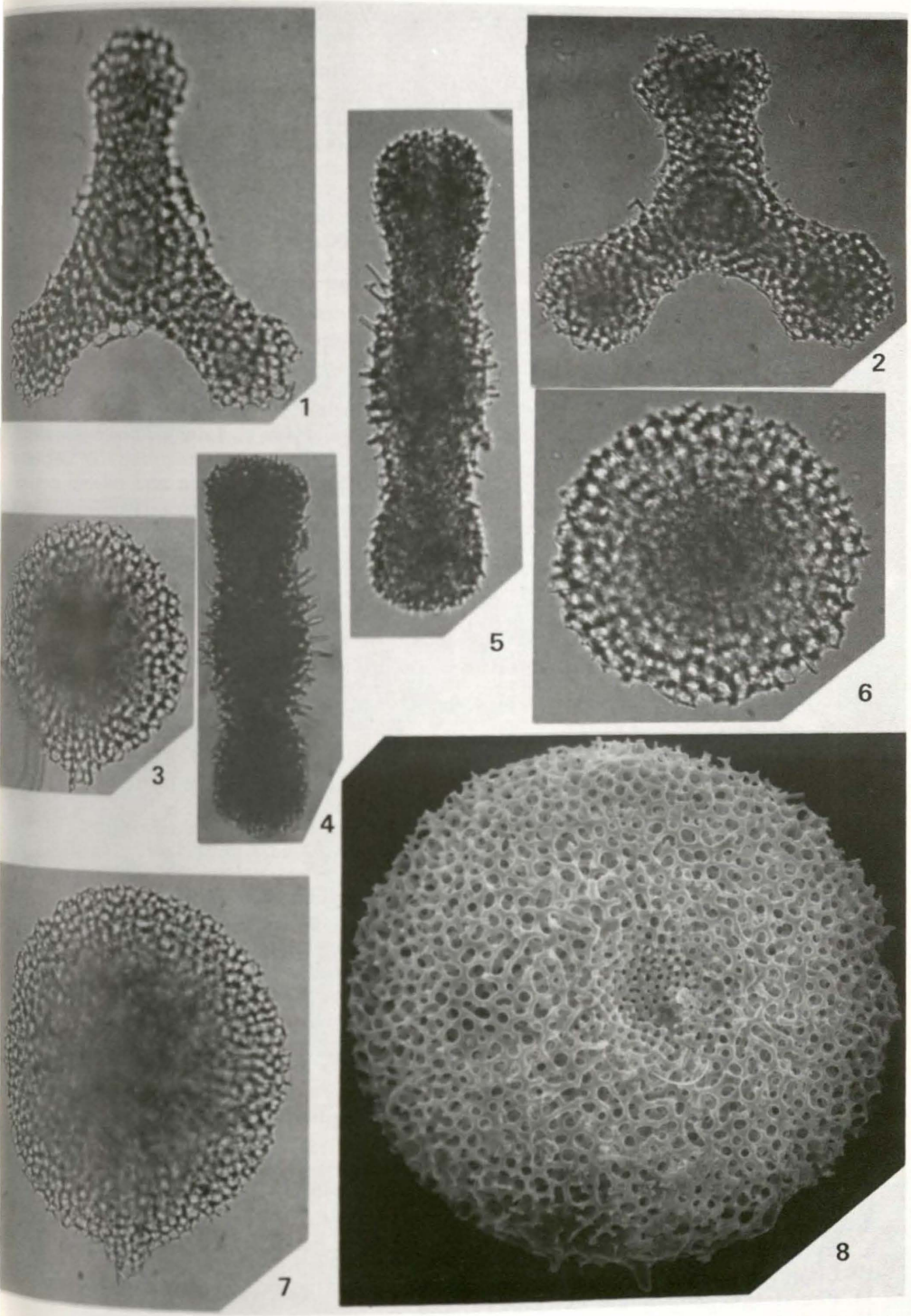


PLATE 2

2, fig. 3 (only), text-fig. 2 (with description); PETRUSHEVSKAYA, 1967, p. 53, fig. 27, 28, I; 29, I; NIGRINI and MOORE, 1979, p. S137, pl. 17, fig. 5; NIGRINI and LOMBARI, 1984, p. S97-S98, pl. 14, fig. 2a-b (with discussion of genus and sp.).

Nigrini and Lombari (1984, p. S98) found this species "common in most of the Miocene sections from both tropical and temperate latitudes." According to Lozano (1974, fig. IV-20), ". . . it is always present under Antarctic waters and generally present under southern subantarctic waters." In general, specimens having thicker and shorter spirals than seen in the holotype of *L. minor* were assigned to *L. nautiloides*.

Genus LITHOCARPIUM Stohr, 1880, emend. Petrushevskaya, 1975

LITHOCARPIUM POLYACANTHA (Campbell and Clark)

Pl. 3, fig. 6

Larnacantha polyacantha CAMPBELL and CLARK, 1944, p. 30, pl. 5, fig. 4-7.

Lithocarpium polyacantha (Campbell and Clark) group. PETRUSHEVSKAYA, 1975, p. 572, pl. 3, fig. 6-8; pl. 29, fig. 6.

Lithocarpium polyacantha (Campbell and Clark). DUMITRICA, 1978, p. 239, pl. 4, fig. 8.

This is a long ranging species group that probably could be subdivided for useful stratigraphic application. Some of the specimens logged from the Sweeny Road section, as well as some included in counts by Campbell and Clark (1944) may be synonymous with several widely distributed species.

Suborder NASSELLARIA Ehrenberg, 1875

Family PLAGONIIDAE Haeckel, 1881, emend. Riedel, 1967b

Numerous small radiolarians have been found in the Monterey Formation and in the overlying beds that belong to *Antarctissa* and related genera. Like the Acanthodesmids, this group requires extensive study of monographic scope before taxonomic and stratigraphic order can be established. *Antarctissa denticulata* and the three unspeciated forms illustrated herein are only a few of the species groups that could be established within the genus. Preliminary observations of material from Sweeny Road, Point Pedernales, Naples Beach, and Newport Bay indicate that there are coeval horizons within the Middle Miocene to Lower Pliocene sequence that could be recognized by definitive study of *Antarctissa* and related genera. Data by Weaver *et al.* (1981, fig. 20 from the Newport Bay section also suggest this conclusion.

Genus ANTARCTISSA Petrushevskaya, 1967

ANTARCTISSA DENTICULATA (Ehrenberg)

Pl. 4, fig. 3

Lithobotrys denticulata EHRENBERG, 1844, p. 203.

Lithopera denticulata (Ehrenberg). EHRENBERG, 1873, pl. 12, fig. 7.

Antarctissa denticulata (Ehrenberg). PETRUSHEVSKAYA, 1967, p. 88, fig. 49, I.

Specimens from near the top (Pliocene) of the section resemble this species recorded by Petrushevskaya from the Antarctic.

PLATE 3

1. *Spongotrochus*(?) *venustum* (Bailey). 66, x320.
2,3. *Xiphospira* sp. cf. *X. circularis* (Clark and Campbell). 69, x320.
4. *Stylodictya validispina* Jørgensen. 73, x400.
5. *Lithelius nautiloides* Popofsky. 72, x320.
6. *Lithocarpium polyacantha* (Campbell and Clark). 48, x400.
7. *Stylodictya validispina* Jørgensen. 42, x400.
8. *Larcospira quadrangula* Haeckel. 65, x320.
9. *Phorticium polycladum* Tan and Tchang. 39, x362.
10. *Lithelius minor* Jørgensen. 45, x320.
11. *Phorticium polycladum* Tan and Tchang. 72, x320.
12. *Lithelius nautiloides* Popofsky. 68, x320.

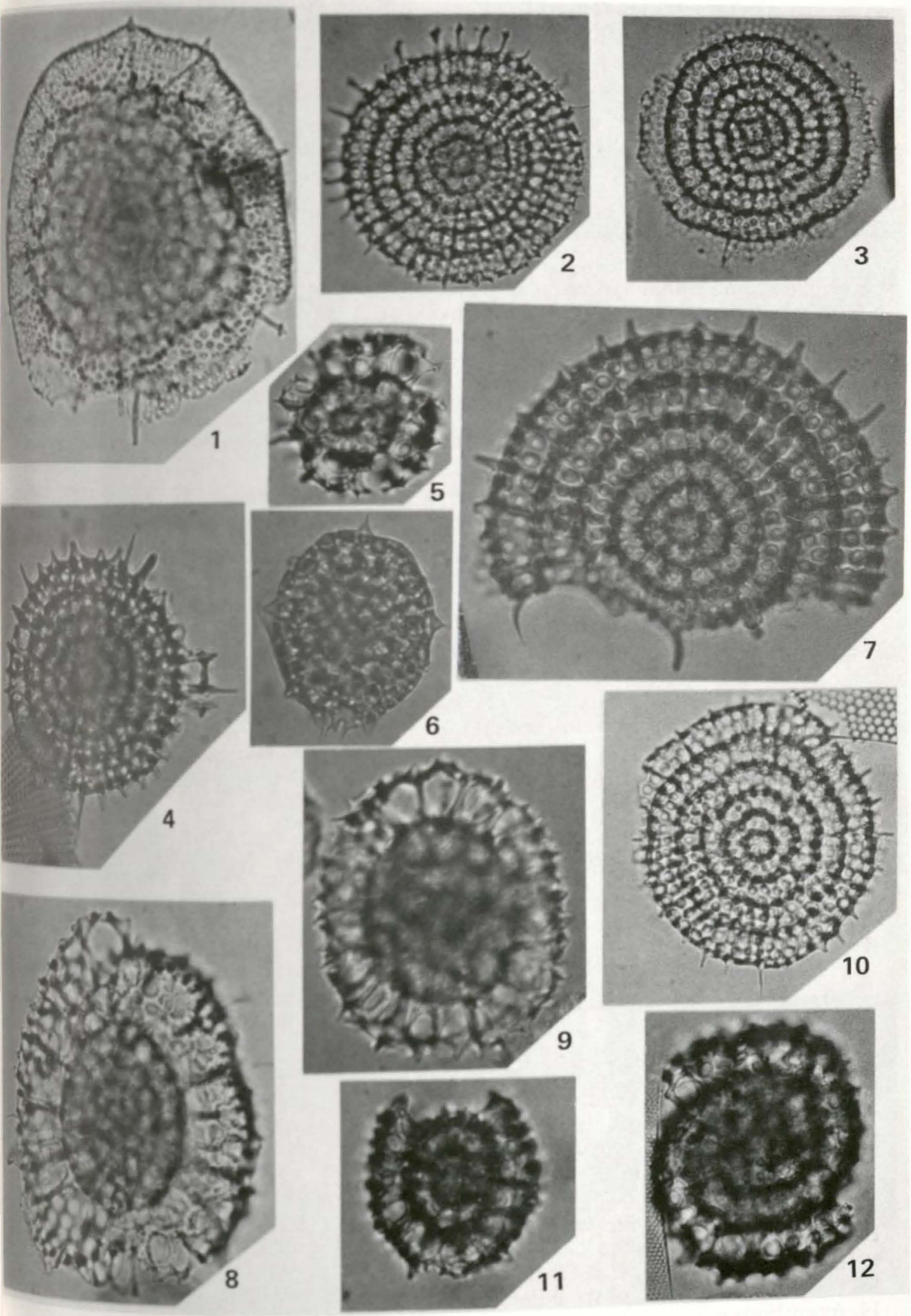


PLATE 3

ANTARCTISSA sp. Group 1
Pl. 4, fig. 1, 2, 4

This group is distinguished by the large size of the thorax relative to the cephalis and by spines that begin as ridges on the proximal portion of the thorax and project beyond the base when not broken off.

ANTARCTISSA sp. Group 2
Pl. 4, fig. 5

This group is distinguished by a large, thorny cephalis that is approximately equal in diameter to the thorax. Spines project beyond the base of the thorax.

ANTARCTISSA sp. Group 3
Pl. 4, fig. 6, 7

This group is distinguished by the hemiellipsoidal shape of the cephalis, a single horn at the tip of the cephalis, and the absence of spines at the distal margin of the shell.

Family TRISSOCYCLIDAE Haeckel, 1881, emend. Goll, 1968
(= Acanthodesmiidae Haeckel, 1862 *in* Riedel, 1971)

Acanthodesmid spp.
Pl. 4, fig. 9-11, 14

Several species belonging to this family were seen throughout the Sweeny Road section, but no attempt was made to record stratigraphic successions or morphologic categories. A comprehensive study of the monographic magnitude and worldwide scope is necessary before the numerous described and unpublished Acanthodesmids can be brought into proper perspective.

Family CARPOCANIIDAE Haeckel, 1881, emend. Riedel, 1967b

Genus et spp. indet.
Pl. 4, fig. 8, 12, 13

This is another family for which monographic treatment is necessary before taxonomic order and stratigraphic successions can be established. Forms assigned to the genera, *Carpocanistrum* and *Carpocanarium*, were logged throughout the Sweeny Road section, but they were not found in high frequency in any of the samples.

Family THEOPERIDAE Haeckel, 1881, emend. Riedel, 1967b

Genus BATHROPYRAMIS Haeckel, 1881

BATHROPYRAMIS WOODRINGI
Campbell and Clark
Pl. 5, fig. 1, 2

Bathropyramis woodringi CAMPBELL and CLARK, 1944, p. 39, pl. 5, fig. 21, 22.
Peripyramis circumtexta Haeckel. CASEY, 1971, pl. 23.1, fig. 11, CASEY *et al.*, 1972, pl. 2, fig. 4.

This long ranging and widely occurring species was found in Early Miocene to Latest Pleistocene at Site 173, Leg 18.

PLATE 4

1. *Antarctissa* sp. Group 1. 43, x375.
2. *Antarctissa* sp. Group 1. 65, x540.
3. *Antarctissa denticulata* (Ehrenberg). 71, x400.
4. *Antarctissa* sp. Group 1. 39, x312.
5. *Antarctissa* sp. Group 2. 69, x400.
6. *Antarctissa* sp. Group 3. 71, x400.
7. *Antarctissa* sp. Group 3. 72, x250.
8. Carpocaniidae, gen. et sp. indet. 39, x320.
9. Acanthodesmid sp. 39, x312.
10. Acanthodesmid sp. 60, x250.
11. Acanthodesmid sp. 39, x250.
12. Carpocaniidae, gen. et sp. indet. 39, x400.
13. Carpocaniidae, gen. et sp. indet. 39, x811, SEM.
14. Acanthodesmid sp. 39, x250.

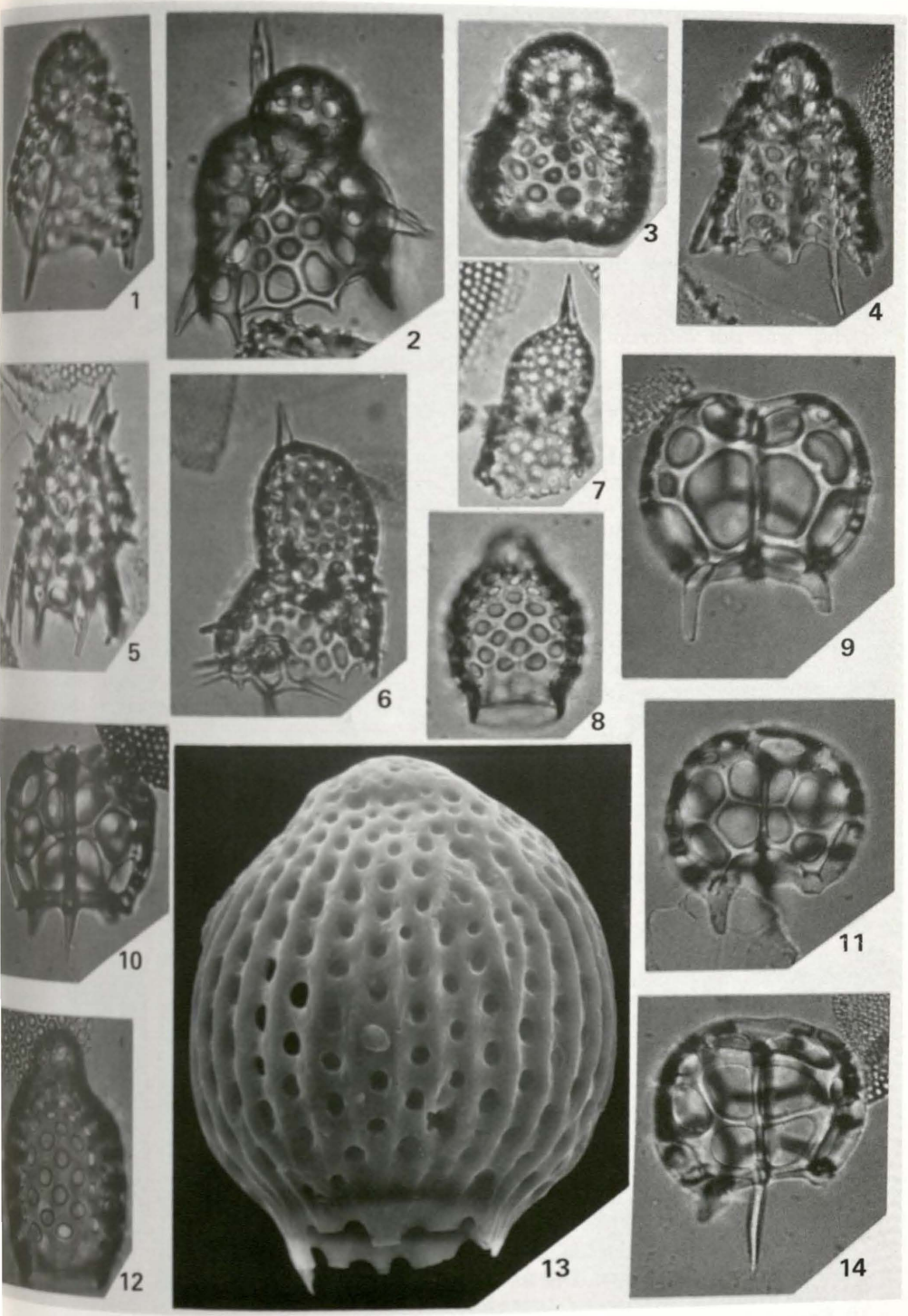


PLATE 4

Genus CLATHROCYCLAS Haeckel, 1887

CLATHROCYCLAS CABRILLOENSIS Campbell and Clark
Pl. 5, fig. 3

Clathrocyclas cabrilloensis CAMPBELL and CLARK, 1944, p. 48, pl. 7, fig. 1-3; KLING, 1973, p. 635, pl. 9, fig. 23-25.

The species may be confined to the Miocene at Site 173 (Kling, 1973, p. 635), but similar forms range higher, and the degree of acceptable variation has not been defined. This species, with two apical horns, was not differentiated from *Conarachnium*(?) *martini* (Campbell and Clark), with a single apical horn, when incomplete specimens were tabulated.

Genus CORNUTELLA Ehrenberg, 1838, emend. Nigrini, 1967

CORNUTELLA PROFUNDA Ehrenberg
Pl. 5, fig. 4

Cornutella clathrata ß *profunda* EHRENBERG, 1854b, p. 241.
Cornutella profunda Ehrenberg. EHRENBERG, 1858, p. 31; NIGRINI, 1967, p. 60, pl. 6, fig. 5a-c (with comprehensive synonymy).
Cornutella paloverdensis CAMPBELL and CLARK, 1944, p. 40, pl. 5, fig. 17, 20, 23, 24, 25.

According to Kling (1973, p. 636), "this species includes numerous intergrading variants, many of which have been described as separate species." He recorded the species from Early Miocene to Late Pleistocene at Site 173.

Genus CYRTOCAPSELLA Haeckel, 1887

CYRTOCAPSELLA CORNUTA (Haeckel)
Pl. 5, fig. 7

Cyrtocapsa (Cyrtocapsella) cornuta HAECKEL, 1887, p. 1513, pl. 78, fig. 9.
Cyrtocapsella cornuta (Haeckel). SANFILIPPO and RIEDEL, 1970, p. 453, pl. 1, fig. 19-2 (with synonymy).

Theyer *et al.* (1978) date the first occurrence of this species at 21.75 Ma and the last occurrence of this species at 11.7 Ma. Rare specimens in the Sweeny Road section have been recycled from Middle or Lower Miocene sediments.

CYRTOCAPSELLA TETRAPERA (Haeckel)
Pl. 6, fig. 8

Cyrtocapsa tetrapera Haeckel, 1887, p. 1512, pl. 78, fig. 5.
Cyrtocapsella tetrapera (Haeckel). SANFILIPPO and RIEDEL, 1970, p. 453, pl. 1, fig. 16-18 (with comprehensive synonymy); NIGRINI and LOMBARI, 1984, p. N109, pl. 23, fig. 5.

Specimens from Sweeny Road material are rare and abraded. The first occurrence of this species has been dated at 21.75 Ma by Theyer *et al.* (1978) and the last occurrence at 12.4-12.7 Ma by Nigrini (Nigrini and Lombari, 1984, p. N110) and more recently at 11.55-11.75 by Nigrini (pers. comm.); therefore, rare occurrences in the Sweeny Road section are considered to have been reworked.

Genus DICTYOPHIMUS Ehrenberg, 184

DICTYOPHIMUS CRISIAE Ehrenberg
Pl. 5, fig. 6

Dictyophimus crisiae EHRENBERG, 1854b, p. 241; NIGRINI, 1967, p. 66, pl. 6, fig. 7a-c; KLING, 1973, p. 636, pl. 4, fig. 11-15; pl. 10, fig. 18-20.
Pterocorys hirundo Haeckel. CASEY, 1971, p.

PLATE 5

1. *Bathropyramis woodringi* Campbell and Clark. 42, x320.
2. *Bathropyramis woodringi* Campbell and Clark. 69, x651, SEM.
3. *Clathrocyclas cabrilloensis* Campbell and Clark. 65, x320.
4. *Cornutella profunda* Ehrenberg. 39, x320.
5. *Dictyophimus*(?) sp. 69, x320.
6. *Dictyophimus crisiae* Ehrenberg. 39, x350. SEM.
7. *Cyrtocapsella cornuta* (Haeckel). 10, x320.
8. *Cyrtocapsella tetrapera* (Haeckel). 72, x250.
9,11. *Eucyrtidium* cf. *E. calvertense* Martin. 72, x250.
10. *Eucyrtidium* cf. *E. calvertense* Martin. 66, x250.

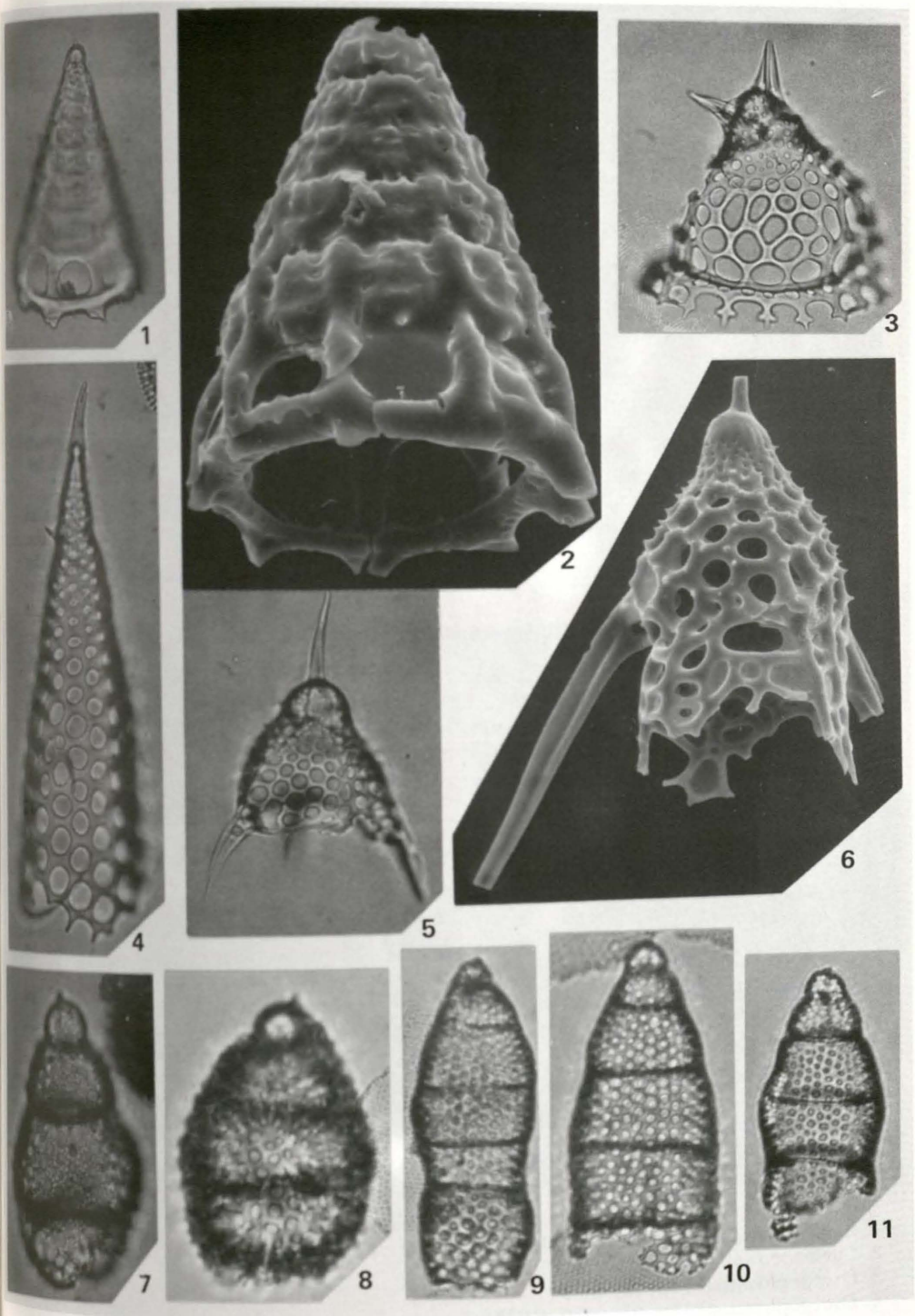


PLATE 5

23.1, fig. 6, 7; Petrushevskaya, 1967 *(partim)*, p. 115, fig. 4, 5.

(?)*Pterocorys hirundo* Haeckel. RIEDEL, 1958, p. 238, pl. 3, fig. 11; pl. 4, fig. 1; PETRUSHEVSDKAYA, 1967 (*partim*), p. 115, fig. 1-3.

Pterocorys splendens CAMPBELL and CLARK, 1944, p. 46, pl. 6, fig. 16, 19, 20; WEAVER *et al.*, 1981, pl. 3, fig. 5, 6.

The range recorded at Site 173 is from the *Dorcadospyris alata* Zone (Miocene) to the *Artostrobium miralestense* Zone (Late Pleistocene). Weaver *et al.* (1981, p. 79, 80) speculated that this form (jr. syn., *Pterocorys splendens)*, along with other species that characterize the *Stichocorys delmontensis* assemblage, including *S. delmontensis, Axoprunum angelinum*, and *Clathrocyclas cabrilloensis*, are "deeper living forms which became more abundant because shallow living radiolarians were generally unsuccessful in competing with diatoms for silica and nutrients at this time."

DICTYOPHIMUS (?) sp.
Pl. 5, fig. 5; Pl. 6, fig. 3, 4.

Forms are referred to here that have approximately twice as many thoracic pores and shorter thoracic spines than *D. crisiae*. Monographic-type research is necessary for these genera if the occasional specimens recovered from the California coastal formations are to be speciated.

Genus EUCYRTIDIUM Ehrenberg, 1847, emend. Nigrini, 1967.

EUCYRTIDIUM sp. cf. E. CALVERTENSE Martin
Pl. 5, fig. 9-11

Eucyrtidium calvertense MARTIN, 1904, p. 450, pl. 130, fig. 5; HAYS, 1965, p. 181, pl. 3, fig. 4; 1970, p. 213, pl. 1, fig. 6; KLING, 1973, p. 636, pl. 4, fig. 16, 18, 19; pl. 11, fig. 1-5.

Definitive work is needed on the species of this genus. Several species occur in the coastal California outcrops. My specimens are assigned tentatively to *E. calvertense*. The range of this species at Site 173 is Early Miocene to Late Pleistocene (Kling, 1973).

Genus LYCHNOCANOMA Haeckel, 1887

LYCHNOCANOMA GRANDE
(Campbell and Clark)
Pl. 6, fig. 1

Lychnocanium grande CAMPBELL and CLARK, 1944, p. 42, pl. 6, fig. 3, 4, 6.

Lychnocanoma grande (Campbell and Clark) KLING, 1973, p. 637, pl. 10, fig. 10-14; WEAVER *et al.*, 1981, pl. 2, fig. 4, 5.

Kling (1973, p. 10, fig. 10-14) logged and illustrated specimens throughout the Miocene section at DSDP Site 173, but he also illustrated specimens from the Pleistocene (Kling, 1973, pl. 4, fig. 9, 10) as *L.* sp. cf. *L. grande* that are similar to the Miocene forms. His Pleistocene specimens appear to have smaller, more closely spaced, and more numerous thoracic pores than seen in his Miocene forms, judging solely by the figures.

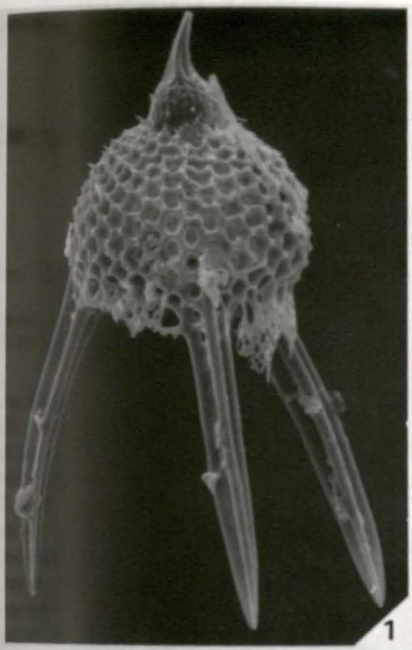
Weaver *et al.* (1981, fig. 2) gave the lowermost occurrence (BM) of *L. grande* at 13.25 Ma (Middle Miocene) and the uppermost occurrence (TM) at 5.75 Ma (Late Miocene) in the section at Newport Bay.

LYCHNOCANOMA sp.
Pl. 6, fig. 2

The cephalis in this form is smooth and without pores, having no distinct demarcation between cephalis and the broad, tapering horn, if, indeed, the animal can be said to have a cephalis. The feet are three-bladed and similar to those of *L. grande*, but the thoracic wall structure differs in that *L.* sp. has pores that are twice as large and thorns that are coarser. Further attention to these differences is necessary to determine the precisely relative stratigraphic implications of the members of the genus *Lychnocanoma*.

PLATE 6

1. *Lychnocanoma grande* (Campbell and Clark). 60, x316, SEM.
2. *Lychnocanoma* sp. 39, x340, SEM.
3. *Dictyophimus*(?) sp. 39, x320.
4. *Dictyophimus*(?) sp. 51, x379, SEM.



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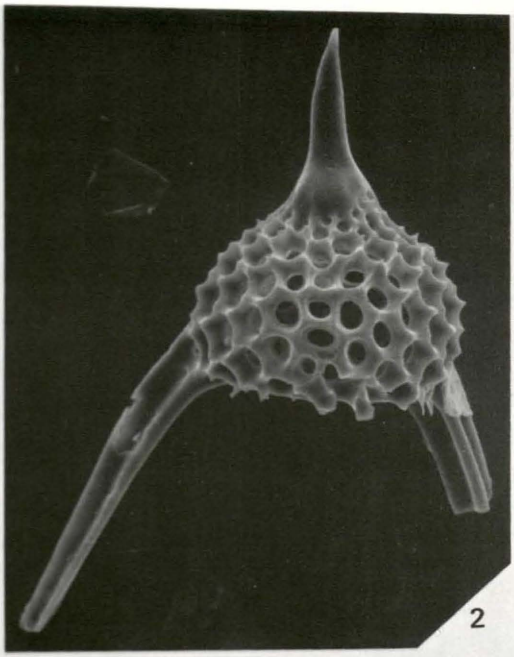

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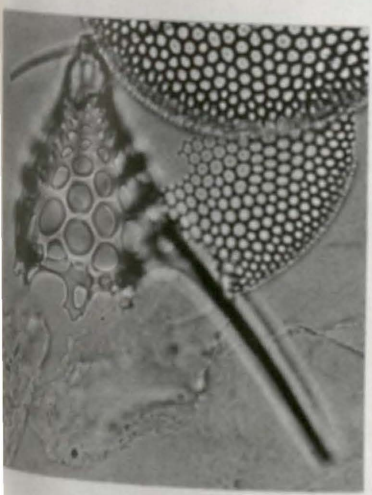

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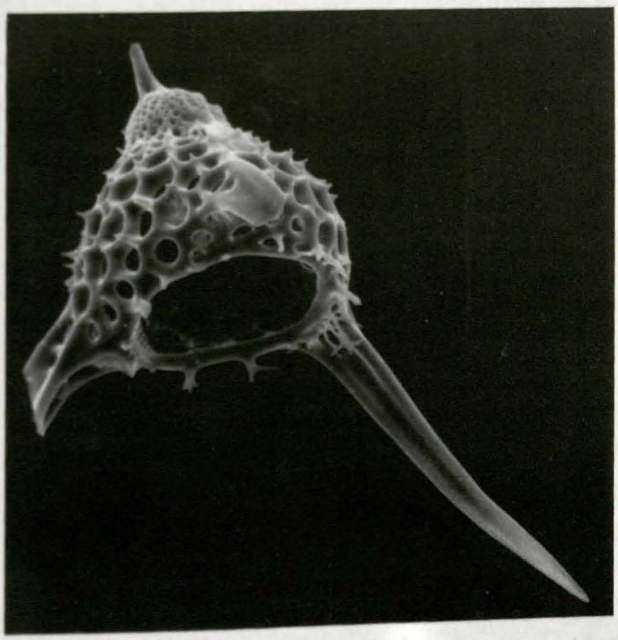


4

PLATE 6

Genus STICHOCORYS Haeckel, 1881

STICHOCORYS PEREGRINA (Riedel)
Pl. 7, fig. 1-3

Eucyrtidium elongatum peregrinum RIEDEL, 1953, p. 812, pl. 85, fig. 2; Riedel, 1957, p. 94.
Stichocorys peregrina (Riedel). SANFILIPPO and RIEDEL, 1970, p. 451, pl. 1, fig. 10; NIGRINI and LOMBARI, 1984, p. N133, pl. 25, fig. 6 (with data on identification and distribution).

Nigrini and Lombari (1984, p. N134) found this species abundant throughout Late Miocene sections in both tropical and temperate latitudes. They did not find it in any of the Early and Middle Miocene sections.

Theyer *et al.* (1978) dated the first occurrence at 6.4 Ma in the equatorial Pacific. Weaver *et al.* (1981) place the first occurrence at 7.0 Ma in the Newport Bay section (by correlation). The last occurrence is dated by Theyer *et al.* (1978) at 2.4 Ma and more recently at 2.55-2.85 by Nigrini (pers. comm). This is close to the date given by Kling (1973, fig. 1) of 2.8 Ma for Site 173 but at variance with the date (by correlation?) of Weaver *et al.*, 4.4 Ma, for Newport Bay.

The test is resistant to corrosion, a useful feature in diagenetic intervals where diatoms and the more fragile Nassellarians have been destroyed.

Genus STICHOPERA Haeckel, 1881

STICHOPERA PECTINATA Haeckel group
Pl. 7, fig. 4

Stichopera pectinata HAECKEL, 1887, p. 1449, pl. 75, fig. 11; Kling, 1973, p. 638, pl. 3, fig. 25-27; pl. 10, fig. 1-5.
Cyrtopera laguncula HAECKEL, 1887, p. 1451, pl. 75, fig. 10.

The species group is rare in the Monterey Formation. It ranges from Early Miocene to Late Pleistocene at Site 173.

Genus THEOCALYPTRA Haeckel, 1887

THEOCALYPTRA BICORNIS (Popofsky)
Pl. 7, fig. 6, 8

Pterocorys bicornis POPOFSKY, 1908, p. 29 pl. 34, fig. 7, 8.
Theocalyptra bicornis (Popofsky). RIEDEL 1958, p. 240, pl. 4, fig. 4; PETRUSHEVSKAYA, 1967, p. 126, pl. 71, fig. 2-9; pl. 72, fig. 1-4; NIGRINI and MOORE, 1979, p. N53, pl. 24, fig. 1.

Definitive study is needed for this group and should include species referred to *Theocalyptra* and *Clathrocyclas*. Forms with a single horn are tentatively included here, as well as specimens bearing two well-developed horns. Other differences are not apparent.

Genus THEOCORYS Haeckel, 1881

THEOCORYS sp. cf. T. REDONDOENSIS (Campbell and Clark)
Pl. 7, fig. 5

Theocyrtis redondoensis CAMPBELL and CLARK, 1944, p. 49, pl. 7, fig. 4; CASEY *et al.*, 1972, pl. 2, fig. 3.
Theocorys redondoensis (Campbell and Clark). KLING, 1973, p. 638, pl. 11, fig. 26-28; NIGRINI and LOMBARI, 1984, p. N143, pl. 26, fig. 4 (descriptive notes and distribution).

At Site 173, *T. redondoensis* ranges from the *Dorcadospyris alata* Zone (Early Miocene) to the *Stichocorys peregrina* Zone (Late Miocene). It is rare in the Sweeny Road section. The illustrated specimen bears traces (remnants?) of thoracic spines and, accordingly, is not typical of the species. Most of our specimens have spines, whereas specimens without spines are rare, and we wonder if the species should be emended to include forms with spines.

PLATE 7

1-3. *Stichocorys peregrina* (Riedel). 1, 39, x384, SEM; 2, 69, x400; 3, 31, x320.
4. *Stichopera pectinata* Haeckel group. 39, x400.
5. *Theocorys* cf. *T. redondoensis* (Campbell and Clark). 60, x320, SEM.
6,8. *Theocalyptra bicornis* (Popofsky). 6, 72, x320; 8, 69, x320.
7,9. *Theocorys* sp. 7, 66, x250; 9, 51, x505, SEM.

