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MIOCENE AND PLIOCENE MARINE DIATOMS FROM CALIFORNIA

By

Walter W. Wornardt, Jr.

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Abstract: The stratigraphic distribution of diatoms in the upper member of the typical Monterey formation and the Sisquoc formation is recorded and analyzed. About 160 species and varieties of these organisms are systematically classified, described, and figured. Some individuals of the floras studied are planktonic and others are benthonic. They are found to range in age from late Miocene to middle Pliocene. Two diatom floras are recognized from the formations studied. The floras are found in superpositional relationship near Lompoc, California. On the basis of their demonstrated stratigraphic relationships, and their recognition at other localities widely distributed in the Miocene and Pliocene strata of the Pacific Coast, the diatoms appear to be useful for correlating strata throughout the Coast Range area.

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Introduction

The West Coast of North America seems to have had environments particularly conducive to the accumulation and preservation of the most extensive marine deposits of diatomaceous sediments in the world. Extensive occurrences of these diatomaceous rocks are especially prevalent throughout the State of California. These strata range in age from Cretaceous to Pleistocene.

Many fossil diatoms from California have been described and figured (Hanna, 1927, 1931, 1932, 1934) and to some extent their local stratigraphic distribution has been tabulated (Lohman, 1938). The geologic age of these diatoms has usually been based upon observable stratigraphic relationships with other well dated megafossils and microfossils.

Diatoms were collected stratigraphically from diatomaceous deposits in three areas: near Monterey, California; the Purisima Hills, north of Lompoc, California; and from an area south of Lompoc, California. In these areas stratigraphic sequences of richly diatomaceous beds attain 100 feet to more than 3,000 feet in thickness and are locally very well exposed.

Acknowledgments

The writer is very grateful to Dr. G Dallas Hanna of the California Academy of Sciences and to Professor Robert M. Kleinpell, University of California, for suggesting, directing, and supervising the investigation and for the assistance furnished through them by the National Science Foundation. Dr. Hanna's type diatom slides, many strewn slides, and unpublished manuscripts were made available for this study. The writer is especially indebted to Dr. Hanna for his instruction in preparing, mounting, and photographing these minute fossil diatoms.

Acknowledgments are likewise due to Dr. Leo G. Hertlein, California Academy of Sciences, for his excellent advice on numerous editorial and systematic problems; the late Ignatius McGuire, Librarian at the California Academy of Sciences, for his diligent assistance in locating numerous obscure publications, many of which were cited under inadequate references; William W. Porter II, geologist, for helpful direction and advice on matters related to the stratigraphy and geology of the Santa Maria Basin; Dr. Friedrich Hustedt, Bremen, Germany; Mr. Richard Ross, British Museum of Natural History, London, England; and Mr. N. Ingram Hendey, British Admiralities, Poole, England, for their valuable advice concerning the systematics of this manuscript; Dr. Taro Kanaya and Dr. Reimer Simonsen for their advice and discussions concerning diatoms; Mrs. Walter Wornardt, Jr., for her typing, drafting, and general assistance in preparing the manuscript; Mr. James Flood of Sisquoc Ranch, and the Johns Manville Company for permis-

sion to visit their properties; the University of California library for the use of numerous foreign journals.

Finally, the writer would like to record his indebtedness to the California Academy of Sciences, at which institution this project was carried out and for the facilities rendered, especially the use of the many hundreds of diatom books and reprints in the Academy library.

Earlier Investigations of the Monterey District

The town of Monterey, California, named in honor of the Count of Monte Rey, the viceroy of New Spain, about 1602, and the first Spanish military establishment in California, is located around 121° W., and 36° 35" N., in Monterey County, about 100 miles south of the City of San Francisco. The Monterey formation, exposed in and about Monterey, which is its type area, has the distinction of being the first formation to be described in California. According to Hanna (1928), the discovery of the white organic shale cropping out at Monterey, California, should be credited to Alexander S. Taylor. This was probably not later than 1852.

The first description of the white organic shale exposed at Monterey, was given by W. P. Blake in 1856 (pp. 180-182), who was a geologist for the Pacific Railway Survey. He cited the principal outcrop as a "white spot on the side of a hill about 2 miles from the center of town." This description is the type designation of the Monterey formation.

The first adequate description of the Monterey formation exposed at Monterey, California, was given by Galliher in 1931. He described a 3160-foot section of Monterey strata and divided it into five lithologic units. Member no. 1, the youngest member, Galliher records as 770 feet of "earthy, diatomaceous, opal silt. Contains approximately 80 percent of silica showing organic structure" (p. 71).

In 1938 R. M. Kleinpell described the "richly organic shale, which outcrops in the hills south and east of the towns of Monterey and Del Monte" as representing the type for the Delmontian stage (p. 131). Within the Delmontian stage, Kleinpell recognized only one time-stratigraphic zone, the *Bolivina obliqua* zone. This zone is essentially the lower substage of this stage and corresponds to the lower half of the overlying diatomite of Galliher's member no. 1. Zones in the upper substage, if any, were left formally unnamed.

This richly organic shale is largely composed of siliceous skeletons of diatoms, silicoflagellates, foraminifers, fish remains, and mollusks, and has been known to paleontologists for the past 110 years. Thomas Brightwell described the first fossil as well as the first diatom, *Triceratium montereyii*, from the Monterey formation in 1853 (p. 251).

In 1854 J. B. Trask recorded five species of "discoid diatoms" from the type Monterey formation but made no attempt to name them. He stated that this valuable "earth" was placed in the hands of the diatomists C. G. Ehrenberg and J. W. Bailey.

These works were followed by papers from a number of diatom students: Brightwell (1858); Greville (1860); Ralfs (1861); Edwards (1873); Grunow (1884); Van Heurck (1880-1885); Rattray (1888, 1889, 1890); De-Toni (1891-1894); P. T. Cleve (1894-1895); Tempère and Peragallo (1907-1915); and A. Schmidt (1874-1961). Each study contained at least one of the following: original description; original drawings; original photomicrographs of diatom species from the diatomaceous earth exposed at Monterey, California.

It is interesting to note that relatively few papers have been published on fossils from the type Monterey formation other than those on diatoms.

In the present study, the writer identified 116 species and varieties of diatoms referable to genera and families, from the upper member of the Monterey formation of the type area. Three samples were collected from a stratigraphic sequence of diatomite exposed in the quarry of the Monterey Products Company 4 miles east of Del Monte on the Monterey-Salinas highway. Four additional samples were collected along the Los Lureles road, east of Monterey and south of Del Monte, California.

Many species occur only in the lowermost portion of the samples, others range through the entire sequence collected, and still others occur only in the upper samples from this member of the Monterey. In the case of certain species, and even genera, proportional representations also vary vertically through the stratigraphic sequence sampled.

Sufficient differences, both qualitative and quantitative, are apparent between assemblages stratigraphically low and high in this sequence to suggest the presence of discrete florules at different horizons within the 770 feet of the upper Monterey diatomite. Sampling, however, has been too local to permit the definition of such florules and of their possible zonules with any assurance at this time. Actually, viewed in its entirety, a fairly high degree of uniformity in the diatom assemblages exists through the stratal sequence, from the base to the uppermost strata of the upper member of the type Monterey.

The diatom flora from the upper member of the type Monterey formation is unlike any other diatom flora described from California. It is therefore difficult to state anything as to the age of the Monterey flora other than its superpositional relationship with the Sharkstooth Hill diatom flora below (from the Temblor formation) of Relizian age (middle Miocene) and the Etchegoin formation of middle Pliocene age above.

The stratigraphic position of the upper member of the type Monterey formation, however, was set forth in detail by Kleinpell (1938). He assigned this sequence of diatomites, a chert and cherty siliceous shale unit below the diatomaceous member of the Monterey formation, as exposed near Monterey, California, to his Delmontian stage and to the Miocene series. He used, as his discipline, the stratigraphic position of this member, with a Mohnian, late Miocene, foraminiferal fauna stratigraphically below and an early Pliocene *Astrodapsis jacalitosensis* megafauna conformably above.

Inasmuch as the diatom assemblages collected from the lower part of the upper diatomite member of the type Monterey formation coincides with and represents Kleinpell's samples numbers 27-33, these diatom assemblages are by definition lower Delmontian. They are equivalent in age to the *Bolivina obliqua* zone, and thus they are clearly older than the early Pliocene beds of the type Jacalitos formation which carry *Astrodapsis jacalitosensis* and age equivalents of them elsewhere in California.

The diatoms herein described from the type Monterey formation, have been exceedingly helpful in determining the stratigraphic relationships of this particular horizon in many parts of California. This same diatom assemblage of common species occurs both in surface outcrops and in well samples throughout California, such as in the Coast Ranges; in the Santa Cruz Mountains; Lompoc; Santa Barbara coast; Palos Verdes Hills; Newport Beach; in the San Joaquin Valley; in Devils Den, Chico Martinez Creek, Belridge, and Modelo Canyon.

Only a few of the 116 diatom species present in the upper type Monterey were truly oceanic forms. Others were planktonic species that were always neritic in habitat; that is to say, near-shore rather than truly oceanic. On the other hand, most of the 116 diatom species were bottom dwellers. Of these, some were vagile benthonic forms, such as many of the species of *Diploneis* and *Navicula*. Other forms were sessile benthonic, such as most of the species of *Arachnoidiscus*, *Aulacodiscus*, *Cocconeis*, and *Stictodiscus*.

The Purisima Hills, named for the colonial mission La Purisima, now a state park, are located approximately 34° 38" N. lat., and 120°, 39'W. long., in Santa Maria district, Santa Barbara County, California. They are bounded on the north by the narrow Los Alamos valley, and the San Antonio valley; on the south by the Santa Ynez River valley.

The geology of the Santa Maria basin has not been treated as extensively in the earlier literature of California as has the Monterey area.

The first record of geologic investigations in the Purisima Hills area was by Thomas Antisell (1856) in the Pacific Railway Reports. He made brief notes concerning the general geologic features of the area.

In 1932 W. W. Porter II, named the Sisquoc formation. This was based upon a "well exposed section on the Sisquoc Ranch, on the southside of Sisquoc River in the Sisquoc Grant" (p. 139). This formation was described as "mostly fine, muddy, silty, friable, gray sandstone" (p. 139). In the same paper he correlated the upper part of the thick diatomite section exposed along the Harris grade in the Purisima Hills, with the Sisquoc formation in its type area on the Sisquoc Ranch.

In their study of the geology and paleontology of the Santa Maria district, California, Woodring and Bramlette (1950) mapped the thick diatomite section along the Harris grade road as the "basin facies" of the Sisquoc formation.

Although the highly fossiliferous Sisquoc formation is well exposed throughout the Santa Maria basin, the paleontology of this formation has not been treated as extensively in the earlier literature of California as has the Monterey formation.

G Dallas Hanna published a very important paper in 1930 on the observations of *Lithodesmium cornigerum* Brun in which he stated that "The species appears to be an excellent marker of one of the zones of the Pliocene diatom-shale in California because it has been abundant on the four occasions when found. It cannot have a long vertical range in the strata and has not thus far been found in Monterey shale" (p. 191).

In Woodring and Bramlette (1950), Lohman identified and listed 18 species and varieties of diatoms from the Sisquoc formation exposed along the Cabrillo Highway (Harris grade road). He also stated that "*Lithodesmium cornigerum* is the most distinctive species. This three-pronged diatom is much like a three-bladed airplane propeller in outline and is not likely to be confused with any other species. It is common in the lower three-quarters of the sampled basin facies of the Sisquoc, occurs in silty diatomaceous strata in the syncline near Sisquoc River, is recorded from the Sisquoc of Graciosa Ridge and the NTU mine, but was not found in the underlying Monterey shale, or in the overlying Foxen mudstone." (p. 36).

In the present study, a total of 71 species and varieties referable to genera and families were obtained from 17 samples collected from the Sisquoc formation exposed along State Highway 1, the Harris grade road, about 2 miles south of Harris and about 7 miles north of Lompoc, California. This sequence was measured initially by Mr. Wents with a plane table and aledaide, and 167 samples were collected and stratigraphically allocated. After careful examination of these samples, 17 samples were selected for detailed study. Subsequently, the writer systematically collected several hundred additional samples from this same measured section and also from the same stratigraphic intervals as those collected by Mr. Wents. Examination of these samples revealed the same diatom assemblages as those found in the earlier collection of Mr. Wents.

The base of the Sisquoc formation is not clearly defined along the Harris grade road because the stratigraphic section crosses the axis of the Purisima anticline to the south. The lower 600 feet of this formation is characterized by porcelaneous shale interbedded with thin cherty layers and some diatomite. The next highest 1500 feet is characterized by light-colored diatomaceous mudstone, interbedded with white laminated diatomite. The next 500 feet is dominately clayey diatomaceous shale and diatomites. The overlying 800 feet is characterized by light-colored diatomaceous shales and diatomites. The upper limit of the Sisquoc formation along the Harris grade road is taken at the uppermost limit of the more massive diatomaceous shales. Actually, the entire section is remarkably uniform from top to bottom, with the massive character of the diatomaceous shale and the scarcity of bedding planes in the upper two-thirds of the section being the most conspicuous features.

The Foxen formation conformably overlies the Sisquoc formation along the Harris grade road. This formation consists of 800 feet of mudstone, clayey siltstone, and thin beds of diatomaceous shales in the basal part.

As is true of the upper member of the type Monterey formation, different species are restricted to separate parts of the Sisquoc formation, whereas other species range throughout it and quantitative representation again emphasized the probable presence of possibly three discrete florules in the Harris grade column.