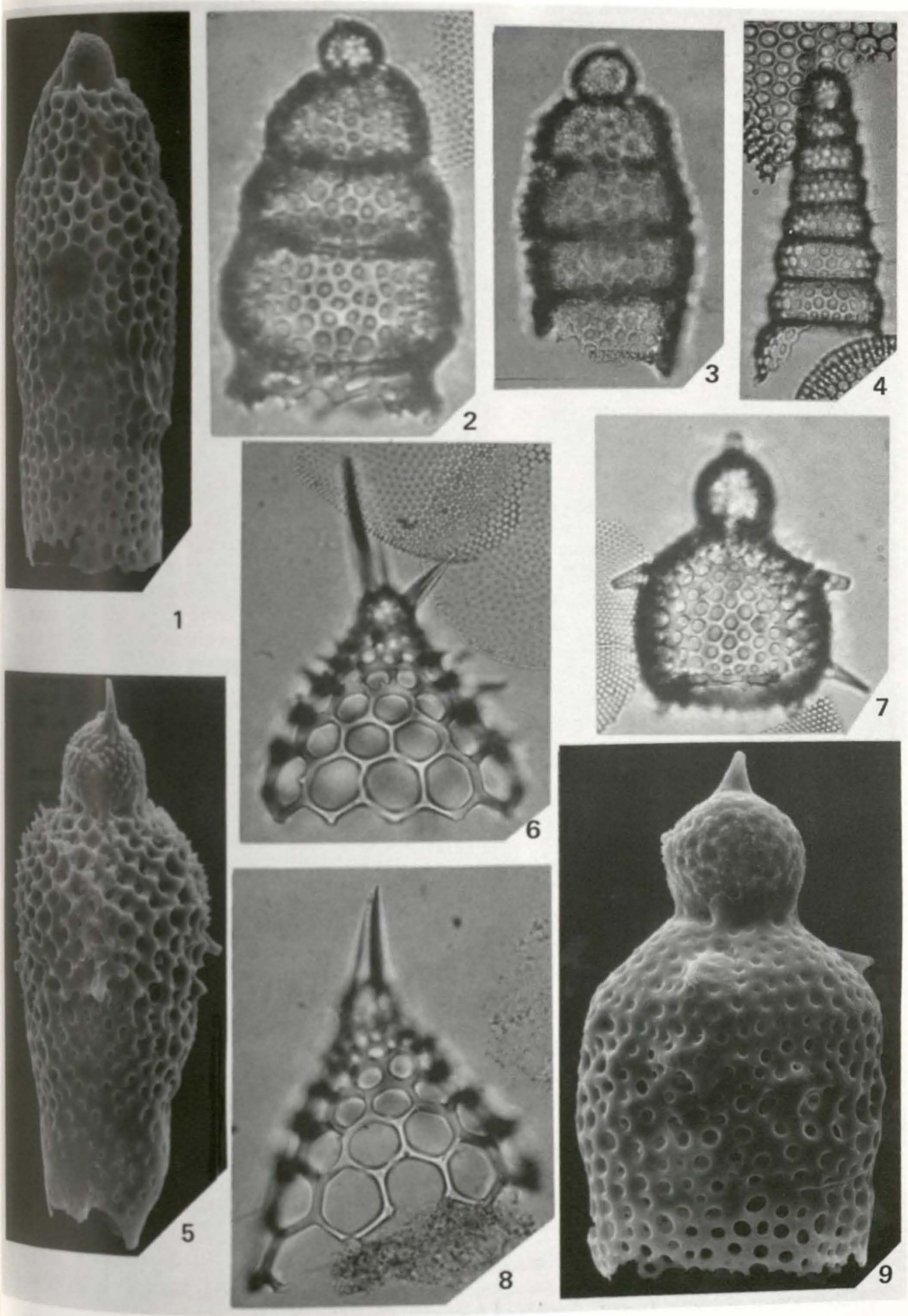


PLATE 7

THEOCORYS sp.
Pl. 7, fig. 7, 9

This group is designated for those specimens with two series of long, well-developed thoracic spines. See *T.* sp. cf. *T. redondoensis*.

Family PTEROCORYTHIDAE Haeckel, 1881, emend. Riedel, 1967b emend. Moore, 1972

Genus ANTHOCYRTIDIUM Haeckel, 1881

ANTHOCYRTIDIUM OPHIRENSE (Ehrenberg)
Pl. 8, fig. 1

Anthocyrtis ophirensis EHRENBERG, 1872, p. 301; Haeckel, 1887, p. 1270.
Anthocyrtidium ophirense (Ehrenberg). NIGRINI, 1967, p. 56, pl. 6, fig. 3 (with synonymy); NIGRINI and MOORE, 1979, p. N67, pl. 25, fig. 1.

Pores are larger in specimens from the Monterey Formation than illustrated for *A. ehrenbergi ehrenbergi* (Stohr) or *A. ophirensis* (Ehrenberg).

Genus LAMPROCYRTIS Kling, 1973

LAMPROCYRTIS(?) HANNAI
(Campbell and Clark)
Pl. 8, fig. 2-5

Calocyclas hannai CAMPBELL and CLARK, 1944, p. 48, pl. 6, fig. 21-22; CASEY *et al.*, 1972, pl. 2, fig. 19.
(?)*Calcocyclas margatensis* CAMPBELL and CLARK, 1944, p. 47, pl. 6, fig. 17-18; CASEY *et al.*, 1972, pl. 3, fig. 10-22.
Lamprocyrtis(?) *hannai* (Campbell and Clark). KLING, 1973, p. 638, pl. 5, fig. 12-14; pl. 12, fig. 10-14; NIGRINI and MOORE, 1979, p. N83, pl. 25, fig. 8.

This species has been found throughout Miocene sections from both tropical and temperate latitudes (Nigrini and Lombari, 1984, p. N166). Kling (1973, pl. 5, fig. 12-14; pl. 12, fig. 10-14) figured specimens from the *Calocycletta costata* Zone (Early Miocene) to the *Artostrobium miralestense* Zone (Late Pleistocene) for DSDP Site 173. It is also present in Holocene samples (Nigrini and Moore, 1979, p. N84), but to my knowledge, neither modern nor fossil occurrences are known outside the Pacific Ocean region. Kling (1973, p. 638), proposed *L.*(?) *hannai* as a likely ancestor of the Piocene-Pleistocene *L. heteroporos*.

LAMPROCYRTIS HETEROPOROS (Hays)
Pl. 8, fig. 6-9

Lamprocyclas heteroporos HAYS, 1965, p. 178, pl. 3, fig. 1; KLING, 1971, p. 1088, pl. 1, fig. 1.
Lamprocyclas heteroporos? Hays. HAYS, 1970, p. 214, pl. 1, fig. 3.
Lamprocyrtis heteroporos (Hays). KLING, 1973, p. 618, 639, pl. 5, fig. 19-21; pl. 15, fig. 6; WEAVER *et al.*, 1981, p. 80, 81, pl. 5, fig. 1.

This species is characteristic of the upper part of the Sweeny Road section (Pliocene). It is also well represented in the Pliocene beds at DSDP Site 173 and Newport Bay. The following quotations are worthy of note in regard to these localities and other occurrences of *L. heteroporos* in the Pacific Coast region:

"Pliocene. The base of the Pliocene in the Pacific Coast region is tentatively taken as the earliest appearance of *Lamprocyrtis heteroporos* (= *Lamprocyclas heteroporos*). This level occurs near the top of the Capistrano formation at Newport Bay, California (unpublished data), at a level approximating the Miocene-Pliocene boundary based on foraminifera" (Ingle, 1967, 1972). At Malaga Cove, California, it occurs in the Malaga Mudstone with the Delmontian stage according to Casey *et al.* (1972).

"At Site 173, *Lamprocyrtis heteroporos* ranges above the first appearance of *Eucyrtidium matuyamai*, its extinction level in the North Pacific. Therefore, the first evolutionary appearance of *E. matuyamai* is taken as the top of the *L. heteroporos* Zone and base of the overlying *E. matuyamai* Zone. This level appears

PLATE 8

1. *Anthocyrtidium ophirense* Ehrenberg. 43, x320.
2-5. *Lamprocyrtis(?) hannai* (Campbell and Clark). 2, 64, x334, SEM; 3-4, 64, x375, A specimen at two different levels of focus; 5, 60, x450, SEM.
6-9. *Lamprocyrtis heteroporos* (Hays). 6, 71, x320; 7, 60, x250; 8, 69, x460, SEM; 9, 72, x250.

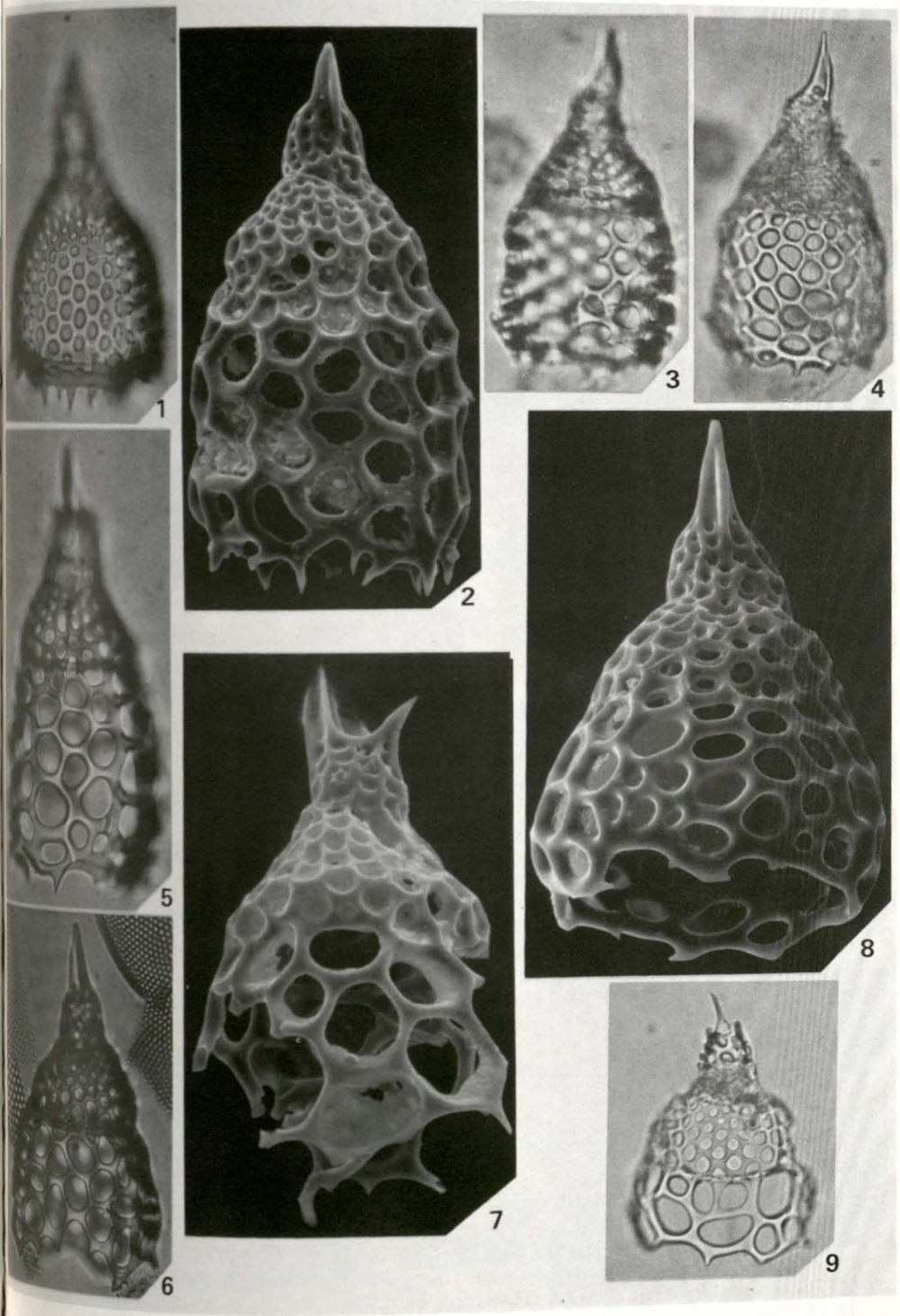


PLATE 8

consistent with the first appearance of *E. matuyamai* in the North Pacific and agrees more closely with estimates of the Pliocene-Pleistocene boundary based on other microfossils at Site 173 than does the top of *Lamprocyrtis heteroporos*. Radiometric-paleomagnetic dates are assumed to be the same as in the Gulf of Alaska, although comparison with the paleomagnetic results from this site (Heinrichs, this volume) may reveal some disagreement due to differing species ranges." (Kling, 1973, p. 618).

"The *Lamprocyrtis heteroporos* assemblage is very similar to the *Stichocorys peregrina* assemblage with the exception that *Lamprocyrtis heteroporos* is present. Just as in the upper portion of the range of the *Stichocorys peregrina* assemblage, warm water radiolarians are nearly absent. When they do occur, percentages never exceed 1%. These warm water radiolarians usually consist of specimens of *Eucyrtidium acuminatum, Lamprocyclas maritalis*, or *Theoconus zancleus*.

"The *Lamprocyrtis heteroporos* assemblage, at least up to 4.7 m.y. B.P., appears to be a continuation of the cool temperate to transitional California Current fauna of the Late Miocene *Stichocorys peregrina* assemblage.

"At approximately 4.7 m.y. B.P., prior to the base of Barron's (in press) *Thalassiosira oestrupii* Zone, we observe the widespread occurrence of the *Lamprocyrtis heteroporos* acme. It is not uncommon to find *Lamprocyrtis heteroporos* representing up to 15% of the total fauna in any one sample. The exact significance of this acme as it may relate to paleoceanographic conditions is uncertain. However, at Centerville Beach, this acme is associated with the occurrence of tropical to warm temperate diatoms in the uppermost Pullen Formation. This suggests that this acme may be somehow related to the global warming that commenced at about this time which is well documented in the literature (Ingle, 1967; Stainforth *et al.*, 1975)" (Weaver *et al.*, 1981, p. 80-81).

Our studies of the section exposed in the cliffs at Newport back bay confirm the earliest occurrence of *L. heteroporos* as reported by Weaver *et al.* (1981, fig. 2, see Figure 7). This occurrence approximates their placement of the Miocene-Pliocene boundary.

Family ARTOSTROBIIDAE Riedel, 1967b, emend. Foreman, 1973

Genus BOTRYOSTROBUS Haeckel, 1887, emend. Nigrini, 1977

BOSTRYOSTROBUS AURITUS/AUSTRALIS (Ehrenberg) group
Pl. 9, fig. 1, 2, 5

Botryostrobus auritus/australis (Ehrenberg) group. NIGRINI, 1977, p. 246, pl. 1, fig. 3 (synonymy).

This group has been recorded from the *Diartus petterssoni* Zone to Holocene (Nigrini, 1977, p. 248).

BOTRYOSTROBUS BRAMLETTEI (Campbell and Clark)
Pl. 9, fig. 3, 4, 8

Lithomitra bramlettei CAMPBELL and CLARK, 1944, p. 53, pl. 7, fig. 10-14.
Botryostrobus bramlettei (Campbell and Clark). NIGRINI, 1977, p. 248, pl. 1, fig. 7 (synonymy); NIGRINI and LOMBARI, 1984, p. N175, pl. 31, fig. 2a-c.

Nigrini (1977, p. 249) recorded this species from the *Diartus petterssoni* Zone (Middle Miocene) to the *Stichocorys peregrina* Zone (Upper Miocene), but we found it in Sample 66, Sweeny Road, and Kling

PLATE 9

1,2,5. *Botryostrobus auritus/australis* (Ehrenberg) group. 1, 71, x320; 2, 39, x601, SEM; 5, 48, x320.
3,4,8. *Botryostrobus bramlettei* (Campbell and Clark). 3, 39, x568, SEM; 4, 72, +28 microns, x400; 8, 39, x312.
6,7,9. *Phormostichoartus fistula* Nigrini. 6,7, 73, x400; 9, 70, x320.
10. *Botryostrobus* cf. *B. miralestensis* (Campbell and Clark). 39, x526, SEM.
11. *Phormostichoartus corbula* (Harting). 44, x320.
12-14. *Phormostichoartus* sp. 12, 72, x400; 13, 39, +28 microns, x480; 14, 43, x400.

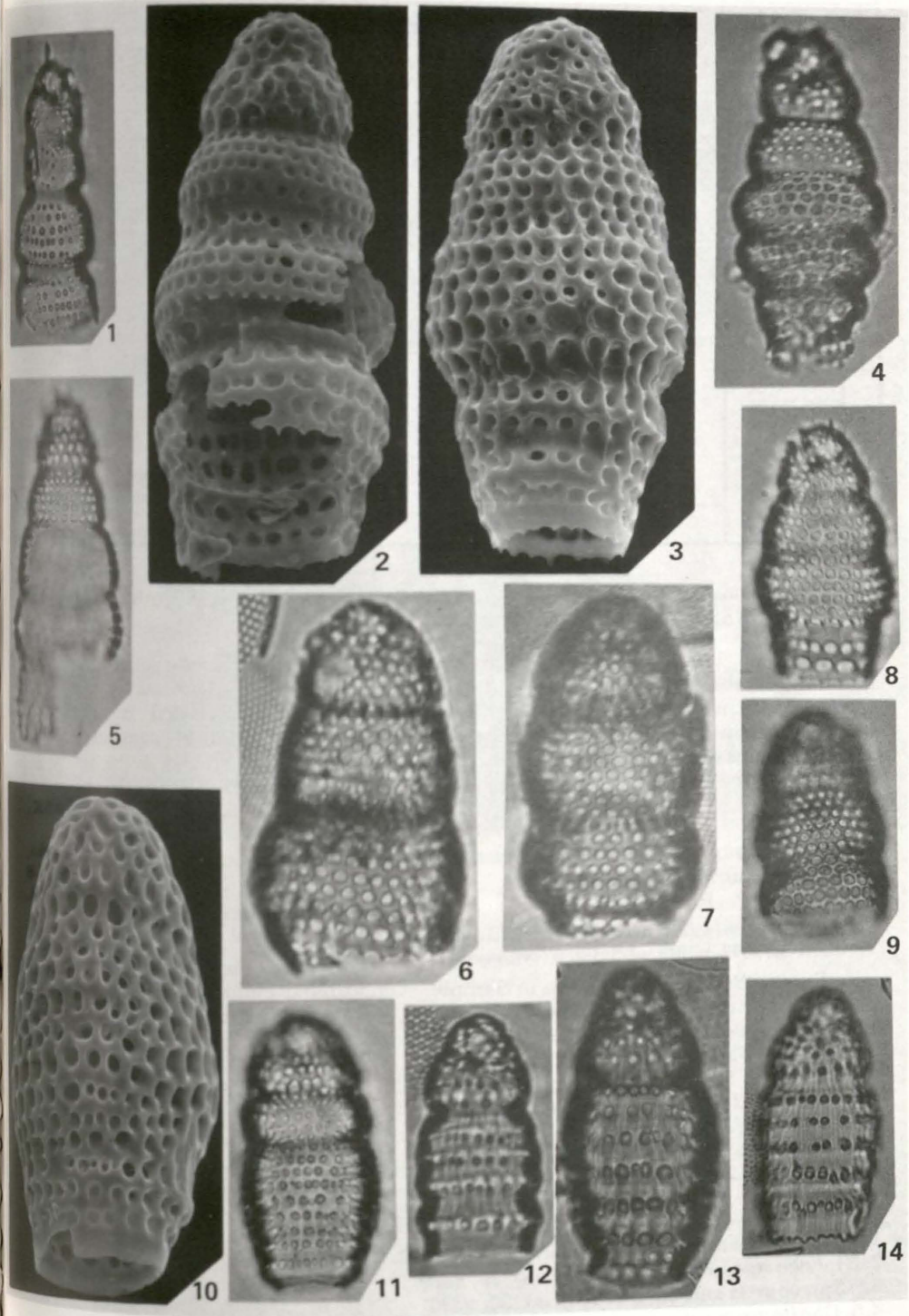


PLATE 9

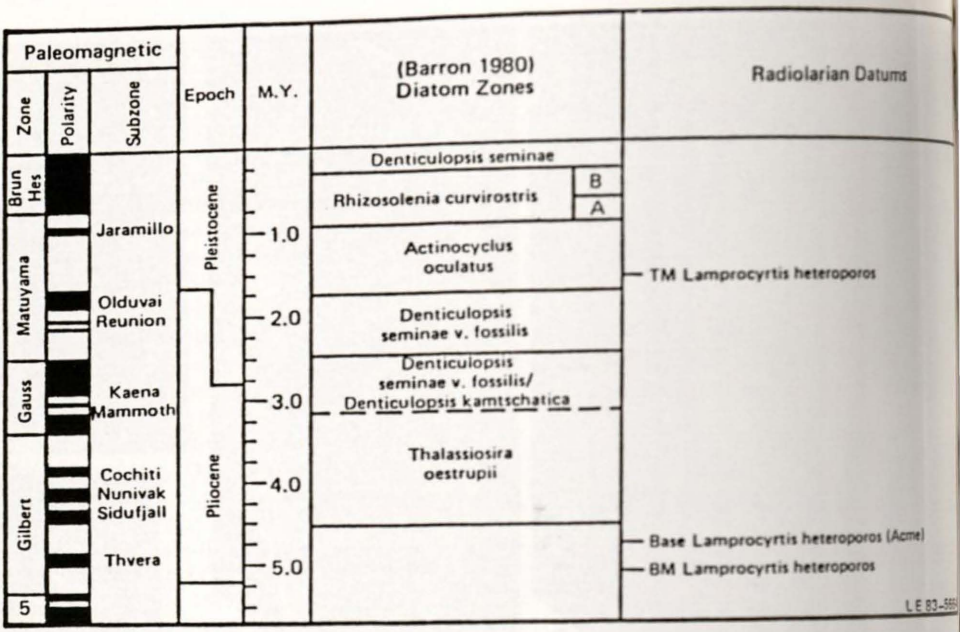


Figure 7. *Lamprocyrtis heteroporos* in the section at Newport Bay (After Weaver et al. 1981, portion of fig. 2).

(1973, pl. 5, 12) may have logged the species well above the Miocene at Site 173 as *Artostrobium auritum* (Ehrenberg). This species lived into the Pliocene, if these latter occurrences are, indeed, *B. bramlettei* and if they are not the result of redeposition.

BOTRYOSTROBUS cf. B. MIRALESTENSIS
(Campbell and Clark)
Pl. 9, fig. 10

Botryostrobus miralestensis CAMPBELL and CLARK, 1977, p. 249, pl. 1, fig. 9 (synonymy).

A diverse *Botryostrobus* fauna in Sample 39 contains rare specimens that are tentatively referred to the taxon of Campbell and Clark. The form was not found elsewhere in the Sweeny Road section. *Artostrobium miralestense* was logged by Kling (1973) from Early Miocene to latest Pleistocene at Site 173, but Nigrini (1977, p. 249, pl. 1, fig. 9) figured a similar form as *Botryostrobus miralestensis* (Campbell and Clark) and recorded it from Lower Miocene to Middle Miocene only.

Genus PHORMOSTICHOARTUS
Campbell, 1951, emend. Nigrini, 1977

PHORMOSTICHOARTUS CORBULA (Harting)
Pl. 9, fig. 11

Phormostichoartus corbula (Harting). NIGRINI, 1977, p. 252, pl. 1, fig. 10 (with synonymy).

This species is "rare to few from the *Dorcadospyris alata* Zone (Middle Miocene) to Recent," according to Nigrini (1977, p. 252).

PHORMOSTICHOARTUS FISTULA Nigrini
Pl. 9, fig. 6, 7, 9

Phormostichoartus fistula NIGRINI, 1977, p. 253, pl. 1, fig. 11-13 (with synonymy); NIG-

PLATE 10

1. *Siphocampe arachnea* (Ehrenberg). 42, x320.
2. *Siphocampe nodosaria* (Haeckel). 39, x320.
3. ?*Spirocyrtis subscalaris* Nigrini. 39, x320.
4,5. *Challengeron diodon* Haeckel. 4, 54, x320; 5, 60, x320.

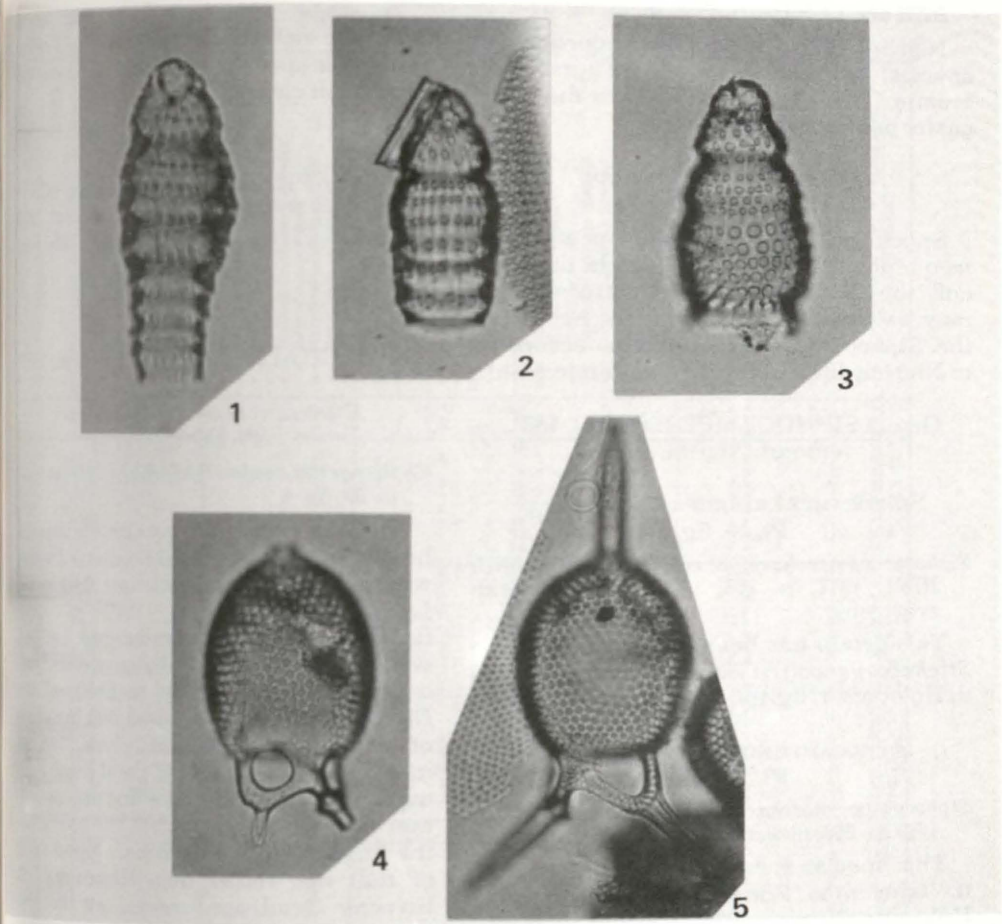


PLATE 10

RINI and LOMBARI, 1984, pl. 31, fig. 6a-c.

Nigrini (1977a, p. 253) has recorded this species as rare from the *Thyrsocyrtis bromia* Zone (Upper Eocene) to the *Spongaster pentas* Zone (Pliocene).

PHORMOSTICHOARTUS sp.
Pl. 9, fig. 12-14

Specimens of this group are of such low frequency that species concepts are difficult to visualize. Forms illustrated here may belong to several species, especially the *Siphocampe lineata* group, according to Nigrini, 1977 (personal communication).

Genus SIPHOCAMPE Haeckel, 1881, emend. Nigrini, 1977

SIPHOCAMPE ARACHNEA (Ehrenberg)
Pl. 10, fig. 1

Siphocampe arachnea (Ehrenberg) group. NIGRINI, 1977, p. 255, pl. 3, fig. 7-8 (with synonymy).

This group has been recorded from the *Stichocorys wolffii* Zone (Lower Miocene) to Holocene (Nigrini, 1977, p. 255).

SIPHOCAMPE NODOSARIA (Haeckel)
Pl. 10, fig. 2

Siphocampe nodosaria (Haeckel). NIGRINI, 1977, p. 256, pl. 3, fig. 11 (with synonymy).

This species is rare from the *Thyrsocyrtis triacantha* Zone (Middle Eocene) to Holocene (Nigrini, 1977, p. N192).

Genus SPIROCYRTIS Haeckel, 1881, emend. Nigrini, 1977

?SPIROCYRTIS SUBSCALARIS Nigrini
Pl. 10, fig. 3

Lithamphora furcaspiculata POPOFSKY, 1913, p. 408, text-fig. 132 (*partim*).
Spirocyrtis sp. aff. *S. scalaris* Haeckel. RIEDEL and SANFILIPPO, 1971, pl. 1G, fig. 19, 20, 22 (*partim*).
Spirocyrtis ex. gr. *scalaris* Haeckel. DUMITRICA, 1973, p. 840, pl. 15, pl. 9.
Artostrobiid cf. *Artostrobium rhinoceros* SANFILIPPO and RIEDEL, 1974, pl. 4, fig. 10 (*partim*).
Spirocyrtis subscalaris NIGRINI, 1977, p. 259, pl. 3, fig. 1, 2.

A single specimen from the Artostrobiidae-rich bed 39 is provisionally referred to this species. The duck-billed vertical tube is not clearly visible.

Order PHAEODARIA Haeckel, 1879
Suborder PHAEOGROMIA Haeckel, 1879
Family CHALLENGERIIDAE Murray, 1876

Genus CHALLENGERON Haeckel, 1887

CHALLENGERON DIODON Haeckel
Pl. 10, fig. 4, 5

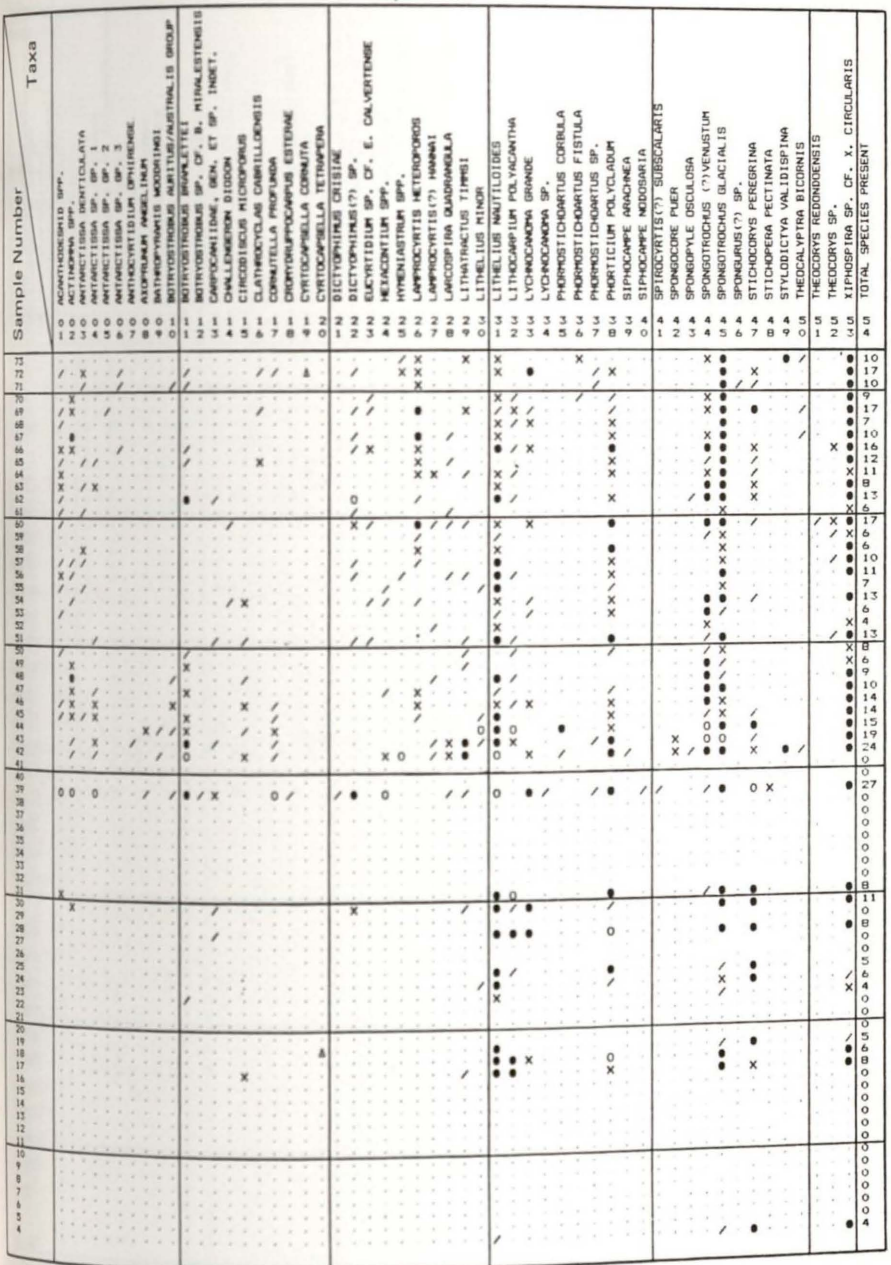
Challengeron diodon HAECKEL, 1887, p. 1654, pl. 99, fig. 6.

Rare specimens are conspecific with the holotype from "the southeastern Pacific, west of Valparaiso, *Challenger* Station 298, Lat. 40°3′S, Long. 132°58′W, 2600 fathoms." Haeckel characterized the shell wall of this genus as "diatomaceous," because of the similarity to shells of the Diatomaceae, and he noted that members of this phaeodarian family are "for the most part, inhabitants of great depth." To my knowledge, this is the first documentation of both the genus and the species in the Pliocene, unless Haeckel's type level is of that age rather than Holocene. The Sweeny Road occurrences are the first documentation of the order in the coastal California formations.

Dumitrica (1973c, p. 755) considered the challengeriids as "incontestably the most frequent phaeodarians in sediments, if not numerically, at least specifically." He recorded almost all suborders and families of Phaeodaria in cores of Leg 21 of the DSDP. This leg comprised an almost continuous radiolarian sequence from Oligocene to Quaternary, enabling him to trace the origin of some living taxa "to various levels of the Quaternary, Pliocene, or Miocene."

Haeckel (1887, p. 1653) attributed the genus to John Murray ("1879, in *litteris et schedulis*"), which was never validated by publication.

Check Chart I
Sweeny Road Radiolarians
Alphabetized



Symbol	Frequency Key No. Specimens/Slide (2x4 cm)
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X	2–4
0	5 or More
●	5 or More and One of the 5 Most Frequent
&	Reworked

Check Chart II
Sweeny Road Radiolarians
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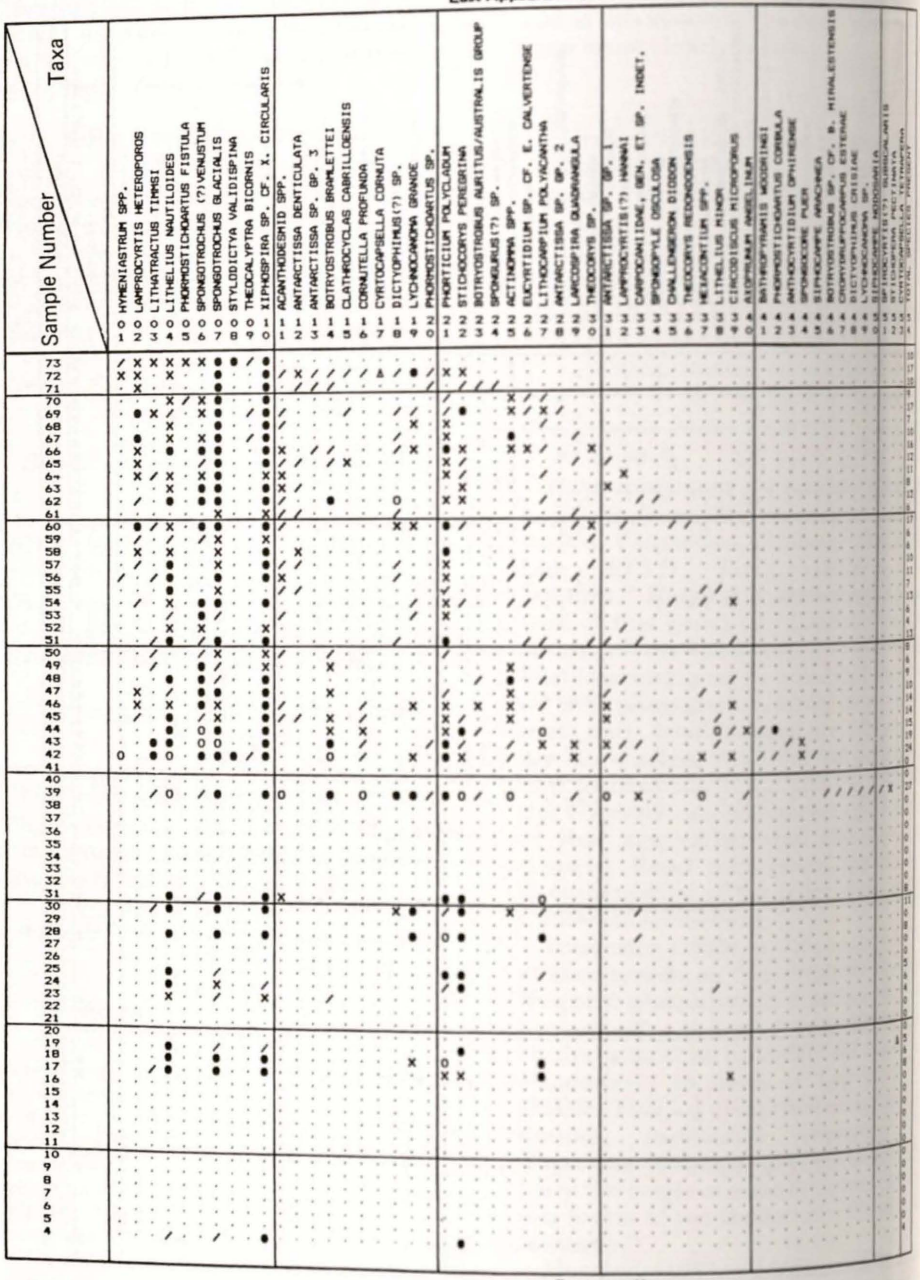
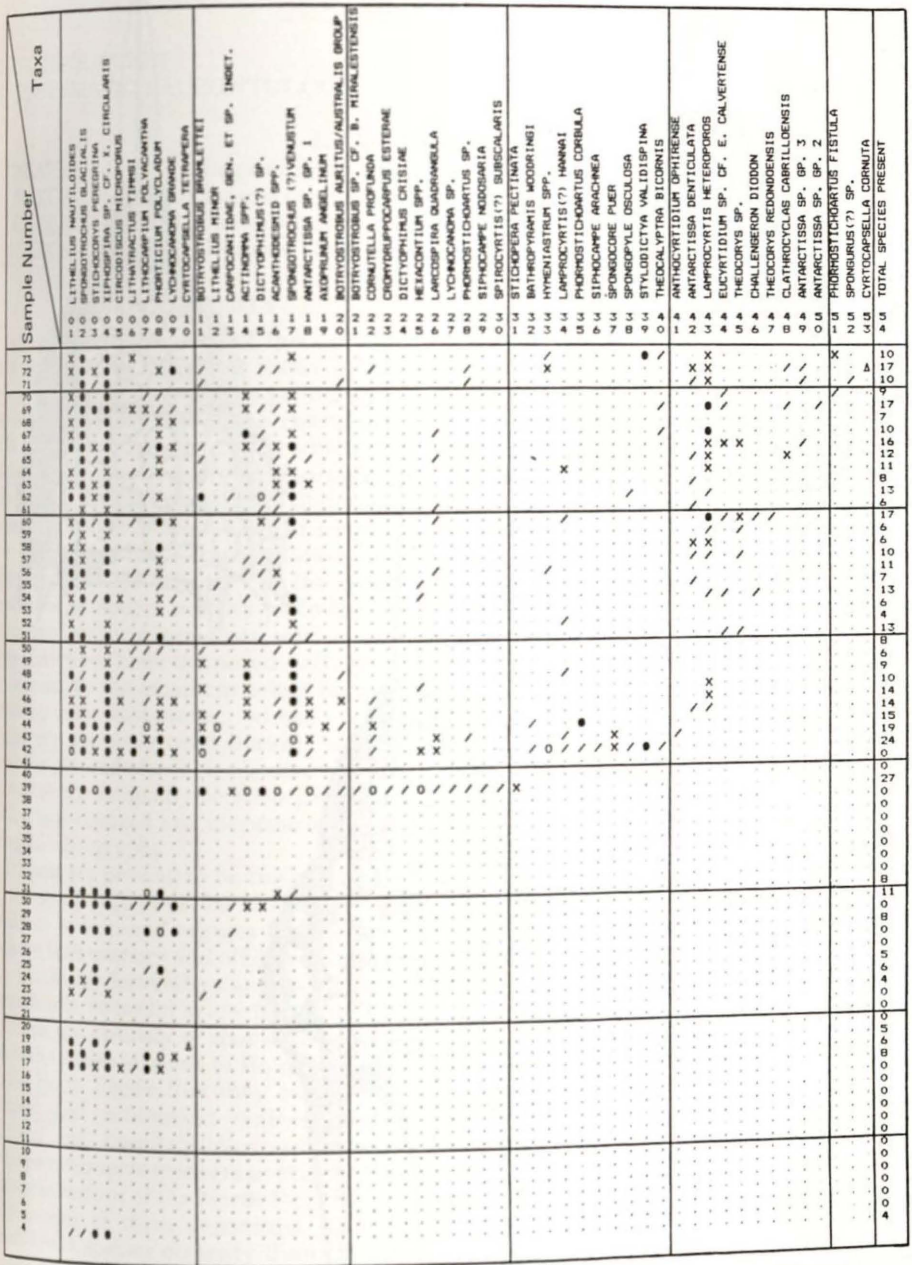
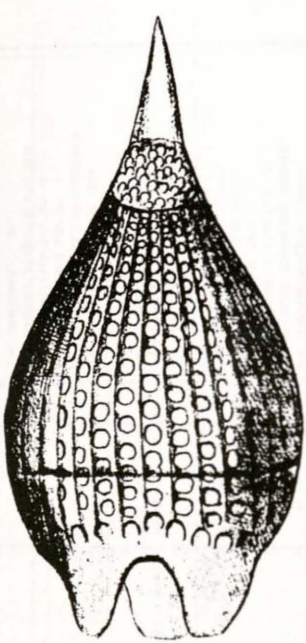


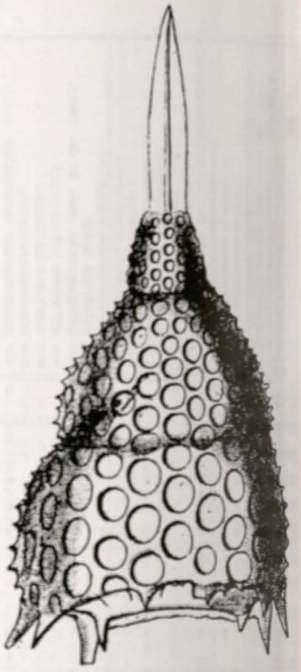
Check Chart III
Sweeny Road Radiolarians
First Appearance Datum

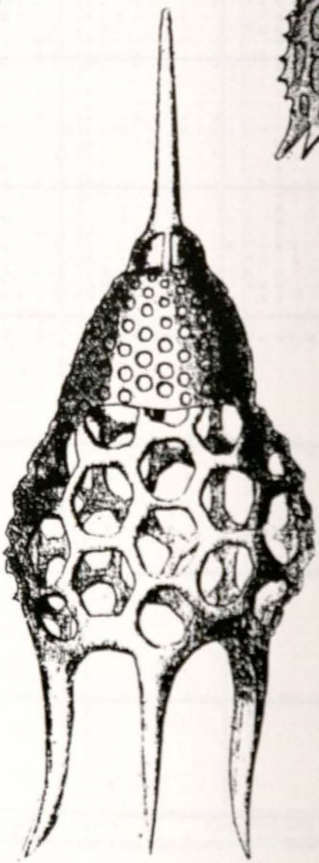


Frequency Key
No. Specimens/Slide (2x4 cm)

Symbol	
Blank	0
/	1
X	2–4
0	5 or More
●	5 or More and One of the 5 Most Frequent
Δ	Reworked







PART III
DIATOMS

R. J. NAVARRETTE

CONTENTS

ILLUSTRATIONS

I. INTRODUCTION

An illustrated inventory of the diatoms that occur in the Neogene rocks of the Sweeny Road section was the primary objective of this study. Our check charts provide the relative frequencies in which the various taxa were observed throughout the section. Critical taxonomy of diatoms is hampered by the unavailability of some of the early literature. This situation has often required the adoption of the interpretations of modern authors as to the intentions of earlier systematists, whose data may often have been tempered with artistic license. To this small but select body of contemporary diatomists, whose references are copiously cited herein, we extend our gratitude for their pioneer efforts, as well as our sympathy for their problems with a time-ravaged and increasingly multilingual bibliography.