The lower flora, samples CAS 27295-3 to CAS 27295-57 inclusive, is characterized by the dominance of *Actinocyclus ehrenbergii*, *Bacteriastrum varians*, *Coscinodiscus excentricus*, *C. marginatus*, *C. lineatus*, *C. radiatus*, *Lithodesmium cornigerum*, *Nitzschia pliocena*, and *Rhaponeis ischaboensis*.

Samples CAS 27295-64 to CAS 27295-102 inclusive are sufficiently similar to permit a designation of a middle flora. *Coscinodiscus asteromphalus*, *C. obscurus*, *Nitzschia pliocena*, *Biddulphia aurita*, and *Hemidiscus simplicissimus* make their first appearance, while *Lithodesmium cornigerum* and *Rhaponeis ischaboensis* become rare near the upper limit of this flora.

The diatom assemblages found in samples CAS 27295-113 to CAS 27295-154 inclusive compose the upper flora in this stratigraphic section along the Harris grade. Actually, sample CAS 27295-154, the uppermost sample in this flora, was obtained from the Foxen formation. *Lithodesmium cornigerum* and *Nitzschia ischaboensis* disappear near the uppermost portion of this flora. *Arachnoidiscus ehrenbergii*, *Asteromphalus arachne*, *Coscinodiscus obscurus*, *C. lineatus* var. *convexus*, and *C. robustus* var. *herculus*, make their first appearance in this upper flora.

Porter (1932) stated that the Pliocene age of the Sisquoc formation was based upon the identifications of fossil mollusks from this area by Mrs.

Castle. In her unpublished report to Porter, the lower type Sisquoc was determined as "Lower Jacalitos, lower Pliocene." She stated that the upper Sisquoc formation contains mollusks which seem to "correlate with Arnold's lowest Fernando horizon of the Santa Maria area. The horizon is Pliocene, probably Jacalitos (lower Etchegoin)," In the conclusion of the same report, she also stated that the lower part of the Sisquoc section "is lower in the Pliocene than any Pliocene so far known in the Santa Maria Basin."

Also within the upper few hundred feet of the Sisquoc formation is a molluscan assemblage which they considered middle Pliocene and correlated with "at least part of the Etchegoin Formation." A few megafossils from the middle part of the basin facies have "Pliocene affinities" according to Woodring and Bramlette (1950, p. 101). There have been no megafossils of definite Miocene age reported from the Sisquoc formation in the Purisima Hills.

The age of the Sisquoc formation is therefore based in part on the superpositional relationship with the overlying Foxen formation of middle Pliocene age and the underlying upper member of the Monterey formation of late Miocene age.

It is also based in part on the megafossils from the middle part of the Sisquoc formation, having Pliocene affinities and lower Jacalitos, "lower Pliocene" megafossils, from the lower part of the type Sisquoc formation.

The diatoms from the Sisquoc formation make up a very distinct flora. It is difficult to state the precise age of the Sisquoc formation from the diatoms themselves. Its general age, however, can be based on its superpositional relationships with the typical Monterey diatom flora below, from the upper Monterey formation of Delmontian age (late Miocene) and the San Joaquin formation, late Pliocene age above. It should be noted that the San Joaquin formation stratigraphically overlies the Etchegoin formation in the San Joaquin Valley, and the megafossil fauna in the upper part of the type Sisquoc formation was considered a correlative at least in part of the Etchegoin formation.

The diatoms herein described from the Sisquoc formation and lower part of the Foxen formation have been exceedingly helpful in determining the stratigraphic relationships of these particular horizons in many parts of California.

The characteristic diatom assemblage seems to be sufficiently distinct for recognition throughout much of the Santa Maria basin. Additional samples have been examined to warrant the belief that the flora is recognizable for considerable distances, such as from: Pt. Reyes peninsula, Santa Cruz Mountains, Lompoc, Goleta Point, Kettleman Hills, and North Belridge Field.

In contrast to the Monterey diatom flora, the forms from the lower and middle parts of the Sisquoc formation exposed along Harris grade are main-ly planktonic species. These diatoms constitute almost the entire flora found in the lower 2300 feet of section CAS 27295-3 to CAS 27295-102 inclusive. These planktonic diatoms decrease in number of species beginning in sample CAS 27295-113 and continue to decrease upward through the Harris grade sequence. They are replaced by an increasing number of bottom dwelling forms. The later are most numerous in the upper 1200 feet of the Sisquoc formation and lower Foxen formation.

A considerable number of these bottom dwellers are sessile benthonic and vagile benthonic forms, such as *Arachnoidiscus*, *Cocconeis*, *Triceratium*, *Navicula*, and *Diploneis*. Other littoral forms are also common, such as *Coscinodiscus robustus* and several species of *Stephanopyxis*.

Two diatomaceous samples were collected from the stratigraphically highest outcrop of diatomite in the main quarry of the Johns Manville plant in Lompoc, California. Here the stratigraphic sequence is continuous and exhibits a dip of about 5 degrees toward the north. In this sequence the Sisquoc formation, in typical brownish massive lithologic expression, conformably overlies the upper most and distinctively white, punky diatomite so characteristic of the upper member of the type Monterey formation.

Each of the two samples collected from the quarry at Lompoc yielded different diatom assemblages. The uppermost diatomite assemblage is sufficiently similar to the lower flora of the Sisquoc formation as it occurs along the Harris grade to permit a designation of lower Sisquoc flora. Similarly, the lower diatomite assemblage is sufficiently similar to the Monterey flora of the type Monterey formation, Monterey, California, to permit a designation of upper Monterey flora.

When the Harris grade Sisquoc flora is compared with the upper member of the type Monterey flora, the differences between the two floras are striking. Then if we consider the difference in floral content between Sisquoc flora of the Harris grade and the upper Monterey flora of the Lompoc area, again we find a striking difference between floras. Finally, if we consider the similarity in specific floral content, of the Harris grade and the Sisquoc of the Lompoc area (which directly overlies the upper Monterey flora), the similarities are just as striking.

It is thus possible to evaluate to some extent at least the differences and similarities in the distribution of diatom species and of diatom florules in the upper member of the Monterey and Sisquoc formation both stratigraphically and regionally.

Diatoms

In view of these geologic age determinations and correlations as summarized above, the marked differences in diatom floras from the upper member of the type Monterey formation and from the Sisquoc formation respectively, take on added significance for purposes of determining the geologic age of diatom floras and diatomaceous strata. In the case of the upper type Monterey diatom flora, its containing stratum immediately underlies sandstones of early Pliocene age. In the case of the Sisquoc diatom flora, its containing strata are lateral equivalents of early and middle Pliocene sandstones. That these differences between the two diatom floras studied are of geologic significance is then independently checked by the direct evidence from the stratigraphic relationships between essentially the same two diatom floras in the Lompoc area, where two samples of the Monterey flora (CAS 1736) occur in strata directly overlain by beds carrying the Sisquoc flora (CAS 27730) of the Sisquoc formation.

Additional examples may be cited in passing in which still other and different diatom floras are shown to be of comparably different geologic age. They are: those from the upper Temblor formation of Sharktooth Hill in Kern County, California, which are very different both from the upper Monterey and from the Sisquoc floras and are, through other lines of evidence, known to be of middle Miocene age; and those from the Etchegoin formation of the Kettleman Hills, which are again different and known to be of middle or late Pliocene age. It is probably significant to note further that the Etchegoin floras in reference have many more diatom species in common with the Sisquoc than with the Monterey floras, and that the Temblor flora in reference has many more species in common with the Monterey than with the Sisquoc flora.

Finally, floras very comparable to those of the upper type Monterey have been collected from the upper Modelo formation of Girard (on the northern slopes of the Santa Monica Mountains), from the Malaga mudstone member of the Monterey formation in the Palos Verdes Hills, and from the lower Belridge diatomite of the Monterey formation in Chico Martinez Creek. All of these stratigraphic occurrences are altogether in keeping with the age correlations to be inferred from these very closely related diatom floras, according to all known lines of evidence other than those furnished directly by the diatoms themselves.

All these occurrences corroborate the association of the characteristic Delmontian diatom floras as found in the upper member of the type Monterey, with the foraminiferal fauna of the Delmontian stage as found elsewhere.

Insofar as these relationships between diatom floras and foraminiferal faunas are not only true in the Monterey area, but are generally true where the two are found elsewhere in the Coast ranges, it seems likely that the many other areas where these diatom floras are found unassociated with other fossils (foraminifers or other fossils, as the case may be), that the containing strata may be considered to be Delmontian age, even though neither fossil foraminifers nor megafossils may be locally present.

The distinctive diatom flora of the Sisquoc formation from the Harris grade sequence has also been found in other areas widely deployed in the California Coast ranges, namely, Point Reyes, the Taft area, Naples, of the Santa Barbara coast, and especially the Santa Maria basin, other than the Harris or Lompoc areas. The rocks in these areas stratigraphically overlie rocks of demonstrable Delmontian age. On the basis of the direct evidence from the diatom floras, the strata as well as the flora must be of that age or younger.

In summary, comparison of the diatoms in both the Monterey and the Sisquoc areas, plus direct superposition of the same floras in the Lompoc area, point directly to the relative age determinations of the two floras, respectively, that are entirely in keeping with age determinations and correlations based upon other lines of evidence. It strongly indicates that diatoms and diatom floras evolved according to the same principles as other life and that they may be used to correlate strata in a comparable manner. These should aid significantly, especially where other fossils, larger marine invertebrates, foraminifers, and even mammals, are rare or occur only sporadically as is so often true in many local stratigraphic columns throughout the Coast ranges and elsewhere.

Descriptions of California Academy of Sciences Localities

Locality 866 (CAS). Diatomaceous shale. Four miles east of Del Monte on road to Salinas, California, at plant for preparation of diatomaceous earth. Soft, pure samples some from near top of deposit. Strata dip steeply to west and strike almost north. G D. Hanna, collector, November, 1923.

Locality 1274 (CAS). Impure shale from the base of the Monterey section very close to granite contact. The locality is on the road from Salinas-Monterey Highway to Tassajara Springs and near top of hill, 3.7 miles north of Carmel Valley. The dip is almost flat. G D. Hanna and W. M. Grant, collectors, November, 1927.

Locality 1275 (CAS). On same road as 1274 and 0.8 mile north and higher in section. Dip about 5 degrees.

Locality 1276 (CAS). On same road as 1274 and 0.07 mile north of 1275. Dip is 10 degrees.

Locality 1277 (CAS). On same road as 1274 and 0.2 mile north of 1276. Dip is 45 degrees.

Locality 1278 (CAS). On same road as 1274 and 0.7 mile north of 1277. Dip is vertical.

Locality 27295 (CAS). Diatomite. A long series of samples from the highway grade over Purisima Hills from Harris to Lompoc, Santa Barbara County, California. J. H. Wents, collector, 1931. Pliocene. The samples extend from the axis of the anticline upward in the section 4250 feet. The upper three samples contain foraminifera. The section was studied in detail by G D. Hanna (report in files of the Department of Geology of the California Academy of Sciences). Numbers 1-167 were originally put on the bags and are now sub-numbers. Reference in the present paper is to 19 samples located stratigraphically with reference to the axis of the anticline mentioned under locality 27295 (CAS) as datum, as follows:

3 (CAS). Buff diatomite, at base of section on south limb of Purisima anticline.

7 (CAS). Light buff impure diatomite, at base of section, south of Purisima anticline in Todos Santos member of Sisquoc formation.

25 (CAS). Whitish diatomite, 650 feet above crest of Purisima anticline.

29 (CAS). Buff diatomite, 760 feet above crest of Purisima anticline.

38 (CAS). Buff diatomite, 890 feet above crest of Purisima anticline.

49 (CAS). Buff diatomite, 1016 feet above crest of Purisima anticline.

57 (CAS). Buff diatomite, 1418 feet above crest of Purisima anticline.

64 (CAS). Buff diatomite, 1570 feet above crest of Purisima anticline.

73 (CAS). Buff diatomite, 1750 feet above crest of Purisima anticline.

83 (CAS). Buff diatomite, 1800 feet above crest of Purisima anticline.

94 (CAS). Buff diatomite, 2075 feet above crest of Purisima anticline.

102 (CAS). Buff diatomite, 2280 feet above crest of Purisima anticline.

113 (CAS). Buff diatomite, 2445 feet above crest of Purisima anticline.

122 (CAS). Buff diatomite, 2760 feet above crest of Purisima anticline.

129 (CAS). Buff, impure, ashy diatomite, 3105 feet above crest of Purisima anticline.

135 (CAS). Buff, impure, ashy diatomite, 3250 feet above crest of Purisima anticline.

154 (CAS). Buff, impure diatomite with impressions of foraminifers 3525 feet above crest of Purisima anticline.

155 (CAS). Buff, silty shale, foraminifers abundant, 3600 feet above crest of Purisima anticline.

162 (CAS). Buff, ashy shale, 4070 feet above crest of Purisima anticline.

Locality 1736 (CAS). Diatomite from extreme top of deposits in Celtite quarry 2 miles south of Lompoc, California. Sample taken from top of hill northwest of the plant and in axis of the syncline. W. W . Wornardt, Jr., collector, 1962.

Locality 27730 (CAS). Diatomite. Lompoc, Santa Barbara County, California. Sample from highest part of exposure. Pliocene. W. W. Wornardt, Jr., collector, 1962.