Diatoms are proving to be the most useful group of organisms for chronostratigraphy in widespread regions of Neogene rocks in both onshore and offshore California. Planktonic forminifera and calcareous nannofossils, so useful in low-latitudes, did not have the diversity of species and genera in the colder Miocene to Holocene seas of the North Pacific that they enjoyed in tropical and subtropical waters. Radiolarians and silicoflagellates are useful chronostratigraphic markers in Miocene to Holocene regions of the North Pacific, but assemblages of these organisms have a much lower species diversity than do the diatom floras, especially in land-based sections.

The development of siliceous chronostratigraphic models for middle to high latitudes has been a major break-through in global biostratigraphy. Among the contributors of significant data on diatoms should be mentioned Burckle (1972) for a low latitude zonation, Koizumi (1975) for a high latitude zonation, and Schrader (1973a) and Barron (1976) for the nearshore transitional zonation used in California. Subsequent data, such as provided by Barron and Von Huene (1978) and DSDP Hole 438A, have related paleogeographic zones and correlated diatom events with paleomagnetic stratigraphy. The correlation of diatom events (earliest occurrence and last occurrence of key forms) with the magnetic time scale provides absolute ages by which sediment accumulation rates may be derived. Figure 1 lists forms, identified in the section at Sweeny Road, that have been used by biostratigraphers to zone and date Neogene formations in the North Pacific region (Barron, 1975, 1976; Schrader, 1973a; Dumont, 1984).

Estimated dates (m.y.) are noted for the first appearance (FAD) and last appearance (LAD) of these diatoms. In several cases only a geological age is given for the range.

Diatoms are commonly reworked, and great care must be taken in interpreting the age of beds in which they occur. The occurrence of *Denticulopsis dimorpha* in sample 43, for example, is considered to be anomalous, because the last occurrence of this species is well established at 9.9 m.y., and ample other diatom events indicate that the oldest diatom yielding interval, sample 39, was deposited after that date in the succession at Sweeny Road.

All illustrations are Polaroid prints from type 667 film, except as otherwise noted, when 35 mm film was used. The taxonomic designation for each figure is followed in order by the horizon (sample) number, the sieve fraction, and the magnification. The prefix, CRC 40396, was assigned to all sam-

ples collected from the Sweeny Road section, but most references to horizons and samples in this report are cited without the prefix. The diatoms are illustrated in approximately alphabetical order by genus and species, as listed in the catalog of species.

II. SYSTEMATIC PALEONTOLOGY

The following catalog of diatoms from the Sweeny Road section is arranged in alphabetical order by genus and by species within each genus. This procedure adopts the format of contemporary authors to facilitate use of this report as a reference for Neogene species.

Diatom nomenclature is generally hampered by the unavailability of some of the early literature, and confusion has arisen by the use of inadequate optical equipment and slide mounting media. We are grateful to H. J. Schrader (personal communication) for his emphasis on the minimum magnification and resolution necessary for light microscopy and photography of the smaller diatoms, such as *Denticulopsis* spp., among which there are so many key markers.

Genus ACTINOCYCLUS Ehrenberg, 1838

ACTINOCYCLUS CHOLNOKYI Van Landingham
Pl. 1, fig. 1

Actinocyclus cholnokyi VAN LANDINGHAM, 1967, I, p. 83; BARRON, 1975, pl. 1, fig. 2, 3 (with synonymy and distribution)
Actinocyclus divisus (Grunow) KOIZUMI, 1968, p. 207, pl. 32, fig. 3 (with description)

ACTINOCYCLUS CUBITUS Hanna and Grant
Pl. 1, fig. 2

Actinocyclus cubitus HANNA and GRANT, 1926, p. 118, pl. 11, fig. 3; BARRON, 1975, p. 117, pl. 1, fig. 4

ACTINOCYCLUS CURVATULUS Janisch
Pl. 1, fig. 3

Actinocyclus curvatulus Janisch in Schmidt, 1878; KOIZUMI, 1973a, p. 831, fig. 1-6 (with description)

ACTINOCYCLUS EHRENBERGII Ralfs
Pl. 1, fig. 5

Actinocyclus ehrenbergii Ralfs in Pritchard, 1861; SCHRADER, 1973, p. 701, pl. 19, fig. 1

	FAD	LAD
		m.y.
Actinocyclus ingens	17.8	4.5
Denticulopsis hustedtii	14.0	11-3 (common)
D. hyalina	15.0	7.0
D. kamtschatica	6.7	2.4
D. seminae var. *fossilis*	4.3	
Lithodesmium asketogonium	Upper Miocene	
L. cornigerum	Lower Pliocene	
Nitzschia jouseae	4.5	2.6
N. miocenica	6.8	5.5
N. reinholdii	6.8	0.65
Pseudoeunotia doliolus	1.8	0
Rhizosolenia barboi	11.2	0.4
Rouxia californica	15.0	6.2 (common)
Thalassiosira antiqua	7.6	1.7
T. convexa var. *aspinosa*	6.0	2.2
T. miocenica	6.15	5.05
T. nativa	11.0	3.2
T. oestrupii	5.0	0
T. praeconvexa	6.2	5.5

Figure 1. Diatom taxa from the Sweeny Road outcrop that have been used for dating Neogene sections in the North Pacific region (Barron, 1975, 1976; Barron, in press; Schrader, 1973).

ACTINOCYCLUS EHRENBERII Ralfs
var. ASTERISCUS Barron
Pl. 1, fig. 4

Actinocyclus ehrenbergii var. *asteriscus* BARRON, 1975, p. 117-118, pl. 1, fig. 9

ACTINOCYCLUS EHRENBERGII Ralfs
var. TENELLA Brébisson
Pl. 1, fig. 6

Eupodiscus tenellus BRÉBISSON, 1854, pl. 1, fig. 9 (inaccessible)
Actinocyclus ehrenbergii var. *tenella* (Brébisson) HUSTEDT, 1929, p. 530, fig. 302; BARRON, 1975, p. 118, pl. 1, fig. 6

ACTINOCYCLUS ELLIPTICUS Grunow
Pl. 1, fig. 7

Actinocyclus ellipticus Grunow *in* Van Heurck, 1881, *fide* SCHRADER, 1973, p. 701, pl. 8, fig. 7-9, 11-14, 16, 17

ACTINOCYCLUS ELLIPTICUS Grunow
var. MORONENSIS (Deby)
Pl. 1, fig. 8

Actinocyclus ellipticus Grunow var. *moronensis* (Deby) *fide* KOLBE, 1954, p. 21, pl. 3, fig. 29, 30; BARRON, 1975, p. 118, pl. 1, fig. 8

ACTINOCYCLUS INGENS Rattray
Pl. 1, fig. 9-10

Actinocyclus ingens RATTRAY, 1890, p. 149, pl. 11, fig. 7, *fide* KANAYA, 1959, p. 97, pl. 7, fig. 6-9; pl. 8, fig. 1-4; BARRON, p. 118, pl. 1, fig. 10, 12, 13, 16

ACTINOCYCLUS OCHOTENSIS Jousé
Pl. 1, fig. 11

Actioncyclus ochotensis JOUSÉ, 1968, fig. 2, no. 2, 5, *fide* KOIZUMI, 1968, p. 208, pl. 32, fig. 7-10; SCHRADER, 1973, pl. 18, fig; 8, 15, 17; p. 19, fig. 6 (with description)

Modern distribution: planktonic, north-boreal (Barron, 1975, p. 118)

ACTINOCYCLUS OCULATUS Jousé
Pl. 1, fig. 12

Actinocyclus oculatus Jousé, 1961, *fide* KOIZUMI, 1968, p. 208, pl. 32, fig. 11-14 (with description)

ACTINOCYCLUS TSUGARUENSIS Kanaya
Pl. 1, fig. 13

Actinocyclus tsugaruenis KANAYA, 1959, p. 99, pl. 8, fig. 5-8 (with description); BARRON, 1975, p. 119, pl. 1, fig. 15

Genus ACTINOPTYCHUS Ehrenberg, 1839

ACTINOPTYCHUS BISMARCKII Schmidt
Pl. 2, fig. 1

Actinoptychus bismarckii SCHMIDT, 1886, pl. 91, fig. 4; WORNARDT, 1967, pl. 42, fig. 65 (with description)

ACTINOPTYCHUS CLEVEI Schmidt
Pl. 2, fig. 2

Actinoptychus clevei SCHMIDT, 1886, pl. 91, fig. 1; BARRON, 1975, p. 119, pl. 2, fig 6

ACTINOPTYCHUS SPLENDENS Shadbolt
var. HALIONYX Grunow
Pl. 2, fig. 3

Actinoptychus splendens Shadbolt var. *halionyx* Grunow *in* Van Heurck, 1883, *fide* BARRON, 1974, p. 120, pl. 2, fig. 4

ACTINOPTYCHUS SPLENDENS Shadbolt
var. INCISA Grunow
Pl. 2, fig. 4

Actinoptychus splendens Shadbolt var. *incisa* Grunow *in* SCHMIDT, 1890, pl. 154, fig. 2, 3; WORNARDT, 1967, p. 48, fig. 68-71, 73

ACTINOPTYCHUS STELLA Schmidt
var. CLEVEI Schmidt, Wornardt
Pl. 2, fig. 5

Actinoptychus clevei SCHMIDT, 1886, pl. 91, fig. 1
Actinoptychus stella var. *clevei* Schmidt, WORNARDT, 1967, p. 48, fig. 78

Remarks: "The little difference between the typical species of *Actinoptychus stella* and *Actinoptychus clevei* Schmidt is not of the specific magnitude, and so I have placed it as a variety of the species *Actinoptychus stella*" (Wornardt, 1967, p. 48).

ACTINOPTYCHUS UNDULATUS (Bailey) Ralfs
Pl. 2, fig. 6

Actinoptychus undulatus (Bailey) Ralfs *in* Pritchard, 1861, *fide* SCHRADER, 1973, p. 702, pl. 22, fig. 4, 12, 15, 17 (?)

ACTINOPTYCHUS VULGARIS Schumann
var. MONICAE Grunow
Pl. 2, fig. 7

Actinoptychus vulgaris Schumann var. *monicae* Grunow *in* VAN HUERCK, 1883, pl. 121, fig. 9; WORNARDT, 1967, pl. 51, pl. 47, fig. 79-81 (with description)

Genus ARACHNOIDISCUS Deane *ex* Pritchard, 1852

ARACHNOIDISCUS DECORUS Brown
Pl. 2, fig. 8

Arachnoidiscus decorus BROWN, 1933, p. 71, pl. 6, fig. 3; WORNARDT, 1967, p. 40, p. 41, fig. 53

ARACHNOIDISCUS EHRENBERGII Bailey *ex* Ehrenberg
Pl. 2, fig. 9

Arachnoidiscus ehrenbergii Bailey *ex* EHRENBERG, 1849, p. 64; BARRON, 1975, p. 121, p. 2, fig. 15

Modern distribution: "littoral, favors tropical and subtropical waters . . . probably spends part of its time as a bottom form, epiphytic" (Hendey, 1937, p. 267).

ARACHNOIDISCUS ORNATUS Ehrenberg var. MONTEREYANUS Schmidt
Pl. 2, fig. 10

Arachnoidiscus ornatus Ehrenberg var. *montereyanus* SCHMIDT, 1882, pl. 73, fig. 8, 9; BARRON, 1975, p. 122, pl. 3, fig. 1

Genus ASTEROMPHALUS Ehrenberg, 1844

ASTEROMPHALUS DARWINII Ehrenberg
Pl. 2, fig. 11

Asteromphalus darwinii EHRENBERG, 1844, p. 200, pl. (June), fig. 1; BARRON, 1975, p. 122, pl. 3, fig. 4

Genus AULACODISCUS Ehrenberg, 1844

AULACODISCUS CONCENTRICUS (Mann) Boyer
Pl. 2, fig. 12

Tripodiscus concentricus MANN, 1907, p. 278, pl. 54, fig. 1, 2

Aulacodiscus concentricus (Mann) BOYER, 1926, p. 76; BARRON, 1975, p. 123, pl. 3, fig. 10

AULACODISCUS KITTONII Arnott
Pl. 3, fig. 1

Aulacodiscus kittonii Arnott *in* PRITCHARD, 1861, p. 844, pl. 8, fig. 24; BARRON, 1975, p. 123, pl. 3, fig. 11

AULACODISCUS MARGARITACEUS Ralfs
Pl. 3, fig. 2

Aulacodiscus margaritaceus Ralfs *in* PRITCHARD, 1861, p. 844; BARRON, 1975, p. 123, pl. 3, fig. 8

AULACODISCUS SIMPLEX Rattray
Pl. 3, fig. 3

Aulacodiscus simplex RATTRAY, 1888, p. 349; BARRON, 1975, p. 123, pl. 3, fig. 9

Genus AULISCUS Brun *in* Schmidt, 1882

AULISCUS CAELATUS Bailey
Pl. 3, fig. 4

Auliscus caelatus BAILEY, 1853, p. 6, pl. 1, fig. 3, 4; BARRON, 1975, p. 124, pl. 4, fig. 1

AULISCUS CAELATUS Bailey var. CONSTRICTA Rattray
Pl. 3, fig. 5

Auliscus caelatus var. *constricta* RATTRAY, 1888, p. 887, pl. 15, fig. 8; WORNARDT, 1967, p. 53, fig. 88-91, 95

AULISCUS PUNCTATUS Bailey
Pl. 3, fig. 6

Auliscus punctatus BAILEY, 1853, p. 5, pl. 1, fig. 9; BARRON, 1975, p. 125, pl. 4, fig. 6

Genus BACTERIASTRUM Shadbolt, 1853

BACTERIASTRUM sp.
Pl. 3, fig. 7

Modern distribution: Oceanic; commonly found in tropical waters (Hendey, 1937, p. 308).

Genus BIDDULPHIA Gray, 1821

BIDDULPHIA AURITA (Lyngbye) Brébisson and Godey
Pl. 3, fig. 8

Diatoma auritum LYNGBYE, 1819, pl. 182, pl. 652, fig. D

Biddulphia aurita (Lygbye) BRÉBISSON and GODEY, 1838, p. 12; WORNARDT, 1967, p. 60, p. 63, fig. 113

BIDDULPHIA AURITA (Lyngbye) Brébisson and Godey var. OBTUSA (Kützing) Hustedt
Pl. 3, fig. 9

Odontella obtusa KÜTZING 1844, p. 137, pl. 18, fig. 8, 1-3, 6-8
Biddulphia aurita (Lyngbye) Brébisson and Godey var. *obtusa* (Kützing) HUSTEDT, 1930, p. 848-849, fig. 502; WORNARDT, 1967, p. 60, pl. 63, fig. 116

BIDDULPHIA RHOMBUS (Ehrenberg) Wm. Smith
Pl. 3, fig. 10

Zygoceros rhombus EHRENBERG, 1839, p. 80, pl. 4, fig. 11
Biddulphia rhombus (Ehrenberg) WM. SMITH, 1856, p. 49, pl. 45, fig. 320; pl. 61, fig. 320; WORNARDT, 1967, p. 62, p. 63, fig. 118

Modern distribution: Widespread, neritic (Hendey, 1854, p. 103.

BIDDULPHIA SUBORBICULARIS Grunow
Pl. 3, fig. 11

Biddulphia suborbicularis Grunow *in* VAN HEURCK, 1882, p. 100, fig. 15, 16; BARRON, 1975, p. 126, pl. 4, fig. 17

BIDDULPHIA TRIDENS (Ehrenberg) Ehrenberg
Pl. 3, fig. 12, 13

Denticella tridens EHRENBERG, 1838, p. 129
Biddulphia tridens (Ehrenberg) EHRENBERG, 1840, p. 205 (according to Boyer, 1926, p. 121); BARRON, 1975, p. 126, pl. 4, fig. 12, 13

Genus CESTODISCUS Greville, 1865

CESTODISCUS PULCHELLUS Greville var. MACULATUS Kolbe
Pl. 3, fig. 14

Cestodiscus pulchellus Greville var. *maculatus* KOLBE, 1954, p. 25, pl. 1, fig. 8

Genus CHAETOCEROS Ehrenberg, 1844

CHAETOCEROS CINCTUS Gran (resting spore)
Pl. 3, fig. 15

Chaetoceros cinctus GRAN, 1897, p. 24, pl. 2, fig. 23-27; BARRON, 1975, p. 127, pl. 5, fig. 4

CHAETOCEROS DIADEMA (Ehrenberg) Gran (resting spore)
Pl. 3, fig. 16

Syndendrium diadema EHRENBERG, 1854, pl. 35a, fig. 18
Chaetoceros diadema (Ehrenberg) GRAN, 1897, p. 20, p. 2, fig. 16-18; BARRON, 1975, p. 128, pl. 5, fig. 5

CHAETOCEROS DICLADIA Castracane (resting spore)
Pl. 3, fig. 17

Chaetoceros dicladia CASTRACANE, 1886, p. 82, pl. 8, fig. 1, pl. 19, fig. 7, 8; BARRON, 1975, p. 128, pl. 5, fig. 6, 7

CHAETOCEROS sp. (spore) Schrader
Pl. 4, fig. 1

Chaetoceros sp. (spore) SCHRADER, 1973, p. 702, pl. 17, fig. 5, 6, 7

Genus CLADOGRAMMA Ehrenberg, 1844

CLADOGRAMMA CALIFORNICUM Ehrenberg
Pl. 4, fig. 2

Cladogramma californicum EHRENBERG, 1854, pl. 33, fig. 13; BARRON, 1975, p. 128, pl. 5, fig. 9

CLADOGRAMMA DUBIUM Lohman
Pl. 4, fig. 3

Cladogramma dubium LOHMAN, 1948, p. 168, pl. 9, fig. 5; BARRON, 1975, p. 128, pl. 5, fig. 10

Genus COCCONEIS Ehrenberg, 1838

COCCONEIS COSTATA Gregory
Pl. 4, fig. 4

Cocconeis costata GREGORY, 1855, p. 39, pl. 4, fig. 10; BARRON, 1975, p. 129, pl. 5, fig. 12

COCCONEIS DECIPIENS Cleve
Pl. 4, fig. 5

Cocconeis decipiens CLEVE, 1873, p. 14, fig. 1, pl. 6; BARRON, 1975, p. 129, pl. 5, fig. 13

COCCONEIS DIRUPTA Gregory var. TRIUMPHIS (Hanna and Grant) Fenguelli
Pl. 4, fig. 6

Cocconeis triumphis HANNA and GRANT, 1926, p. 135, pl. 14, fig. 11-13
Cocconeis dirupta Gregory var. *triumphis* (Hanna and Grant) FRENGUELLI, 1949, p. 111, pl. 6, fig. 9; BARRON, 1975, p. 129, pl. 5, fig. 15

Genus COSCINODISCUS Ehrenberg, 1838

COSCINODISCUS ANTIQUUS (Grunow) Rattray
Pl. 4, fig. 7

Coscinodiscus (excentricus var.?) *antiquus* GRUNOW, 1884, p. 84, pl. 4, fig. 24

Coscinodiscus antiquus (Grunow) RATTRAY, 1890, p. 461, fig. 13; WORNARDT, 1967, p. 20, p. 29, fig. 23

COSCINODISCUS ASTEROMPHALUS Ehrenberg

Pl. 4, fig. 8

Coscinodiscus asteromphalus EHRENBERG, 1844, p. 77; WORNARDT, 1967, p. 20, fig. 14-18

COSCINODISCUS BIRADIATUS Greville

Pl. 4, fig. 9

Coscinodiscus biradiatus GREVILLE, 1861, p. 42, pl. 4, fig. 7; BARRON, 1975, p. 132, pl. 6, fig. 4

COSCINODISCUS EXCENTRICUS Ehrenberg var. LEASAREOLATUS Kanaya

Pl. 4, fig. 10

Coscinodiscus excentricus Ehrenberg var. *leasareolatus* Kanaya, 1966, *fide* KOIZUMI, 1973, p. 832, pl. 3, fig. 7-10

COSCINODISCUS HIROSAKIENSIS Kanaya

Pl. 4, fig. 11

Coscinodiscus hirosakiensis KANAYA, 1959, p. 78, pl. 4, fig. 1, 2 (with description); BARRON, 1975, pl. 4, fig. 13

COSCINODISCUS KURZII Grunow

Pl. 4, fig. 12

Coscinodiscus kurzii Grunow *in* SCHMIDT, 1888, pl. 113, fig. 17; BARRON, 1975, p. 133, pl. 6, fig. 19

COSCINODISCUS MARGINATUS Ehrenberg

Pl. 5, fig. 1

Coscinodiscus marginatus EHRENBERG, 1841, p. 142; EHRENBERG 1854, pl. 18, fig. 44, pl. 33, fig. 12; BARRON, 1975, pl. 134, pl. 7, fig. 1

Modern distribution: "An oceanic species frequent in North Atlantic water, North Sea" (Hendey, 1964, p. 78). North boreal (Jousé *et al.*, 1969).

COSCINODISCUS MONICAE (Grunow) Rattray

Pl. 5, fig. 3

Coscinodiscus janischii var. *monicae* GRUNOW, 1884, p. 76

Coscinodiscus monicae Grunow RATTRAY, 1890, p. 563, pl. 115; BARRON, 1975, p. 134, pl. 7, fig. 2

COSCINODISCUS NITIDUS Gregory

Pl. 5, fig. 2

Coscinodiscus nitidus GREGORY, 1857, pl. 27, pl. 2, fig. 45; BARRON, 1975, p. 134, pl. 7, fig. 3

Modern distribution: "Neritic, in coastal regions of all seas" (Cupp, 1943, p. 55).

COSCINODISCUS NODULIFER Schmidt

Pl. 5, fig. 4

Coscinodiscus nodulifer Schmidt *in* Schmidt, 1878, *fide* KOLBE, 1954, p. 33, pl. 3, fig. 35, 36 (with description); BARRON, 1975, p. 135, pl. 7, fig. 4

Modern distribution: Tropical, planktonic (Jousé *et al.*, 1969).

COSCINODISCUS OBSCURUS Schmidt

Pl. 5, fig. 6

Coscinodiscus obscurus Schmidt *in* SCHMIDT, 1878, pl. 61, fig. 16; BARRON, 1975, p. 135, pl. 7, fig. 4

PLATE 1

1. *Actioncyclus cholnokyi* Van Landingham. 73, -28 microns, x1000.
2. *Actinocyclus cubitus* Hanna and Grant. 43, +28 microns, x780.
3. *Actinocyclus curvatulus* Janisch. 69, +28 microns, x540, 35 mm.
4. *Actinocyclus ehrenbergii* Ralfs var. *asteriscus* Barron. 51, +28 microns, x540.
5. *Actinocyclus ehrenbergii* Ralfs. 57, +28 microns, x960.
6. *Actinocyclus ehrenbergii* Ralfs var. *tenella* Brébisson. 73, -28 microns, x1000.
7. *Actinocyclus ellipticus* Grunow. 43, +28 microns, x940.
8. *Actinocyclus ellipticus* Grunow var. *moronesis* (Deby). 43, +28 microns, x 960.
9-10. *Actinocyclus ingens* Rattray. Fig. 9, 58, +28 microns, x640. Fig. 10, 54, +28 microns, x640.
11. *Actinocyclus ochotensis* Jousé. 60, -28 microns, x1300.
12. *Actinocyclus oculatus* Jousé. 60, -28 microns, x 1300.
13. *Actinocyclus tsugaruensis* Kanaya. 54, +28 microns, x740, 35 mm.

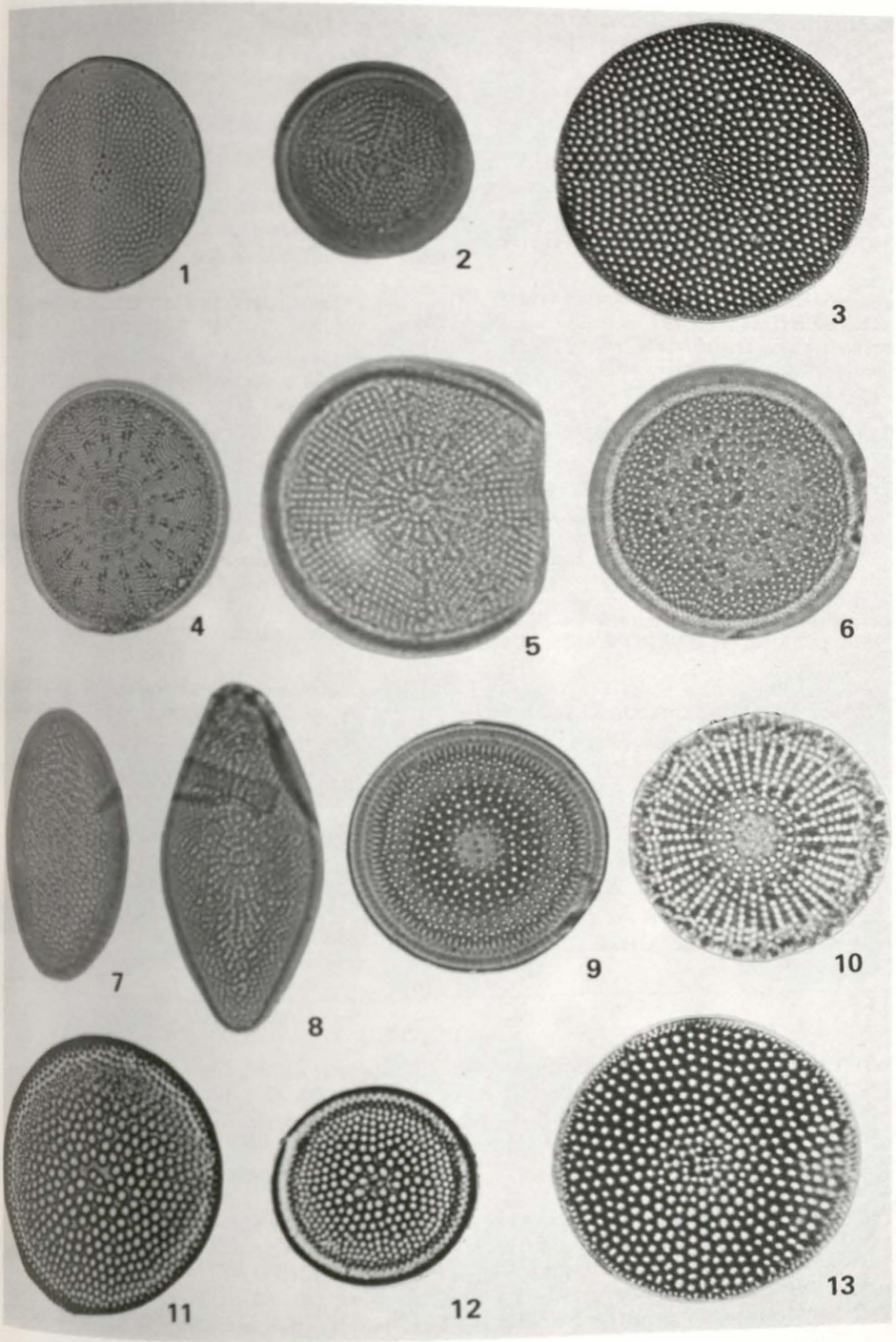


PLATE 1

COSCINODISCUS OCULUSIRIDIS Ehrenberg var. BOREALIS (Bailey) Cleve
Pl. 5, fig. 7

Coscinodiscus borealis BAILEY, 1856, p. 3
Coscinodiscus oculusiridis Ehrenberg var. *borealis* (Bailey) CLEVE, 1883, p. 488; BARRON, 1975, p. 135, pl. 7, fig. 6

COSCINODISCUS OCULUSIRIDIS (OCULUS-IRIDIS) Ehrenberg var. OCULUSIRIDIS Barron
Pl. 5, fig. 8

Coscinodiscus oculusiridis (oculus-iridis) EHRENBERG, 1839, p. 147
Coscinodiscus oculusiridis Ehrenberg var. *oculusiridis* BARRON, 1975, p. 135, pl. 7, fig. 9

COSCINODISCUS PILOSUS Schmidt
Pl. 5, fig. 5

Coscinodiscus pilosus SCHMIDT, 1890, p. 148, fig. 8; BARRON, 1975, p. 135, pl. 7, fig. 8

COSCINODISCUS PLICATUS Grunow
Pl. 5, fig. 9

Coscinodiscus plicatus Grunow *in* SCHMIDT, 1878, p. 59, fig. 1; BARRON, 1975, p. 136, pl. 7, fig. 10

COSCINODISCUS RADIATUS Ehrenberg
Pl. 6, fig. 2

Coscinodiscus radiatus EHRENBERG, 1839, p. 148, pl. 3, fig. 1a-c; BARRON, 1975, p. 136, pl. 7, fig. 12, 16

COSCINODISCUS ROBUSTUS Greville var. INCRETUS Schmidt, Wornardt
Pl. 6, fig. 3

Coscinodiscus robustus Greville, SCHMIDT, 1886, pl. 62, fig. 16, 17

Coscinodiscus incretus SCHMIDT, 1888, pl. 139, fig. 1, 1a
Coscinodiscus robustus Greville var. *incretus* Schmidt, WORNARDT, 1967, p. 32, fig. 43

COSCINODISCUS STELLARIS Roper var. SYMBOLOPHORA (Grunow) Jørgensen
Pl. 6, fig. 4

Coscinodiscus stellaris Roper var. *symbolophora* (Grunow) JØRGENSEN, 1905, p. 196; KOIZUMI, 1973, p. 832, pl. 4, fig. 5

COSCINODISCUS SUBTILIS Ehrenberg
Pl. 6, fig. 5

Coscinodiscus subtilis EHRENBERG, 1841, p. 412, pl. 1, fig. 3; BARRON, 1975, p. 136, pl. 7, fig. 17, 18

COSCINODISCUS TABULARIS Grunow var. EGREGIUS (Rattray) Hustedt
Pl. 6, fig. 6

Coscinodiscus tabularis Grunow var. *egregius* (Rattray) Hustedt, 1928, p. 428, fig. 230b, *fide* SCHRADER, 1973, p. 704, pl. 20, fig. 3, 4

COSCINODISCUS VETUSTISSIMUS Pantocsek
Pl. 6, fig. 7

Coscinodiscus vetustissimus Pantocsek, 1886, p. 71, pl. 20, fig. 186, *fide* BARRON, 1975, p. 137, pl. 7, fig. 15

Genus DENTICULOPSIS Simonsen, 1979

DENTICULOPSIS DIMORPHA (Schrader) Simonsen
Pl. 6, fig. 8

Denticula lauta BAILEY, SIMONSEN and KANAYA, 1961, pl. 1, fig. 9-10 (with synonymy)

PLATE 2

1. *Actinoptychus bismarckii* Schmidt. 73, -28 microns, x1000.
2. *Actinoptychus clevei* Schmidt. 52, -29 microns, x1000, 35 mm.
3. *Actinoptychus splendens* Shadbolt var. *halionyx* Grunow. 73, +28 microns, x700.
4. *Actinoptychus splendens* Shadbolt var. *incisa* Grunow. 65, +28 microns, x287.5.
5. *Actinoptychus stella* Schmidt var. *clevei* Schmidt, Wornardt. 73, +28 microns, x700, 35 mm.
6. *Actinoptychus undulatus* (Bailey) Ralfs. 58, +28 microns, x50.
7. *Actinoptychus vulgaris* Schumann var. *monicae* Grunow. 65, +28 microns, x337.5.
8. *Arachnoidiscus decorus* Brown. 39, +28 microns, x275.
9. *Arachnoidiscus ehrenbergii* Bailey *ex* Ehrenberg. 56, +28 microns, x300.
10. *Arachnoidiscus ornatus* Ehrenberg var. *montereyanus* Schmidt. 42, +28 microns, x250.
11. *Asteromphalus darwinii* Ehrenberg. 56, +28 microns, x520.
12. *Aulacodiscus concentricus* (Mann) Boyer. 52, +28 microns, x400.