SYSTEMATIC TREATMENT

Kingdom PLANTAE
Division CHRYSOPHYCOPHYTA
Phylum CHRYSOPHYCEAE
Class BACILLARIOPHYCEAE [1] Fritsch [2], 1935
Order BACILLARIALES [3] Schütt [4], 1896
Suborder COSCINODISCINEAE Hendey, 1964
Family COSCINODISCACEAE Kützing [5], 1844
Subfamily MELOSIROIDEAE Kützing [6], 1844

Genus **Melosira** Agardh, 1824

Melosira clavigera Grunow.

(Figures 1, 2.)

Melosira clavigera GRUNOW, *in* Schmidt, 1876, pl. 74, figs. 13-15. HANNA, 1951, p. 284, fig. 3 (1).
"M. ?Clavigera GRUN." *in* Van Heurck, 1882, pl. 91, figs. 1,2. "Monterey et San Francisco."

GEOLOGIC RANGE. Late Miocene to late Pliocene.[7]

Melosira sulcata (Ehrenberg) Kützing.

Gaillonella sulcata EHRENBERG, 1838, p. 170, pl. 21, fig. 5.
Melosira sulcata (Ehrenberg) KÜTZING, 1844, p. 55, pl. 2, fig. 7. HUSTEDT, 1928, p. 276, figs. 118, 119.

GEOLOGIC RANGE. Late Eocene to Recent.

ECOLOGY. Reported to be temperate, subtropical, and sometimes found in neritic plankton. "A true bottom form...," according to Hendey (1964, p. 73).

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1 Rabenhorst was the first person to raise the diatoms to the level of class as Diatomphyceae.

2 Fritsch, 1935, pp. 7, 564. West (1904, p. 273), first used the name Bacillarieae but as a class, while Engler and Gilg (1919, p. 13) first used the name Bacillariophyta but used it as a division.

3 Some may prefer Diatomales as the order name (Webster's New International Dictionary, 1951, p. 198).

4 Schütt, 1896, pp. v, 31, as a subclass; new status Hendey, 1937, pp. 200, 202. Nitzsch (1817, p. 56) used Bazillarien as a "group" name for all diatoms known to him. Bory de Saint Vincent (1822, p. 127) used Bacillariées as a family grouping.

5 Kützing, 1844, p. 130, as family Coscinodisceae; change of spelling, De-Toni, 1890, pp. 894, 915.

6 Kützing, 1844, pp. 32, 48, as a family Melosireae; new status and change of spelling, Hustedt, 1930, pp. 55, 82.

7 Geologic range. This refers to the presently known geologic range of the particular species as recorded from the west coast of North America, California to Alaska.

Genus **Hyalodiscus** Ehrenberg, 1845

Hyalodiscus valens Schmidt.

(Figure 3.)

Hyalodiscus valens Schmidt, 1888, pl. 140, fig. 1.

Geologic range. Late Miocene.

Subfamily Skeletonemoideae Schütt, 1896 [8, 9]

Genus **Endictya** Ehrenberg, 1845

Endictya oceanica Ehrenberg.

(Figures 5-7.)

Endictya oceanica Ehrenberg, 1845, p. 76. Ehrenberg, 1854, pl. 35, gr. 18, figs. 6, 7. Schmidt, 1886, pl. 65, figs. 10, 12, 13. Hustedt, 1928, p. 297-299, fig. 136. Lohman, 1941, p. 66, pl. 12, fig. 3. A. Cleve-Euler, 1951, p. 36, figs. 37 a-e. Hendey, 1957, p. 41, pl. 6, fig. 5. Not *Endictya oceanica* Ehrenberg, of Long, Fuge, and Smith, 1946, p. 106.

Coscinodiscus divisus Grunow. A. Cleve-Euler, p. 58, figs. 80, c, d.

"*Orthosira oceanica (Endictya oceanica)*, Ehr." Brightwell, 1860, Quart. Jour. Micr. Sci., vol. 8, p. 96, pl. 6, fig. 14 [cited as fig. 16].

Geologic range. Late Miocene.

Remarks. Valve surface slightly convex, areolation coarse, approximately the same size over the entire valve surface, about 2½ to 3 areolae in 0.01 mm. Areolation is not unlike the pattern of *Coscinodiscus excentricus* Ehrenberg. The border appears as a wide, dark area in photomicrographs. A mill-like edge on border encircles valve.

Endictya species.

(Figure 4.)

Geologic range. Late Miocene.

Remarks. Valves convex. Areolation very coarse, from 2½ to 3 areolae in the central region, continuing nearly equal in size to the margin. The areolae appear rounded over the entire surface. The areolation pattern is not unlike *Coscinodiscus lineatus* Ehrenberg. It has a distinctive elevated rim, a mill-like network of protrusions, about 0.01 mm. high. From this rim the valve turns vertically downward and continues for about 40-50 microns. The areolae follow the valve surface as it turns vertically downward with about 2½ or 3 areolae in 0.01 mm.

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[8] Schütt, 1896, p. 55, as a subtribe Skeletoneminae.

[9] Hustedt, 1930, p. 55, new status and change of spelling.

Genus **Stephanopyxis** Ehrenberg, 1845

Stephanopyxis antiqua Pantocsek.

(Figure 8.)

Stephanopyxis antiqua Pantocsek, 1883, p. 96, pl. 19, fig. 280.

Geologic range. Middle Pliocene.

Remarks. This species is characterized by a very convex valve "in lineas excentricas dispositae," according to Pantocsek (1893, p. 96).

Stephanopyxis lineata (Ehrenberg) Forti.

(Figures 9-11.)

Stephanodiscus ?lineatus (=Peristephania lin.?) Ehrenberg, 1854, pl. 33, gr. 13, fig. 22.

Stephanopyxis lineata (Ehrenberg), Forti, 1913, p. 1547 (p. 13), pl. 1, figs. 21, 23; pl. 2, fig. 3. Lohman, 1948, p. 158, pl. 6, fig. 3.

Geologic range. Middle Miocene to late Miocene.

Remarks. Distinguished by the high marginal spines near the border and the linear pattern of the areolae.

Stephanopyxis turris var. **cylindrus** Grunow.

Stephanopyxis turris var. *cyclindrus* Grunow, 1884, p. 35 (p. 87). Schmidt, 1888, pl. 130, fig. 25 [no name].

"Stephanopyxis appendiculata var.?" *in* Schmidt, 1888, pl. 130, fig. 34,

Geologic range. Late Miocene to late Pliocene.

Stephanopyxis turris var. **polaris** Grunow.

Stephanopyxis turris var. *polaris* Grunow, 1884, p. 37 (p. 89), pl. 5 (pl. E), figs. 19, 23, 25. Hustedt, 1928, p. 306, fig. 144. Schmidt, 1878, pl. 58, fig. 9.

Geologic range. Early Pliocene.

Ecology. The typical species is a pelagic form, frequent in temperate seas and rare in polar waters, according to Hendey (1937, p. 237).

Remarks. The present identification is based upon the illustration in Schmidt's Atlas. This species, when observed under a proper adjustment of the microscope, so the valve is properly in focus, compares favorably with the diatom on pl. 58, fig. 9 of Schmidt, 1878.

Stephanopyxis appendiculata Ehrenberg.

(Figures 12, 13.)

Pyxidicula appendiculata Ehrenberg, 1844, pp. 85, 264.

Stephanopyxis appendiculata Ehrenberg, 1854, pl. 18, fig. 4. Mann, 1907, pp. 244, 245.

Coscinodiscus antiqua Pantocsek, Reinhold, 1937, p. 114, pl. 15, fig. 13.

Geologic range. Late Miocene.

Remarks. This species is distinguished by its conical valve, coarse areolae, radially arranged in a trilinear pattern and by the narrow border. The small spines at the crest of the valve can best be seen in girdle view.

Subfamily Coscinodiscoideae Schütt, 1896 [10, 11]

Genus **Coscinodiscus** Ehrenberg, 1838

Coscinodiscus argus Ehrenberg.

Coscinodiscus argus Ehrenberg, 1838, p. 129. Hustedt, 1928, p. 422, fig. 226. Lohman, 1941, p. 70, pl. 13, figs. 1, 3.
Coscinodiscus heteroporus Ehrenberg, 1844, p. 265 [1845].
Coscinodiscus woodwardii Schmidt, 1878, p. 61, figs. 2, 3.

Figure 1. *Melosira clavigera* Grunow. Hypotype no. 3121 (CAS), from locality 866 (CAS), Monterey, California. Diameter 0.0672 mm.

Figure 2. *Melosira clavigera* Grunow. Hypotype no. 3121a (CAS), from locality 866 (CAS), Monterey, California. Diameter 0.0872 mm.

Figure 3. *Hyalodiscus valens* Schmidt. Hypotype no. 3897 (CAS), from locality 1277 (CAS), Monterey, California. Diameter 0.1695 mm.

Figure 4. *Endictya* new species. Hypotype no. 3898 (CAS), locality 866 (CAS), Monterey, California. Diameter 0.0910 mm.

Figure 5. *Endictya oceanica* Ehrenberg. Hypotype no. 3899 (CAS), from locality 1277 (CAS), Monterey, California. Diameter 0.1020 mm.

Figure 6. *Endictya oceanica* Ehrenberg. Hypotype no. 3900 (CAS), from locality 1277 (CAS), Monterey, California.

Figure 7. *Endictya oceanica* Ehrenberg. Hypotype no. 3901 (CAS), from locality 1277 (CAS), Monterey, California. Diameter 0.1100 mm.

Figure 8. *Stephanopyxis antiqua* Pantocsek. Hypotype no. 3902 (CAS), from locality 27295-155 (CAS), Harris grade, Purisima Hills, Santa Barbara County, California. Diameter 0.0190 mm.

Figure 9. *Stephanopyxis lineata* Ehrenberg. Hypotype no. 3903 (CAS), from locality 866 (CAS), Monterey, California. Diameter 0.1102 mm.

Figure 10. *Stephanopyxis lineata* Ehrenberg. Hypotype no. 3904 (CAS), from locality 866 (CAS), Monterey, California. Diameter 0.1270 mm.

Figure 11. *Stephanopyxis lineata* Ehrenberg. Hypotype no. 3905 (CAS), from locality 866 (CAS), Monterey, California. Diameter 0.1070 mm.

Figure 12. *Stephanopyxis appendiculata* Ehrenberg. Hypotype no. 3906 (CAS), from locality 866 (CAS), Monterey, California. Diameter 0.0820 mm.

Figure 13. *Stephanopyxis appendiculata* Ehrenberg. Hypotype no. 3907 (CAS), from locality 866 (CAS), Monterey, California. Diameter 0.0770 mm.

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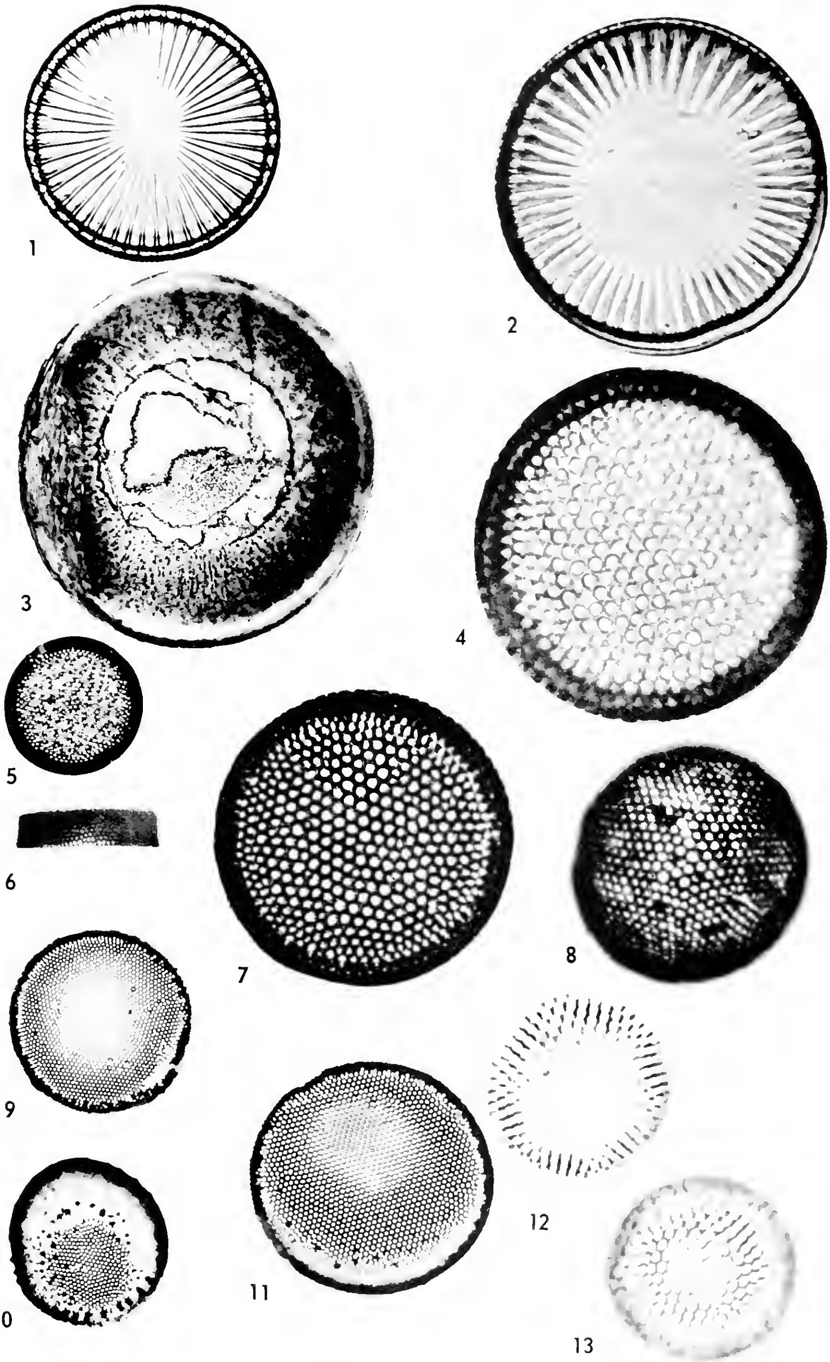
[10] Schütt, 1896, pp. 55, 64, as a subtribe Coscinodiscinae.

[11] Kolbe, 1927, pp. 29, 31, new status and change of spelling.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Geologic range. Late Eocene to Recent.

Ecology. This species lives in warm marine water in the neritic zone, according to Lohman (1941).

Kolbe (1954, p. 28) adds confirmation to Hustedt's assumption that *C. argus* Ehrenberg is a littoral species.

Remarks. This species is distinguished from *C. radiatus* Ehrenberg in having its areolae increase in diameter toward the border; from *C. obscurus* Schmidt in lacking interstitial meshes.

Coscinodiscus antiquus (Grunow) Rattray.

(Figure 23.)

Coscinodiscus (exentricus, var.?) *antiquus* Grunow, 1884, p. 84, pl. iv (D), fig. 24.
Coscinodiscus antiquus (Grunow) Rattray, 1889, p. 461 (13).

Geologic range. Late Miocene to Recent.

Remarks. This species differs from the typical *Coscinodiscus excentricus* in possessing coarser areolae and a distinct border.

Coscinodiscus asteromphalus Ehrenberg.

(Figures 14-18.)

Coscinodiscus asteromphalus Ehrenberg, 1844, p. 77 [1845]. Ehrenberg, 1854, pl. 18, fig. 45; pl. 33, group 15, fig. 7. Schmidt, 1878, pl. 63, fig. 12; 1888, pl. 113, figs. 22, 23.

Geologic range. Late Miocene to Recent.

Ecology. Hendey (1937, p. 244) describes this species as "a neritic diatom, favouring a fairly high salinity." He also states that it "was observed only in material from the Pacific Ocean."

"A pelagic plankton species with a world wide distribution," according to Hendey (1964, p. 78).

Coscinodiscus asteromphalus var. **omphalantha** (Ehrenberg) Grunow.

(Figure 19.)

Coscinodiscus omphalanthus, Ehrenberg, 1844, p. 266.
Coscinodiscus asteromphalus var. *omphalantha* (Ehrenberg) Grunow, 1884, p. 78. Rattray, 1890, p. 549 (101). Lohman, 1938, pl. 20, fig. 2.

Geologic range. Late Miocene to late Pliocene.

Coscinodiscus concavus Gregory.

(Figure 20.)

Coscinodiscus concavus Gregory, 1857, p. 500, pl. 10, fig. 47. Schmidt, 1878, pl. 62, fig. 8.

Geologic range. Late Miocene.

Remarks. Coarse areolae, 2½ to 3 in 0.01 mm. Border distinct.

Coscinodiscus confusus Rattray.

(Figure 21.)

Coscinodiscus confusus Rattray, 1890, p. 451 (p. 3). Schmidt, 1877, pl. 64, fig. 15 [no name].

Geologic range. Late Miocene.

Ecology. This species has been reported previously only from Campeachy Bay.

Coscinodiscus curvatulus Grunow.

Coscinodiscus curvatulus Grunow, *in* Schmidt, 1878, pl. 57, fig. 33. Rattray, 1890, p. 486. Hustedt, 1928, p. 406, fig. 214. Lohman, 1941, p. 74, pl. 15, fig. 8.

Geologic range. Late Miocene to Recent.

Ecology. According to Hendey (1937, p. 252) this oceanic species is widely distributed in the temperate seas. Later Hendey (1964, p. 81) stated that this is 'A neritic boreal species."

Lohman (1941, p. 74) states that this oceanic planktonic species occurs more abundantly in cold northern waters, but according to Lebour (1930, p. 46), this is a neritic species.

Coscinodiscus curvatulus var. **minor** (Ehrenberg) Grunow.

(Figure 22.)

Coscinodiscus minor Ehrenberg, 1838, p. 129, pl. 12e [1840].
Coscinodiscus curvatulus var. *minor* (Ehrenberg) Grunow, 1884, p. 83, pl. 4(d), figs. 8-10. Rattray, 1890, p. 487. Hustedt, 1928, p. 409, fig. 217. Lohman, 1941, p. 75, pl. 16, fig. 3.

Geologic range. Late Miocene.

Ecology. Typically found pelagic in all seas, usually with *C. excentricus* and usually more abundant in colder waters, according to Lohman (1941, p. 75).

Remarks. The curved fascicles immediately distinguish this variety of *C. curvatulus* from the typical form.

Coscinodiscus excentricus Ehrenberg.

Coscinodiscus eccentricus Ehrenberg, 1838, p. 146 [1841]. Ehrenberg, 1841, pp. 322, 323, 371, pl. 3, gr. 3, fig. 5. Smith, 1853, p. 23, pl. 3, figs. 38, 38´, 38b, 38d.

Coscinodiscus excentricus (Ehrenberg) Schmidt, 1886, pl. 58, figs. 46-49. Van Heurck, 1881, pl. 130, figs. 4, 7, 8. Rattray, 1890, p. 461 (p. 13). Mann, 1907, p. 251. Hanna, 1927, p. 111, pl. 17, fig. 8. Hustedt, 1928, p. 388, fig. 201. Lohman, 1938, p. 82, pl. 20, fig. 5; pl. 21, fig. 5. Lohman, 1941, p. 67, pl. 12, fig. 7; pl. 13, fig. 8.

Coscinodiscus lineatus Ehrenberg, Hanna, 1932, pl. 8, fig. 3.

Geologic range. Oligocene to Recent.

Ecology. Hustedt (1928, p. 390) states that this species is "Im ozeanischen Plankton der meisten Meere verbreitet und häufig. Findet sich gewöhnlich auch in allen Flussmündungen."

Cupp (1943) cites *C. excentricus* Ehrenberg as being widely distributed, oceanic, often near the coast, but never abundant off California. Hendey (1964, p. 81) reported that this is one of the most common and widespread diatoms in the neritic plankton, with a world-wide distribution.

Remarks. The original description of *C. excentricus* Ehrenberg, appeared in 1839 (p. 146 [1841]). He did not use the present day spelling of the species name *C. excentricus* but rather used the spelling *C. eccentricus*. This was again followed by Ehrenberg in 1841 and 1854; by Kützing (1844); and by W. Smith (1853). The writer has not been able to find any discussion concerning the reason for the change in spelling of the species name.

Figure 14. *Coscinodiscus asteromphalus* Ehrenberg. Hypotype no. 3909 (CAS), from locality 866 (CAS), Monterey, California. Diameter 0.1741 mm.

Figure 15. *Coscinodiscus asteromphalus* Ehrenberg. Hypotype no. 3910 (CAS), from locality 27295-102 (CAS), Harris grade, Purisima Hills, Santa Barbara County, California. Diameter 0.3240 mm.

Figure 16. *Coscinodiscus asteromphalus* Ehrenberg. Hypotype no. 3911 (CAS), from locality 27295-155 (CAS), Harris grade, Purisima Hills, Santa Barbara County, California. Diameter 0.2312 mm.

Figure 17. *Coscinodiscus asteromphalus* Ehrenberg. Hypotype no. 3912 (CAS), from locality 27295-102 (CAS), Harris grade, Purisima Hills, Santa Barbara County, California. Diameter 0.2248 mm.

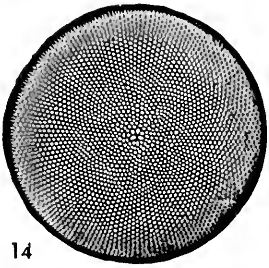
Figure 18. *Coscinodiscus asteromphalus* Ehrenberg. Hypotype no. 3913 (CAS), from locality 27295-155 (CAS), Harris grade, Purisima Hills, Santa Barbara County, California. Diameter 0.3795 mm.

Figure 19. *Coscinodiscus asteromphalus* var. *omphalantha* (Ehrenberg) Grunow. Hypotype no. 3914 (CAS), from locality 866 (CAS), Monterey, California. Diameter 0.1740 mm.

Figure 20. *Coscinodiscus concavus* Gregory. Hypotype no. 3915 (CAS), from locality 866 (CAS), Monterey, California. Diameter 0.0650 mm.

Figure 21. *Coscinodiscus confusus* Rattray. Hypotype no. 3916 (CAS), from locality 866 (CAS), Monterey, California. Diameter 0.0820 mm.

Figure 22. *Coscinodiscus curvatulus* var. *minor* (Ehrenberg) Grunow. Hypotype no. 3917 (CAS), from locality 866 (CAS), Monterey, California. Diameter 0.0420 mm.



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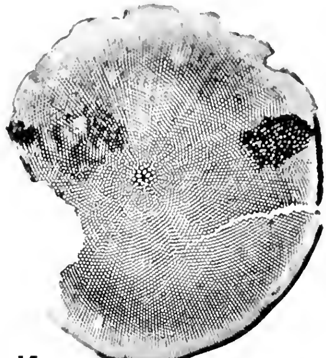

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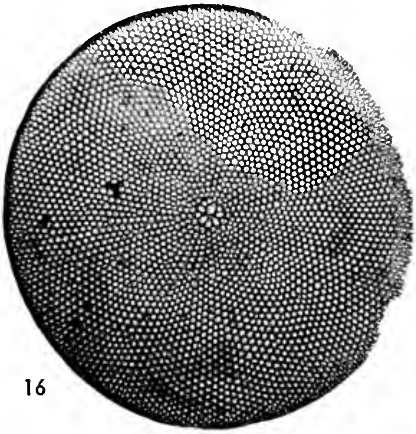

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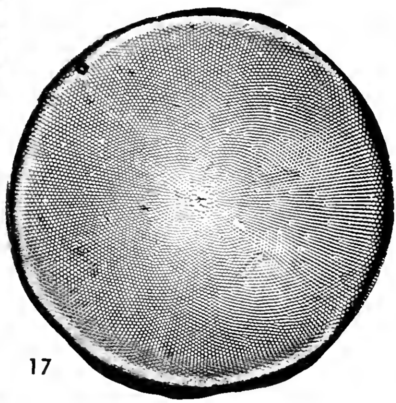

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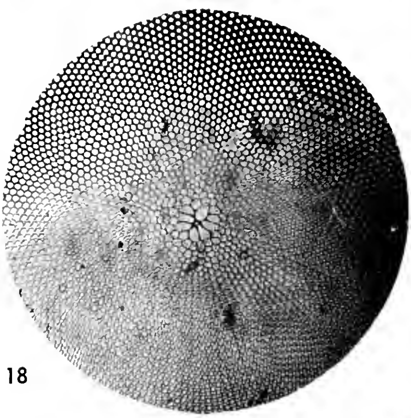

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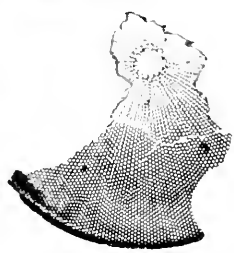

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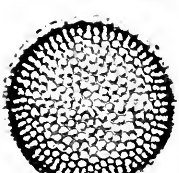

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All the valves of this species do not have the same convexity, some range from flat to moderately convex.

The forms with the same areolation pattern, but without a border of any kind, have been placed with *Planktoniella sol* (Wallich) Schütt.

Hustedt and Lohman and others have put *C. labyrinthus* Roper in synonymy with *C. excentricus* Ehrenberg. The writer, however, feels that this species may be a variety of *C. excentricus* or even a different species entirely based on Roper's original description and illustrations (1858, p. 21). He states, "but the arrangement of the cellules is so different from any yet figured, that it may fairly be entitled to rank as a new species. It has somewhat of the aspect, under low power, of a finely marked specimen of *C. excentricus*, but differs in the absence of a spinous margin, and in the peculiar arrangement of the cellules, which have the appearance of whorls or coils of dots as shown in figure 2b. The surface of the valve is thus divided into large and irregularly shaped hexagonal spaces without any clearly defined margin."

Coscinodiscus gigas var. **diorama** (Schmidt) Grunow.

(Figure 25.)

Coscinodiscus diorama Schmidt, 1878, pl. 64, fig. 2. Cleve-Euler, 1951, p. 64, fig. 93.

Coscinodiscus gigas var. *diorama* (Schmidt) Grunow, 1884, p. 76. Rattray, 1890, p. 94.

Geologic range. Late Miocene to Recent.

Ecology. According to Cleve-Euler (1951, p. 64) "Mar. In südlichen Meeren. *Foss.* u. tertiar mehrere Fragmente in Sudlappl.," and "Eine verwandte Riesenart ist *Cosc. gigas* E. aus warmeren Meeren, der aber gegen das Zentrum ein zusammenhangendes Areolennetz hat."

The species *C. gigas* Ehrenberg is oceanic, widely distributed in tropical and subtropical seas, probably stenohaline, and has its optimum in water of high salinity.

Coscinodiscus kurzii Grunow.

Coscinodiscus kurzii Grunow, *in* Schmidt, 1888, pl. 113, fig. 17. Rattray, 1890, p. 564. Lohman, 1938, pl. 20, fig. 1; pl. 21, fig. 2. Lohman, 1941, p. 71, pl. 13, fig. 5.

Geologic range. Pliocene to Pleistocene.

Coscinodiscus kützingi Schmidt.