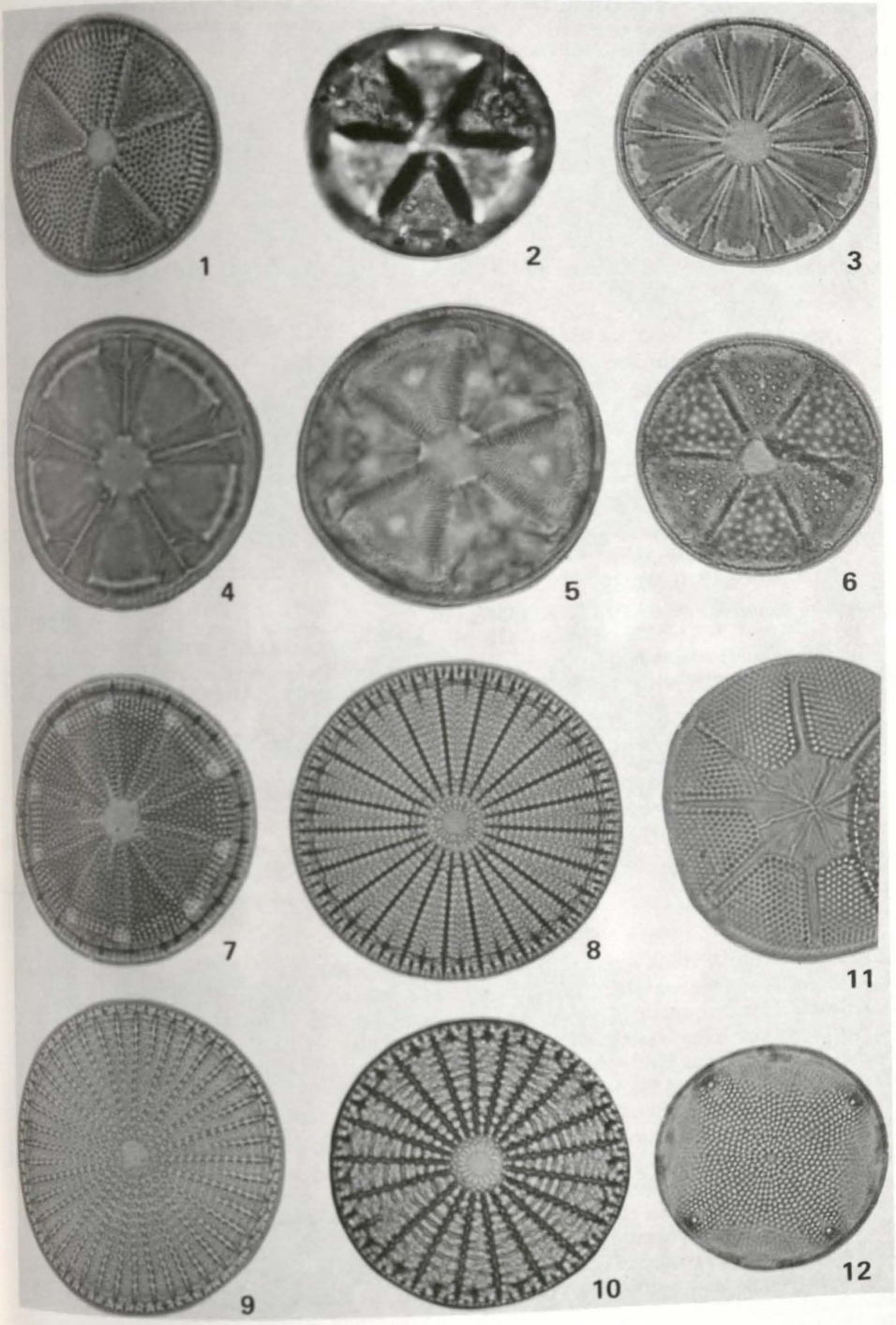


PLATE 2

Denticula dimorpha SCHRADER, 1973b, p. 418, pl. 1, fig. 16-17 (with description)
Denticulopsis dimorpha (Schrader) SIMONSEN, 1979, p. 64

DENTICULOPSIS HUSTEDTII (Simonsen and Kanaya) Simonsen
Pl. 6, fig. 9

Denticula hustedtii SIMONSEN and KANAYA, 1961, p. 501, pl. 1, fig. 19-25; BARRON, 1975, p. 138, pl. 8, fig. 9, 10
Denticulopsis hustedtii (Simonsen and Kanaya) SIMONSEN, 1979, p. 64

DENTICULOPSIS HYALINA (Schrader) Simonsen
Pl. 6, fig. 10

Denticula hyalina SCHRADER, 1973b, p. 418, pl. 1, fig. 22
Denticulopsis hyalina (Schrader) SIMONSEN, 1979, p. 64

DENTICULOPSIS KAMTSCHATICA (Sabelina) Simonsen
Pl. 6, fig. 11

Denticula kamtschatica SABELINA, 1934, p. 16, 19, fig. 7-9; SCHRADER, 1973b, p. 418, pl. 1, fig. 7-8 (with description)
Denticulopsis kamtschatica (Sabelina) SIMONSEN, 1979, p. 64

DENTICULOPSIS SEMINAE (Simonsen and Kanaya) var. FOSSILIS (Schrader) Simonsen
Pl. 6, fig. 12

Denticula seminae var. *fossilis* SCHRADER, 1973b, p. 420, pl. 1, fig. 5-6 (with description)
Denticulopsis seminae var. *fossilis* (Schrader) SIMONSEN, 1979, p. 64

Genus DIMEROGRAMMA Ralfs, 1861

DIMEROGRAMMA sp.?
Pl. 6, fig. 13

Dimerogramma sp.? BARRON, 1975, p. 139, pl. 8, fig. 13

Genus DIPLONEIS Ehrenberg, 1854

DIPLONEIS CRABRO (Ehrenberg) Ehrenberg
Pl. 6, fig. 14

Pinnularia crabro EHRENBERG, 1844, p. 85
Diploneis crabro (Ehrenberg) EHRENBERG, 1854, pl. 19, fig. 29; BARRON, 1975, p. 139, pl. 8, fig. 18

Genus DOSSETIA Azpeitia, 1911

DOSSETIA LACERA (Forti) Hanna
Pl. 6, fig. 15

Xanthiopyxis lacera Forti in TEMPÈRE and PERAGALLO, 1910, p. 197
Dossetia lacera (Forti) HANNA, 1932, p. 190, pl. 11, fig. 3; BARRON, 1975, p. 140, pl. 8, fig. 23

Genus ENDICTYA Ehrenberg, 1845

ENDICTYA OCEANICA Ehrenberg
Pl. 6, fig. 16

Endictya oceanica EHRENBERG, 1845, p. 76; BARRON, 1975, p. 141, pl. 8, fig. 21

PLATE 3

1. *Aulacodiscus kittoni* Arnott. 73, +28 microns, x800.
2. *Aulacodiscus margaritaceus* Ralfs. 44, +28 microns, x400.
3. *Aulacodiscus simplex* Rattray. 48, +28 microns, x250.
4. *Auliscus caelatus* Bailey. 64, +28 microns, x600.
5. *Auliscus caelatus* Bailey var. *constricta* Rattray. 52, +28 microns, x250.
6. *Auliscus punctatus* Bailey. 43, +28 microns, x250.
7. *Bacteriastrum* sp. 73, -28 microns, x160.
8. *Biddulphia aurita* (Lyngbye) Brébisson and Godey. 60, -28 microns, x1250.
9. *Biddulphia aurita* (Lyngbye) Brébisson and Godey var. *obtusa* (Kutzing) Hustedt. 44, +28 microns, x 300.
10. *Biddulphia rhombus* (Ehrenberg) Wm. Smith. 42, +28 microns, x300.
11. *Biddulphia suborbicularis* Grunow. 39, +28 microns, x1000.
12-13. *Biddulphia tridens* (Ehrenberg) Ehrenberg. 39, +28 microns, x400.
14. *Cestodiscus pulchellus* Greville var. *maculatus* Kolbe. 64, +28 microns, x400.
15. *Chaetoceros cinctus* (spore) Gran. 58, -28 microns, x1000, 35 mm.
16. *Chaetoceros diadema* (spore) (Ehrenberg) Gran. 73, -28 microns, x1000.
17. *Chaetoceros dicladia* (spore) Castracane. 73, +28 microns, x400.

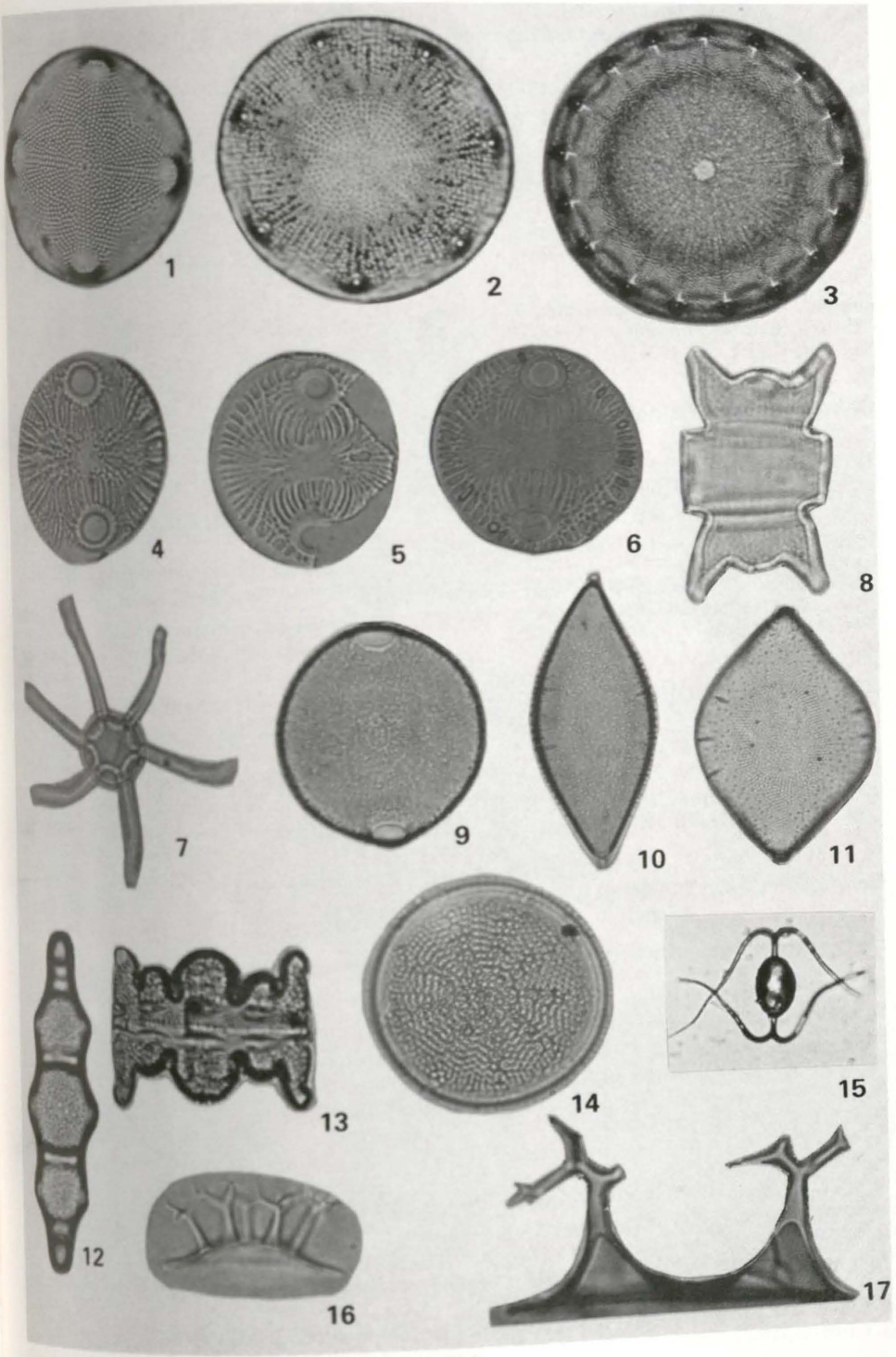


PLATE 3

ENDICTYA ROBUSTA
(Greville) Hanna and Grant
Pl. 6, fig. 17

Endictya robustus (Greville) HANNA and GRANT, 1926, p. 144, pl. 16, fig. 2-3; BARRON, 1975, p. 141, pl. 8, fig. 22

Genus ENTOPYLA Ehrenberg, 1841

ENTOPYLA AUSTRALIS var. GIGANTEA (Greville) Fricke
Pl. 6, fig. 18

Entopyla australis var. *gigantea* (Greville) Fricke, 1902, *in* Schmidt *et al.*, pl. 230, fig. 1-11, *fide* BARRON, 1975, p. 141, pl. 8, fig. 24

Genus GLYPHODESMUS Greville, 1862

GLYPHODESMUS WILLIAMSONII (Wm. Smith) Grunow
Pl. 6, fig. 19

Himantidium williamsonii WM. SMITH, 1856, p. 14, pl. 33, fig. 287
Glyphodesmus williamsonii (Wm. Smith) Grunow *in* VAN HEURCK, 1881, pl. 36, fig. 14; BARRON, 1975, p. 142, pl. 9, fig. 4

Genus GLYPHODISCUS Greville, 1862

GLYPHODISCUS STELLATUS Greville
Pl. 6, fig. 20

Glyphodiscus stellatus GREVILLE, 1862, p. 91, pl. 9, fig. 5; BARRON, 1975, p. 142, pl. 9, fig. 5

Genus GRAMMATOPHORA Ehrenberg, 1840

GRAMMATOPHORA ANGULOSA Ehrenberg
Pl. 6, fig. 21

Grammatophora angulosa EHRENBERG, 1840, p. 73; BARRON, 1975, p. 142, pl. 9, fig. 10

GRAMMATOPHORA MERLETTA
Hanna and Grant
Pl. 6, fig. 22

Grammatophora merletta HANNA and GRANT, 1926, p. 146, pl. 16, fig. 11, 12, 14 (with description); BARRON, 1975, p. 143, pl. 9, fig. 11

Genus HEMIAULUS Ehrenberg, 1845

HEMIAULUS POLYMORPHUS Grunow
Pl. 7, fig. 1

Hemiaulus polymorphus GRUNOW, 1884, p. 14, fig. 66; BARRON, 1975, p. 143, pl. 9, fig. 6

Genus HEMIDISCUS Wallich, 1860

HEMIDISCUS CUNEIFORMIS Wallich
Pl. 7, fig. 2

Hemidiscus cuneiformis WALLICH, 1860, p. 42, pl. 2, fig. 3-4; BARRON, 1975, p. 143, pl. 9, fig. 7, 8

Modern distribution: tropical, planktonic (Jousé *et al.*, 1969).

HEMIDISCUS SIMPLICISSIMUS
Hanna and Grant
Pl. 7, fig. 3

Hemidiscus simplicissimus HANNA and GRANT, 1926, p. 147, pl. 16, fig. 13; SCHRADER, 1973, p. 706, pl. 24, fig. 12, 13

PLATE 4

1. *Chaetoceros* sp. (spore). 73, +28 microns, x400.
2. *Cladogramma californicum* Ehrenberg. 73, -28 microns, x1000.
3. *Caldogramma dubium* Lohman. 46, -28 microns, x1000.
4. *Cocconeis costata* Gregory. 56, -28 microns, x1200, 35 mm.
5. *Cocconeis decipiens* Cleve. 73, +28 microns, x400.
6. *Cocconeis dirupta* Gregory var. *triumphis* (Hanna and Grant) Frenguelli. 43, +28 microns, x400.
7. *Coscinodiscus antiquus* (Grunow) Rattray. 46, -28 microns, x1250.
8. *Coscinodiscus asteromphalus* Ehrenberg. 60, +28 microns, x250.
9. *Coscinodiscus biradiatus* Greville. 39, -28 microns, x1000.
10. *Coscinodiscus excentricus* Ehrenberg var. *leasareolatus* Kanaya. 54, -28 microns, x1200.
11. *Coscinodiscus hirosakiensis* Kanaya. 61, +28 microns, x500.
12. *Coscinodiscus kurzii* Grunow. 39, +28 microns, x250.

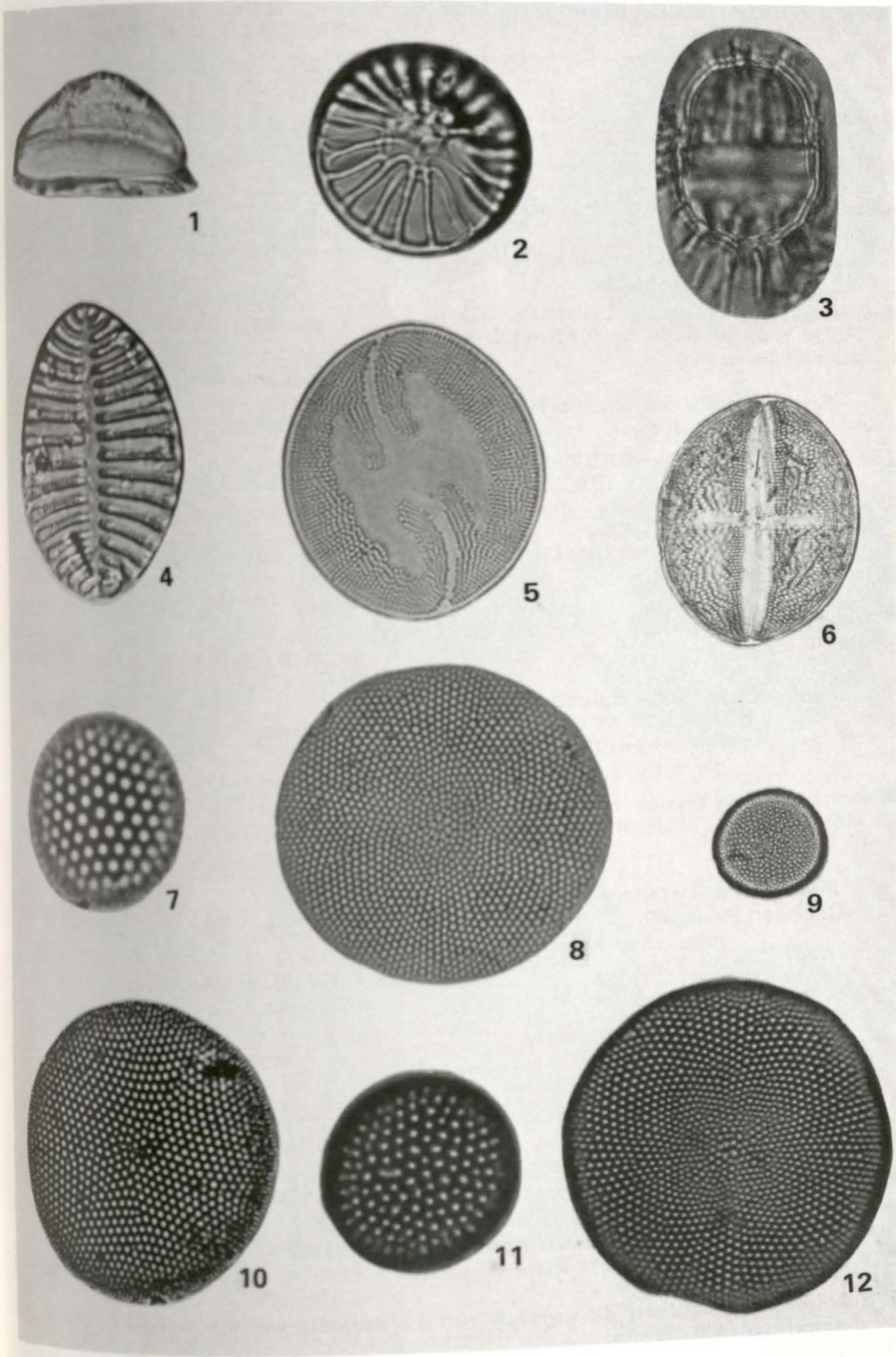


PLATE 4

Genus HERCOTHECA Ehrenberg, 1844

HERCOTHECA MAMILLARIS Ehrenberg
Pl. 7, fig. 4

Hercotheca mamillaris EHRENBERG, 1844 (1845), p. 269; EHRENBERG, 1854, pl. 33, fig. 18; BARRON, 1975, p. 143, pl. 9, fig. 13

Genus LITHODESMIUM Ehrenberg, 1840

LITHODESMIUM ASKETOGONIUM Barron
Pl. 7, fig. 5

Lithodesmium asketogonium BARRON, 1975, p. 145, pl. 9, fig. 20; pl. 10, fig. 1, 2 (with description and discussion)

LITHODESMIUM CORNIGERUM Brun
Pl. 7, fig. 6

Lithodesmium cornigerum BRUN, 1896, p. 239, pl. 24, fig. 15-17; WORNARDT, 1967, p. 67, fig. 131

LITHODESMIUM MINUSCULUM Grunow
Pl. 7, fig. 7

Lithodesmium minusculum Grunow *in* VAN HEURCK, 1883, pl. 116, fig. 1-5; BARRON, 1975, p. 145, pl. 10, fig. 4

Genus MELOSIRA Agardh, 1824

MELOSIRA CLAVIGERA Grunow
Pl. 7, fig. 8

Melosira clavigera Grunow *in* VAN HEURCK, 1882, pl. 91, fig. 1, 2; BARRON, 1975, p. 146, pl. 10, fig. 6

MELOSIRA SULCATA var. BISERIATA (Grunow) Peragallo and Peragallo (nom. cons.)
Pl. 7, fig. 9

Paralia sulcata var. *biseriata* GRUNOW, 1884, p. 92, fig. 42

Melosira sulcata var. *biseriata* (Grunow) PERAGALLO and PERAGALLO, 1897-1908, p. 448, pl. 119, fig. 14; BARRON, 1975, p. 146, pl. 10, fig. 7

MELOSIRA SULCATA var. CORONATA (Ehrenberg) Grunow (nom. cons.)
Pl. 7, fig. 10

Melosira sulcata var. *coronata* (Ehrenberg) Grunow *in* Van Heurck, 1882, pl. 91, fig. 17, *fide* BARRON, 1975, p. 146, pl. 10, fig. 20

MELOSIRA SULCATA var. SIBERICA Grunow (nom. cons.)
Pl. 7, fig. 11

Melosira sulcata var. *siberica* Grunow *in* VAN HEURCK, 1882, pl. 91, fig. 22; BARRON, 1975, p. 146, pl. 10, fig. 13

Genus MUELLERIELLA Van Heurck, 1896

MUELLERIELLA LIMBATA (Ehrenberg) Van Heurck
Pl. 7, fig. 12

Muelleriella limbata (Ehrenberg) VAN HEURCK, 1896, p. 435, fig. 160; BARRON, 1975, p. 147, pl. 10, fig. 9

Genus NAVICULA Bory, 1824

NAVICULA LYRA var. EHRENBERGII Cleve
Pl. 7, fig. 13

Navicula lyra Ehrenberg var. *ehrenbergii* CLEVE, 1895, p. 63, BARRON, 1975, p. 148, pl. 10, fig. 19

NAVICULA OPTIMA Hanna
Pl. 7, fig. 14

Navicula optima HANNA, 1932, p. 202, pl. 13, fig. 6 (with description); BARRON, 1975, p. 148, pl. 10, fig. 14

PLATE 5

1. *Coscinodiscus marginatus* Ehrenberg. 71, +28 microns, x400.
2. *Coscinodiscus nitidus* (Gregory). 42, +28 microns, x540.
3. *Coscinodiscus monicae* (Grunow) Rattray. 48, -28 microns, x1000.
4. *Coscinodiscus nodulifer* Schmidt. 39, +28 microns, x540.
5. *Coscinodiscus pilosus* Schmidt. 39, +29 microns, x400.
6. *Coscinodiscus obscurus* Schmidt. 42, +63 microns, x400, 35 mm.
7. *Coscinodiscus oculusiridis* Ehrenberg var. *borealis* (Bailey) Cleve. 70, +63 microns, x400.
8. *Coscinodiscus oculusiridis (oculus-iridis)* Ehrenberg var. *oculusiridis* Barron 73, +63 microns, x400, 35 mm.
9. *Coscinodiscus plicatus* Grunow. 65, -28 microns, x1000.

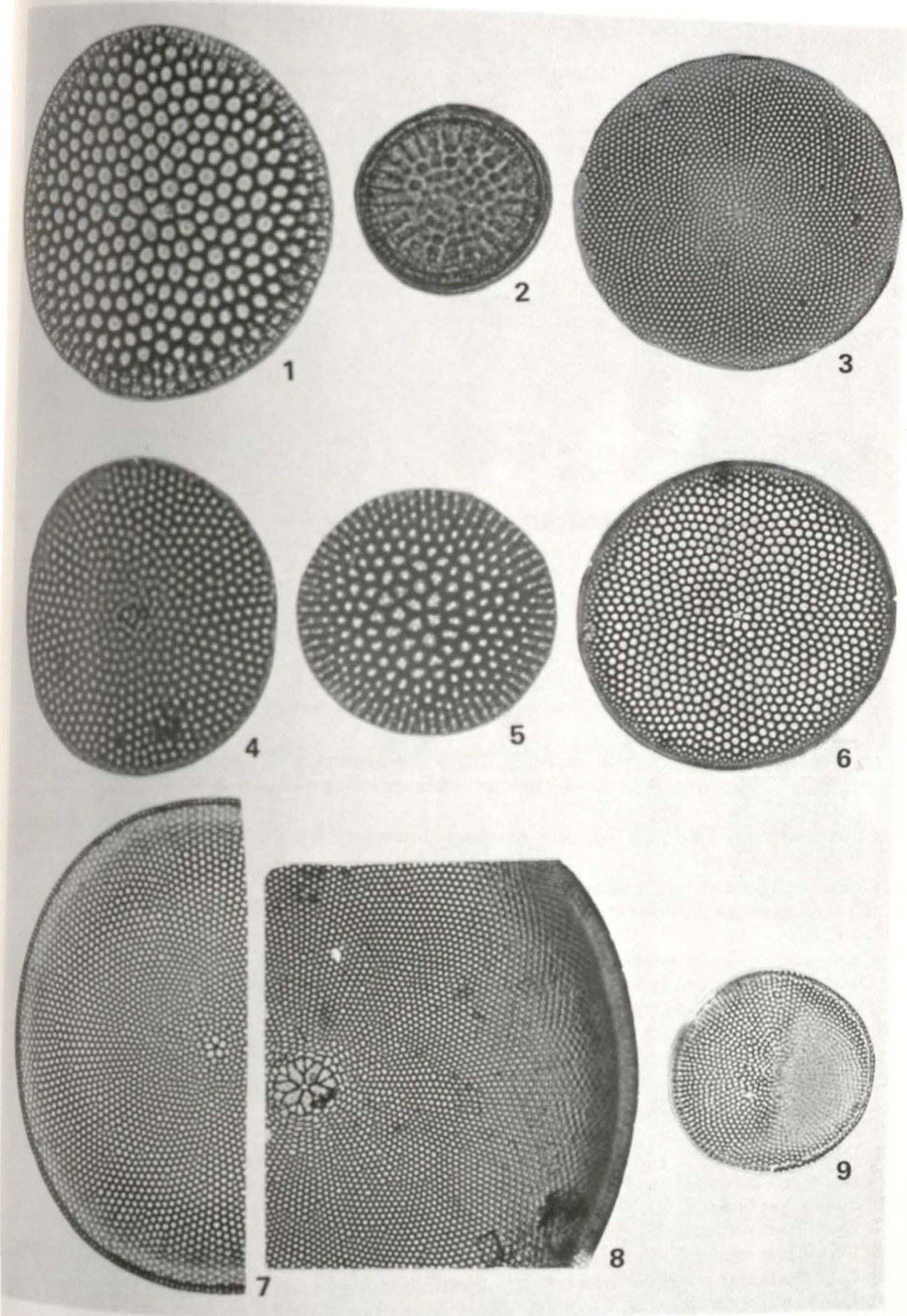


PLATE 5

Genus NITZSCHIA Hassal, 1845

NITZSCHIA CALIFORNICA Schrader
Pl. 8, fig. 1

Nitzschia californica SCHRADER, 1973, p. 707, pl. 5, fig. 15; pl. 26, fig. 6 (with description)

NITZSCHIA FOSSILIS (Frenguelli) emend. Kanaya
Pl. 8, fig. 2

Nitzschia fossilis (Frenguelli) emend. Kanaya *in* Kanaya and Koizumi, 1970, *fide* BARRON, 1975, p. 149, pl. 11, fig. 8

NITZSCHIA JOUSEAE Burckle
Pl. 8, fig. 3

Nitzschia jouseae BURCKLE, 1972, p. 240, pl. 2, fig. 17-20 (with description); SCHRADER, 1973, p. 707, pl. 4, fig. 20, 21, 22, 23

NITZSCHIA MIOCENICA Burckle
Pl. 8, fig. 4

Nitzschia miocenica BURCKLE, 1972, p. 240, pl. 2, fig. 10- 15 (with description)

NITZSCHIA REINHOLDII Kanaya
Pl. 8, fig. 5

Nitzschia reinholdii Kanaya, 1970, in KANAYA and KOIZUMI, 1970, p. 58; SCHRADER, 1973, p. 708, pl. 4, fig. 12-16; pl. 5, fig. 1-9 (with description)

NITZSCHIA ROLANDII Schrader
Pl. 8, fig. 6

Nitzschia rolandii SCHRADER, 1973, p. 708, pl. 5, fig. 31; pl. 26, fig. 3, 4 (with description); BARRON, 1975, p. 150, pl. 11, fig. 5, 7

Genus OPEPHORA Petit, 1888

OPEPHORA SCHWARTZII (Grunow) Petit
Pl. 8, fig. 7

Opephora schwartzii (Gruno) Petit in Pelletan, 1889, *fide* BARRON, 1975, p. 150, pl. 11, fig. 10

Genus PERIPTERA Ehrenberg, 1845

PLATE 6

1. *Rossiella praepaleaceus* (Schrader) Gersonde and Schrader. 43, -28 microns, x1000, 35 mm.
2. *Coscinodiscus radiatus* Ehrenberg. 70, +63 microns, x580, 35 mm.
3. *Coscinodiscus robustus* Greville var. *incretus* Schmidt, Wornardt. 39, +28 microns, x250.
4. *Coscinodiscus stellaris* Roper var. *symbolophora* (Grunow) Jørgensen. 56, -28 microns, x1000, 35 mm.
5. *Coscinodiscus subtilis* Ehrenberg. 47, +63 microns, x600.
6. *Coscinodiscus tabularis* Grunow var. *egregius* (Rattray) Hustedt. 42, -28 microns, x1000.
7. *Coscinodiscus vetustissimus* Pantocsek. 39, +28 microns, x1000, 35 mm.
8. *Denticulopsis dimorpha* (Schrader) Simonsen. 42, -28 microns, x1350.
9. *Denticulopsis hustedtii* (Simsonsen and Kanaya) Simonsen. 44, -28 microns, x1500.
10. *Denticulopsis hyalina* (Schrader) Simsonsen. 60, -28 microns, x1950.
11. *Denticulopsis kamtschatica* (Zabelina) Simonsen. 49, -28 microns, x1500.
12. *Denticulpsis seminae* (Simonsen and Kanaya) var. *fossilis* (Schrader) Simonsen. 60, -28 microns, x1250.
13. *Dimerogramma* sp.? 42, -28 microns, x1000.
14. *Diploneis crabro* (Ehrenberg). 46, -28 microns, x1000, 35 mm.
15. *Dossetia lacera* (Forti) (spore) Hanna. 64, +28 microns, x640.
16. *Endictya oceanica* Ehrenberg. 73, -28 microns, x1000, 35 mm.
17. *Endictya robusta* (Greville) Hanna and Grant. 54, +63 microns, x250.
18. *Entopyla australis* var. *gigantea* (Greville) Fricke. 67, +28 microns, x400.
19. *Glyphodesmus williamsonii* (Wm. Smith) Grunow. 42, -28 microns, x1000, 35 mm.
20. *Glyphodiscus stellatus* Greville. 56, +28 microns, x640.
21. *Grammatophora angulosa* Ehrenberg. 73, -28 microns, x1200.
22. *Grammatophora merletta* Hanna and Grant. 73, -28 microns, x1000.

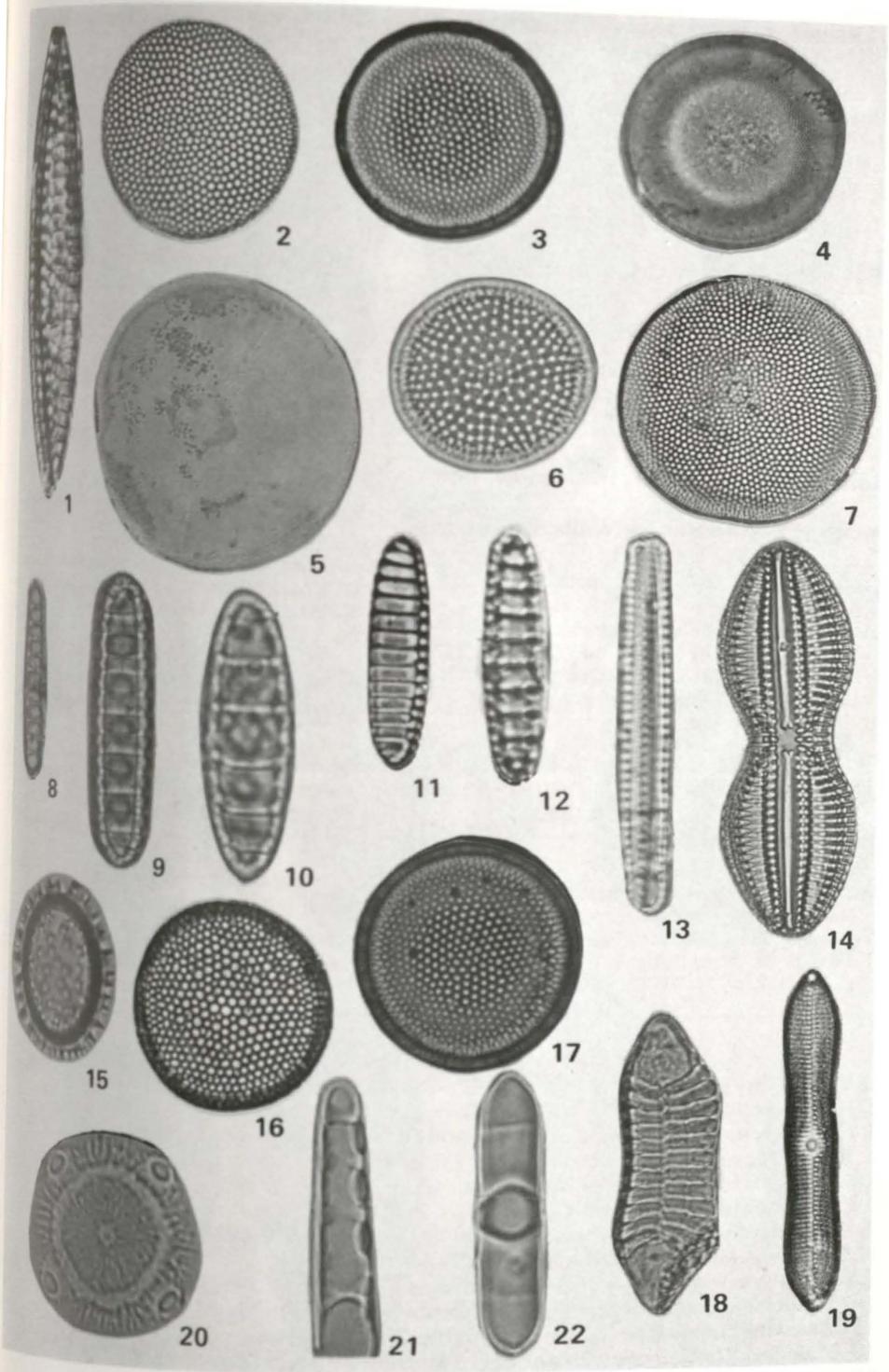


PLATE 6

PERIPTERA TETRACLADIA? Ehrenberg
(resting spore)
Pl. 8, fig. 8

Periptera tetracladia EHRENBERG, 1845, p. 270; HANNA, 1932, p. 205, pl. 13, fig. 8; BARRON, 1975, p. 150

Genus POROSIRA Jørgensen, 1905

POROSIRA GLACIALIS (Grunow) Jørgensen
Pl. 8, fig. 9

Podosira hormoidesi var. *glacialis* GRUNOW, 1884, p. 108, pl. 5, fig. 32
Porosira glacialis (Grunow) JØRGENSEN, 1905, p. 97, pl. 6, fig. 7; KOIZUMI, 1973, pl. 4, fig. 17, 18

Genus PSEUDOEUNOTIA Grunow, 1865

PSEUDOEUNOTIA DOLIOLUS (Wallich) Grunow
Pl. 8, fig. 10

Synedra doliolus WALLICH, 1860, p. 48, pl. 2, fig. 19
Pseudoeunotia doliolus (Wallich) Grunow *in* VAN HEURCK, 1881, pl. 35, fig. 22; SCHRADER, 1973a, p. 709, pl. 9, fig. 1-5, 10, 12, 22, 23; pl. 10, fig. 24, 29

Genus PSEUDOPYXILLA Forti, 1909

PSEUDOPYXILLA AMERICANA (Ehrenberg) Forti
Pl. 8, fig. 11

Rhizosolenia americana EHRENBERG, 1841 (1843), p. 422
Pseudopyxilla americana (Ehrenberg) FORTI, 1909, p. 28, 30, pl. 1, fig. 6, 7; BARRON, 1975, p. 151, 152, pl. 11, fig. 12

PSEUDOPYXILLA DUBIA (Grunow) Forti
Pl. 8, fig. 12

Pyxilla dubia Grunow *in* VAN HEURCK, 1882, pl. 83, fig. 7, 8, pl. 83b, fig. 12
Pseudopyxilla dubia (Grunow) FORTI, 1909, p. 28, pl. 1, fig. 22; BARRON, 1975, p. 152, pl. 11, fig. 13

Genus RHABDONEMA Kützing, 1844

RHABDONEMA JAPONICUM Tempère
var. SPARSICOSTATUM Tempère and Brun
Pl. 8, fig. 13

Rhabdonema japonicum Tempère var. *sparsicostatum* TEMPÈRE and BRUN, 1889, p. 53; BARRON, 1975, p. 152, pl. 11, fig. 16

Genus RHAPHONEIS Ehrenberg, 1844

RHAPHONEIS AMPHICEROS Ehrenberg
var. ELONGATA Peragallo and Peragallo
Pl. 8, fig. 16

Rhaphoneis amphiceros Ehrenberg var. *elongata* PERAGALLO and PERAGALLO, 1901, pl. 83, fig. 10; BARRON, 1975, p. 152, pl. 12, fig. 1

RHAPHONEIS AMPHICEROS (Ehrenberg) var.
GEMMIFERA Peragallo and Peragallo
Pl. 8, fig. 17

Rhaphoneis amphiceros (Ehrenberg) var. *gemmifera* PERAGALLO and PERAGALLO, 1901, pl. 83, fig. 11-14; BARRON, 1975, p. 152, pl. 12, fig. 2

RHAPHONEIS FATULA Lohman
Pl. 8, fig. 14

Rhaphoneis fatula LOHMAN, 1938, p. 93, pl. 22, fig. 5; ANDREWS, 1975, p. 213, pl. 3, fig. 3 (with description)

PLATE 7

1. *Hemiaulus polymorphus* Grunow. 42, -28 microns, x1100, 35 mm.
2. *Hemidiscus cuneiformis* Wallich. 43, +28 microns, x520, 35 mm.
3. *Hemidiscus simplicissimus* Hanna and Grant. 46, -28 microns, x1000.
4. *Hercotheca mamillaris* Ehrenberg. 73, -28 microns, x1000.
5. *Lithodesmium asketogonium* Barron. 43, +28 microns, x600.
6. *Lithodesmium cornigerum* Brun. 60, +28 microns, x400.
7. *Lithodesmium minusculum* Grunow. 54, -28 microns, x1600.
8. *Melosira clavigera* Grunow. 39, +28 microns, x315.
9. *Melosira sulcata* var. *biseriata* (Grunow) Pergallo and Pergallo. 73, -28 microns, x1000.
10. *Melosira sulcata* var. *coronata* (Ehrenberg) Grunow. 73, -28 microns, x1300.
11. *Melosira sulcata* var. *siberica* Grunow. 73, -28 microns, x1300.
12. *Muelleriella limbata* (Ehrenberg) Van Heurck. 73, +28 microns, x520.
13. *Navicula lyra* var. *ehrenbergii* Cleve. 52, +28 microns, x400.
14. *Navicula optima* Hanna. 60, -28 microns, x1600.

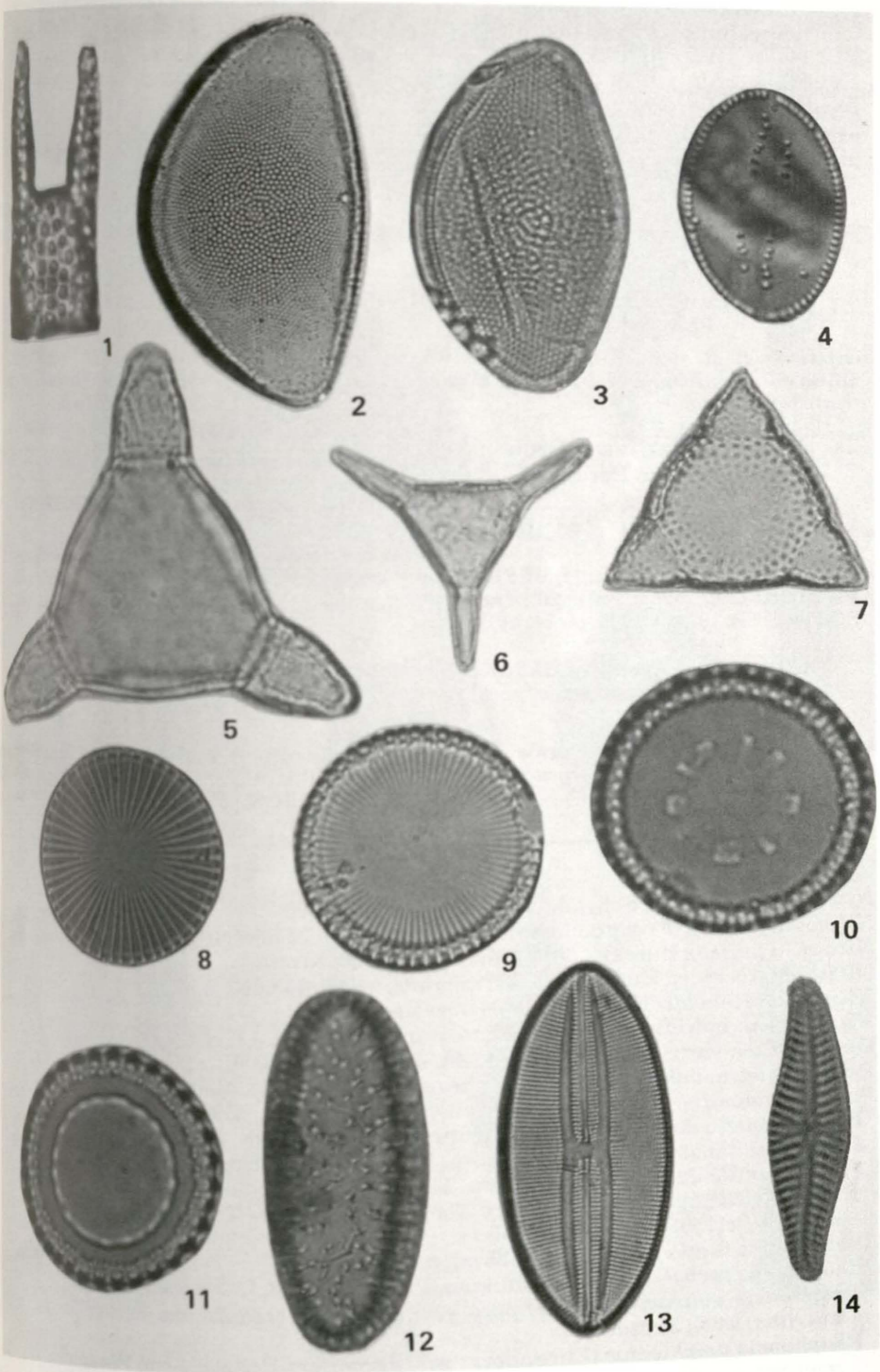


PLATE 7

RHAPHONEIS SACHALINENSIS
Sheshukova-Poretzkaya
Pl. 8, fig. 15

Rhaphoneis sachalinensis SHESHUKOVA-PORETZKAYA, 1967, p. 242, pl. 42, fig. 2 (with description); BARRON, 1975, p. 153, pl. 12, fig. 3

Genus RHIZOSOLENIA Brightwell, 1858

RHIZOSOLENIA cf. R. ALATA
Brightwell, Schrader
Pl. 8, fig. 18

Rhizosolenia cf. *R. alata* Brightwell, SCHRADER, 1973a, p. 709, pl. 10, fig. 14-17, 23 (with discussion)

RHIZOSOLENIA BARBOI (Brun)
Tempère and Peragallo
Pl. 9, fig. 1

Pyxilla barboi BRUN, 1894, p. 87, pl. 5, fig. 16, 17, 23
Rhizosolenia barboi (Brun) TEMPÈRE and PERAGALLO, 1908, p. 26, no. 47; SCHRADER, 1973a, p. 709, pl. 24, fig. 4, 7

RHIZOSOLENIA HEBETATA Bailey
forma HIEMALIS Gran
Pl. 9, fig. 2

Rhizosolenia hebetata Bailey forma *hiemalis* GRAN, 1904, p. 527, pl. 27, fig. 9; KOIZUMI, 1973, p. 844, pl. 5, fig. 34, 35

RHIZOSOLENIA PRAEBERGONII Muchina
Pl. 9, fig. 3

Rhizosolenia praebergonii MUCHINA, 1965, p. 24, pl. 2, fig. 3, 4; KOIZUMI, 1968, p. 217, pl. 34, fig. 20a-21b

RHIZOSOLENIA STYLIFORMIS Brightwell
Pl. 9, fig. 4

Rhizosolenia styliformis BRIGHTWELL, 1858, p. 95, pl. 5, fig. 5a, b, d; BARRON, 1975, p. 153, pl. 12, fig. 6

Genus ROSSIELLA
Desikachary and Maheshwari, 1958

ROSSIELLA PRAEPALEACEA (Schrader)
Gersonde and Schrader
Pl. 6, fig. 1

Coscinodiscus praepaleacea SCHRADER, 1973, p. 703, pl. 3, fig. 1-9
Cussia praepaleacea SCHRADER, 1974, p. 543, fig. 1, 8.
Rossiella praepaleacea (Schrader) GERSONDE and SCHRADER, 1984, p. 104, pl. 1, fig. 11, 12

Genus ROUXIA Brun and Heribaud, 1893

ROUXIA CALIFORNICA Peragallo
Pl. 9, fig. 5

Rouxia californica Peragallo in TEMPÈRE and PERAGALLO, 1910, p. 245, no. 468-469; BARRON, 1975, p. 154, pl. 12, fig. 11

PLATE 8

1. *Nitzschia californica* Schrader. 73, -28 microns, x1000.
2. *Nitzschia fossilis* (Frenguelli) emend. Kanaya. 42, -28 microns, x1000.
3. *Nitzschia jouseae* Burckle. 66, -28 microns, x2750, 35 mm.
4. *Nitzshia miocenica* Burckle. 55, -28 microns, x1200, 35 mm.
5. *Nitzschia reinholdii* Kanaya. 52, -28 microns, x1200.
6. *Nitzschia rolandii* Schrader. 43, -28 microns, x1600.
7. *Opephora schwartzii* (Grunow) Petit. 44, -28 microns, x1000.
8. *Periptera tetracladia*? (spore) Ehrenberg. 67, -28 microns, x1000, 35 mm.
9. *Porosira glacialis* (Grunow) Jørgensen. 54, +28 microns, x1200.
10. *Pseudoeunotia doliolus* (Wallich) Grunow. 70, -28 microns, x1200.
11. *Pseudopyxilla americana* (Ehrenberg) Forti. 39, +28 microns, x520, 35 mm.
12. *Pseudopyxilla dubia* (Grunow) Forti. 54, +28 microns, x340.
13. *Rhabdonema japonicum* Tempère var. *sparsicostatum* Tempère and Brun. 73, -28 microns, x1150.
14. *Rhaphoneis fatula* Lohman. 73, -28 microns, x1000.
15. *Rhaphoneis sachalinensis* Sheshukova-Poretzkaya. 54, -28 microns, x1500.
16. *Rhaphoneis amphiceros* Ehrenberg var. *elongata* Peragallo and Peragallo. 39, +28 microns, x400, 35 mm.
17. *Rhaphoneis amphiceros* (Ehrenberg) var. *gemmifera* Peragallo and Peragallo. 73, -28 microns, x1000.
18. *Rhizosolenia* cf. *R. alata* Brightwell, Schrader. 71, +28 microns, x800.

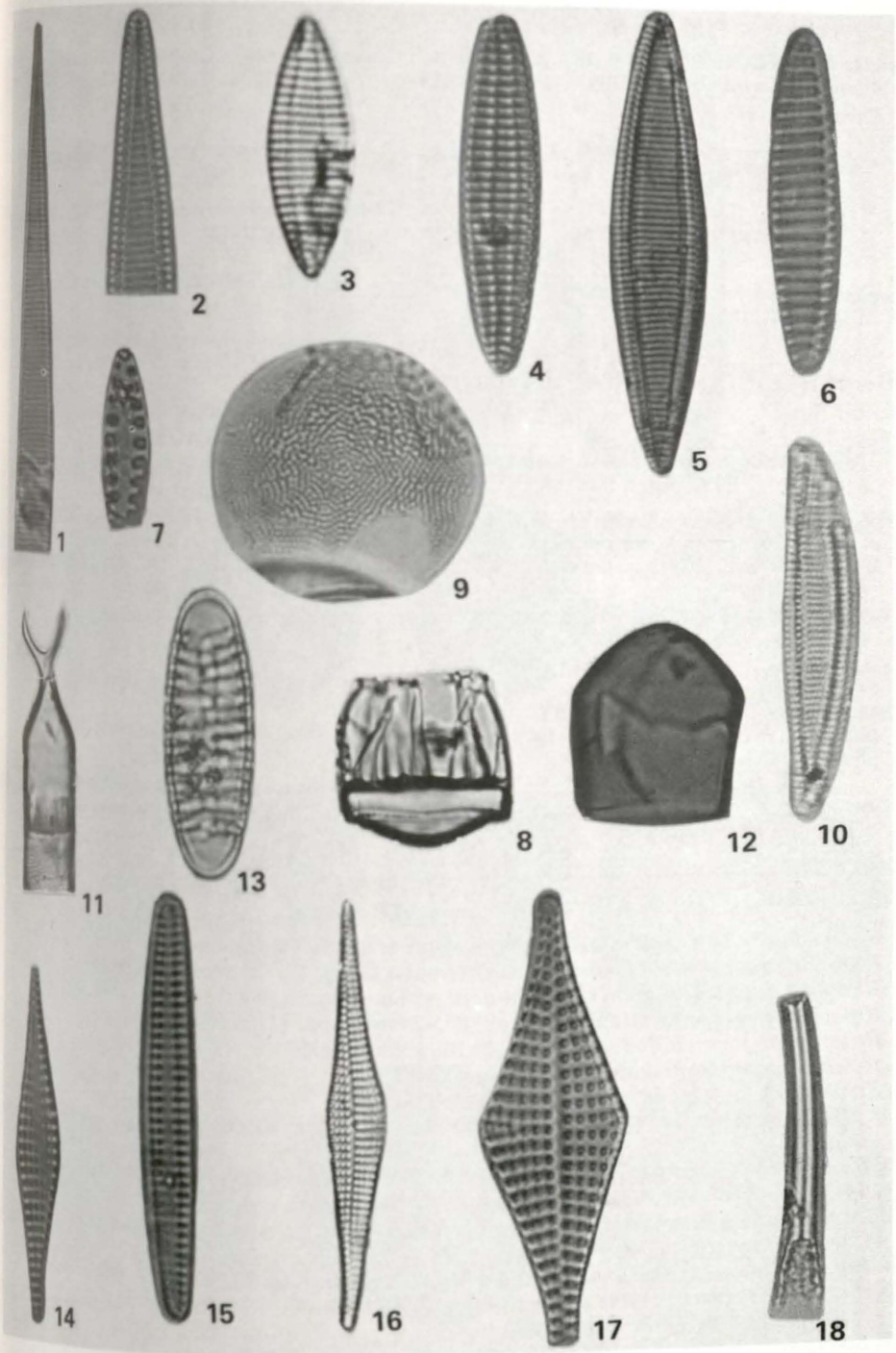


PLATE 8

ROUXIA YABEI Hanna
Pl. 9, fig. 6

Rouxia yabei HANNA, 1930, p. 185, pl. 14, fig. 2-4 (with description); BARRON, 1975, p. 154, pl. 12, fig. 7

Genus STEPHANODISCUS Ehrenberg, 1845

STEPHANODISCUS sp.
Pl. 9, fig. 7

Stephanodiscus sp. JOUSÉ, KAZARINA and MUCHINA, 1982, pl. 4, fig. 5, 6

Genus STEPHANOGONIA Ehrenberg, 1844

STEPHANOGONIA HANZAWAE Kanaya
Pl. 9, fig. 8-9

Stephanogonia hanzawae KANAYA, 1959, p. 118, pl. 11, fig. 3-7 (with description); BARRON, 1975, p. 154, pl. 12, fig. 12 (spore)

STEPHANOGONIA POLYACANTHA Forti
Pl. 9, fig. 10

Stephanogonia actinoptychus var. *polyacantha* FORTI, 1910, p. 1310, pl. 62
Stephanogonia polyacantha FORTI, 1913, p. 1560, pl. 12, fig. 11; BARRON, 1975, p. 154, pl. 12, fig. 13

Genus STEPHANOPYXIS Ehrenberg, 1844

STEPHANOPYXIS APPENDICULATA Ehrenberg
Pl. 9, fig. 11

Stephanopyxis appendiculata Ehrenberg, 1854, pl. 18, fig. 4; WORNARDT, 1967, p. 17, fig. 12, 13

STEPHANOPYXIS HORRIDUS Koizumi
Pl. 9, fig. 12-13

Stephanopyxis horridus KOIZUMI, 1972, p. 349, pl. 42, fig. 1a, 2b

STEPHANOPYXIS SPINOSSIMA Grunow
Pl. 9, fig. 14

Stephanopyxis spinossima Grunow, 1884, *fide* BARRON, 1975, p. 155, pl. 12, fig. 18

STEPHANOPYXIS TURRIS (Greville and Arnott) Ralfs
Pl. 9, fig. 15-16

Cresswellia turris GREVILLE and ARNOTT, 1857, p. 538, pl. 14, fig. 109
Stephanopyxis turris (Greville and Arnott) Ralfs *in* PRITCHARD, 1861, p. 826, pl. 5, fig. 74; BARRON, 1975, p. 155, pl. 13, fig 1-3

Genus STICTODISCUS Greville, 1861

STICTODISCUS BURYANUS Greville
Pl. 9, fig. 17

Stictodiscus buryanus GREVILLE, 1861, p. 40, pl. 4, fig. 1; BARRON, 1975, p. 156, pl. 13, fig. 5

PLATE 9

1. *Rhizosolenia barboi* (Brun) Tempère and Peragallo. 73, -28 microns, x600.
2. *Rhizosolenia hebetata* Bailey forma *hiemalis* Gran. 42, -28 microns, x1000.
3. *Rhizosolenia praebergonii* Muchina. 68, -28 microns, x1000.
4. *Rhizosolenia styliformis* Brightwell. 60, -28 microns, x1100.
5. *Rouxia californica* Peragallo. 46, -28 microns, x1200.
6. *Rouxia yabei* Hanna. 39, -28 microns, x1000.
7. *Stephanodiscus* sp. 48, +28 microns, x600.
8-9. *Stephanogonia hanzawae* Kanaya. 73, -28 microns, x1500, specimen at two different levels of focus.
10. *Stephanogonia polyacantha* Forti. 64, +28 microns, x650.
11. *Stephanopyxis appendiculata* Ehrenberg. 64, +63 microns, x280.
12-13. *Stephanopyxis horridus* Koizumi. 73, -28 microns, x1000, specimen at two different levels of focus.
14. *Stephanopyxis spinossima* Grunow. 39, +328 microns, x325.
15-16. *Stephanopyxis turris* (Greville and Arnott) Ralfs. Fig. 15, 73, +28 microns, x500. Fig. 16, 44, +28 microns, x500.
17. *Stictodiscus buryanus* (Greville). 39, +28 microns, x250.
18. *Stictodiscus californicus* Greville. 52, +63 microns, x250.

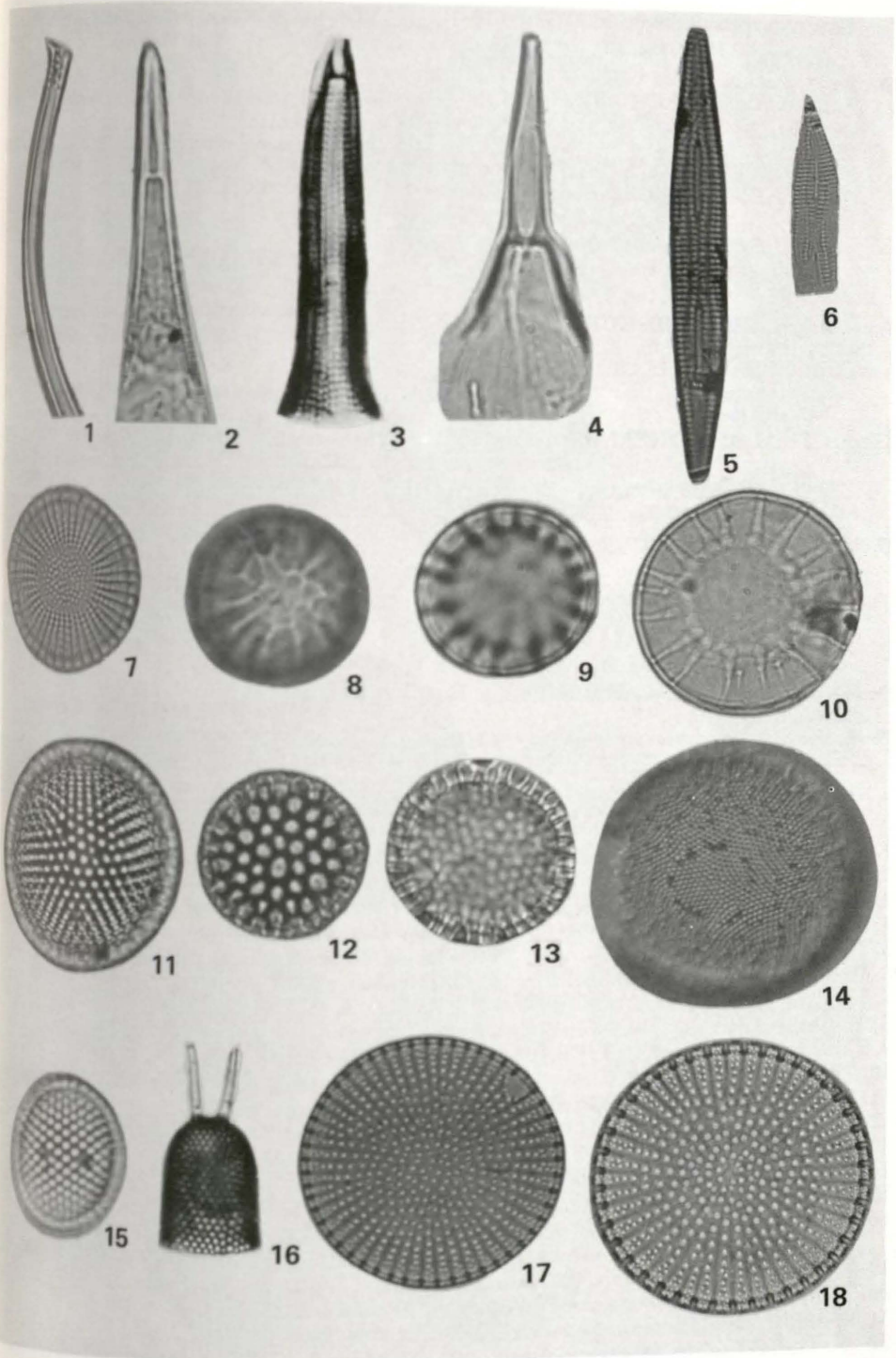


PLATE 9

STICTODISCUS CALIFORNICUS Greville
Pl. 9, fig. 18

Stictodiscus californicus GREVILLE, 1861, p. 79, pl. 10, fig. 1; WORNARDT, 1967, p. 38, fig. 54, 55

Genus SYNEDRA Ehrenberg, 1830

SYNEDRA JOUSEANA
Sheshukova-Poretzkaya
Pl. 10, fig. 1

Synedra jouseana SHESHUKOVA-PORETZKAYA, 1962, p. 208, fig. 4; SCHRADER, p. 710, pl. 23, fig. 21-23, 25, 38

Genus THALASSIONEMA Grunow, 1881

THALASSIONEMA ANTIQUA Schrader
Pl. 10, fig. 2

Thalassionema antiqua SCHRADER, 1973a, p. 711, pl. 23, fig. 26-30

THALASSIONEMA HIROSAKIENSIS (Kanaya)
Schrader
Pl. 10, fig. 3

Fragilaria hirosakiensis KANAYA, 1959, p. 104-106, pl. 9, fig. 11-15
Thalassionema hirosakiensis (Kanaya) SCHRADER, 1973, p. 711, pl. 23, fig. 31-33

THALASSIONEMA NITZSCHIOIDES (Grunow)
Van Heurck
Pl. 10, fig. 4

Synedra nitzschioides GRUNOW, 1862, p. 403, pl. 5, fig. 18
Thalassionema nitzschioides (Grunow) VAN HEURCK, 1896, p. 319, fig. 75; SCHRADER, 1973, p. 712, pl. 23, fig. 2, 6, 8

Genus THALASSIOSIRA Cleve, 1873

THALASSIOSIRA ANTIQUA (Grunow)
Cleve-Euler
Pl. 10, fig. 5

Coscinodiscus antiquus GRUNOW, 1884, p. 84, pl. 4, fig. d
Thalassiosira antiqua (Grunow) CLEVE-EULER, 1941, p. 173, fig. 4; BARRON, 1975, p. 157, pl. 13, fig. 10, 13

THALASSIOSIRA CONVEXA Muchina
Pl. 10, fig. 6

Thalassiosira convexa MUCHINA, 1965, p. 22, pl. 11, fig. 1, 2; SCHRADER, 1973, p. 712, pl. 11, fig. 37, 38

THALASSIOSIRA CONVEXA Muchina
var. ASPINOSA Schrader
Pl. 10, fig. 7

PLATE 10

1. *Synedra jouseana* Sheshukova-Poretzkaya. 48, -28 microns, x1000.
2. *Thalassionema antiqua* Schrader. 60, -28 microns, x1150.
3. *Thalassionema hirosakiensis* (Kanaya) Schrader. 57, -28 microns, x1300.
4. *Thalassionema nitzschioides* (Grunow) Van Heurck. 46, -28 microns, x1000.
5. *Thalassiosira antiqua* (Grunow) Cleve-Euler. 43, +28 microns, x0000.
6. *Thalassiosira convexa* Muchina. 60, -28 microns, x2000.
7. *Thalassiosira convexa* var. *aspinosa* Schrader. 4, -28 microns, x1500.
8. *Thalassiosira* cf. *T. decipiens* (Grunow) Jørgensen. 60, -28 microns, x1200.
9. *Thalassiosira excentrica* (Ehrenberg) Cleve. 57, +28 microns, x800.
10. *Thalassiosira gravida* Cleve forma *fossilis* Jousé. 68, +28 microns, x525.
11. *Thalassiosira hyalina* (Grunow) Gran. 60, -28 microns, x1250.
12. *Thalassiosira hyalinopsis* Barron. 59, -28 microns, x1000.
13. *Thalassiosira miocenica* Schrader. 54, -28 microns, x1000.
14. *Thalassiosira nativa* Sheshukova-Poretzkaya. 46, -28 microns, x1500.
15. *Thalassiosira nidulus* (Tempère and Brun) Jousé. 43, +28 microns, x500.
16-18. *Thalassiosira oestrupii* (Ostenfeld) Proshkina-Lavrenko. Fig. 16. 60, -28 microns, x1200. Fig. 17. 62, -28 microns, x1000. Fig. 18. 64, -28 microns, x1000.
19. *Thalassiosira* cf. *T. pacifica* Gran and Angst. 57, +28 microns, x400.
20. *Thalassiosira praeconvexa* Burckle. 43, -28 microns, x650.
21. *Thalassiosira punctata* Jousé. 59, +28 microns, x650.
22-23. *Thalassiosira zabelinae* Jousé. 73, -28 microns, x1000, specimen at two different levels of focus.

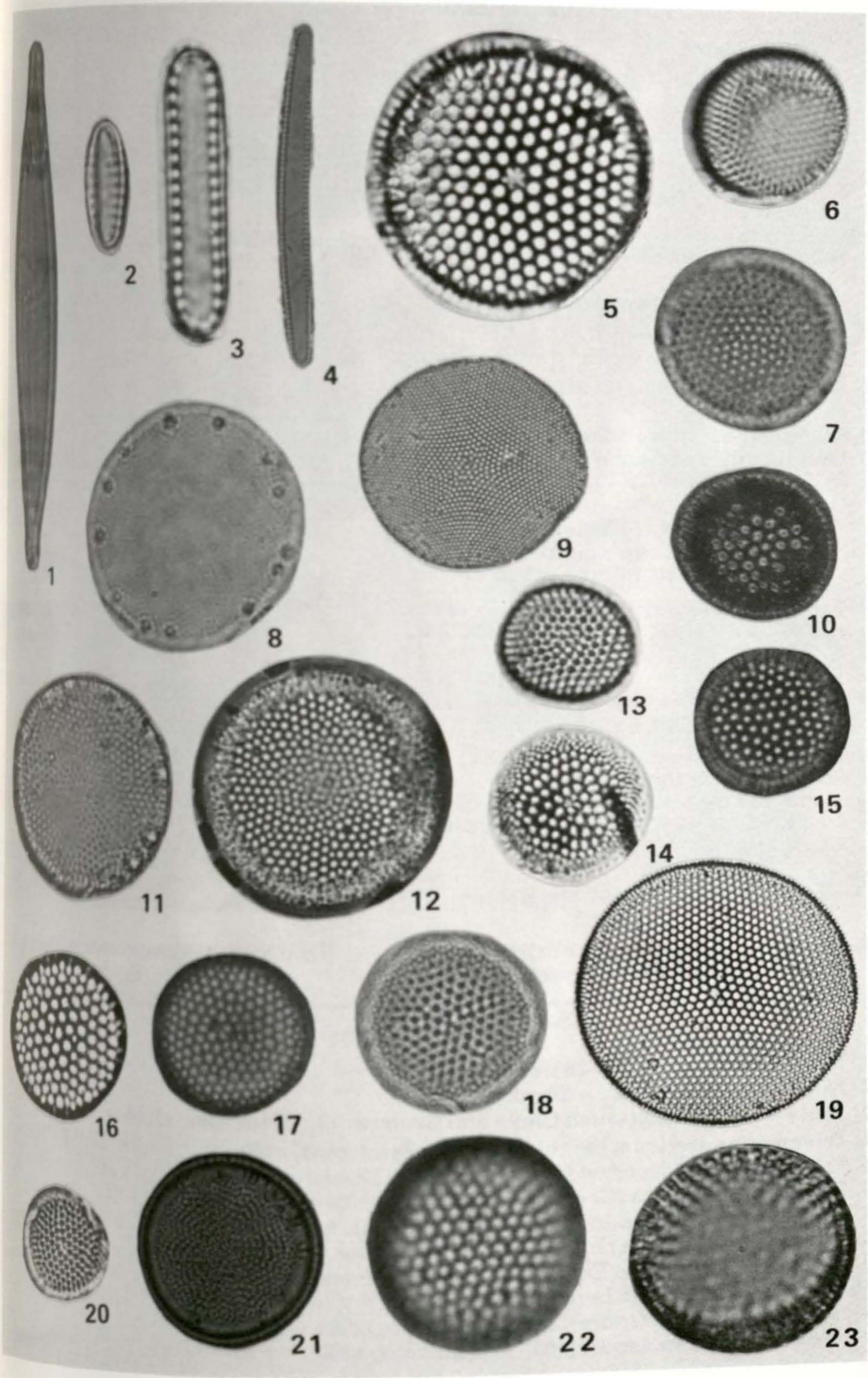


PLATE 10

Thalassiosira convexa var. *aspinosa* SCHRADER, 1974b, p. 916, pl. 2, fig. 8, 9, 13a-21

THALASSIOSIRA cf. T. DECIPIENS (Grunow) Jørgensen
Pl. 10, fig. 8

Coscinodiscus excentricus var. *decipiens* GRUNOW, 1878, p. 125, pl. 4, fig. 18
Thalassiosira cf. *T. decipiens* (Grunow) JØRGENSEN, 1905, p. 96, pl. 6, fig. 3; BARRON, 1975, p. 157, pl. 13, fig. 11, 14

THALASSIOSIRA EXCENTRICA (Ehrenberg) Cleve
Pl. 10, fig. 9

Coscinodiscus excentricus EHRENBERG, 1839, p. 146
Thalassiosira excentrica (Ehrenberg) CLEVE, 1903, p. 216; Schrader, 1974b, p. 916, pl. 11, fig. 7-8; pl. 14, fig. 6-7, 9-10

THALASSIOSIRA GRAVIDA Cleve forma FOSSILIS Jousé
Pl. 10, fig. 10

Thalassiosira gravida Cleve forma *fossilis* JOUSÉ, 1961, p. 63, pl. 1, fig. 9; KOIZUMI, 1975a, p. 803, pl. 5, fig. 7, 8, 9, 10

THALASSIOSIRA HYALINA (Grunow) Gran
Pl. 10, fig. 11

Coscinodiscus hyalinus Grunow *in* CLEVE and GRUNOW, 1880, p. 113, pl. 7, fig. 128
Thalassiosira hyalina (Grunow) GRAN, 1887, p. 4, pl. 1, fig. 17, 18; KOIZUMI, 1973, p. 834, pl. 8, fig. 1, 2

THALASSIOSIRA HYALINOPSIS Barron
Pl. 10, fig. 12

Thalassiosira hyalinopsis BARRON, 1975, p. 157, pl. 13, fig. 12, 15 (with description)

THALASSIOSIRA MIOCENICA Schrader
Pl. 10, fig. 13

Thalassiosira miocenica SCHRADER, 1974b, p. 916, pl. 22, fig. 4 (with description and discussion)

THALASSIOSIRA NATIVA Sheshukova-Poretzkaya
Pl. 10, fig. 14

Thalassiosira nativa SHESHUKOVA-PORETZKAYA, 1959, p. 41, pl. 1, fig. 8; BARRON, 1975, p. 158, pl. 14, fig. 4

THALASSIOSIRA NIDULUS (Tempère and Brun) Jousé
Pl. 10, fig. 15

Stephanopyxis nidulus Tempère and Brun in BRUN and TEMPÈRE, 1889, p. 57, pl. 8, fig. 10
Thalassiosira nidulus (Tempère and Brun) JOUSÉ, 1961, p. 63, pl. 3, fig. 4-5; SCHRADER, 1973, p. 712, pl. 11, fig. 1-7

THALASSIOSIRA OESTRUPII (Ostenfeld) Proshkina-Lavrenko
Pl. 10, fig. 16, 17, 18

Coscinosira oestrupii OSTENFELD, 1900, p. 52
Thalassiosira oestrupii (Ostenfeld) PROSHKINA-LAVRENKO, 1960, p. 8, pl. 1, fig. 5, 7, 11; BARRON, 1975, p. 158, pl. 14, fig. 5, 6

THALASSIOSIRA cf. T. PACIFICA Gran and Angst
Pl. 10, fig. 19

Thalassiosira pacifica GRAN and ANGST, 1931, p. 437-438, fig. 12; p. 712, pl. 25, fig. 18, 20, 21; pl. 14, fig. 13, 14

THALASSIOSIRA PRAECONVEXA Burckle
Pl. 10, fig. 20

PLATE 11

1. *Thalassiosira* sp. 3. 60, -28 microns, x1350.
2. *Thalassiosira* sp. 6. 60, +28 microns, x600.
3. *Thalassiothrix longissima* Cleve and Grunow. 73, -28 microns, x1000.
4. *Triceratium arcticum* Brightwell. 49, +28 microns, x400.
5. *Triceratium condecorum* Ehrenberg. 51, +28 microns, x500.
6. *Triceratium elegans* (Greville) Grunow. 67, +28 microns, x400.
7. *Triceratium thumii* Schmidt. 44, +28 microns, x400.
8. *Triceratium validum* Grunow. 42, +28 microns, x400.
9. *Xanthiopyxis oblonga* Ehrenberg. 54, -28 microns, x1250.
10. *Xanthiopyxis ovalis* Lohman (spore). 73, -28 microns, x1200.
11. *Xanthiopyxis* sp. (spore). 64, +28 microns, x700.
12. *Xanthiopyxis* sp. (spore). 64, +28 microns, x400.

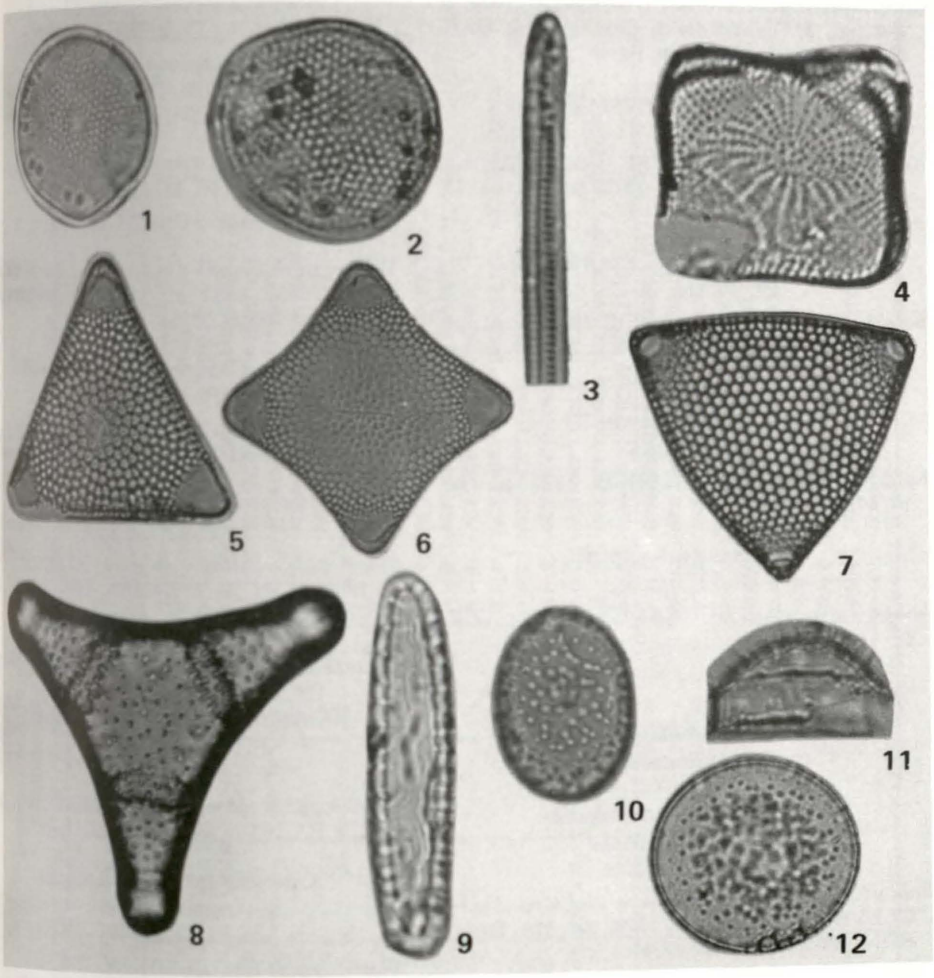


PLATE 11

Thalassiosira praeconvexa BURCKLE, 1972, p. 242, pl. 2, fig. 7-9 (with description); BARRON, 1975, p. 158, pl. 14, fig. 9

THALASSIOSIRA PUNCTATA Jousé
Pl. 10, fig. 21

Thalassiosira punctata JOUSÉ, 1959, p. 55, pl. 4, fig. 5, 17; SCHRADER, 1973, p. 712, pl. 17, fig. 20

THALASSIOSIRA ZABELINAE Jousé
Pl. 10, fig. 22-23

Thalassiosira zabelinae JOUSÉ, 1959, p. 41, pl. 2, fig. 1a, b; KOIZUMI, 1973, p. 834, pl. 8, fig. 10-12

THALASSIOSIRA sp. 3
Pl. 11, fig.1

Thalassiosira sp. 3 SCHRADER, 1973, p. 712, pl. 14, fig. 19, 20

THALASSIOSIRA sp. 6
Pl. 11, fig. 2

Thalassiosira sp. 6 SCHRADER, 1973, p. 712, pl. 17, fig. 21-23

Genus THALASSIOTHRIX Cleve and Grunow, 1880

THALASSIOTHRIX LONGISSIMA Cleve and Grunow
Pl. 11, fig. 3

Thalassiothrix longissima Cleve and Grunow *in* CLEVE and MÖLLER, 1878, no. 118; BARRON, 1975, pl. 14, fig. 10, 11

Modern distribution: North boreal (Jousé *et al.*, 1969).

Genus TRICERATIUM Ehrenberg, 1840

TRICERATIUM ARCTICUM Brightwell
Pl. 11, fig. 4

Triceratium arcticum BRIGHTWELL, 1853, p. 250, pl. 4, fig. 11; BARRON, 1975, pl. 14, fig. 13

TRICERATIUM CONDECORUM Ehrenberg
Pl. 11, fig. 5

Triceratium condecorum EHRENBERG, 1844, p. 272; BARRON, 1975, p. 159, pl. 14, fig. 15; pl. 15, fig. 4

TRICERATIUM ELEGANS (Greville) Grunow
Pl. 11, fig. 6

Amphitetras elegans GREVILLE, 1866, p. 9, pl. 2, fig. 717

Triceratium elegans (Greville) Grunow *in* VAN HEURCK, 1883, pl. 109, fig. 1; BARRON, 1975, p. 160, pl. 15, fig. 1

TRICERATIUM THUMII Schmidt
Pl. 11, fig. 7

Triceratium thumii SCHMIDT, 1886, pl. 93, fig. 2; WORNARDT, 1967, p. 67, fig. 129

TRICERATIUM VALIDUM Grunow
Pl. 11, fig. 8

Triceratium validum Grunow *in* SCHMIDT, 1886, pl. 94, fig. 5; HANNA, 1970, p. 195, p. 229, fig. 85

Genus XANTHIOPYXIS Ehrenberg, 1844

XANTHIOPYXIS OBLONGA Ehrenberg (resting spore)
Pl. 11, fig. 9

Xanthiopyxis oblonga EHRENBERG, 1844, p. 273; BARRON, 1975, p. 161, pl. 15, fig. 12

XANTHIOPYXIS OVALIS Lohman (resting spore)
Pl. 11, fig. 10

Xanthiopyxis ovalis LOHMAN, 1938, p. 91, pl. 20, fig. 6; pl. 22, fig. 12; BARRON, 1975, p. 161, pl. 15, fig. 13

XANTHIOPYXIS sp. (resting spore)
Pl. 11, fig. 11

Xanthiopyxis sp. D. WORNARDT, 1967, p. 73, 76, 77, fig. 155, 155a

XANTHIOPYXIS sp. (resting spore)
Pl. 11, fig. 12

Xanthiopyxis sp. BARRON, 1975, p. 161, pl. 15, fig. 15

CHECK CHARTS, NOTE

Check charts I-III were designed to display a concise overview of the diatom inventories for the beds exposed in the Sweeny Road section. Check charts IV-VI tabulate the occurrence of some of the taxa that contemporary diatomists have found to be the most biostratigraphically useful for deep sea cores and outcrops in the North Pacific Ocean regions.

Check Chart I
Sweeny Road Diatoms
Alphabetized

Sample Number / Taxa	1	2	3	4	5	6	7	8	9	0
	0	0	0	0	0	0	0	0	0	0
	1	2	3	4	5	6	7	8	9	0
ACTINOCYCLUS CHOLNOKYI										
ACTINOCYCLUS CUBITUS										
ACTINOCYCLUS CURVATULUS										
ACTINOCYCLUS EHRENBERGII										
ACTINOCYCLUS EHRENBERGII VAR. ASTERISCUS										
ACTINOCYCLUS EHRENBERGII VAR. TENELLA										
ACTINOCYCLUS ELLIPTICUS										
ACTINOCYCLUS ELLIPTICUS VAR. MORONENSIS										
ACTINOCYCLUS INGENS										
ACTINOCYCLUS OCHOTENSIS										
ACTINOCYCLUS OCULATUS										
ACTINOCYCLUS TSUGARUENIS										
ACTINOPTYCHUS BISMARCKII										
ACTINOPTYCHUS CLEVEI										
ACTINOPTYCHUS SPLENDENS VAR. HALIONYX										
ACTINOPTYCHUS SPLENDENS VAR. INCISA										
ACTINOPTYCHUS STELLA VAR. CLEVEI										
ACTINOPTYCHUS UNDULATUS										
ACTINOPTYCHUS VULGARIS VAR. MONICAE										
ARACHNOIDISCUS DECORUS										
ARACHNOIDISCUS EHRENBERGII										
ARACHNOIDISCUS ORNATUS VAR. MONTEREYANUS										
ASTEROMPHALUS DARWINII										
AULACODISCUS CONCENTRICUS										
AULACODISCUS KITTONI										
AULACODISCUS MARGARITACEUS										
AULACODISCUS SIMPLEX										
AULISCUS CAELATUS										
AULISCUS CAELATUS VAR. CONSTRICTA										
AULISCUS PUNCTATUS										

Frequency Key

- • = Abundant. 2 or More Specimens Within 1 Field of View at X400.
- o = Common. 1 Specimen Within 2 Field of View.
- x = Few. 1 Specimen Per Traverse (2cm).
- / = Rare. Specimens Sparser Than 1 Per Traverse.
- Δ = Reworked.