Coscinodiscus kützingi Schmidt, 1878, pl. 57, figs. 17, 18. Rattray, 1890, p. 481. Hustedt, 1928, p. 398, fig. 209. Lohman, 1949, p. 161.

Geologic range. Middle Pliocene to Recent.

Ecology. According to Hendey (1964, p. 81), this is a common neritic species.

Remarks. This species is characterized by submarginal apiculi, narrow striated border and marginal zone of fine areolae arranged in quincunx. According to Hendey (1964, p. 81), this is a common neritic species.

Coscinodiscus lewisianus Greville.

(Figure 26.)

Coscinodiscus lewisianus Greville, 1866, p. 78,79, pl. 8, figs. 8-10. Schmidt, 1886, pl. 66, fig. 121. Pantocsek, 1886, p. 73, pl. 25, fig. 232. Rattray, 1890, p. 598 (p. 150). Reinhold, 1937, p. 96, pl. 8, fig. 11. Lohman, 1948, p. 161, pl. 6, fig. 7. Kolbe, 1954, p. 30,31, pl. 2, fig. 21.

Geologic range. Late Miocene.

Remarks. This species is easily recognized by its characteristic areolation and shape. It has not been found in rocks either older or younger than the Miocene, according to Lohman (1948, p. 161).

Coscinodiscus lineatus Ehrenberg.

Coscinodiscus lineatus Ehrenberg, 1838, p. 129; 1841, p. 371, pl. 1, gr. 3, fig. 20. Hanna and Grant, 1926, p. 139, pl. 15, fig. 6; pl. 3, gr. 7, figs. 7, 8. Hustedt, 1928, p. 392, fig. 204. Hanna, 1934, p. 355, pl. 48, fig. 9. Reinhold, 1937, p. 97, pl. 11, fig. 7. Lohman, 1941, p. 68, pl. 12, fig. 10. Cupp, 1943, p. 53, figs. 15a, b, c. Long, Fuge, and Smith, 1946, p. 103, pl. 16, fig. 5.

Geologic range. Late Cretaceous to Recent.

Ecology. A truly neritic diatom, in temperate and subtropical seas according to Hendey (1937, p. 243). "A common and widespread plankton species," as reported by Hendey (1964, p. 76).

This species has been reported to be chiefly oceanic but also frequently neritic in all oceans by Cupp (1943).

Kanaya (1959) suggests that "the high frequency of this species in a diatom thanatocoenosis indicates that its accumulation has taken place under the prevalence of tropical or subtropical waters, rather than of temperate or cold ones."

Coscinodiscus lineatus var. **convexus** (Ehrenberg), new combination.

Coscinodiscus lineatus Ehrenberg, Hanna, 1932, p. 180, pl. 8, figs. 1, 2. Schmidt, pl. 114, fig. 13.

Geologic range. Middle Miocene to middle Pliocene.

Remarks. This variety can be easily recognized by the linear pattern of areolae, the coarseness of the areolae, and massiveness of the border.

Coscinodiscus lineatus var. **ellipticus** Kolbe.

Coscinodiscus lineatus var. *ellipticus* Kolbe, 1954, p. 32, pl. 11, fig. 15.

Geologic range. Middle Pliocene.

Remarks. This variety has been reported only from one of the cores taken from the Pacific Ocean.

Coscinodiscus lineatus var. **leptopus** Grunow.

(Figure 24.)

Coscinodiscus lineatus var. *leptopus* Pelletan, 1888, p. 181, fig. 433.
Coscinodiscus leptopus Grunow, *in* Van Heurck, 1881, pl. 131, figs. 5, 6. Rattray, 1890, p. 476 (p. 28). Wolle, 1894, pl. 90, fig. 6. De-Toni, 1894, p. 1219. Peragallo, 1904, p. 427, pl. 116, fig. 8. Boyer, 1927, p. 46.
Coscinodiscus lineatus Schmidt, 1886, pl. 59, fig. 26.

Geologic range. Late Miocene to Recent.

Remarks. This variety is distinguished by having the areolae in straight rows, or nearly so, that become granular in a marginal zone, and by one large apiculus near the border.

Coscinodiscus marginatus Ehrenberg.

(Figures 27, 28.)

Coscinodiscus marginatus Ehrenberg, 1841, p. 12 [usually erroneously cited as pp. 142, 421, 241, etc.] [1843] Ehrenberg, 1854, pl. 18, fig. 44; pl. 33, gr. 12, fig. 13, pl. 38B, gr. 22, fig. 8. Schmidt, 1878, pl. 62, figs. 1, 2 ("Monterey"), 3, 4, 9 ("Monterey"), 11, 12. Rattray, 1890, p. 509 (p. 61). Hustedt, 1928, p. 416, fig. 223. Lohman, 1941, p. 71, pl. 14, figs. 1?, 6.
Not *Coscinodiscus marginatus* Ehrenberg of Hanna and Grant, 1926, p. 139, pl. 15, fig. 7.
Coscinodiscus limbatus Ehrenberg, 1840, p. 206 [1841].
Coscinodiscus fimbriatus-limbatus Ehrenberg, 1854, pl. 19, fig. 4.
Coscinodiscus radiatus forma *heterosticta* Grunow, *in* Pantocsek, 1886, p. 70, pl. 20, fig. 184.
Coscinodiscus robustus Schmidt, 1878, pl. 62, fig. 5.
Coscinodiscus subconcavus forma *major* Schmidt, 1878, pl. 62, fig. 7("Monterey").

Geologic range. Late Cretaceous to Recent.

Ecology. This species is reported to live in all warm to temperate seas by Lohman (1941) and also in boreal to cold waters by Jouse (1957). It is interesting to note that Kolbe did not find this species in the equatorial deep-sea cores of the Atlantic (1956) or the Indian Oceans (1957), but did record it occurring frequently in the cores from the Equatorial Pacific (1954).

Common in all temperate seas, probably a bottom form, and meroplanktonic, according to Hendey (1937, p. 248). Also as stated by Hendey (1964, p. 78), "An oceanic species frequent in North Atlantic water, North Sea."

REMARKS. This species is characterized by broad, massive margins (borders), somewhat obscure radial areolae slightly diminishing toward the border, and by the great convexity of the valve.

Coscinodiscus marginatus has been frequently confused with *Endictya robustus* (Greville), but the latter species has valves that are cup-shaped, not convex disks. The marginal bands turn vertically downward from the disk and are ornamented, like the face of the valve, with a coarse network.

Coscinodiscus monicae Grunow.

(Figure 29.)

Coscinodiscus janischii var. ?*monicae* GRUNOW, 1884, p. 76.
Coscinodiscus monicae Grunow, RATTRAY, 1890, p. 563 (p. 115. DE-TONI, 1894, p. 1278. SCHMIDT, 1877, pl. 63, fig. 10 [unnamed, but named in Fricke's Index, 1902]. HANNA, 1932, p. 182, pl. 9, fig. 2. LOHMAN, 1948, p. 162, pl. 7, fig. 6.

GEOLOGIC RANGE. Middle Miocene to late Miocene.

REMARKS. This species has no secondary markings, the areolae seem to vary considerably, and the central large areolae may or may not be in contact with one another.

Coscinodiscus nitidus Gregory

(Figures 30, 31.)

Coscinodiscus nitidus GREGORY, 1857, p. 27, pl. 1, fig. 45. RATTRAY, 1890, p. 478 (p. 30). HANNA AND GRANT, 1926, p. 140, pl. 15, fig. 9. HUSTEDT, 1928, p. 414, fig. 221b.

GEOLOGIC RANGE. Late Cretaceous to Recent.

ECOLOGY. The species is meroplanktonic, probably a bottom form, according to Hendey (1937, p. 242).

REMARKS. Although Hustedt (1928, p. 413) placed *Coscinodiscus nitidulus* Grunow in synonymy with the above species, I believe that there is ample justification for making a distinction between the two species.

Coscinodiscus obscurus Schmidt.

(Figure 32.)

Coscinodiscus obscurus SCHMIDT, 1878, p. 61, fig. 16. RATTRAY, 1890, p. 513. HUSTEDT, 1928, p. 418, fig. 224.

GEOLOGIC RANGE. Late Cretaceous to Recent.

ECOLOGY. This species is "Pelagisch im Nordatlantischen Ozean!" according to Hustedt (1928, p. 420). Hendey (1957, p. 37), however, states that it "is probably a member of the oceanic plankton."

Coscinodiscus oculus-iridis var. **borealis** (Bailey) Cleve.

(Figure 33.)

Coscinodiscus borealis BAILEY, 1856, p. 3. SCHMIDT, 1878, p. 63, fig. 11. RATTRAY, 1890, p. 558.

Coscinodiscus oculus-iridis var. *borealis* (Bailey) CLEVE, 1883, p. 488. HUSTEDT, 1928, p. 456, fig. 253.

GEOLOGIC RANGE. Late Miocene to Recent.

ECOLOGY. According to Lohman (1941, p. 73) this species is definitely a cold-water form.

REMARKS. This variety is characterized by large areolae and by a raised area which is present about 1/5 of the radius from the margin.

Coscinodiscus oculus-iridis Ehrenberg.

(Figures 34, 35.)

Coscinodiscus oculus-iridis EHRENBERG, 1839, p. 147 [1841]. EHRENBERG, 1854, pl. 18, fig. 42; pl. 19, fig. 2. SCHMIDT, 1878, pl. 63, figs. 6, 7, 9; 1888, pl. 113, figs. 1, 3, 5, 20. RATTRAY, 1890, p. 559. HANNA AND GRANT, 1926, p. 141, pl. 15, fig. 11. HUSTEDT, 1928, p. 454, fig. 252.

GEOLOGIC RANGE. Late Eocene to Recent.

ECOLOGY. Hendey (1937, p. 249) states that this is "probably an oceanic species, but in the material examined it was always found as a mero-

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FIGURE 23. *Coscinodiscus antiquus* Grunow. Hypotype no. 3918 (CAS), from locality 27295-7 (CAS), Harris grade, Purisima Hills, Santa Barbara County, California. Diameter 0.0348 mm.

FIGURE 24. *Coscinodiscus lineatus* var. *leptopus* Grunow. Hypotype no. 3919 (CAS), from locality 866 (CAS), Monterey, California. Diameter 0.1840 mm.

FIGURE 25. *Coscinodiscus gigas* var. *diorama* (Schmidt) Grunow. Hypotype no. 3920 (CAS), from locality 866 (CAS), Monterey, California. Diameter 0.0220 mm.

FIGURE 26. *Coscinodiscus lewisianus* Greville. Hypotype no. 3921 (CAS), from locality 866 (CAS), Monterey, California. Length 0.0450 mm., breadth 0.0250 mm.

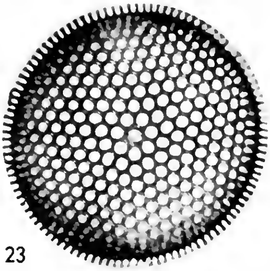
FIGURE 27. *Coscinodiscus marginatus* Ehrenberg. Hypotype no. 3922 (CAS), from locality 27295-155 (CAS), Harris grade, Purisima Hills, Santa Barbara County, California. Diameter 0.1708 mm.

FIGURE 28. *Coscinodiscus marginatus* Ehrenberg. Hypotype no. 3923 (CAS), from locality 27295-155 (CAS), Harris grade, Purisima Hills, Santa Barbara County, California. Diameter 0.1780 mm.

FIGURE 29. *Coscinodiscus monicae* Grunow. Hypotype no. 3924 (CAS), from locality 866 (CAS), Monterey, California. Diameter 0.2040 mm.

FIGURE 30. *Coscinodiscus nitidus* Gregory. Hypotype no. 3925 (CAS), from locality 866 (CAS), Monterey, California. Diameter 0.0510 mm.

FIGURE 31. *Coscinodiscus nitidus* Gregory. Hypotype no. 3926 (CAS), from locality 866 (CAS) Monterey, California. Diameter 0.1085 mm.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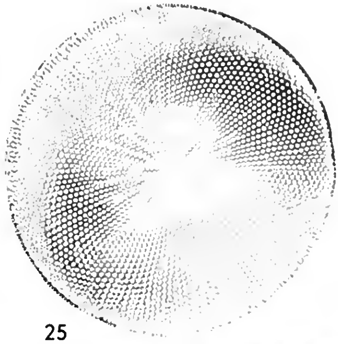
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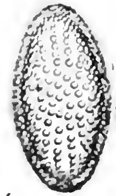
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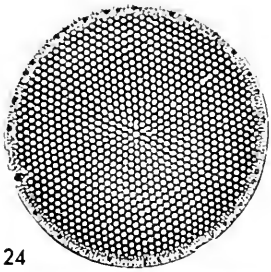
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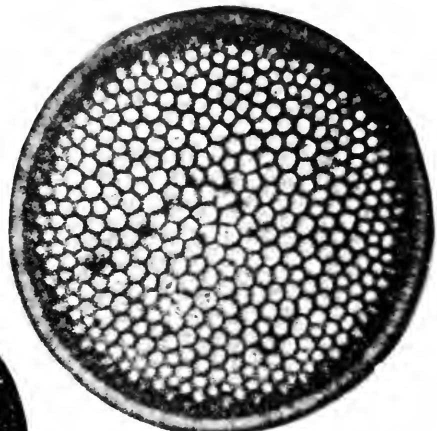
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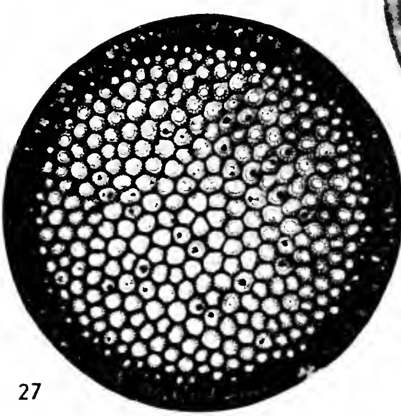
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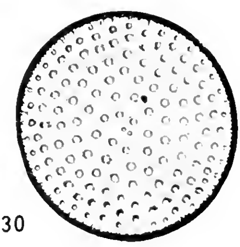
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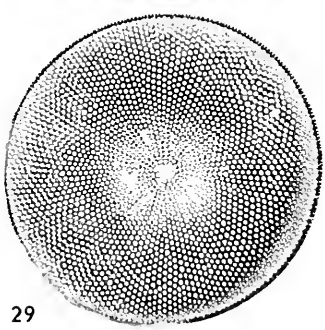
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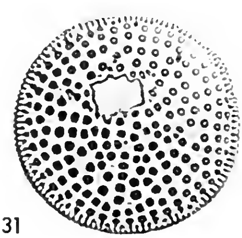
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planktonic form." Also, according to Hendey (1964, p. 78), "it is an oceanic pelagic species found all over the world."