Check Chart I
Sweeny Road Diatoms
Alphabetized

Sample Number	031 BACTERIASTRUM SP.	032 BIDDULPHIA AURITA	033 BIDDULPHIA AURITA VAR. OBTUSA	034 BIDDULPHIA RHOMBUS	035 BIDDULPHIA SUBORBICULARIS	036 BIDDULPHIA TRIDENS	037 CESTODISCUS PULCHELLUS VAR. MACULATUS	038 CHAETOCEROS CINCTUS	039 CHAETOCEROS DIADEMA	040 CHAETOCEROS DICLADIA	041 CHAETOCEROS SPECIES [SPORE]	042 CLADOGRAMMA CALIFORNICUM	043 CLADOGRAMMA DUBUIM	044 COCCONEIS COSTATA	045 COCCONEIS DECIPIENS	046 COCCONEIS DIRUPTA VAR. TRIUMPHIS	047 COSCINODISCUS ANTIQUUS	048 COSCINODISCUS ASTEROMPHALUS	049 COSCINODISCUS BIRADIATUS	050 COSCINODISCUS EXCENTRICUS VAR. LEASAREOLATUS	051 COSCINODISCUS HIROSAKIENSIS	052 COSCINODISCUS KURZII	053 COSCINODISCUS MARGINATUS	054 COSCINODISCUS MONICAE	055 COSCINODISCUS NITIDUS	056 COSCINODISCUS NODULIFER	057 COSCINODISCUS OBSCURUS	058 COSCINODISCUS OCULUSIRIDIS VAR. BOREALIS	059 COSCINODISCUS OCULUSIRIDIS VAR. OCULUSIRIDIS	060 COSCINODISCUS PILOSUS
73	X	·	·	·	·	·	·	/	X	O	·	·	·	·	·	·	·	·	·	·	·	·	X	·	·	·	·	·	X	·
72	X	X	·	·	·	·	·	/	O	X	·	·	·	·	·	·	/	·	·	/	·	·	X	·	·	·	·	·	O	·
71	·	X	·	·	·	/	·	·	/	X	·	·	·	·	·	·	·	·	·	·	·	·	/	·	·	·	·	·	O	·
70	·	·	·	·	·	·	·	·	·	/	·	·	·	/	·	·	·	·	·	·	·	·	X	·	·	·	·	/	X	·
69	·	/	·	·	·	·	·	/	/	/	·	·	·	·	·	·	·	·	·	·	·	·	X	·	·	·	·	X	O	·
68	/	·	·	·	·	·	·	·	X	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	X	·
67	/	·	·	·	·	·	·	·	X	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	X	·
66	/	X	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	X	O	·
65	·	·	·	·	·	·	·	·	/	/	·	·	·	/	·	·	·	·	·	/	·	·	·	·	·	·	·	X	●	·
64	/	·	·	·	·	X	·	·	·	/	·	·	·	·	·	·	·	·	·	·	·	·	X	·	·	·	·	/	O	·
63	·	·	·	·	·	·	·	·	/	X	·	·	·	·	·	·	X	·	·	·	·	·	X	·	·	·	·	·	X	·
62	·	·	·	·	·	·	·	·	/	X	·	·	·	·	·	·	·	·	·	·	·	·	/	·	·	·	·	·	·	·
61	·	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	X	·	·	·	·	·	X	·
60	·	·	/	·	·	·	·	X	·	X	·	·	·	·	·	·	·	·	·	·	·	·	O	·	·	·	·	·	O	·
59	X	·	·	·	·	·	·	·	·	/	·	·	·	/	·	·	·	·	·	/	·	·	/	·	·	·	·	/	O	·
58	O	X	·	·	·	·	·	/	·	X	·	·	·	·	·	·	·	·	·	·	·	·	X	·	·	·	·	X	X	·
57	X	·	·	·	·	·	·	·	·	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	X	·
56	X	·	·	·	·	·	·	·	/	X	·	·	·	·	·	·	·	·	·	X	·	·	X	·	·	·	·	X	O	·
55	/	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	/	·	·	·	·	/	O	·
54	·	/	·	·	·	·	·	·	·	X	·	·	·	·	·	·	·	X	·	·	·	·	X	·	·	·	·	X	O	·
53	·	X	·	·	·	·	·	·	/	·	·	·	·	/	·	·	·	·	·	·	·	·	X	·	·	·	/	·	X	·
52	X	·	·	·	·	·	·	·	O	·	·	·	·	·	·	·	·	·	·	·	/	·	X	·	·	·	·	·	X	·
51	/	·	·	·	·	X	·	·	X	X	·	·	·	·	·	·	·	O	·	·	·	·	O	·	·	/	X	·	O	·
50	/	·	·	·	·	/	·	X	·	X	·	·	/	·	·	·	·	X	·	·	·	·	●	·	·	/	/	X	●	·
49	·	/	·	·	·	·	·	/	·	·	·	/	·	·	X	·	·	X	·	·	·	·	●	·	·	/	·	X	●	·
48	·	·	·	·	/	·	·	X	/	·	/	·	/	·	·	·	·	X	·	·	·	·	●	/	·	·	·	·	X	·
47	·	·	·	·	/	·	·	/	·	·	·	·	·	·	/	·	·	O	·	·	·	·	O	X	·	·	·	/	O	·
46	·	·	·	·	·	·	·	·	·	·	/	X	·	·	·	·	·	/	·	·	/	·	X	·	/	·	X	/	O	·
45	·	/	·	/	·	·	·	/	·	/	X	·	·	X	·	·	·	·	·	·	·	·	O	/	/	·	/	·	X	·
44	·	·	·	·	·	·	·	X	·	·	·	·	/	·	·	·	·	/	·	·	·	·	O	/	·	/	·	·	X	·
43	·	/	·	·	·	·	·	/	X	/	·	/	·	·	·	·	·	X	·	·	·	/	X	·	/	·	/	X	O	·
42	·	·	/	·	·	/	·	X	/	/	/	/	·	·	·	·	·	X	·	·	·	·	X	X	·	/	·	X	O	·
41	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
40	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
39	·	·	·	/	·	/	/	·	·	·	·	/	·	·	/	/	·	X	/	·	X	/	●	X	/	/	/	/	X	●

Frequency Key
- ● = Abundant. 2 or More Specimens Within 1 Field of View at X400.
- o = Common. 1 Specimen Within 2 Field of View.
- x = Few. 1 Specimen Per Traverse (2cm).
- / = Rare. Specimens Sparser Than 1 Per Traverse.
- Δ = Reworked.

Check Chart I
Sweeny Road Diatoms
Alphabetized

Sample Number / Taxa	66 1	66 2	66 3	66 4	66 5	66 6	66 7	66 8	66 9	67 0
COSCINODISCUS PLICATUS	0	0	0	0	0	0	0	0	0	0
COSCINODISCUS RADIATUS										
COSCINODISCUS ROBUSTUS VAR. INCRETUS										
COSCINODISCUS STELLARIS VAR. SYMBOLOPHORA										
COSCINODISCUS SUBTILIS										
COSCINODISCUS TABULARIS VAR. EGREGIUS										
COSCINODISCUS VESTUSTISSIMUS										
DENTICULOPSIS DIMORPHA										
DENTICULOPSIS HUSTEDII										
DENTICULOPSIS HYALINA										
DENTICULOPSIS KAMTSCHATICA	0	0	0	0	0	0	0	0	0	0
DENTICULOPSIS SEMINAE VAR. FOSSILIS										
DIMEROGRAMMA SP.?										
DIPLONEIS CRABRO										
DOSSETIA LACERA										
ENDICTYA OCEANICA										
ENDICTYA ROBUSTUS										
ENTOPYLA AUSTRALIS VAR. GIGANTEA										
GLYPHODESMUS WILLIAMSONII										
GLYPHODISCUS STELLATUS										
GRAMMATOPHORA ANGULOSA										
GRAMMATOPHORA MERLETTA										
HEMIAULUS POLYMORPHUS										
HEMIDISCUS CUNEIFORMIS										
HEMIDISCUS SIMPLICISSIMUS										
HERCOTHECA MAMILLARIS										
LIHODESMIUM ASKETOGONIUM										
LIHODESMIUM CORNIGERUM										
LIHODESMIUM MINUSCULUM										
MELOSIRA CLAVIGERA										

Frequency Key

- ● = Abundant. 2 or More Specimens Within 1 Field of View at X400.
- o = Common. 1 Specimen Within 2 Field of View.
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- Δ = Reworked.

Check Chart I
Sweeny Road Diatoms
Alphabetized

Sample Number \ Taxa	MELOSIRA SULCATA VAR. BISERIATA	MELOSIRA SULCATA VAR. CORONATA	MELOSIRA SULCATA VAR. SIBERICA	MUELLERIELLA LIMBATA	NAVICULA LYRA VAR. EHRENBERGII	NAVICULA OPTIMA	NITZSCHIA CALIFORNICA	NITZSCHIA FOSSILIS	NITZSCHIA JOUSEAE	NITZSCHIA MIOCENICA	NITZSCHIA REINHOLDII	NITZSCHIA ROLANDII	OPEPHORA SCHWARTZII	PERIPTERA TETRACLADIA	POSOSIRA GLACIALIS	PSEUDOEUNOTIA DOLIOLUS	PSEUDOPYXILLA AMERICANA	PSEUDOPYXILLA DUBIA	RHABDONEMA JAOPNICUM	RHAPHONEIS AMPHICEROS VAR. ELONGATA	RHAPHONEIS AMPHICEROS VAR. GEMMIFERA	RHAPHONEIS FATULA	RHAPHONEIS MIOCENICA	RHAPHONEIS SACHALINENSIS	RHIZOSOLENIA BARBOI	RHIZOSOLENIA CF. R. ALATA	RHIZOSOLENIA HEBETATA	RHIZOSOLENIA PRAEBERGONII	RHIZOSOLENIA STYLIFORMIS	ROSSIELLA PRAEPALAEACEUS
	90	90	90	90	90	90	90	90	90	91	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
	12	23	34	45	56	67	78	89	90	01	02	13	24	45	56	67	78	89	90	01	12	23	34	45	56	67	78	89	90
73	O	/	·	·	/	/	/	X	·	·	·	·	·	X	·	·	/	·	·	X	O	/	·	·	X	X	X	·	/
72	X	X	·	·	X	·	·	·	·	·	·	·	·	/	·	·	/	·	·	/	X	X	·	·	/	·	X	·	·
71	X	X	·	·	·	·	X	·	/	·	·	·	·	·	·	·	·	·	·	/	X	·	·	·	·	/	X	·	·
70	X	·	·	·	·	·	/	·	·	·	·	·	·	/	·	·	·	·	X	O	·	·	·	·	X	·	X	·	·
69	/	·	·	·	·	·	/	·	·	·	·	·	·	·	·	·	·	·	·	X	·	·	·	·	·	·	·	·	·
68	·	X	·	·	·	·	·	X	·	·	·	·	·	·	·	·	·	·	·	·	/	·	·	·	X	·	·	/	·
67	·	X	·	X	X	·	·	·	·	·	·	·	·	X	·	·	·	·	·	·	·	·	·	·	·	/	/	·	·
66	·	·	·	·	·	X	·	·	·	·	·	/	·	/	·	·	·	·	·	·	X	·	·	·	·	·	X	·	·
65	X	·	·	·	·	X	·	·	·	·	/	·	·	·	·	·	·	·	·	·	·	·	·	O	/	·	/	·	·
64	·	·	·	/	/	·	·	·	·	·	·	·	·	/	·	·	·	·	·	/	·	·	·	X	X	·	/	/	X
63	·	·	/	·	·	/	·	·	·	·	·	·	·	/	·	·	·	·	·	·	·	·	·	X	/	·	·	·	·
62	·	·	·	/	·	·	·	·	·	·	·	/	·	·	·	·	·	·	·	·	/	·	·	●	·	·	X	·	·
61	·	/	·	·	/	·	·	·	·	/	X	·	·	/	·	·	·	·	·	·	X	·	·	●	/	·	/	X	·
60	X	·	·	·	·	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	X	·	·	O	X	·	/	·	·
59	X	·	·	·	·	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	/	·	·	X	·	·	/	·	·
58	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	O	·	·	X	/	·	X	·	·
57	·	·	·	X	·	·	·	·	·	/	X	·	·	·	·	·	·	·	·	·	O	·	·	X	·	·	X	·	·
56	/	·	·	·	·	/	/	·	·	·	·	·	·	X	·	·	·	·	·	·	X	/	/	O	X	·	X	·	·
55	·	/	·	·	·	·	·	·	·	·	X	X	·	/	·	·	·	·	·	·	X	X	·	O	·	·	X	·	·
54	/	·	·	/	·	X	·	·	·	·	·	/	·	·	·	/	·	·	·	/	X	·	·	X	X	·	X	·	·
53	·	/	·	·	·	/	/	·	·	/	/	·	·	/	X	·	·	·	·	·	X	·	/	/	·	·	X	·	X
52	·	·	·	·	·	X	·	·	·	·	·	X	·	·	·	·	/	·	·	·	O	·	·	·	O	/	/	·	·
51	X	·	·	·	·	X	·	/	·	·	·	·	·	·	·	·	·	·	/	·	O	·	·	·	O	·	/	X	·
50	/	·	·	·	/	X	·	·	·	/	·	·	·	·	X	X	·	/	X	·	/	·	·	·	O	·	X	/	·
49	·	/	/	·	X	/	·	·	·	·	/	·	·	X	·	·	/	X	X	·	X	/	·	·	O	·	/	X	·
48	·	·	·	/	/	·	·	·	·	·	/	·	·	·	X	/	·	/	·	·	X	·	·	X	/	·	X	·	·
47	/	X	·	·	·	X	·	·	/	·	·	·	·	X	·	·	/	/	·	·	X	·	·	●	·	·	X	X	·
46	·	·	·	·	·	X	/	·	·	·	X	/	·	X	·	·	/	/	·	·	X	·	·	●	·	·	/	·	·
45	·	/	·	·	·	/	·	·	·	·	X	/	·	·	·	·	X	X	/	·	/	·	·	●	X	/	X	·	·
44	·	·	·	·	/	X	/	/	·	·	O	X	·	·	·	·	/	/	·	·	X	·	·	O	X	·	X	·	·
43	/	·	·	/	·	·	·	·	·	·	O	·	·	·	·	·	/	/	·	/	X	·	·	O	/	·	X	·	·
42	·	X	·	·	/	X	·	·	·	·	O	X	·	·	·	·	/	X	/	X	X	·	·	O	·	/	/	/	·
41	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
40	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
39	/	/	X	·	/	/	·	·	·	·	·	·	·	/	·	·	·	X	/	O	/	·	·	X	·	·	X	·	/

Frequency Key

● = Abundant. 2 or More Specimens Within 1 Field of View at X400.
O = Common. 1 Specimen Within 2 Field of View.
X = Few. 1 Specimen Per Traverse (2cm).
/ = Rare. Specimens Sparser Than 1 Per Traverse.
Δ = Reworked.

Check Chart I
Sweeny Road Diatoms
Alphabetized

Sample Number / Taxa	73 72 71 70 69	68 67 66 65 64	63 62 61 60 59	58 57 56 55 54	53 52 51 50 49	48 47 46 45 44	43 42 41 40 39
1 2 ROUXIA CALIFORNICA	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·
1 2 ROUXIA YABEI	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·
1 2 STEPHANODISCUS SP.	· · X · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·
1 2 STEPHANOGONIA HANZAWAE	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·
1 2 STEPHANOGONIA POLYACANTHA	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·
1 2 STEPHANOPYXIS APPENDICULATA	X X X · ·	· · · X ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·
1 2 STEPHANOPYXIS HORRIDUS	X X · / ·	· · / · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·
1 2 STEPHANOPYXIS SPINOSSIMA	· · / · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·
1 2 STEPHANOPYXIS TURRIS	X / · X ·	/ · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·
1 2 STRICTODISCUS BURYANUS	· · · · ·	· · · · ·	· · · · ·	X · · · ·	· · · · ·	· · · · ·	· · · · ·
1 2 STRICTODISCUS CALIFORICUS	· · · · ·	· · · · ·	· · · · ·	· · · · ·	X · · · ·	· · · · ·	· · · · ·
1 2 SYNEDRA JOUSEANA	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·
1 2 THALASSIONEMA ANTIQUA	X X · · ·	/ / · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·
1 2 THALASSIONEMA HIROSAKIENSIS	X X · · ·	· / · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·
1 2 THALASSIONEMA NITZSCHIODES	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·
1 2 THALASSIOSIRA ANTIQUA	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·
1 2 THALASSIOSIRA CF.T.DECIPIENS	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·
1 2 THALASSIOSIRA CF.T.PACIFICA	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·
1 2 THALASSIOSIRA CONVEXA	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·
1 2 THALASSIOSIRA CONVEXA VAR. ASPINOSA	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·
1 2 THALASSIOSIRA EXCENTRICA	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·
1 2 THALASSIOSIRA GRAVIDA CF.T.FORMA FOSSILIS	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·
1 2 THALASSIOSIRA HYALINA	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·
1 2 THALASSIOSIRA HYLINOPSIS	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·
1 2 THALASSIOSIRA MIOCENICA	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·
1 2 THALASSIOSIRA NATIVA	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·
1 2 THALASSIOSIRA NIDULUS	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·
1 2 THALASSIOSIRA OESTRUPII	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·
1 2 THALASSIOSIRA PRAECONVEXA	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·
1 2 THALASSIOSIRA PUNCTATA	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·	· · · · ·

Frequency Key

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o = Common. 1 Specimen Within 2 Field of View.
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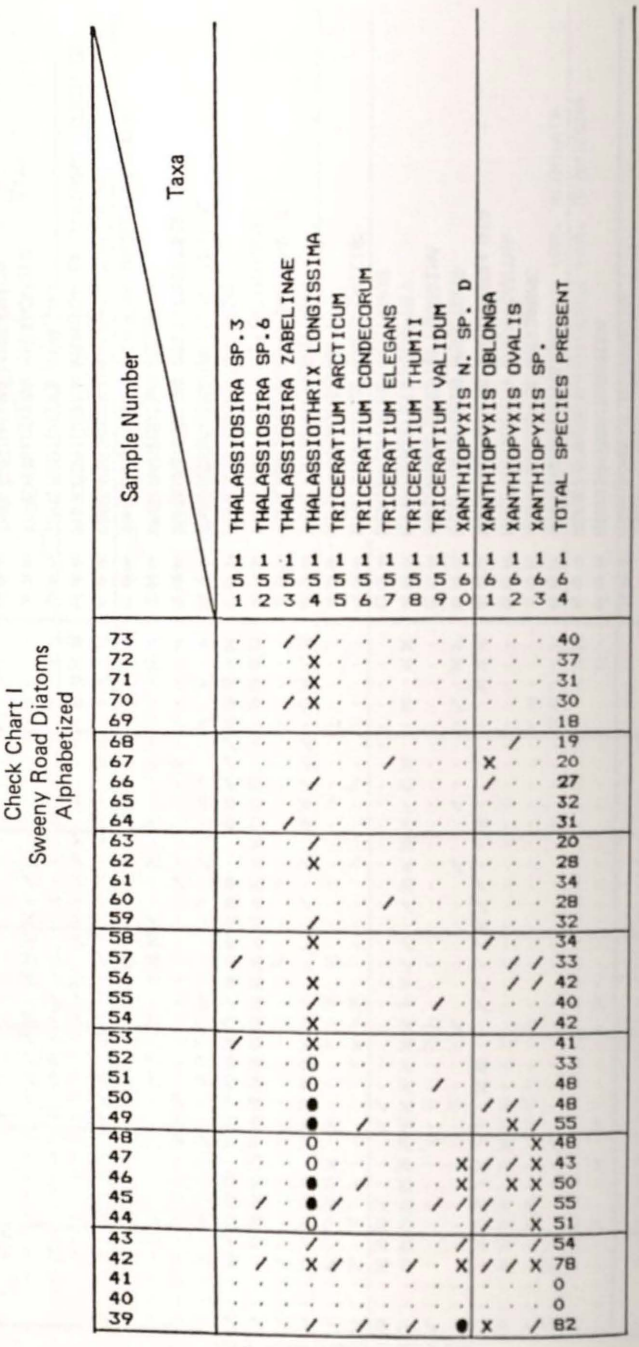
Δ = Reworked.



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- ● = Abundant. 2 or More Specimens Within 1 Field of View at X400.
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Check Chart II
Sweeny Road Diatoms
First Appearance Datum

Sample Number \ Taxa	1 ACTINOCYCLUS CHOLNOKYI	2 ACTINOCYCLUS CURVATULUS	3 ACTINOCYCLUS EHRENBERGII	4 ACTINOCYCLUS OCHOTENSIS	5 ACTINOCYCLUS OCULATUS	6 ACTINOPTYCHUS UNDULATUS	7 BACTERIASTRUM SP.	8 CHAETOCEROS CINCTUS	9 CHAETOCEROS DIADEMA	10 CHAETOCEROS DICLADIA	11 COSCINODISCUS MARGINATUS	12 COSCINODISCUS OCULUSIRIDIS VAR. OCULUSIRIDIS	13 COSCINODISCUS RADIATUS	14 LIHODESMIUM CORNIGERUM	15 LIHODESMIUM MINUSCULUM	16 MELOSIRA SULCATA VAR. BISERIATA	17 MELOSIRA SULCATA VAR. CORONATA	18 MUELLERIELLA LIMBATA	19 NAVICULA LYRA VAR. EHRENBERGII	20 NAVICULA OPTIMA	21 NITZSCHIA CALIFORNICA	22 PERIPTERA TETRACLADIA	23 PSEUDOEUNOTIA DOLIOLUS	24 RHAPHONEIS AMPHICEROS VAR. ELONGATA	25 RHAPHONEIS AMPHICEROS VAR. GEMMIFERA	26 RHAPHONEIS FATULA	27 RHIZOSOLENIA BARBOI	28 RHIZOSOLENIA CF. R. ALATA	29 RHIZOSOLENIA HEBETATA	30 RHIZOSOLENIA STYLIFORMIS
73	X	●	X	X	X	X	X	/	X	0	X	X	/	X	X	0	/	/	/	/	X	X	/	X	0	/	X	X	X	/
72	X	●	/	X	X	/	X	/	0	X	X	0	X	X	/	X	·	X	·	·	·	X	/	/	X	X	/	·	X	·
71	0	●	/	X	/	X	·	·	/	X	/	0	X	X	/	X	·	·	·	X	·	/	/	·	X	·	/	X	X	·
70	·	0	·	·	·	/	/	·	·	/	X	X	/	X	·	X	·	·	·	·	·	/	/	·	0	·	·	·	X	·
69	X	/	·	/	·	·	·	/	/	/	X	0	/	0	X	/	·	·	·	/	·	·	·	·	X	·	·	·	·	·
68	·	·	X	/	X	X	/	·	X	·	·	X	·	0	X	·	X	·	·	·	·	·	·	·	/	/	·	·	·	·
67	·	/	/	/	/	·	/	·	X	·	·	X	·	X	X	·	X	X	X	·	·	·	X	·	·	·	·	·	·	·
66	/	X	/	X	·	·	/	·	·	·	·	0	·	●	/	·	·	·	·	X	·	·	/	·	X	·	/	/	X	·
65	·	·	/	·	·	/	/	·	·	/	·	●	X	●	/	X	·	·	·	X	·	·	·	·	·	·	/	·	/	·
64	·	·	·	·	/	/	·	·	·	/	X	●	·	●	/	·	·	/	/	X	·	/	/	·	·	·	X	·	/	·
63	·	·	X	·	X	·	·	·	/	X	X	X	X	·	X	·	/	·	·	/	·	·	/	·	·	·	/	·	·	·
62	X	·	/	·	/	X	·	·	/	X	/	·	/	·	X	·	·	/	·	·	·	·	·	·	·	·	·	X	·	·
61	·	·	/	·	·	/	·	·	·	·	X	X	/	0	X	·	/	·	/	·	·	·	/	·	·	·	·	/	X	·
60	/	·	X	X	X	0	·	X	·	X	0	0	·	0	X	X	·	·	·	·	/	·	·	·	X	·	X	/	·	·
59	·	·	/	·	·	0	X	·	·	/	/	0	X	0	X	X	·	·	·	·	/	·	·	·	/	·	·	/	·	·
58	·	·	/	·	·	/	0	/	·	X	X	X	X	0	X	/	·	·	·	·	·	·	·	·	·	·	·	X	·	·
57	·	·	/	/	X	·	X	X	·	/	·	X	X	0	X	·	·	X	·	·	·	·	·	·	0	·	/	X	·	·
56	·	·	/	/	X	·	X	X	·	/	X	X	0	/	/	0	/	·	·	·	·	/	X	·	X	·	X	X	·	·
55	·	/	X	·	·	·	/	/	·	·	·	0	/	/	●	·	·	/	·	·	·	·	·	·	X	X	·	X	·	·
54	X	·	/	·	·	·	X	·	·	X	X	0	X	0	/	0	/	·	/	·	X	·	·	·	X	·	X	X	·	·
53	·	·	·	/	X	·	/	·	·	·	X	X	·	·	/	·	/	·	·	/	/	/	·	·	·	·	·	/	X	·
52	X	·	·	·	·	·	/	X	·	0	·	X	X	/	·	0	·	·	·	X	·	·	·	·	0	·	·	/	·	·
51	·	·	·	/	·	·	/	/	·	X	X	0	0	X	·	X	X	·	·	·	·	·	·	·	0	·	·	·	X	·
50	·	·	X	·	·	·	0	/	X	·	X	0	·	X	·	X	·	·	/	·	·	·	·	X	/	·	·	·	·	·
49	/	·	/	/	·	·	0	·	/	·	·	●	·	0	·	/	·	·	X	·	·	·	·	·	X	/	·	·	·	·
48	·	·	·	·	·	·	/	·	X	/	·	●	X	X	·	X	·	·	/	/	·	·	·	·	X	/	·	·	·	·
47	·	·	/	X	/	·	X	·	/	·	·	0	0	0	·	·	/	X	·	·	·	/	X	·	X	·	·	/	·	·
46	X	·	·	/	·	0	·	·	/	·	·	X	0	X	·	X	·	·	·	·	·	/	X	·	X	/	·	·	·	·
45	·	·	·	·	·	X	·	·	/	·	/	0	X	·	·	X	·	/	·	·	·	·	·	·	X	·	X	/	·	·
44	·	·	/	/	/	/	·	X	·	/	·	0	X	·	/	·	/	·	·	·	/	/	/	·	X	·	·	X	·	·
43	/	X	·	·	·	X	·	·	X	/	X	0	0	·	X	/	·	/	·	·	X	·	·	·	X	·	/	·	·	·
42	X	·	X	·	·	·	·	X	/	/	X	0	X	·	X	·	X	·	·	/	X	·	·	·	·	·	·	/	/	·
41	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
40	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
39	·	·	X	·	/	X	·	·	·	·	●	X	X	·	X	/	/	·	·	/	·	·	/	·	0	/	·	·	X	/

Frequency Key

● = Abundant. 2 or More Specimens Within 1 Field of View at X400.
o = Common. 1 Specimen Within 2 Field of View.
x = Few. 1 Specimen Per Traverse (2cm).
/ = Rare. Specimens Sparser Than 1 Per Traverse.
Δ = Reworked.

Check Chart II
Sweeny Road Diatoms
First Appearance Datum

Frequency Key

- ● = Abundant. 2 or More Specimens Within 1 Field of View at X400.
- ○ = Common. 1 Specimen Within 2 Field of View.
- × = Few. 1 Specimen Per Traverse (2cm).
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- △ = Reworked.

Frequency Key

- • = Abundant. 2 or More Specimens Within 1 Field of View at X400.
- o = Common. 1 Specimen Within 2 Field of View.
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Check Chart II
Sweeny Road Diatoms
First Appearance Datum

Frequency Key

● = Abundant. 2 or More Specimens Within 1 Field of View at X400.
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△ = Reworked.

Check Chart II
Sweeny Road Diatoms
First Appearance Datum

Sample Number / Taxa	1 1	1 2	1 3	1 4	1 5	1 6	1 7	1 8	1 9	1 0
COCCONEIS DECIPIENS										
MELOSIRA SULCATA VAR. SIBERICA										
ROUXIA CALIFORNICA										
SYNEDRA JOUSEANA										
THALASSIOSIRA MIOCENICA										
TRICERATIUM CONDECORUM										
BIDDULPHIA SUBORBICULARIS										
CHAETOCEROS SPECIES [SPORE]										
COSCINODISCUS MONICAE										
GRAMMATOPHORA ANGULOSA										
STEPHANODISCUS SP.										
STEPHANOGONIA POLYACANTHA										
COSCINODISCUS VESTUSTISSIMUS										
XANTHIOPYXIS N. SP. D										
AULISCUS PUNCTATUS										
COSCINODISCUS NITIDUS										
HEMIDISCUS SIMPLICISSIMUS										
ARACHNOIDISCUS EHRENBERGII										
AULACODISCUS SIMPLEX										
BIDDULPHIA RHOMBUS										
STEPHANOGONIA HANZAWAE										
THALASSIOSIRA PUNCTATA										
THALASSIOSIRA SP.6										
TRICERATIUM ARCTICUM										
OPEPHORA SCHWARTZII										
COSCINODISCUS KURZII										
DENTICULOPSIS DIMORPHA										
ENDICTYA ROBUSTUS										
THALASSIOSIRA PRAECONVEXA										
ACTINOCYCLUS ELLIPTICUS VAR. MORONENSIS										

Frequency Key

- ● = Abundant. 2 or More Specimens Within 1 Field of View at X400.
- o = Common. 1 Specimen Within 2 Field of View.
- x = Few. 1 Specimen Per Traverse (2cm).
- / = Rare. Specimens Sparser Than 1 Per Traverse.
- Δ = Reworked.

Check Chart II
Sweeny Road Diatoms
First Appearance Datum

Sample Number \ Taxa	151 COSCINODISCUS TABULARIS VAR. EGREGIUS	152 THALASSIONEMA HIROSAKIENSIS	153 TRICERATIUM THUMII	154 ACTINOCYCLUS TSUGARUENIS	155 ARACHNOIDISCUS DECORUS	156 AULISCUS CAELATUS VAR. CONSTRICTA	157 CESTODISCUS PULCHELLUS VAR. MACULATUS	158 COCCONEIS DIRUPTA VAR. TRIUMPHIS	159 COSCINODISCUS BIRADIATUS	160 COSCINODISCUS PILOSUS	161 DIPLONEIS CRABRO	162 ROUXIA YABEI	163 STEPHANOPYXIS SPINOSSIMA	164 TOTAL SPECIES PRESENT
73	.	.	.	.	.	.	.	.	.	.	.	.	.	40
72	.	.	.	.	.	.	.	.	.	.	.	.	.	37
71	.	.	.	.	.	.	.	.	.	.	.	.	.	31
70	.	.	.	.	.	.	.	.	.	.	.	.	.	30
69	.	.	.	.	.	.	.	.	.	.	.	.	.	18
68	.	.	.	.	.	.	.	.	.	.	.	.	.	19
67	.	.	.	.	.	.	.	.	.	.	.	.	.	20
66	.	.	.	.	.	.	.	.	.	.	.	.	.	27
65	.	.	.	.	.	.	.	.	.	.	.	.	.	32
64	.	.	.	.	.	.	.	.	.	.	.	.	.	31
63	.	.	.	.	.	.	.	.	.	.	.	.	.	20
62	.	.	.	.	.	.	.	.	.	.	.	.	.	28
61	.	.	.	.	.	.	.	.	.	.	.	.	.	34
60	.	.	.	.	.	.	.	.	.	.	.	.	.	28
59	.	.	.	.	.	.	.	.	.	.	.	.	.	32
58	.	.	.	.	.	.	.	.	.	.	.	.	.	34
57	.	.	.	.	.	.	.	.	.	.	.	.	.	33
56	.	.	.	.	.	.	.	.	.	.	.	.	.	42
55	.	.	.	.	.	.	.	.	.	.	.	.	.	40
54	.	.	.	.	.	.	.	.	.	.	.	.	.	42
53	.	.	.	.	.	.	.	.	.	.	.	.	.	41
52	.	.	.	.	.	.	.	.	.	.	.	.	.	33
51	.	.	.	.	.	.	.	.	.	.	.	.	.	48
50	.	.	.	.	.	.	.	.	.	.	.	.	.	48
49	.	.	.	.	.	.	.	.	.	.	.	.	.	55
48	.	.	.	.	.	.	.	.	.	.	.	.	.	48
47	.	.	.	.	.	.	.	.	.	.	.	.	.	43
46	.	.	.	.	.	.	.	.	.	.	.	.	.	50
45	.	.	.	.	.	.	.	.	.	.	.	.	.	55
44	.	.	.	.	.	.	.	.	.	.	.	.	.	51
43	.	.	.	.	.	.	.	.	.	.	.	.	.	54
42	/	/	/	.	.	.	.	.	.	.	.	.	.	78
41	.	.	.	.	.	.	.	.	.	.	.	.	.	0
40	.	.	.	.	.	.	.	.	.	.	.	.	.	0
39	/	/	/	/	x	/	/	/	/	●	/	/	/	82

Frequency Key

● = Abundant. 2 or More Specimens Within 1 Field of View at X400.
o = Common. 1 Specimen Within 2 Field of View.
x = Few. 1 Specimen Per Traverse (2cm).
/ = Rare. Specimens Sparser Than 1 Per Traverse.
Δ = Reworked.

Check Chart III
Sweeny Road Diatoms
Last Appearance Datum

Sample Number	Taxa
	0 0 ACTINOCYCLUS EHRENBERGII
	1 0 0 ACTINOCYCLUS EHRENBERGII VAR. TENELLA
	2 0 0 ACTINOCYCLUS ELLIPTICUS VAR. MORONENSIS
	3 0 0 ACTINOCYCLUS INGENS
	4 0 0 ACTINOCYCLUS OCULATUS
	5 0 0 ACTINOCYCLUS TSUGARUENIS
	6 0 0 ACTINOPTYCHUS STELLA VAR. CLEVEI
	7 0 0 ACTINOPTYCHUS UNDULATUS
	8 0 0 ACTINOPTYCHUS VULGARIS VAR. MONICAE
	9 0 1 0 ARACHNOIDISCUS DECORUS
	0 0 ARACHNOIDISCUS EHRENBERGII
	1 1 0 ARACHNOIDISCUS ORNATUS VAR. MONTEREYANUS
	1 2 1 1 AULACODISCUS SIMPLEX
	1 3 1 1 AULISCUS CAELATUS VAR. CONSTRICTA
	1 4 0 AULISCUS PUNCTATUS
	1 5 1 0 BIDDULPHIA RHOMBUS
	1 6 0 BIDDULPHIA TRIDENS
	1 7 0 CESTODISCUS PULCHELLUS VAR. MACULATUS
	1 8 1 0 CLADOGRAMMA CALIFORNICUM
	1 9 0 COCCONEIS DECIPIENS
	2 0 0 COCCONEIS DIRUPTA VAR. TRIUMPHIS
	2 1 0 COSCINODISCUS ASTEROMPHALUS
	2 2 0 COSCINODISCUS BIRADIATUS
	2 3 0 COSCINODISCUS HIROSAKIENSIS
	2 4 0 COSCINODISCUS KURZII
	2 5 0 COSCINODISCUS MARGINATUS
	2 6 0 COSCINODISCUS MONICAE
	2 7 0 COSCINODISCUS NITIDUS
	2 8 0 COSCINODISCUS NODULIFER
	2 9 0 COSCINODISCUS OBSCURUS

Frequency Key

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- o = Common. 1 Specimen Within 2 Field of View.
- x = Few. 1 Specimen Per Traverse (2cm).
- / = Rare. Specimens Sparser Than 1 Per Traverse.
- Δ = Reworked.

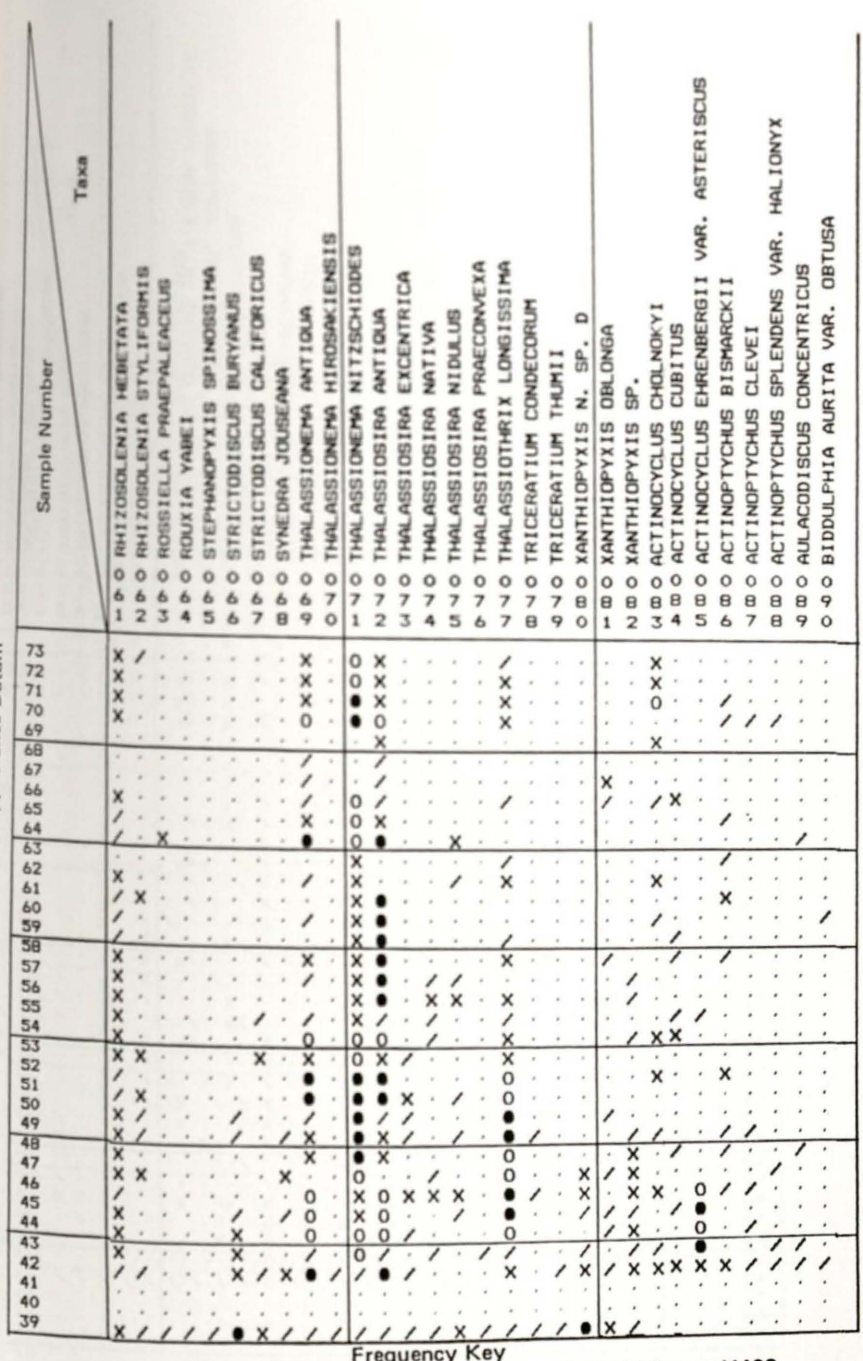
Check Chart III
Sweeny Road Diatoms
Last Appearance Datum

Sample Number / Taxa

Sample Number	COSCINODISCUS OCULUSIRIDIS VAR. BOREALIS	COSCINODISCUS OCULUSIRIDIS VAR. OCULUSIRIDIS	COSCINODISCUS PILOSUS	COSCINODISCUS RADIATUS	COSCINODISCUS ROBUSTUS VAR. INCRETUS	COSCINODISCUS TABULARIS VAR. EGREGIUS	COSCINODISCUS VESTUSTISSIMUS	DENTICULOPSIS HUSTEDII	DENTICULOPSIS HYALINA	DIPLONEIS CRABRO	DOSSETIA LACERA	ENDICTYA ROBUSTUS	ENTOPYLA AUSTRALIS VAR. GIGANTEA	GLYPHODESMUS WILLIAMSONII	GRAMMATOPHORA MERLETTA	HEMIAULUS POLYMORPHUS	HEMIDISCUS CUNEIFORMIS	LIRODESMIUM MINUSCULUM	MELOSIRA CLAVIGERA	MELOSIRA SULCATA VAR. BISERIATA	MELOSIRA SULCATA VAR. CORONATA	MELOSIRA SULCATA VAR. SIBERICA	NAVICULA LYRA VAR. EHRENBERGII	NAVICULA OPTIMA	PERIPTERA TETRACLADIA	PSEUDOPYXILLA DUBIA	RHABDONEMA JAPONICUM	RHAPHONEIS AMPHICEROS VAR. ELONGATA	RHAPHONEIS AMPHICEROS VAR. GEMMIFERA	RHAPHONEIS SACHALINENSIS
73		X		/														X		0	/		/	/	X			X	0	
72		0		X													/	/		X					/			/	X	
71		0		X														/		X				X				/	X	
70	/	X																		X					/		X	0		
69	X	0		/														X		/				/			X			
68		X																X			X								/	X	
67		X																X			X		X		X						
66	X	0															/	/						X	/			X		
65	X	●		X							/							/		X				X					0		
64	/	0							/									/					/		/			/	X		
63		X		X														X						/	/				X		
62				/													X	X										/	●		
61		X		/													/	X			/		/		/			X	●		
60		0																X		X				/				X	0		
59	/	0		X				/										X		X				/				/	X		
58	X	X		X											/			X	/									0	X		
57		X		X														X	/									0	X		
56	X	0		/												X		0	/	/				/	X			X	0		
55	/	0		/				0										●	/	/								X	0		
54	X	0		X	/			X										0		/				X			/		X		
53		X							/		/				/			/		/				/	/			X	/		
52		X		/							X			/			X	0	X					X				0	0		
51		0		X							/		/	X		/	/	X		X					X			/	0	0		
50	X	●		0											/		/	X		/				/	X		/		/	0		
49	X	●		0				X			/			/			/	0	/	/				X	/	/	X	X		X	0		
48		X		X				X			X		/			X		X						/		X	/			X	X		
47	/	0		0		/					X			/			X		X	/	X				X	X	/	/		X	●		
46	/	0		X										/			X		X	X					X	X	/			X	●		
45		X						/						/				X	X	/					/	X	/		/	●		
44		X						X										X	/	/					/	X	/	/		X	0		
43	X	0		0				/			X							/	/	/						/	/	/	/	X	0		
42	X	0		X	/			X	/			/	X	/			X	0	X	X	/				X	/	X	/	X	X	0		
41																																
40																																
39	/	X	●	X	/	/	/	/	X	/	/	X	/	/	X	/	/	X	0	/	/	X	/	/	/	/	X	/	0	/	X		

Frequency Key

● = Abundant. 2 or More Specimens Within 1 Field of View at X400.
○ = Common. 1 Specimen Within 2 Field of View.
× = Few. 1 Specimen Per Traverse (2cm).
/ = Rare. Specimens Sparser Than 1 Per Traverse.
△ = Reworked.