Remarks. Distinguished from *Coscinodiscus pacificus* Rattray in having a more distinct rosette, and marginal apiculi. The latter can be distinguished by the increase in size of the areolae toward the central portion of the valve surface.

Coscinodiscus pacificus Rattray.

(Figures 36, 37.)

Coscinodiscus oculus iridis var. *?pacifica* Grunow, 1884, p. 77.
Coscinodiscus pacificus Rattray, 1890, p. 563 [name for pl. 60, fig. 13, of Schmidt's Atlas, 1877]. Hanna and Grant, 1926, p. 142, pl. 16, fig. 1. Hanna, 1932 p. 184, pl. 10, fig. 1.

Geologic range. Middle Miocene to Recent.

Coscinodiscus perforatus Ehrenberg.

(Figure 38.)

Coscinodiscus perforatus Ehrenberg, 1844, p. 78; 1854, pl. 18, fig. 46. Schmidt, 1878, pl. 64, figs. 12-14. Rattray, 1890, p. 571 (p. 123). Hustedt, 1928, p. 445-447, fig. 245. Lohman, 1948, p. 163.

Geologic range. Middle Miocene to Recent.

Ecology. According to Hustedt (1928, p. 448), it occurs "In allen europäischen Meeren im Plankton verbreitet, doch meist vereinzelt." Hustedt (1955, p. 6) also stated that this species is "Rather frequent, especially on the mud from piles in the harbor." According to Hendey (1964, p. 78) this species is frequently present in the plankton of the North Sea.

Remarks. The areolae are smaller near the central space and near the margin.

Coscinodiscus perforatus var. **cellulosa** Grunow.

Coscinodiscus perforatus var. *cellulosa* Grunow, 1884, p. 75. Schmidt, 1888, pl. 114, fig. 5. Rattray, 1890, p. 572. Hustedt, 1928, p. 447, fig. 246. Lohman, 1948. pp. 163, 164, pl. 8, fig. 3.

Geologic range. Late Miocene to Recent.

Ecology. It is usually found in the same environment with the typical species.

Remarks. This variety is characterized by small punctae at the origin of the shorter radial rows of the areolae. The areolae are constant from 9/10 to 1/10 of the radius, becoming smaller at the border.

It is usually found in the same environment with the typical species.

Coscinodiscus radiatus Ehrenberg.

(Figure 39.)

Coscinodiscus radiatus Ehrenberg, 1839, p. 148, pl. 3, figs. 1 a-c [1841]. Schmidt, 1886, pl. 60, figs. 5, 6, 9, 10; pl. 61, fig. 13 (unnamed); pl. 65, fig. 8 (unnamed). Rattray, 1890, p. 514 (p. 66). De-Toni, 1894, p. 1244. Hanna and Grant, 1926, p. 142, pl. 15, fig. 12. Hanna, 1927, p. 112, pl. 18, fig. 2. Hustedt, 1928, p. 420, fig. 225. Lohman, 1941, p. 73, pl. 15, figs. 7, 8. Cupp, 1943, p. 56, fig. 20; pl. 1, fig. 4.

Geologic range. Late Cretaceous to Recent.

Ecology. Lohman (1941, p. 57) states that this species is confined to "warm to temperate seas," and it is "marine, neritic-oceanic, warm". Recorded by Cupp (1943, p. 56) as "Oceanic and neritic. Ubiquitous. Never in large numbers in California, but not uncommon."

Capable of living and reproducing in coastal waters, according to Lebour (1930, p. 39).

Remarks. Valves fairly flat. Coarse areolae, 2-4 in 0.01 mm., decreasing very slightly in size to the border area where they increase in number to 6-7 in 0.01 mm. No interstitial meshes. No central rosette or central area developed. Areolation irregular. Margin narrow with radial striae.

Coscinodiscus robustus (Greville).

(Figure 40, 41.)

Coscinodiscus robustus Greville, 1886, p. 3, pl. 1, fig. 8. Truan and Witt, 1888, p. 14, pl. 3, fig. 5. Rattray, 1890, p. 511 (p. 53). Boyer, 1927, p. 54.

Not *Coscinodiscus robustus* Greville *in* Schmidt, 1877, pl. 62, figs. 16, 17. Reinhold, 1937, p. 101, pl. 9, fig. 5.

Coscinodiscus subvelatus Grunow, *in* Schmidt, 1881, pl. 65, fig. 9.

Not *Endictya robusta* (Greville) Hanna and Grant *in* Lohman, 1941, p. 66, pl. 12, fig. 4.

Not *Endictya robusta* (Greville) Hanna and Grant, 1926, p. 144, pl.16, figs. 2, 3.

Geologic range. Late Miocene to Recent.

Remarks. Central space absent. Areolation pattern variable. Areolae coarse. Three areolae in 0.01 mm. in the central region continuing nearly equal in size to the margin, where they decrease slightly to four areolae in 0.01 mm. However, the cellules appear rounded and become increasingly smaller in appearance toward the margin. Interstitial meshes absent or very rare. Valve surface is convex over the central 4/5 portion of the valve, then the marginal area rises rapidly and depresses rapidly to the finely striated border. (This marginal area is like a small, sharp but rounded hill.)

I have examined many specimens of the referred species and have found them to agree with Greville's original figure. However, to see the fine striae that appears so clearly in his type figure, one must focus very carefully on the border area of forms belonging to this species.

Coscinodiscus robustus var. **herculus** J. Brun.

(Figure 42.)

Coscinodiscus robustus var. *herculus* J. Brun. "Coscinodiscus Herculus *J. Brun* (SUBVELATUS *Grun.* VAR.)", Brun, 1891, p. 22, pl. 21, fig. 5.

Geologic range. Pliocene.

Remarks. Brun states, "Plus grand et plus robuste que le type 65.9 de l'atlas. Il differe aussi sensiblement de la forme 62, 16, 17 dessinée comme var. du *robustus*. Sendai. Yedo. Santa Maria. Rare."

Valves convex, coarse areolae, 2 to 2½ in 0.01 mm., over entire valve surface. Border area about 0.0020 mm. in photomicrograph.

Coscinodiscus robustus var. **incretus** (Schmidt).

(Figure 43.)

Coscinodiscus robustus Greville, Schmidt, 1886, pl. 62, figs. 16, 17. Tempère and agallo, 1890, p. 230.
Coscinodiscus incretus Schmidt, 1888, pl. 139, figs. 1, 1a.

Geologic range. Late Miocene.

Remarks. This variety differs from the typical species in possessing coarse areolae and large chamber openings in the central region, occupying about 2/5 to 1/2 the diameter of the valve. The chamber openings diminish rapidly from the central region to the border zone about 1/5 to 1/4 the diameter, from 2 to 4 in 0.01 mm., and remain about the same size to the wide, fine striated border.

The marginal area including the elevated rim appears as a dark area in photomicrographs, and is about 0.02 mm. wide. The rim, of course, is best seen in a girdle view.

According to Mann (1925, p. 67, 68) "a recent examination of many specimens of *Coscinodiscus robustus* Greville, collected in Monterey Bay, California, the original locality of Greville's type specimen, unmistakably shows that it is not a *Coscinodiscus* but an *Endictya.*" If Mann considered this new species to be Greville's type specimen, then his statement would be true. But this new species has such a broad characteristic rim that I feel confident such an able diatomist as Greville would have seen the elevated rim and could not have seen the delicate, finely striated border that appears in his original type figure. I have placed specimens such as Greville describes with some variation in areolation pattern under *Coscinodiscus robustus* Greville.

Genus **Craspedodiscus** Ehrenberg, 1845

Craspedodiscus rhombicus Grunow.

(Figures 44, 45.)

Craspedodiscus rhombicus GRUNOW, *in* Schmidt, 1878, pl. 66, fig. 13.

GEOLOGIC RANGE. Late Miocene.

Genus **Cyclotella** Kützing, 1834

Cyclotella kelloggi Hanna.

(Figure 46.)

Cyclotella kelloggi HANNA, 1932, p. 185, pl. 10, figs. 2-4.

GEOLOGIC RANGE. Middle Miocene to late Miocene.

Genus **Actinocyclus** Ehrenberg, 1838

Actinocyclus cubitus Hanna and Grant.

(Figures 47, 48.)

Actinocyclus cubitus HANNA AND GRANT, 1926, p. 118, pl. 11, fig. 3.

GEOLOGIC RANGE. Late Miocene.

REMARKS. This species is characterized by rows of areolae that are parallel to those radii which bisect the sectors of the valve.

Actinocyclus octonarius Ehrenberg.

(Figure 49.)

Actinocylus octonarius EHRENBERG, 1838, p. 172. HENDEY, 1937, p. 262. LOHMAN, 1941, p. 77, pl. 16, fig. 4; 1948, p. 167, pl. 8, fig. 8.

Actinocyclus ehrenbergii RALFS *in* Pritchard, 1861, p. 834. RATTRAY, 1890, pp. 171-182. HUSTEDT, Kieselalgen, 1929, pp. 525-528, fig. 299. LOHMAN, 1938, p. 83, pl. 22, fig. 1.

GEOLOGIC RANGE. Middle Miocene to Recent.

ECOLOGY. "A neritic species, having a cosmopolitan distribution; particularly numerous in temperate seas," according to Hendey (1937, p. 262). Brackish-water and tychopelagic occurrences from Scandinavian localities were reported by Cleve-Euler (1952, p. 81). Hendey (1964, p. 83) stated that this species is found "in neritic plankton."

REMARKS. Valve circular, markings granular, areolae are 7-10 in 0.01 mm. radiating in flexuose lines from center, double lines of radiation appear to divide valve into radial compartments due to the interfasciculate rows

I have examined the plesiotypes of Hanna and Grant's *Endictya robusta* Greville and I have found them to represent two different species of *Coscinodiscus*.

Lohman (1941), following Hanna and Grant, places a form (pl. 12, fig.

4), which he compares with Hanna and Grant's (pl. 16, fig. 2) under the genus *Endictya*. I cannot tell whether or not this belongs to *Endictya* without seeing it in girdle view, but I can state that the dark border, so characteristic in photomicrographs of this genus, is not present.

The main problem in the identification of this genus has been the lack of girdle views along with the valve view of the species concerned. When the girdle view is present (see Hustedt, 1928, p. 298, fig. 139), there is no doubt as to whether the species belongs to *Coscinodiscus* or to *Endictya*. having hyaline spaces on each side at the origin of secondary rows. Pseudo-ocellus distinct, submarginal. Under low magnification, most valves produce prismatic colors. Valves range from 0.0580 mm. to 0.0920 mm. in diameter.

The valid name *Actinocyclus octonarius* Ehrenberg is used here in place of the well known but invalid name *Actinocyclus ehrenbergii* Ralfs, following Hendey (1937, pp. 262, 263), and Lohman (1941, p. 77; 1948, p. 167).

In regard to the history of this species, the author would like to add a few comments to help clear up its already complex history. Ehrenberg (1854, Tafel 18, fig. 10) illustrated a figure of *Actinocyclus octonarius* = *A. ehrenbergii* and *Actinoptychus senarius* (Tafel 18, fig. 21). He also illustrated a figure of *Actinoptychus octonarius* (Tafel 18, fig. 22), an *Actinoptychus* with eight compartments.

Actinocyclus octonarius var. **tenellus** (Brébisson) Hendey.

Eupodiscus tenellus Brébisson, 1854, p. 257, pl. 1, fig. 9.
Actinocyclus ehrenbergii var. *tenella* (Brébisson) Hustedt, 1929, p. 530, fig. 302.
Kanaya, 1959, p. 95, pl. 7, figs. 2, 3.

Geologic range. Lower Pliocene.

Figure 32. *Coscinodiscus obscurus* Schmidt. Hypotype no. 3927 (CAS), from locality 27295-7 (CAS), Harris grade, Purisima Hills, Santa Barbara County, California. Diameter 0.1300 mm.

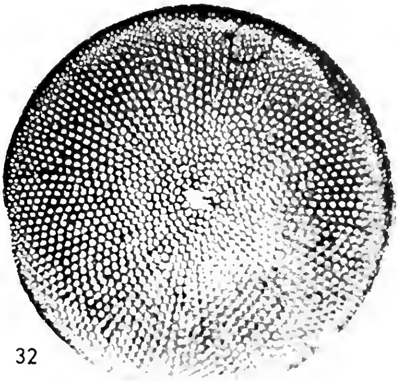
Figure 33. *Coscinodiscus oculus-iridis* var. *borealis* (Bailey). Hypotype no. 3928 (CAS), from locality 27295-155 (CAS), Harris grade, Purisima Hills, Santa Barbara County, California. Diameter 0.2228 mm.

Figure 34. *Coscinodiscus oculus-iridis* Ehrenberg. Hypotype no. 3929 (CAS), from locality 27295-155 (CAS), Harris grade, Purisima Hills, Santa Barbara County, California. Diameter 0.2230 mm.

Figure 35. *Coscinodiscus oculus-iridis* Ehrenberg. Hypotype no. 3930 (CAS), from locality 27295-155 (CAS), Harris grade, Purisima Hills, Santa Barbara County, Diameter 0.2440 mm.

Figure 36. *Coscinodiscus pacificus* Rattray. Hypotype no. 3931 (CAS), from locality 27295-25 (CAS), Harris grade, Purisima Hills, Santa Barbara County, California. Diameter 0.1400 mm.

Figure 37. *Coscinodiscus pacificus* Rattray. Hypotype no. 3931a (CAS), from locality 27295-25 (CAS), Harris grade, Purisima Hills, Santa Barbara County, California. Diameter 0.1146 mm.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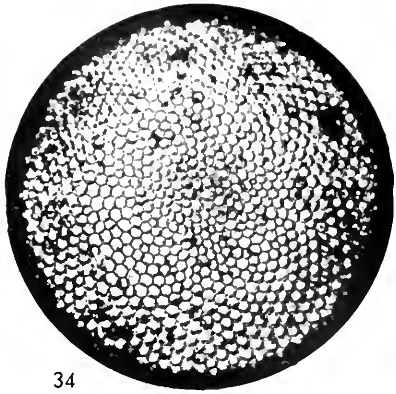
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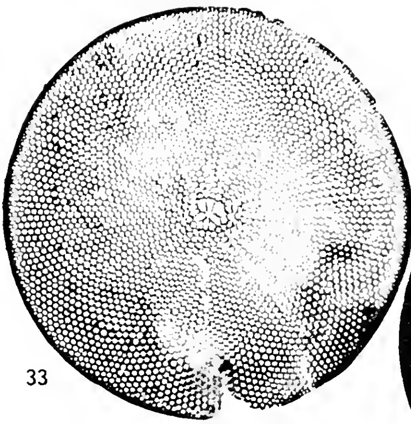
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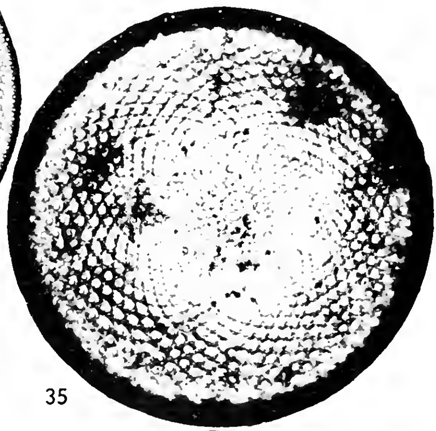
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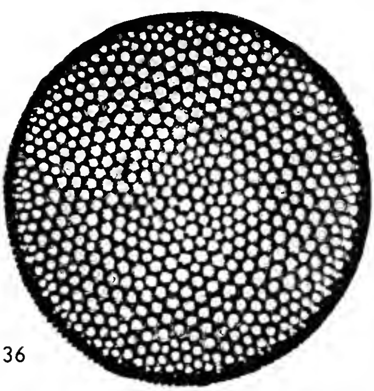
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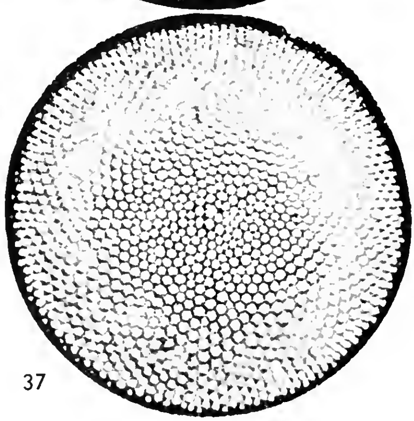
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Ecology. According to Hendey (1964, p. 84) this variety is found in the "neritic plankton on all British coasts."

Remarks. Valve discoid, surface flat from center to submarginal area, then sloping downwards to the border. Valve divided into relatively few (five to eight) sectors (compartments), by radial rays, composed of single dots (areolae). Interfascicular rows of areolae extend parallel to the middle row of each sector. Submarginal zone well developed, with very small areolae. Pseudo-ocellus (pseudo-nodule) submarginal and distinct. Valves range from 0.0490 to 0.0580 mm. in diameter.

Actinocyclus pyrotechnicus Derby.

(Figure 50.)

Actinocyclus pyrotechnicus Derby, *in* Rattray, 1890, p. 144, pl. 11. fig. 15. Hanna and Grant, 1926, p. 119, pl. 11, fig. 4.

Geologic range. Late Miocene.

Family Hemidiscaceae Hendey, 1937 [12]

Subfamily Hemidiscoideae Hendey, 1937 [12]

Genus **Hemidiscus** Wallich, 1860

Hemidiscus cuneiformis Wallich.

(Figure 51.)

Hemidiscus cuneiformis Wallich, 1860, p. 42, pl. 2, figs. 3, 4. Hustedt, 1930, p. 904, figs. 542 b-c. Cupp, 1943, p. 170, fig. 121.

Geologic range. Late Miocene to Recent.

Ecology. This is an oceanic species widely distributed throughout tropical waters, according to Hendey (1937, p. 264).

Figure 38. *Coscinodiscus perforatus* Ehrenberg. Hypotype no. 3932 (CAS), from locality 866 (CAS), Monterey, California. Diameter 0.0830 mm.

Figure 39. *Coscinodiscus radiatus* Ehrenberg. Hypotype no. 3933 (CAS), from locality 866 (CAS), Monterey, California. Diameter 0.1080 mm.

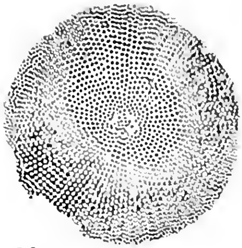
Figure 40. *Coscinodiscus robustus* (Greville). Hypotype no. 3934 (CAS), from locality 1277 (CAS), Monterey, California. Diameter 0.1300 mm.

Figure 41. *Coscinodiscus robustus* (Greville). Hypotype no. 3935 (CAS), from locality 27295-155 (CAS), Harris grade, Purisima Hills, Santa Barbara County, California. Diameter 0.1506 mm.

Figure 42. *Coscinodiscus robustus* var. *herculus* J. Brun. Hypotype no. 3936 (CAS), from locality 27295-155 (CAS), Harris grade, Purisima Hills, Santa Barbara, California. Diameter 0.1332 mm.

Figure 43. *Coscinodiscus robustus* var. *incretus* (Schmidt). Hypotype no. 3937 (CAS), from locality 866 (CAS), Monterey, California. Diameter 0.1190 mm.

12 Hendey, 1937, p. 202.



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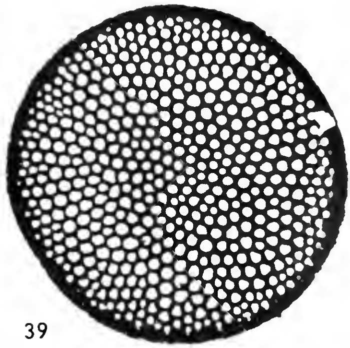

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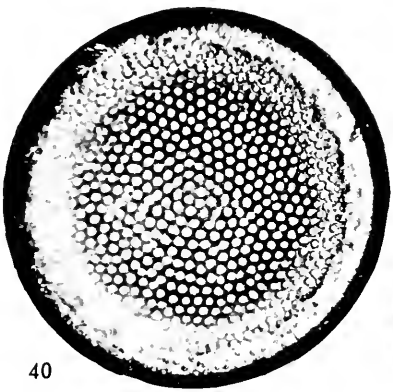

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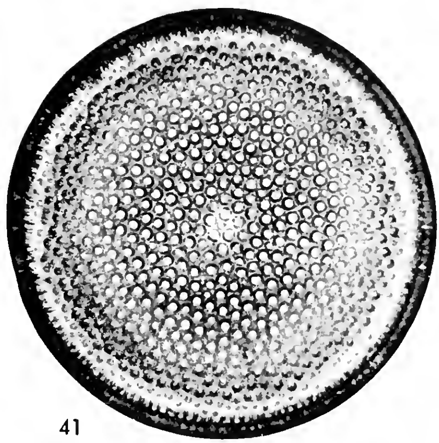

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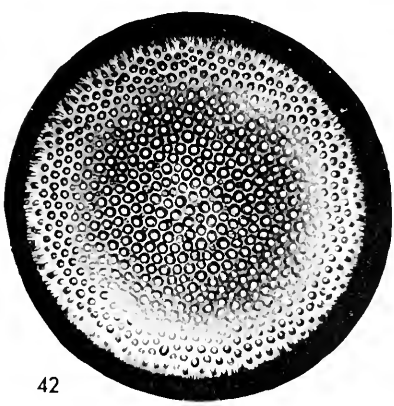

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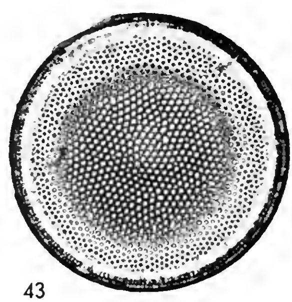

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Family Actinodiscaceae Schütt, 1896 [12a, 12b]
Subfamily Stictodiscoideae Schütt, 1896 [12c, 12d]

Genus **Stictodiscus** Greville, 1861

Stictodiscus buryanus Grunow.

(Figure 52.)

Stictodiscus buryanus Grunow, 1861, p. 40, pl. 4, fig. 1. Hustedt, *in* Schmidt, 1940, pl. 441, fig. 9; pl. 442, fig. 1.

Geologic range. Late Miocene to Pliocene.

Stictodiscus californicus Greville.

(Figures 54, 55.)

Stictodiscus californicus Greville, 1861, p. 79, pl. 10, fig. 1. Hustedt, *in* Schmidt, 1940, pl. 44, figs. 1-9.

Stictodiscus californicus var. *ecostata* Grunow. Schmidt, 1882, pl. 74, fig. 7 (only).

Geologic range. Late Miocene to Pliocene.

Genus **Arachnoidiscus** Bailey from Ehrenberg, 1849

Figure 44. *Craspedodiscus rhombicus* Grunow. Hypotype no. 3938 (CAS), from locality 866 (CAS), Monterey, California. Length 0.0340 mm., breadth 0.0210 mm.

Figure 45. *Craspedodiscus rhombicus* Grunow. Hypotype no. 3939 (CAS), from locality 866 (CAS), Monterey, California. Length 0.0300 mm.

Figure 46. *Cyclotella kelloggi* Hanna. Hypotype no. 3940 (CAS), from locality 866 (CAS), Monterey, California. Diameter 0.0370 mm.

Figure 47. *Actinocyclus cubitus* Hanna and Grant. Hypotype no. 3941 (CAS), from locality 866 (CAS), Monterey, California. Diameter 0.0310 mm.

Figure 48. *Actinocyclus cubitus* Hanna and Grant. Hypotype no. 3942 (CAS), from locality 866 (CAS), Monterey, California. Diameter 0.0470 mm.

Figure 49. *Actinocyclus octonarius* Ehrenberg. Hypotype no. 3943 (CAS), from locality 27295-25 (CAS), Harris grade, Purisima Hills, Santa Barbara County, California. Diameter 0.0982 mm.

Figure 50. *Actinocyclus pyrotechnicus* Derby. Hypotype no. 3944 (CAS), from locality 866 (CAS), Monterey, California. Diameter 0.0950 mm.

Figure 51. *Hemidiscus cuneiformis* Wallich. Hypotype no. 3945 (CAS), from locality 27295-94 (CAS), Harris grade, Purisima Hills, Santa Barbara County, California. Diameter 0.1220 mm.

Figure 52. *Stictodiscus buryanus* Grunow. Hypotype no. 3122 (CAS), from locality 866 (CAS), Monterey, California. Diameter 0.1090 mm.

12a Schütt, 1896, p. 55, as tribe Actinodisceae.

12b Hendey, 1937, p. 202, new status and change in spelling.

12c Schütt, 1896, p. 55, as subtribe Stictodiscinae.

12d Hustedt, 1930, p. 56, new status and change in spelling.