Frequency Key

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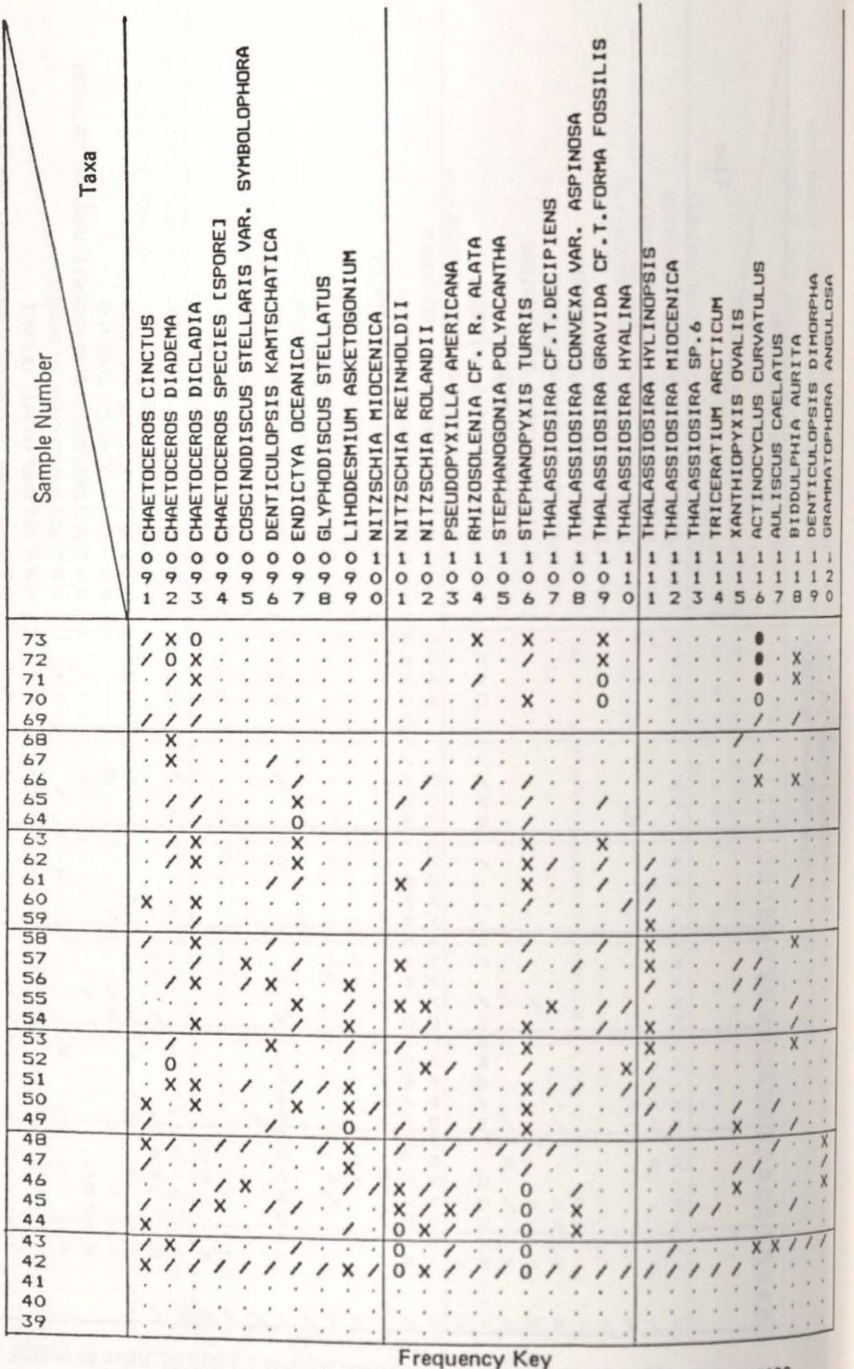

Frequency Key

- ● = Abundant. 2 or More Specimens Within 1 Field of View at X400.
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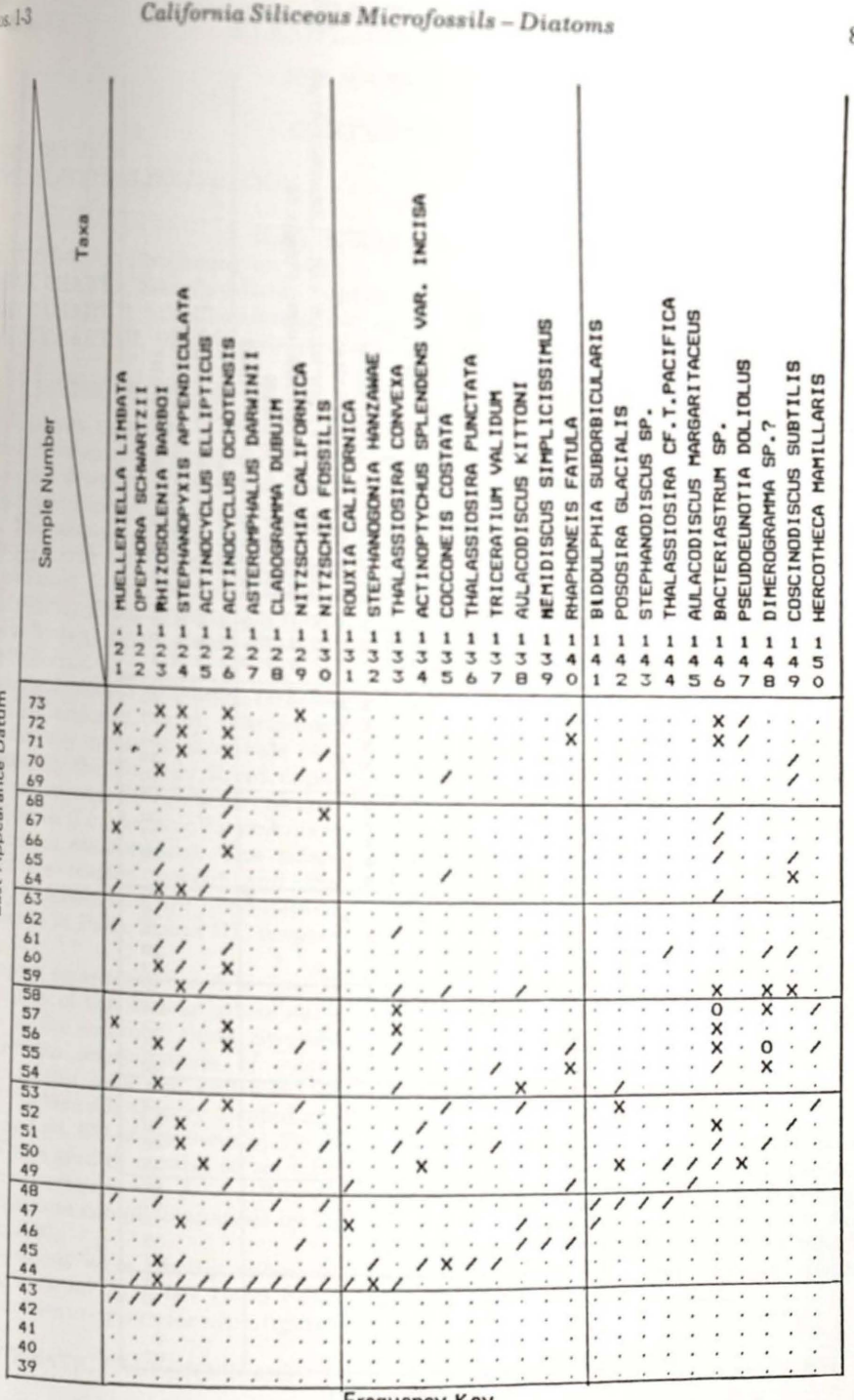

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Check Chart III
Sweeny Road Diatoms
Last Appearance Datum

Sample Number \ Taxa	1 5 1 NITZSCHIA JOUSEAE	1 5 2 RHAPHONEIS MIOCENICA	1 5 3 THALASSIOSIRA DESTRUPII	1 5 4 THALASSIOSIRA SP.3	1 5 5 LIHODESMIUM CORNIGERUM	1 5 6 STEPHANOPYXIS HORRIDUS	1 5 7 COSCINODISCUS EXCENTRICUS VAR. LEASAREOLATUS	1 5 8 DENTICULOPSIS SEMINAE VAR. FOSSILIS	1 5 9 TRICERATIUM ELEGANS	1 6 0 COSCINODISCUS ANTIQUUS	1 6 1 COSCINODISCUS PLICATUS	1 6 2 RHIZOSOLENIA PRAEBERGONII	1 6 3 THALASSIOSIRA ZABELINAE	1 6 4 TOTAL SPECIES PRESENT
73	·	·	X	·	X	X	·	·	·	·	·	·	/	40
72	·	·	/	·	X	X	/	·	·	/	·	·	·	37
71	·	·	X	·	X	·	·	·	·	·	·	·	·	31
70	·	·	X	·	X	/	·	·	·	·	·	·	/	30
69	·	·	·	·	O	·	·	·	·	·	·	·	·	18
68	·	·	/	·	O	·	·	·	·	·	·	/	·	19
67	·	·	·	·	X	·	·	·	/	·	·	/	·	20
66	·	·	·	·	●	·	·	·	·	·	·	·	·	27
65	·	·	/	·	●	/	/	·	·	·	·	·	·	32
64	·	·	·	·	●	·	·	·	·	·	/	/	/	31
63	·	·	·	·	·	·	·	·	·	X	·	·	·	20
62	·	·	X	·	·	/	·	·	·	·	·	·	·	28
61	/	·	X	·	O	·	·	/	·	·	·	·	·	34
60	·	·	X	·	O	·	·	·	/	·	·	·	·	28
59	·	·	O	·	O	·	/	·	·	·	·	·	·	32
58	·	·	O	·	O	·	·	/	·	·	·	·	·	34
57	/	·	·	/	O	·	·	·	·	·	·	·	·	33
56	·	/	·	·	/	·	X	·	·	·	·	·	·	42
55	·	·	/	·	/	·	·	·	·	·	·	·	·	40
54	·	·	/	·	/	/	·	·	·	·	·	·	·	42
53	/	/	X	/	·	·	·	·	·	·	·	·	·	41
52	·	·	·	·	·	·	·	·	·	·	·	·	·	33
51	·	·	·	·	·	·	·	·	·	·	·	·	·	48
50	·	·	·	·	·	·	·	·	·	·	·	·	·	48
49	·	·	·	·	·	·	·	·	·	·	·	·	·	55
48	·	·	·	·	·	·	·	·	·	·	·	·	·	48
47	·	·	·	·	·	·	·	·	·	·	·	·	·	43
46	·	·	·	·	·	·	·	·	·	·	·	·	·	50
45	·	·	·	·	·	·	·	·	·	·	·	·	·	55
44	·	·	·	·	·	·	·	·	·	·	·	·	·	51
43	·	·	·	·	·	·	·	·	·	·	·	·	·	54
42	·	·	·	·	·	·	·	·	·	·	·	·	·	78
41	·	·	·	·	·	·	·	·	·	·	·	·	·	0
40	·	·	·	·	·	·	·	·	·	·	·	·	·	0
39	·	·	·	·	·	·	·	·	·	·	·	·	·	82

Frequency Key

● = Abundant. 2 or More Specimens Within 1 Field of View at X400.
○ = Common. 1 Specimen Within 2 Field of View.
× = Few. 1 Specimen Per Traverse (2cm).
/ = Rare. Specimens Sparser Than 1 Per Traverse.
Δ = Reworked.

PART IV
SILICOFLAGELLATES

R. E. MAROLT

CONTENTS

ILLUSTRATIONS

I. INTRODUCTION

Silicoflagellates constitute a minor yet important microscopic component of diatomaceous deposits of the Monterey Formation and superjacent Sisquoc Formation. The purpose of this study is to identify and document the silicoflagellate floral succession found in the Miocene-Pliocene interval of highly siliceous rocks exposed at Sweeny Road, Santa Barbara County, California.

Siliceous microfossils (diatoms, radiolarians, silicoflagellates, and ebridians) serve as the only means to subdivide biostratigraphically the Sweeny Road exposure, as this section is barren of all calcareous microfossils (i.e., benthic foraminifers and calcareous nannofossils). The silicoflagellates are treated herein and the diatoms and radiolarians are documented and discussed in Parts II and III, respectively.

This report represents the first formal documentation of the diverse silicoflagellate flora in the outcrops along Sweeny Road. Previous investigations of silicoflagellates in this area are restricted to studies of the Manville Quarry located approximately 4 mi. SW of the Sweeny Road section. These studies consist of an incidental documentation by J. A. Barron (1975) and a more complete analysis by L. D. Kourse (1980).

All illustrations were photographed at 800x using Polaroid Type 667 Land Film. Sample numbers are given for each figure.

II. SYSTEMATIC PALEONTOLOGY

Class SILICOFLAGELLATAE Borgert, 1890

Order SIPHONOTESTALES Lemmermann, 1901

Family DICTYOCHACEAE Lemmermann, 1901

Genus CANNOPILUS Haeckel, 1887

CANNOPILUS SPHAERICUS Gemeinhardt
Pl. 1, fig. 1

Cannopilus sphaericus Gemeinhardt, 1931, p. 104, pl. 10, fig. 3, 4. *fide* LOEBLICH *et al.*, 1968, p. 68, pl. 1, fig. 14, 15; LING, 1972, p. 149, 150, pl. 23, fig. 8-10.

CANNOPILUS sp. A
Pl. 1, fig. 4, 7

Remarks: This hexagonal (rarely pentheptagonal) form is distinguished by an apical structure that is divided into two or more openings. This structure is ornamented with minute spines that are randomly distributed and vary in number. In the Sweeny Road study material, this form was restricted to an interval between and including samples #45-63. Further investigation is necessary to determine its taxonomic classification.

CANNOPILUS sp. B
Pl. 1, fig. 10, 11

Remarks: This form possesses an elongate hexagonal basal ring that supports a divided apical ring. Two spines project distally from the apical system and are aligned along the major axis. The length and orientation of these spines distinguishes this form from *C.* sp. A.

Genus DICTYOCHA Ehrenberg, 1837

DICTYOCHA ASPERA CLINATA Bukry
Pl. 2, fig. 1, 2

Dictyocha sp. LING, 1972 (in part), p. 163, pl. 26, fig. 7, *non* fig. 4, 5, 6

Dictyocha sp. A LING, 1975, p. 772, pl. 1, fig. 20, 21
Dictyocha aspera clinata BUKRY, 1975b, p. 687, pl. 1, fig. 1-5; 1980, p. 380, pl. 2, fig. 4

DICTYOCHA BREVISPINA (Lemmermann) Bukry
Pl. 3, fig. 1, 2

Dictyocha fibula EHRENBERG, 1854 (in part), pl. 22, fig. 42a, b
Dictyocha fibula var. *brevispina* LEMMERMANN, 1901b, p. 260, figure cited from Ehrenberg, 1854
Dictyocha fibula var. *aspera* fa. *rhombica* SCHULZ, 1928, p. 253, fig. 37
Dictyocha ausonia DEFLANDRE, 1950, p. 195, fig. 194-196, 199-202
Dictyocha mutabilis DEFLANDRE, 1950, p. 197, fig. 203-208, 210, ?209
Dictyocha rhombica (Schulz) MARTINI, 1971 (in part), p. 1696, pl. 1, fig. 9, 10, *non* fig. 8; BUKRY, 1975b, pl. 4, fig. 5, 6

Remarks: Ehrenberg's (1854) *D. fibula* (pl. 21, fig. 42b) is omitted from this synonomy as it has been placed in synonomy with *D. pulchella* Bukry. *D. fibula* var. *brevispina* was raised in rank to the specific level by Bukry (1976a, p. 723).

DICTYOCHA COMPLEXA (Tsumura) Ling
Pl. 2, fig. 4

Dictyocha pseudofibula var. *complexa* TSUMURA, 1963, p. 56, 57, pl. 11, fig. 4, pl. 24, fig. 1
Dictyocha complexa (Tsumura) LING, 1977, p. 209, pl. 1, fig. 9, 10

Remarks: The original Latin description of this taxon by Tsumura (1963, p. 57) states "Basal ring est heptagonalis...". This description, however, is followed by the English translation "The basal ring is hexagonal...". This contraditction appears unintentional (the figured holotype is hexagonal) and the species concept followed herein is based on the English translation.

DICTYOCHA DELICATA (Bukry) Bukry var. BISECTA Bukry
Pl. 1, fig. 8

Dictyocha delicata (Bukry) Bukry var. *bisecta* BUKRY, 1982, p. 432, pl. 2, fig. 3-6

Remarks: Sweeny Road specimens differ from *D. delicata* var. *bisecta* s. str. by possessing an apical bar, the thickness of which equals that of the basal ring and basal pikes that are small and indistinct. These forms are herein designated *D.* sp. cf. *D. delicata* var. *bisecta*.

DICTYOCHA FIBULA Ehrenberg
Pl. 3, fig. 3, 5

Dictyocha fibula Ehrenberg, 1839, *fide* LOEBLICH *et al.*, 1968, p. 90, pl. 9, fig. 7-12

Remarks: Several forms, that possess asymmetric strut pairs, previously assigned to this species group have been reassigned to other species and subspecies by contemporary authors (Bukry, 1985, pers. comm.). Further investigation of the Sweeny Road study material is necessary to identify these forms and establish their respective stratigraphic significance in the section.

DICTYOCHA FIBULA FIBULA (Ehrenberg) Bukry
Pl. 2, fig. 3

Dictyocha fibula Ehrenberg, 1839, *fide* LOEBLICH *et al.*, 1968 (in part), p. 90, pl. 9, fig. 9, 10, 12 *non* fig. 7, 8, 11
Dictyocha fibula fibula (Ehrenberg) BUKRY, 1978a, p. 697, pl. 2, fig. 1, 2

DICTYOCHA LONGISPINA (Lemmermann) Bukry
Pl. 1, fig. 9

Dictyocha fibula var. *longispina* LEMMERMANN, 1901b, p. 260, pl. 10, fig. 26
Dictyocha fibula Ehrenberg s.l., MARTINI, 1971 (in part), p. 1698, pl. 1, fig. 4, *non* fig. 5-7

PLATE 1
All Figures 800x

1. *Cannopilus spaericus* Gemeinhardt. #69.
2,3. *Dictyocha pentagona* A. 2 - #65. 3 - #68.
4,7. *Cannopilus* sp. A. - #45.
5,6. *Dictyocha pulchella* Bukry. 5 - #62. 6 - #61.
8. *Dictyocha* sp. cf. *D. delicata* (Bukry) Bukry var. *bisecta* Bukry. #72.
9. *Dictyocha longispina* (Lemmermann) Bukry. #63.
10,11. *Cannopilus* sp. B. 10 - #54. 11 - #52.

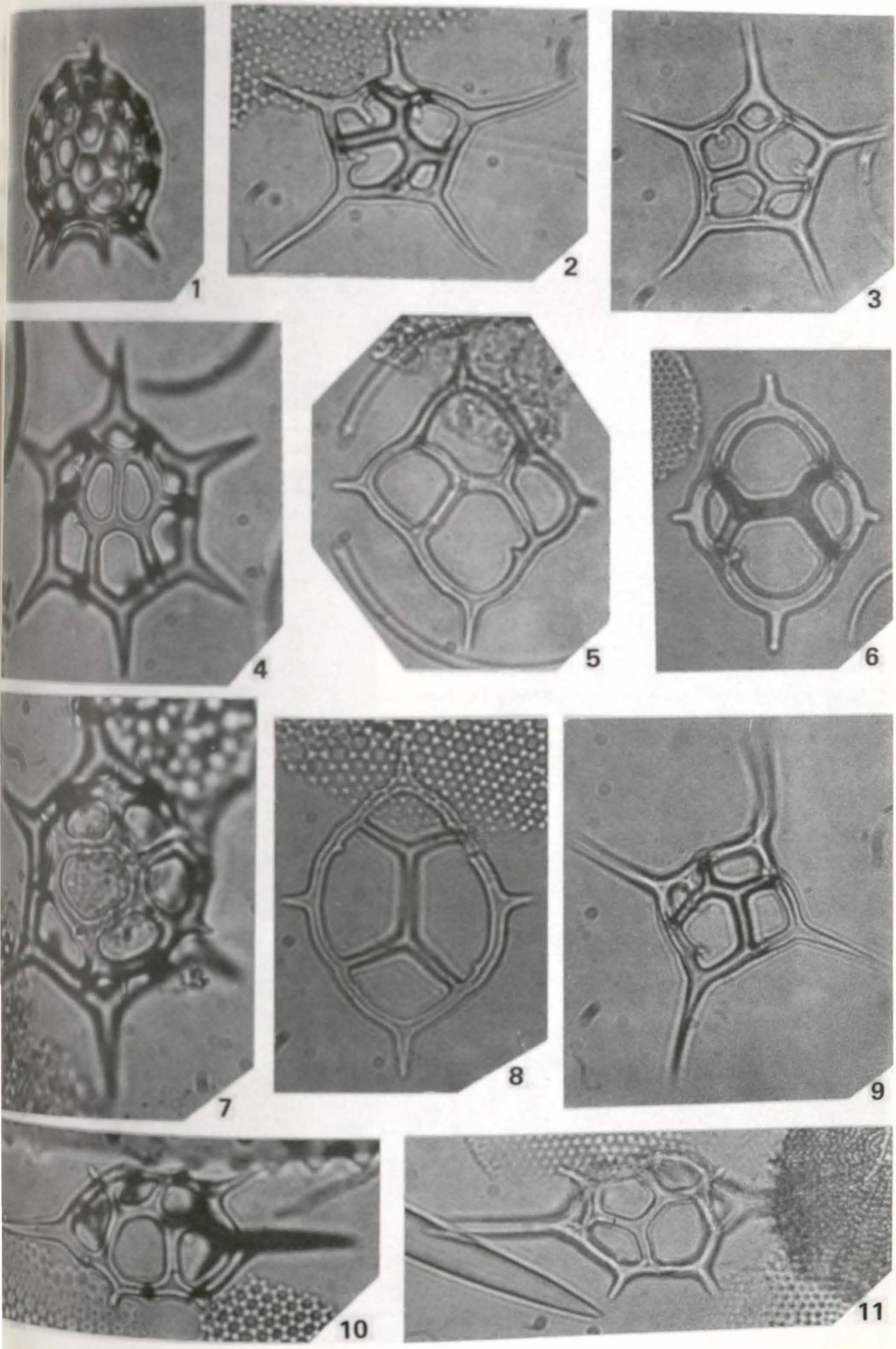

PLATE 1

Dictyocha fibula Ehrenberg, LING, 1975 (in part), p. 768, pl. 1, fig. 5, 6, *non* fig. 3, 4

Remarks: Bukry (1979a, p. 983) elevated this taxon to the specific level.

DICTYOCHA MEDUSA Haeckel
Pl. 3, fig. 4, 6

Dictyocha medusa HAECKEL, 1887, p. 1560, pl. 101, fig. 13, 14; BUKRY and FOSTER, 1973, p. 827, pl. 3, fig. 4, 5 (with description)

Remarks: A polyphyletic morphology of no use for long-range correlation (Bukry, 1985, pers. comm.).

DICTYOCHA PENTAGONA (Schulz)
Bukry and Foster
Pl. 1, fig. 2, 3; Pl. 2, fig. 5, 8

Dictyocha fibula var. *pentagona* SCHULZ, 1928, p. 255, fig. 41a, b

Dictyocha pentagona (Schulz) BUKRY and FOSTER, 1973, p. 827, pl. 3, fig. 10 (with description)

Remarks: Two forms attributable to *D. pentagona* were observed in the Sweeny Road study material, herein designated as *D. pentagona* A and B. *D. pentagona* A is smaller form (approximately 30 micron basal ring maximum internal diameter) and may have been derived from *D. longispina* as is suggested by its stratigraphic relationship with the latter, quadrate form at Sweeny Road. *D. pentagona* B is a larger form (approximately 45 micron maximum internal diameter) and is similar to *Distephanus boliviensis boliviensis* in the manner indicated by Bukry (1976b, p. 894). *D. pentagona* B occurs in low frequency in an interval where *D. boliviensis boliviensis* has its greatest abundance, further suggesting an affinity between these two taxa or the environmental conditions which contributed to their formation (Bukry, 1985, pers. comm.).

DICTYOCHA PULCHELLA Bukry
Pl. 1, fig. 5, 6

Dictyocha fibula EHRENBERG, 1854 (in part), pl. 21 fig. 42b

Dictyocha fibula Ehrenberg, BACHMANN and ICHIKAWA, 1962 (in part), p. 169, pl. 2, fig. 30, pl. 7, fig. 10-14, *non* pl. 2, fig. 24-29, 31-33

Dictyocha fibula fibula rhombica Schulz GLEZER, 1966 (in part), p. 267, pl. 15, fig. 4 ?7, *non* fig. 5, 9

Dictyocha sp. LING, 1972 (in part), p. 163, pl. 26, fig. 4-6, *non* fig. 7, 8

Dictyocha cf. *aspera* Lemmerman, DUMITRICĂ, 1973a (in part), p. 907, pl. 7, fig. 4, 6, 7, *non* pl. 3, fig. 8, pl. 4, fig. 5-7, pl. 7, fig. 5

Dictyocha lingi Dumitrică, DUMITRICĂ, 1973 (in part), p. 848, pl. 3, fig. 4, *non* fig. 5-7

Dictyocha fibula ssp. *aspera* Lemmermann, DUMITRICĂ, 1973b (in part), p. 848, pl. 2, fig. 4-7, 11, ?12-13, *non* fig. 8-10, 15, 16

Dictyocha aspera (Lemmermann) BUKRY, 1973, p. 826, pl. 1, fig. 3

Dictyocha aspera (Lemmermann) s. ampl., BUKRY, 1975a, pl. 1, fig. 9, 10

Dictyocha pulchella BUKRY, 1975b, p. 687, pl. 4, fig. 1-3; BUKRY, 1978b, p. 816, pl. 2, fig. 12-16

Genus DISTEPHANUS Stöhr, 1880

DISTEPHANUS BOLIVIENSIS (Frenguelli)
Bukry and Foster
Pl. 4, fig. 1-3, 6

Dictyocha boliviensis Frenguelli, 1940, p. 44, fig. 4, *fide* LOEBLICH *et al.*, 1968 (in part), p. 83, pl. 9, fig. 3, *non* fig. 4-6

Distephanus boliviensis (Frenguelli) BUKRY and FOSTER, 1973 (in part), p. 827, pl. 4, fig. 1, 2, *non* fig. 3

Remarks: Specimens observed in the Sweeny Road study material that resemble fig. 3 in Bukry and Foster (1973) were tabulated as *D. polyactis*. Samples #60-62, 64 and 66 contain large heptagonal specimens that have been designated *D.* sp. cf. *D. boliviensis*.

PLATE 2
All Figures 800x

1,2. *Dictyocha aspera clinata* Bukry. 1 - #63. 2 - #67.
3. *Dictyocha fibula fibula* (Ehrenberg) Bukry. #47.
4. *Dictyocha complexa* (Tsumura) Ling. #62.
5,8. *Dictyocha pentagona* B. 5 - #60. 8 - #65.
6,7. *Distephanus pseudofibula* (Schulz) Bukry. 6 - #66. 7 - #55.


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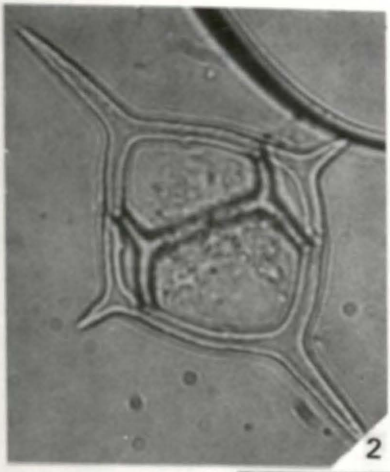
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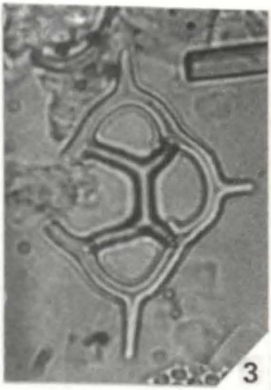
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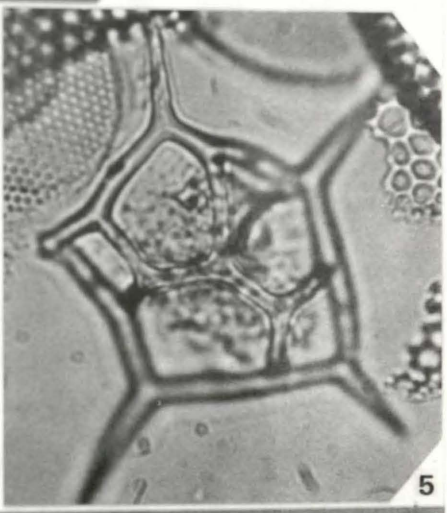
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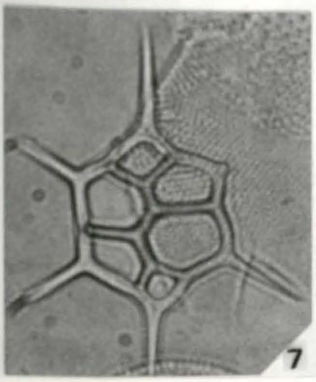
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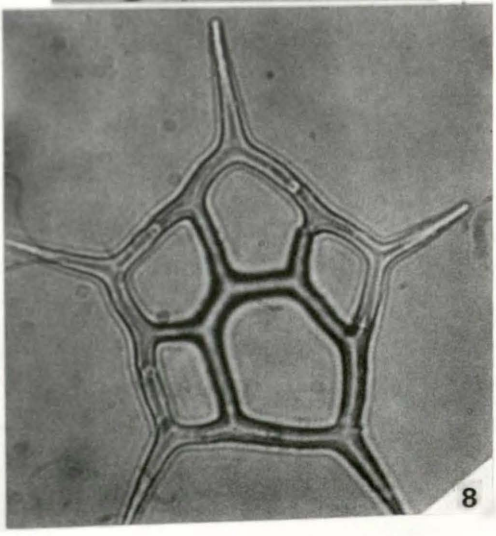

8

PLATE 2

DISTEPHANUS CRUX PARVUS (Bachmann) Bukry
Pl. 4, fig. 4

Dictyocha crux Ehrenberg fa. *parva* Bachmann *in* ICHIKAWA *et al.*, 1967 (in part), p. 156, pl. 4, fig. 14, 15, 19, 23?, 29-31, *non* fig. 16-18, 20-22, 24-28
non Distephanus parvus (Bachmann) BUKRY and FOSTER, 1973, p. 828, pl. 5, fig. 2, 3
Distephanus crux (Ehrenberg) BUKRY, 1978a (in part), p. 697, pl. 2, fig. 8, 9, *non* fig. 7
Distephanus crux (Ehrenberg) BUKRY, 1980a, p. 514, pl. 2, fig. 8
Distephanus crux (Ehrenberg) Haeckel subsp. *parvus* (Bachmann) BUKRY, 1982a, p. 433, pl. 4, fig. 7

Remarks: The assignment of this species to the genus *Distephanus* follows the philosophy of Haeckel (1887). This approach is also used with *Distephanus speculum bispicatus* and *D. speculum speculum* recovered in this section.

DISTEPHANUS FRUGALIS (Bukry) Bukry
Pl. 5, fig. 1, 2, 4, 7

Distephanus speculum (Ehrenberg), small apical ring, BUKRY, 1973, p. 828, pl. 2, fig. 11, pl. 3, fig. 1; MARTINI and MÜLLER, 1976 (in part), pl. 3, fig. 2, *non* pl. 3, fig. 1, 3, pl. 6, fig. 1, pl. 8, fig. 12
Distephanus boliviensis frugalis BUKRY, 1975b, p. 688, pl. 2, fig. 2-7 (with description); BARRON 1976, p. 60, pl. 3, fig. 25, 26
Distephanus frugalis (Bukry) BUKRY, 1979b, p. 561, pl. 3, fig. 5, 6

Remarks: During frequency tabulations, pentagonal forms were recorded independently as *D. frugalis* (pentagonal) in the manner of Barron (1976). Possible synonyms for the pentagonal form are as follows:

Distephanus speculum var. *pentagonus* Lemmermann, LING, 1973, p. 753, pl. 2, fig. 16, 17

Distephanus quinquangellus Bukry and Foster, LING, 1975, p. 772, pl. 2, fig. 3

DISTEPHANUS JIMLINGII (Bukry) Bukry
Pl. 6, fig. 1-7

Distephanus boliviensis jimlingii BUKRY, 1975b, p. 688, pl. 1, fig. 6, 7a, pl. 2, fig. 1
Distephanus jimlingii (Bukry) BUKRY, 1979b, p. 561, pl. 3, fig. 7-12

Remarks: Pentagonal specimens of *D. jimlingii* were tabulated independently as *D. jimlingii* (pentagonal) and exhibit a different stratigraphic distribution in the study material from Sweeny Road.

DISTEPHANUS LONGISPINUS (Schulz) Bukry and Foster
Pl. 4, fig. 5

Distephanus crux fa. *longispina* SCHULZ, 1928, p. 256, fig. 44
Distephanus longispinus (Schulz) BUKRY and FOSTER, 1973, p. 828, pl. 4, fig. 7, 8

DISTEPHANUS MESOPHTHALMUS (Ehrenberg) Dumitrică
Pl. 5, fig. 3

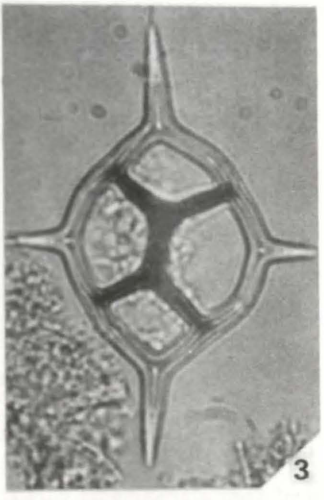
Dictyocha mesophthalma Ehrenberg, 1844a, p. 64, 80, *fide* LOEBLICH *et al.*, 1968, p. 103; EHRENBERG, 1854, pl. 22, fig. 43
Dictyocha crux Ehrenberg fa. *parva* Bachmann *in* ICHIKAWA *et al.*, 1967 (in part), p. 156, pl. 4, fig. 16?, 25-27, *non* pl. 4, fig. 14, 15, 17-24, 29-31
Distephanus parvus (Bachmann) BUKRY and FOSTER, 1973, p. 828, pl. 5, fig. 2, 3
Distephanus mesophthalmus (Ehrenberg) DUMITRICĂ, 1973b, p. 850, pl. 6, fig. 9, 10, 12, 13
Distephanus crux (Ehrenberg) LOCKER, 1974 (in part), p. 637, pl. 3, fig. 8, *non* fig. 10

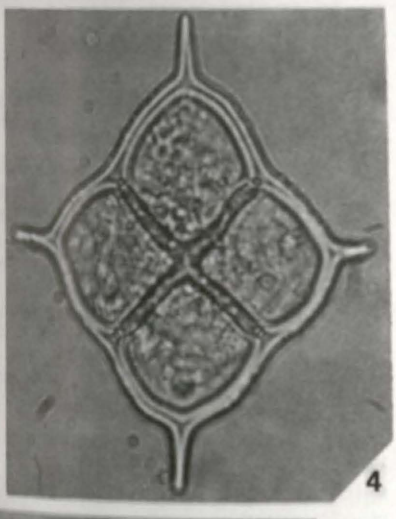
DISTEPHANUS POLYACTIS (Ehrenberg) Deflandre
Pl. 4, fig. 7

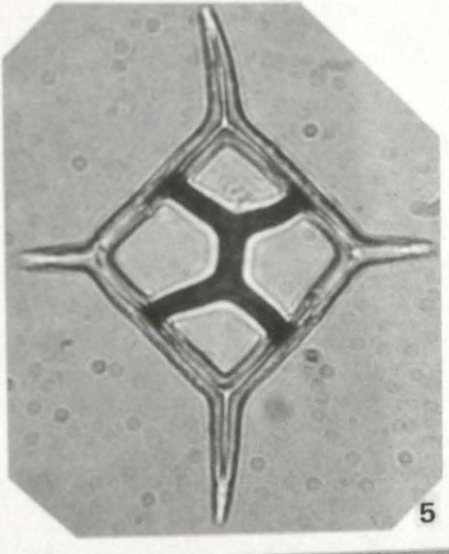
Dictyocha polyactis Ehrenberg, 1839, p. 129, table, *fide* LOEBLICH *et al.*, 1968, p. 109. Figured by Ehrenberg, 1854, pl. 22, fig. 50
Distephanus polyactis (Ehrenberg) DEFLANDRE, 1932, p. 501, 502, fig. 40 (with description); BUKRY and FOSTER, 1973, p. 828, pl. 5, fig. 6, 7

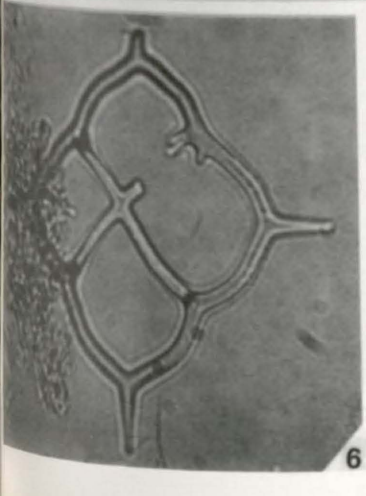
PLATE 3
All Figures 800x

1,2. *Dictyocha brevispina* (Lemmermann) Bukry. #42.
3,5. *Distyocha fibula* Ehrenberg. 3 - #42. 5 - #57.
4,6. *Dictyocha medusa* Haeckel. #42.
7. *Distephanus* sp. A. #43.









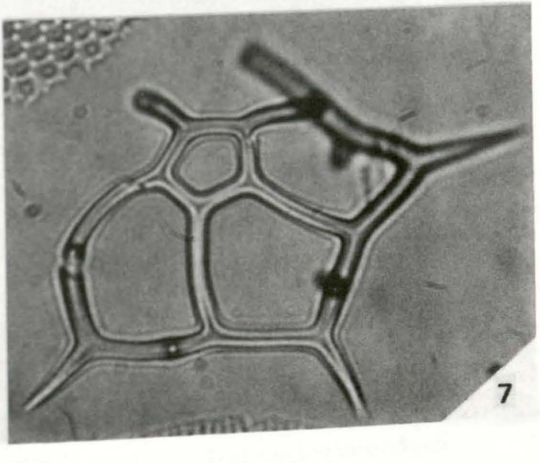


PLATE 3

DISTEPHANUS PSEUDOFIBULA (Schulz) Bukry
Pl. 2, fig. 6, 7

Distephanus speculum fa. *pseudofibula* SCHULZ, 1928, p. 261, fig. 51a, b
Dictyocha pseudofibula (Schulz) TSUMURA, 1963, p. 55, pl. XI, fig. 1-3, pl. XXIV, fig. 2

Remarks: This taxon was transferred back into the genus *Distephanus* by Bukry (1976c, p. 848).

DISTEPHANUS SPECULUM BISPICATUS Bukry
Pl. 5, fig. 5

Distephanus speculum (Ehrenberg) DUMITRIA, 1973a (in part), p. 908, pl. 10, fig. 7, 11, pl. 12, fig. 1, *non* pl. 10, fig. 4-6, 9, 10, pl. 11, fig. 1-9, pl. 12, fig. 2-14
Distephanus speculum (Ehrenberg) Haeckel subsp. *bispicatus* BUKRY, 1928b, p.315, pl. 6, fig. 2-4 (with description)

DISTEPHANUS SPECULUM fa. CORONATA Schulz
Pl. 5, fig. 11

Distephanus speculum fa. *coronata* SCHULZ, 1928, p. 262, fig. 50; Bukry, 1983, p. 331, pl. 7, fig. 7

DISTEPHANUS SPECULUM MINUTUS (Bachmann) Bukry
Pl. 5, fig. 8

Dictyocha speculum fa. *minuta* Bachmann *in* ICHIKAWA *et al.*, 1967, p. 161., pl. 7, fig. 12-15
Distephanus minutus (Bachmann) BUKRY and FOSTER, 1973, p. 828, pl. 4, fig. 10, 11
Distephanus speculum minutus (Bachmann) BUKRY, 1976b, p. 895, pl. 8, fig. 1-3

DISTEPHANUS SPECULUM SPECULUM (Ehrenberg) Haeckel
Pl. 5, fig. 6

Dictyocha speculum Ehrenberg, 1839, p. 150, *fide* LOEBLICH *et al.*, 1968, p. 114-115; EHRENBERG, 1854, pl. 18, fig. 57, pl. 19, fig. 41, pl. 21, fig. 44, pl. 22, fig. 47

DISTEPHANUS STRADNERI (Jerković) Bukry
Pl. 7, fig. 1, 4

Dictyocha schauinslandii Lemmermann, STRADNER, 1961 (in part), p. 92, pl. 2, fig. 60, *non* fig. 61, 63, 64, 69
Dictyocha schauinslandii stradneri Jerković, 1965, p. 3, pl. 2, fig. 2, *fide* LOEBLICH *et al.*, 1968, p. 112, pl. 7, fig. 7, 8

Remarks: Bukry (1978, p. 698) recognized "no obvious affinity of this form to *D. schauinslandii*" and raised it from the subspecific to specific level.

DISTEPHANUS sp. A
Pl. 3, fig. 7

Remarks: This pentagonal form is unusually large with a proportionally small apical ring. The basal ring is slightly indented at the strut junctions and the radial spines are short to moderate and equant. Only fragmented specimens were observed in the Sweeny Road study material and are restricted to samples #43 and 44.

DISTEPHANUS sp. B
Pl. 7, fig. 2, 3, 6

Remarks: This cruxoid form is similar to *D. stradneri* but differs by the placement of one, typically two, long spines on an apical ring that is proportionally larger than *D. stradneri*. A single pentagonal specimen was also observed (Pl. 7, fig. 6). This form is restricted to samples #68, 69.

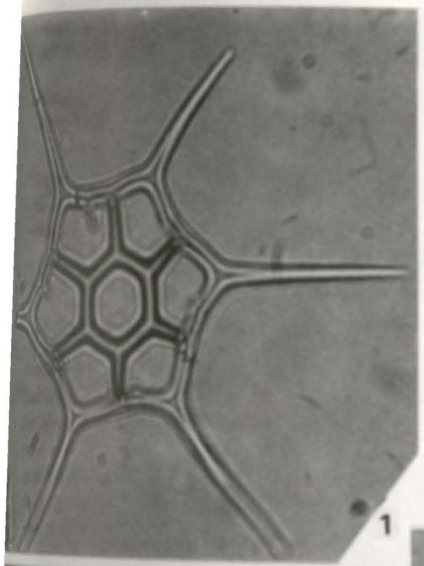
DISTEPHANUS sp. C
Pl. 7, fig. 5, 7, 8

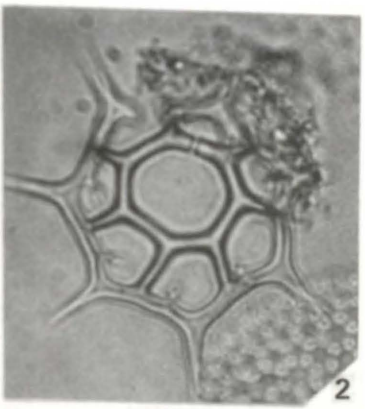
Remarks: This distinct form is characterized by a hexagonal (rarely heptagonal) basal ring, short to moderate equant radial spines, moderate to highly indented basal ring at strut junctions, robust basal pikes and an asymmetric, subcircular apical ring. Cannopilean forms are rare and also included in this group. Probably related to *D. boliviensis*, this form occurs only in samples #59-61, #64-66 from Sweeny Road.

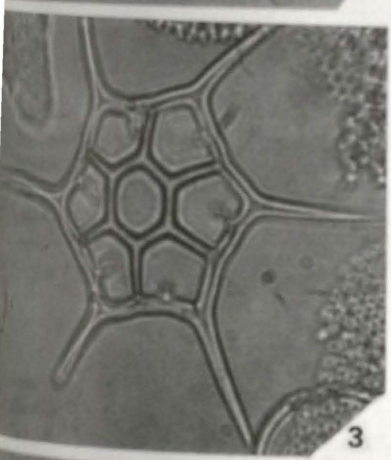
DISTEPHANUS sp. D
Pl. 5, fig. 9, 10

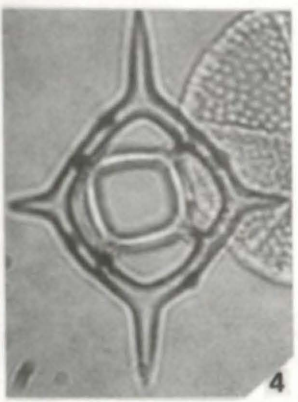
PLATE 4
All Figures 800x

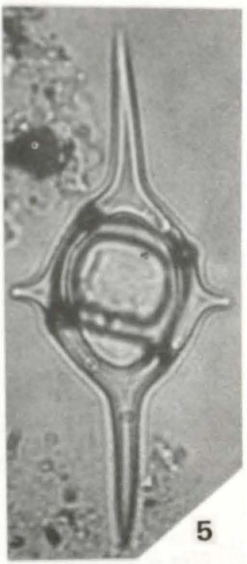
1. *Distephanus boliviensis* (Frenguelli) Bukry. 1 - #62. 4 - #68.
2,6. *Distephanus* sp. cf. *D. boliviensis*. 2 - #62. 6 - #66.
4. *Distephanus crux parvus* (Bachmann) Bukry. #65.
5. *Distephanus longispinus* (Schulz) Bukry and Foster. #63.
7. *Distephanus polyactis* (Ehrenberg) Deflandre. #72.

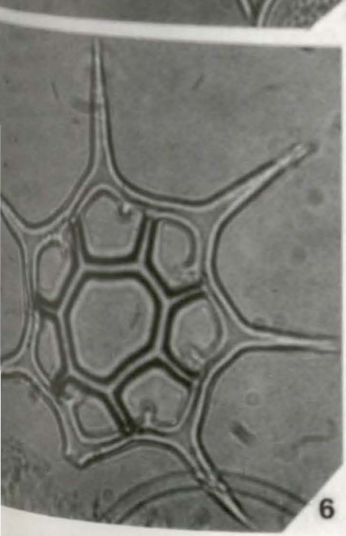












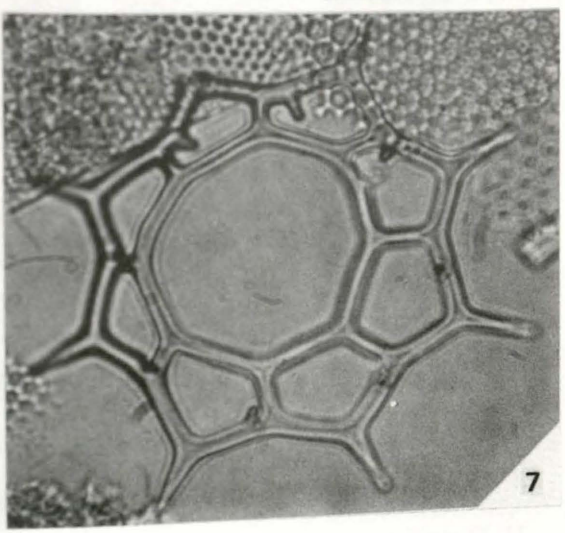


PLATE 4

Remarks: Distinguishing characteristics of specimens in this group are hexagonal (commonly pentagonal) basal ring, moderately sized equant radial spines, and a moderately sized (1/3 maximum internal diameter) asymmetric apical ring that is ornamented by small spines that vary in number. This form differs from *D.* sp. C by the spinose apical ring and slightly elongate basal ring.

Genus MESOCENA Ehrenberg, 1843

MESOCENA CIRCULUS (Ehrenberg) Ehrenberg
Pl. 8, fig. 1, 2

Dictyocha (Mesocena) circulus Ehrenberg, 1840b, p. 208, *fide* LOEBLICH *et al.*, 1968, p. 84; figured by Ehrenberg, 1854, p. 19, fig. 44, as *Mesocena*

Mesocena circula (Ehrenberg) BUKRY and FOSTER, 1973, p. 828, pl. 5, fig. 9, pl. 6, fig. 1 (with remarks)

Remarks: A highly sculpted, nodose form with irregularly placed spines is tabulated herein as *M.* sp. cf. *M. circulus*.

MESOCENA DIODON Ehrenberg s. ampl.
Pl. 8, fig. 4

Mesocena diodon Ehrenberg, 1844, p. 71, 84, *fide* LOEBLICH *et al.*, 1968, p. 128; EHRENBERG, 1854, pl. 33 (15), fig. 18

Mesocena diodon nodosa BUKRY, 1978b (in part), p. 818, pl. 5, fig. 14, 15, pl. 6, fig. 1-3, *non* fig. 4, 5

Mesocena diodon diodon Ehrenberg, BUKRY, 1978b, p. 818, pl. 5, fig. 9-13

Mesocena diodon borderlandensis BUKRY, 1981, p. 547, pl. 4, fig. 5-9, pl. 5, fig. 1, 2

MESOCENA ELLIPTICA (Ehrenberg) Ehrenberg
Pl. 8, fig. 3

Dictyocha (Mesocena) elliptica Ehrenberg, 1840, p. 208, *fide* LOEBLICH *et al.*, 1968, p. 89; EHRENBERG, 1854, pl. 20 (1), fig. 44a, as *Mesocena*

Mesocena elliptica Ehrenberg, LOCKER, 1974, p. 634, pl. 2, fig. 4; Bukry, 1978b, p. 819, pl. 6, fig. 6-13

Remarks: For discussion, see Bukry (1978b)

MESOCENA HEXAGONA Haeckel
Pl. 8, fig. 5

Mesocena hexagona Haeckel, 1887, p. 1556; not figured, *fide* LOEBLICH *et al.*, 1968, p. 128; LING, 1977, p. 208, pl. 3, fig. 3

Remarks: This species may have close affinities to *M. hexalitha* (Bukry,1981, p. 547-548) but until resolved is retained in the older species assignment.

MESOCENA QUADRANGULA Ehrenberg *ex* Haeckel
Pl. 7, fig. 9

Mesocena quadrangula Ehrenberg *ex* HAECKEL, 1887, p. 1556; Lemmermann, 1901b, p. 10, fig. 5-7, *fide* LOEBLICH *et al.*, 1968, p. 57, pl. 30, fig. 4-6; BUKRY, 1978b, p. 819, pl. 7, fig. 1-5

MESOCENA TRIANGULA (Ehrenberg) Ehrenberg
Pl. 8, fig. 6, 7

Dictyocha (Mesocena) triangula (Ehrenberg) 1844, p. 65, 71, *fide* LOEBLICH *et al.*, 1968, p. 118; EHRENBERG, 1854, pl. 22, fig. 41, as *Mesocena*

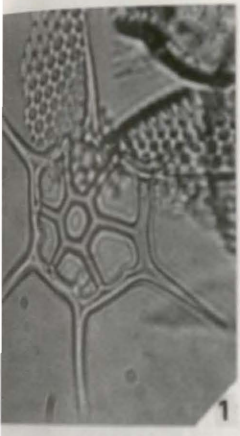
Mesocena polymorpha var. *triangula* (Ehrenberg) SCHULZ, 1928 (in part), p. 237, fig. 3b, *non* fig. 3b, c

?Bachmannocena triangula (Ehrenberg) LOCKER, 1974, p. 636, pl. 2, fig. 10 (holotype)

Remarks: Forms identified as *M. triangula* (Ehrenberg) are present in the Sweeny Road study material together with forms tabulated as *M.* sp. cf. *M. triangula*. These latter forms differ by lacking the distinct symmetry of *M. triangula* s. str.

PLATE 5
All Figures 800x

1,2. *Distephanus frugalis* (Bukry) Bukry. #44.
3. *Distephanus mesophthalmus* (Ehrenberg) Dumitrică. #45.
4,7. *Distephanus frugalis* (Pentagonal)(Bukry) Bukry. 4 - #50. 7 - #70.
5. *Distephanus speculum* (Ehrenberg) Haeckel subsp. *bispicatus* Bukry. #68.
6. *Distephanus speculum speculum* (Ehrenberg) Haeckel. #43.
8. *Distephanus speculum minutus* (Bachmann) Bukry. #42.
9,10. *Distephanus* sp. D. 9 - #45 10 - #46
11. *Distephanus speculum* fa. *coronata* Schulz. #53.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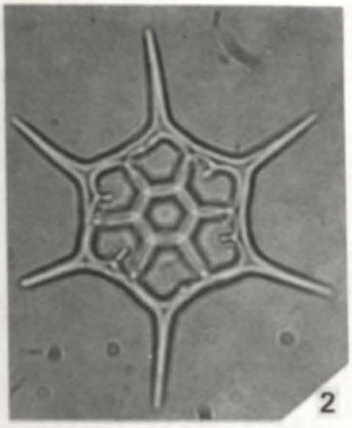
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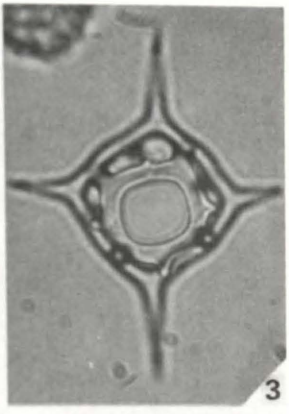
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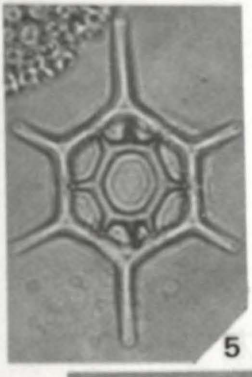
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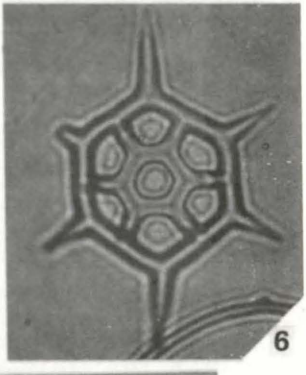
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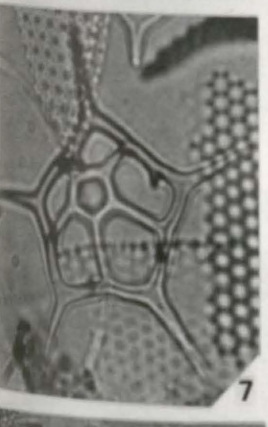
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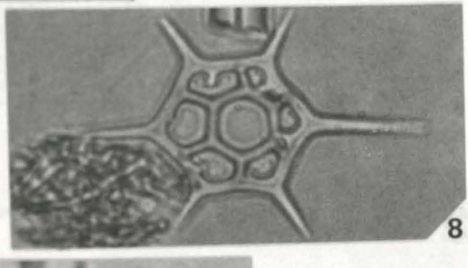
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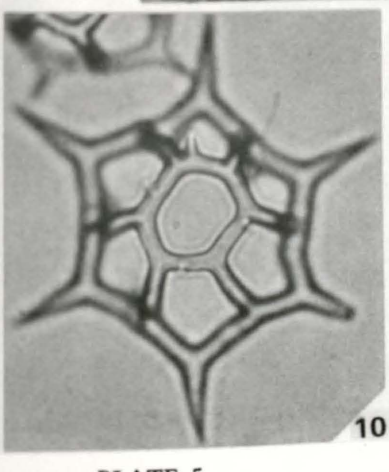
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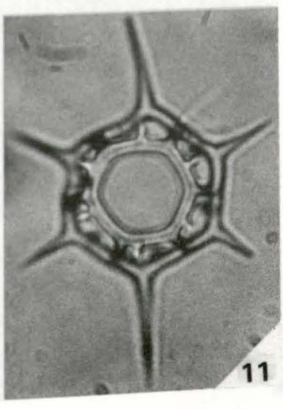
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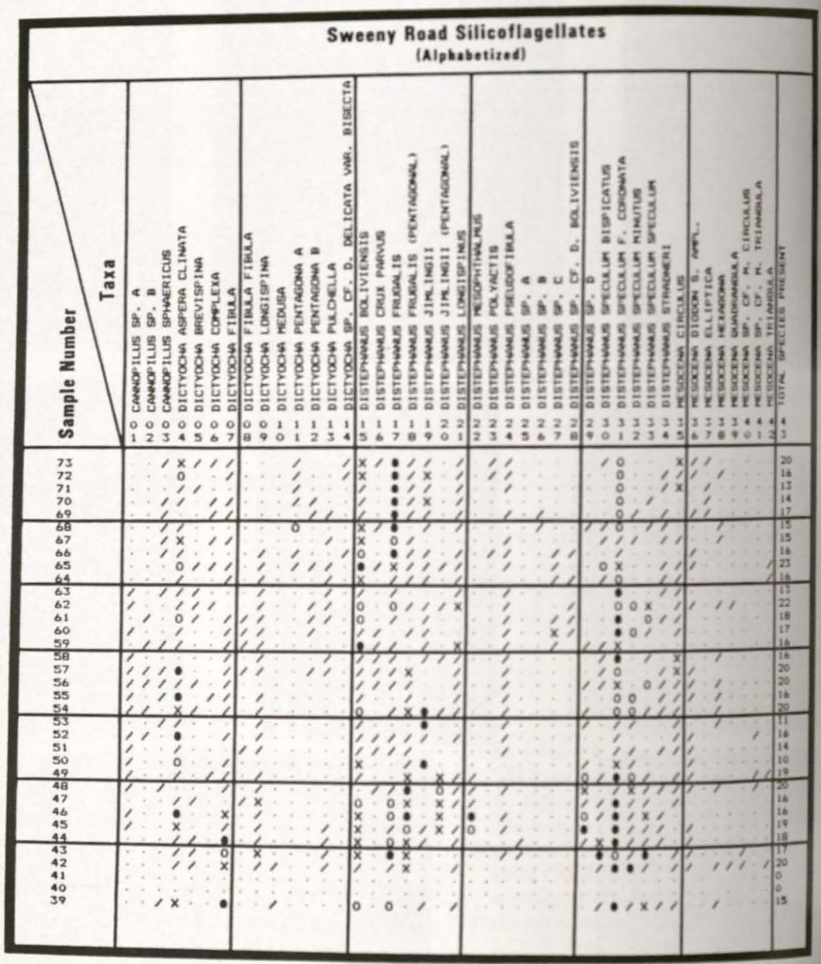
PLATE 5

Check Chart I
Alphabetized Listing of Sweeny Road Silicoflagellates

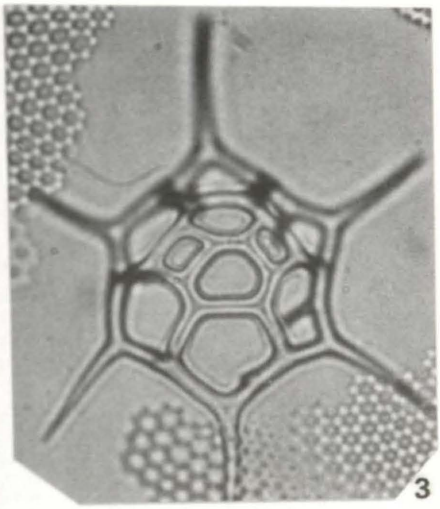


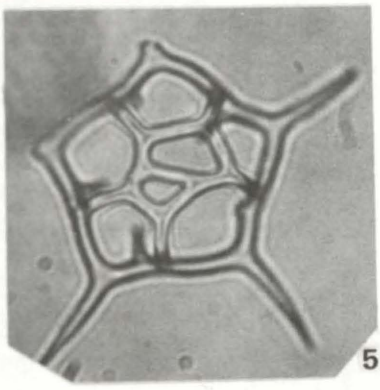
Frequency Key

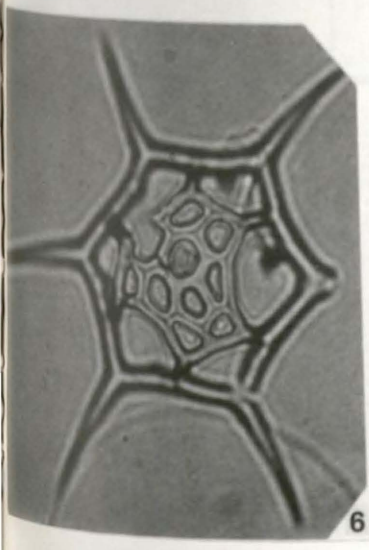
Symbol	Number of Specimens/ Horizontal Traverse of Slide (2x4 cm) @ 250X
●	>20
○	11–20
X	5–10
/	<5
Blank	0

PLATE 6
All Figures 800x

1,3,6. *Distephanus jimlingii* (Bukry) Bukry. 1 - #71. 3 - #50. 6 - #53.
2,4,5,7. *Distephanus jimlingii* (Pentagonal) (Bukry) Bukry. 2 - #65. 4 - #49. 5 - #65. 7 - #45.







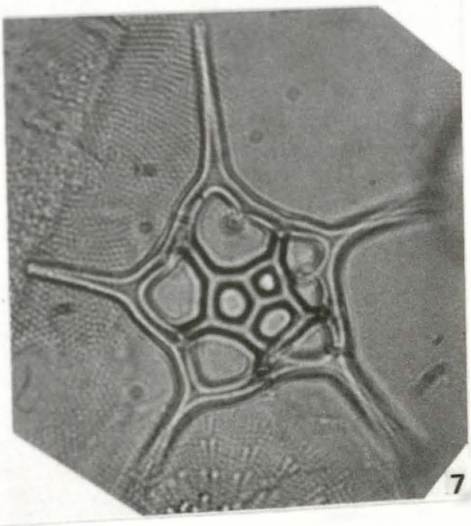
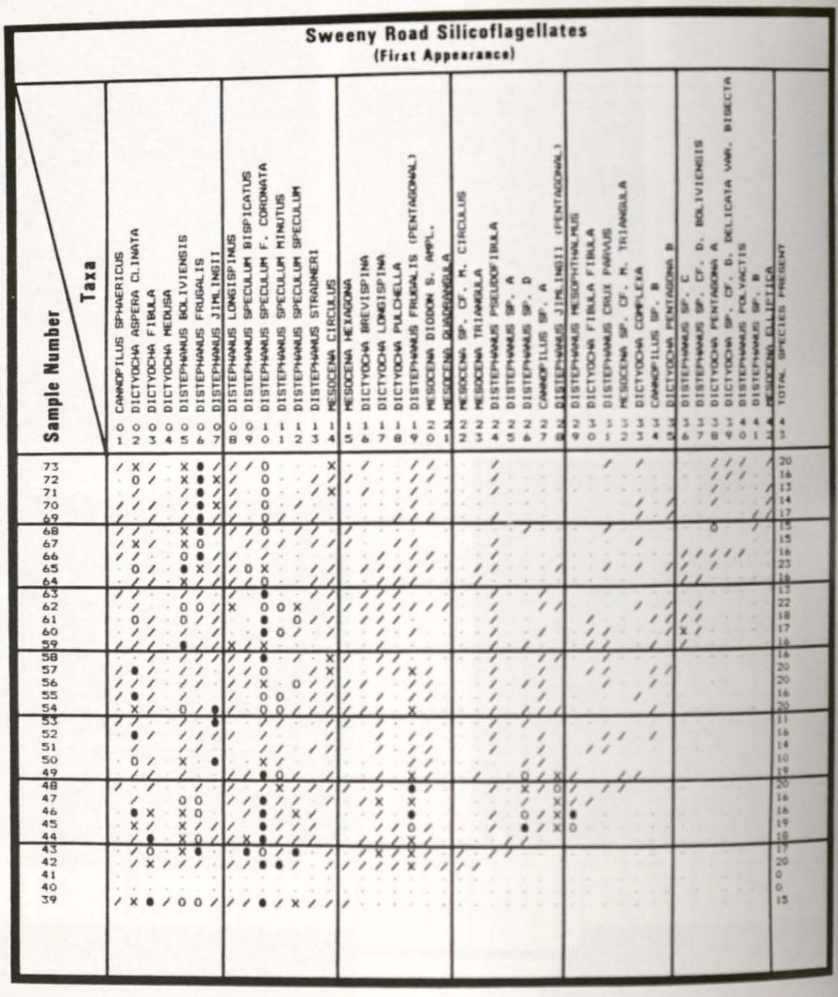


PLATE 6

Check Chart II

Sweeny Road Silicoflagellates Arranged by First Appearance Upsection



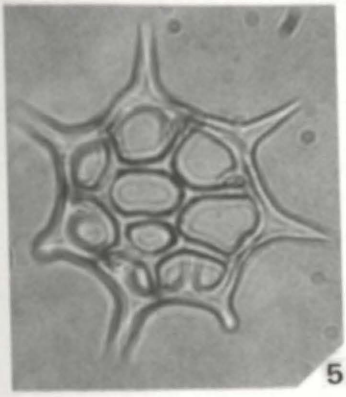
Frequency Key

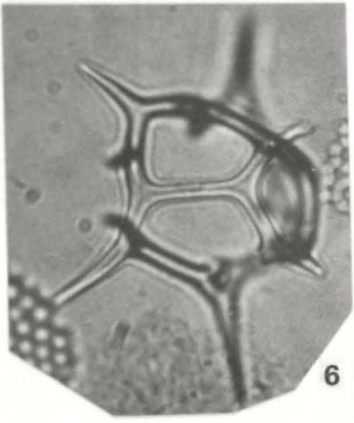
Symbol	Number of Specimens/ Horizontal Traverse of Slide (2×4 cm) @ 250X
●	>20
O	11–20
X	5–10
/	<5
Blank	0

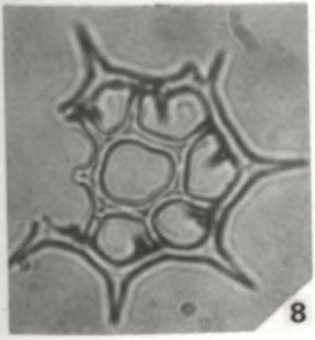
PLATE 7

All Figures 800x

1,4. *Distephanus stradneri* (Jerković) Bukry. 1 - #48. 4 - #39.
2,3,6. *Distephanus* sp. B. 2 - #69. 3 - #69. 6 - #68.
5,7,8. *Distephanus sp.* C. 5 - #64. 7 - #59. 8 - #64.
9. *Mesocena quadrangula* Ehrenberg *ex* Haeckel. #62.







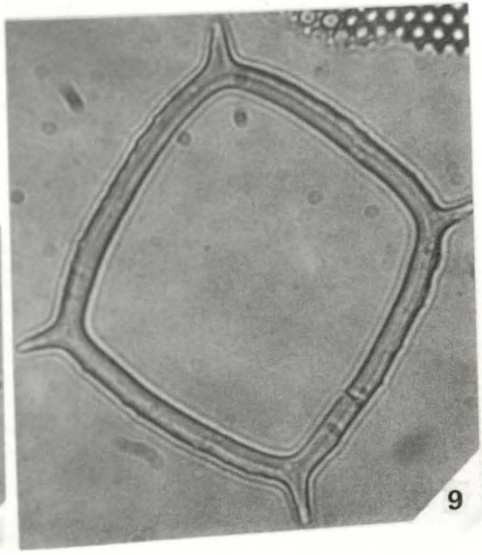


PLATE 7

Check Chart III

Sweeny Road Silicoflagellates Arranged by Last Appearance Upsection

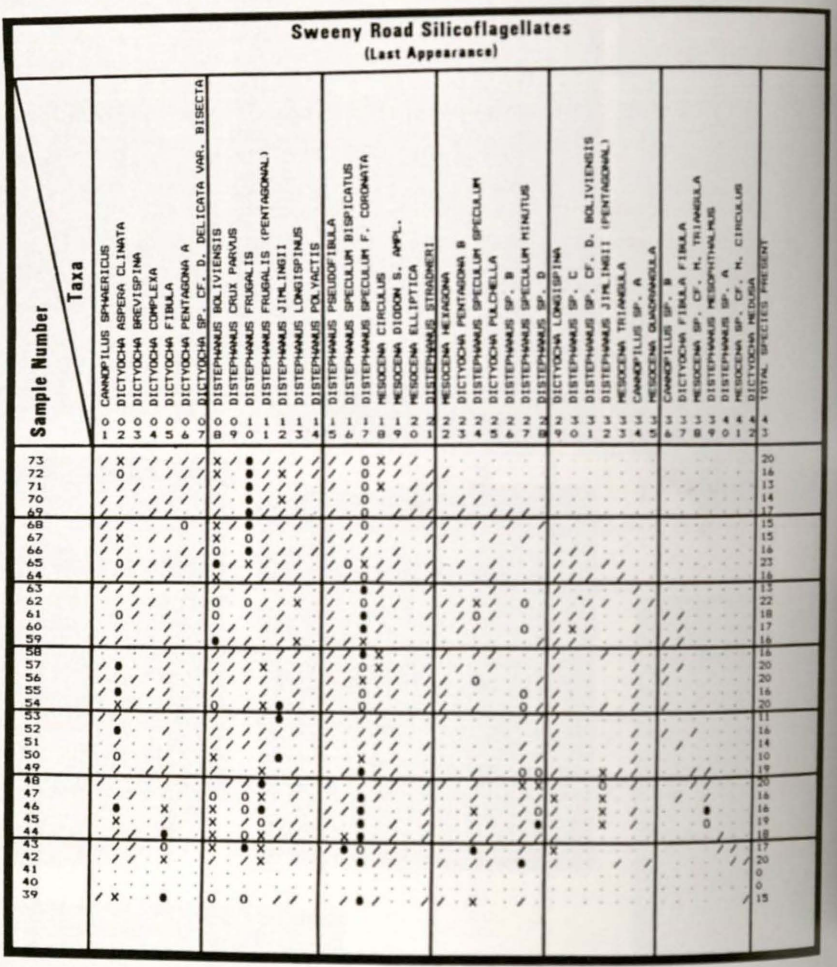
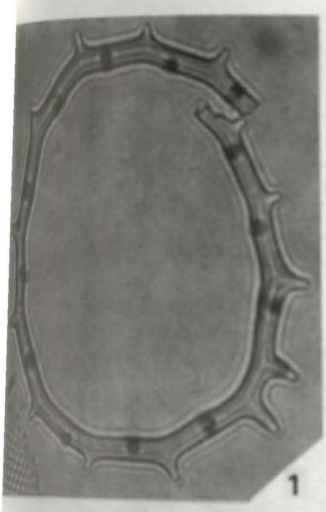
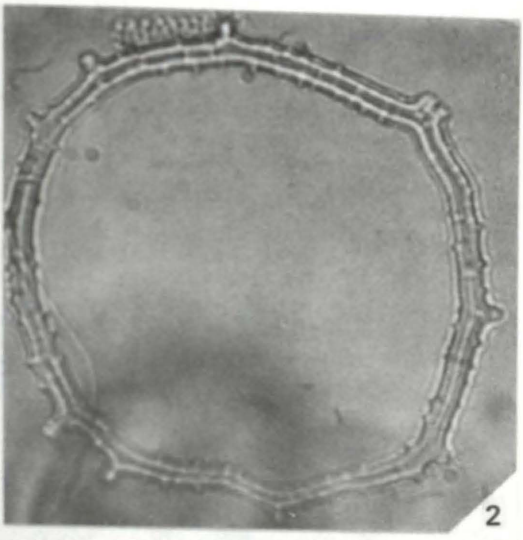


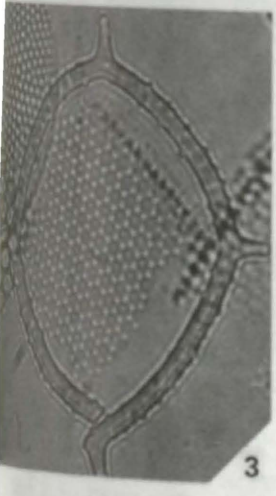
PLATE 8

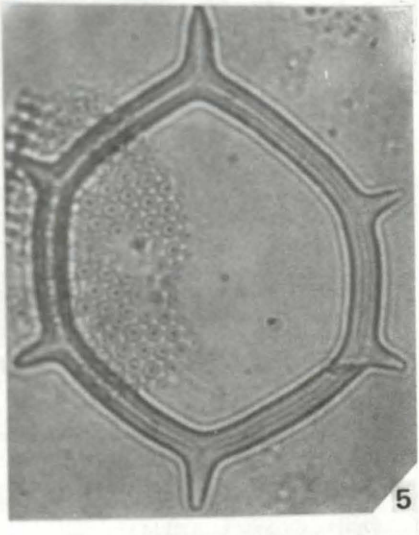
All Figures 800x

1. *Mesocena circulus* (Ehrenberg) Ehrenberg. #65.
2. *Mesocena* sp. cf. *M. circulus*. #43.
3. *Mesocena elliptica* (Ehrenberg) Ehrenberg. #69.
4. *Mesocena diodon* Ehrenberg s. ampl. #57.
5. *Mesocena hexagona* Haeckel. #68.
6. *Mesocena* sp. cf. *M. triangula*. #48.
7. *Mesocena triangula* Ehrenberg. #64.









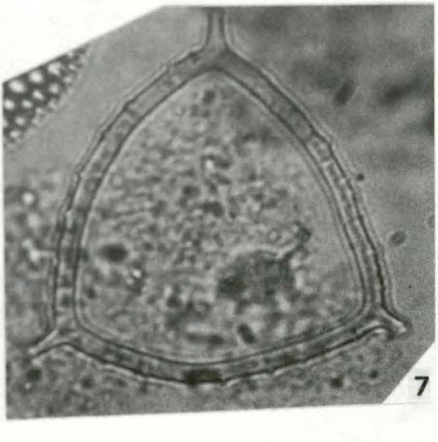
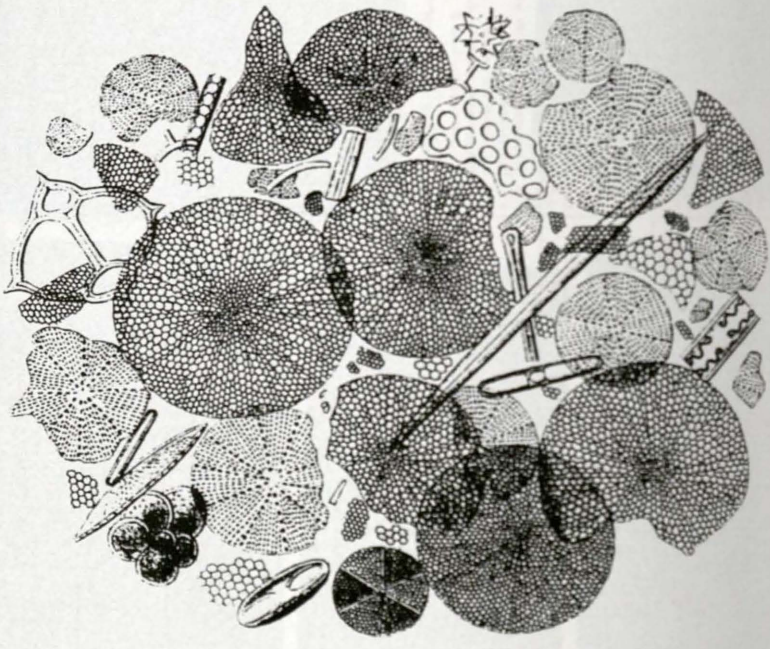


PLATE 8



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