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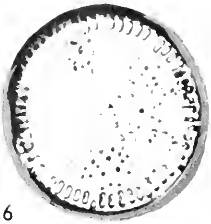
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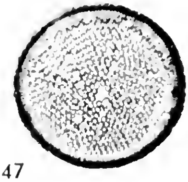
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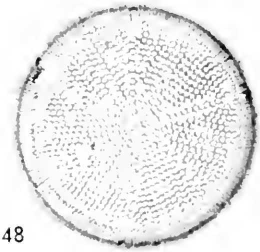
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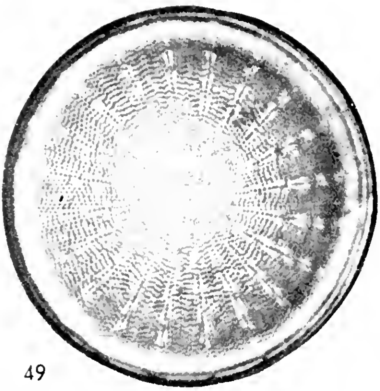
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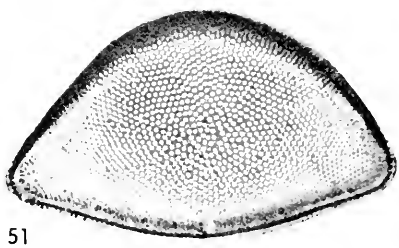
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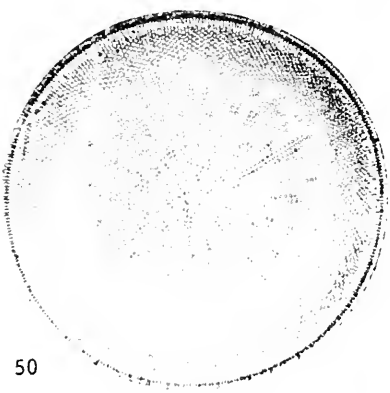
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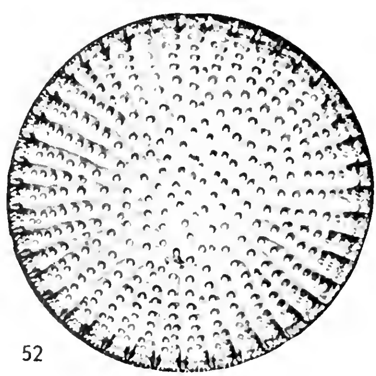
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Arachnoidiscus decorus Brown

(Figure 53.)

Arachnoidiscus decorus Brown, 1933, pp. 71-73, pl. 6, fig. 3.

Geologic range. Late Miocene.

Arachnoidiscus ehrenbergii Bailey.

(Figures 56-60.)

Arachnoidiscus ehrenbergii Bailey, *in* Ehrenberg, 1849, pp. 63,64. Hustedt, 1929, p. 471, fig. 262. Brown, 1933, p. 55, pl. 4, fig. 5. Cupp, 1943, p. 66, fig. 28, pl. 4, fig. 1.

Geologic range. Late Cretaceous to Recent.

Ecology. This species "favours tropical and subtropical waters," and it is a "littoral diatom; it probably spends part of its time as a bottom form, epiphytic often upon red algae and corallines; sometimes found in large numbers," according to Hendey (1937, p. 267).

Arachnoidiscus evanescens Brown.

(Figure 61.)

Arachnoidiscus ehrenbergii var. *evanescens* Grunow, *in* Schmidt, 1881, pl. 68, fig. 7 [stated "Monterey (Grunow), nach Grunow, der übrigens auch *A. indicus* nur als *A. Ehrenbergii* var. *gelten* las will, *A. Ehrenbergii* var. *evanescens*. . . . für *A. indicus* var. *nehmen*."]

Arachnoidiscus evanescens Brown, 1933, p. 74.

Geologic range. Late Miocene.

Remarks. It is distinguished from *A. decorus* Brown by its broader rays, and the cells are not sunk in pits.

Arachnoidiscus ornatus var. **montereyanus** Schmidt.

(Figures 62, 63.)

"*Arachnoidiscus ornatus* var. *montereiana* A.S.," 1882, pl. 73, figs. S, 9. Brown, 1933, p. 50.

Not *Arachnoidiscus ornatus* var. *montereiana* A.S., 1882, pl. 73, fig. 7.

Not *Arachnoidiscus manni* Hanna and Grant, 1926, p. 125, pl. 12, figs. 7-9.

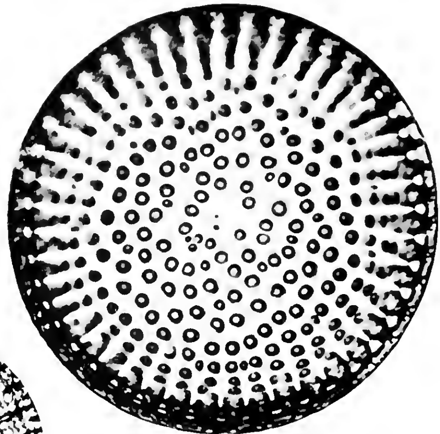
Figure 53. *Arachnoidiscus decorus* Brown. Hypotype no. 3946 (CAS), from locality 866 (CAS), Monterey, California. Diameter 0.1410 mm.

Figure 54. *Stictodiscus californicus* Greville. Hypotype no. 3707 (CAS), from locality 1277 (CAS), Monterey, California. Diameter 0.1300 mm.

Figure 55. *Stictodiscus californicus* Greville. Hypotype no. 3708 (CAS), from locality 1277 (CAS), Monterey, California. Diameter 0.1600 mm.

Figure 56. *Arachnodiscus ehrenbergii* Bailey. Hypotype no. 3709 (CAS), from locality 1277 (CAS), Monterey, California. Diameter 0.1901 mm.

Figure 57. *Arachnoidiscus ehrenbergii* Bailey. Hypotype no. 3710 (CAS), from locality 866 (CAS), Monterey, California. Diameter 0.2240 mm.



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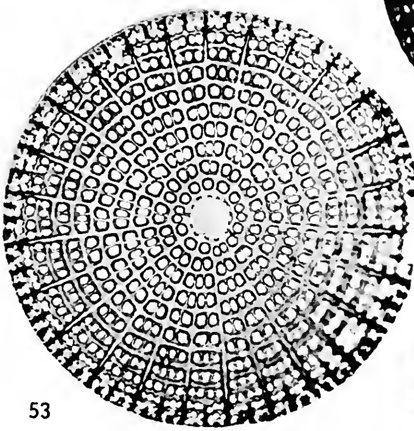

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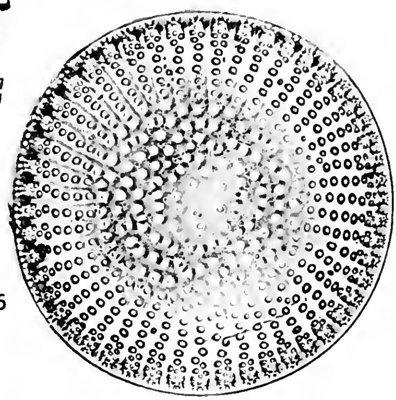

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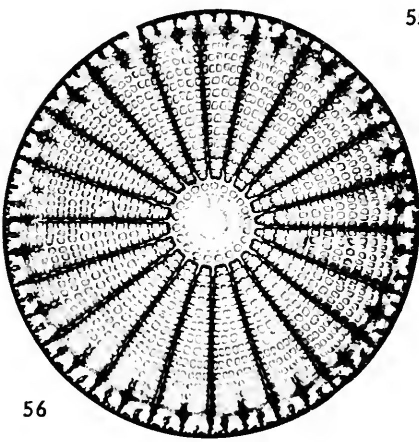

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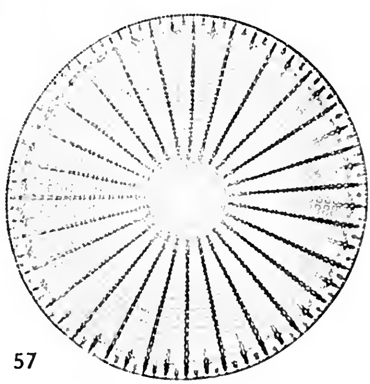

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Geologic range. Middle Miocene to late Miocene.

Remarks. This variety is distinguished from the typical species by having the greater portion of the valve surface covered with an irregular network of dark lines.

Genus **Cladogramma** Ehrenberg, 1844.

Cladogramma californicum Ehrenberg.

(Figure 64.)

Cladogramma californicum Ehrenberg, 1854, pl. 33, no. 13, fig. 1. Van Heurck, 1882, pl. 83 bis, figs. 18, 19.

Geologic range. Late Miocene.

Subfamily Actinoptychoideae Schütt, 1896 [12e, 12f]

Genus **Actinoptychus** Ehrenberg, 1843

Actinoptychus bismarckii Schmidt.

(Figure 65.)

Actinoptychus bismarckii Schmidt, 1886, pl. 91, fig. 4. Wolle, Diatomaceae of North America, 1894, pl. 103, fig. 3. De-Toni, Sylloge Algarum, 1894, p. 1389.
Actinoptychus astur Brun, Hanna, 1951, p. 284, fig. 3, no. 4.

Geologic range. Late Miocene.

Remarks. Valves discoid, with six radial compartments, alternately raised and depressed. The raised compartment with very coarse square to polygonal areolation, usually in parallel rows from the central hyaline area to the narrow margin. The depressed compartments have parallel rows of areolae.

Figure 58. *Arachnoidiscus ehrenbergii* Bailey. Hypotype no. 3711 (CAS), from locality 1277 (CAS), Monterey, California. Diameter 0.1901 mm.

Figure 59. *Arachnoidiscus ehrenbergii* Bailey. Hypotype no. 3712 (CAS), from locality 27295-155 (CAS), Harris grade, Purisima Hills, Santa Barbara County, California. Diameter 0.1828 mm.

Figure 60. *Arachnoidiscus ehrenbergii* Bailey. Hypotype no. 3713 (CAS), from locality 27295-155 (CAS), Harris grade, Purisima Hills, Santa Barbara County, California. Diameter 0.2192 mm.

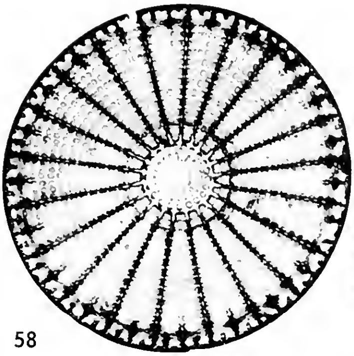
Figure 61. *Arachnoidiscus evanescens* Brown. Hypotype no. 3714 (CAS), from locality 866 (CAS), Monterey, California. Diameter 0.1260 mm.

Figure 62. *Arachnoidiscus ornatus* var. *montereyanus* Schmidt. Hypotype no. 3715 (CAS), from locality 1277 (CAS), Monterey, California. Diameter 0.3120 mm.

Figure 63. *Arachnoidiscus ornatus* var. *montereyanus* Schmidt. Hypotype no. 3716 (CAS), from locality 866 (CAS), Monterey, California. Diameter 0.2480 mm.

Figure 64. *Cladogramma californicum* Ehrenberg. Hypotype no. 3717 (CAS), from locality 866 (CAS), Monterey, California. Diameter 0.0303 mm.

[12e] Schütt, 1896, p. 55, as subtribe Actinoptychinae.
[12f] Hustedt, 1930, p. 56, new status and change in spelling.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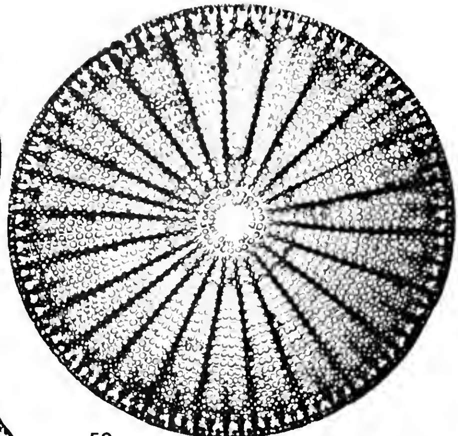
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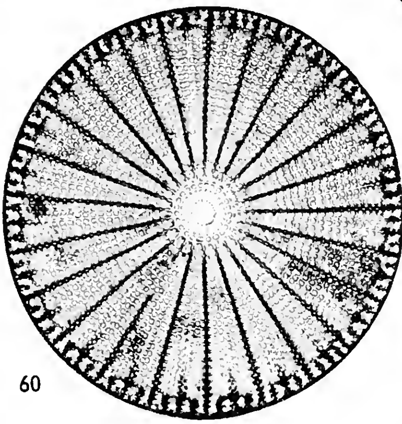
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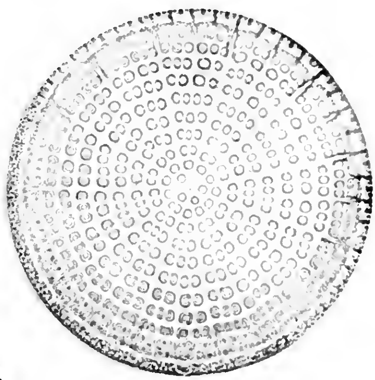
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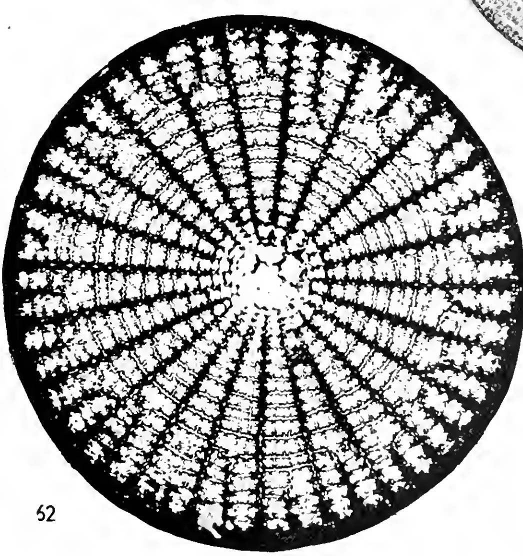
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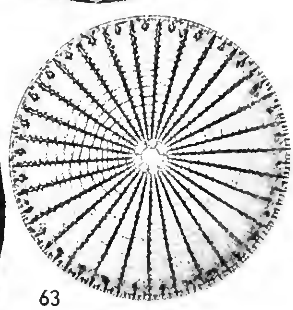
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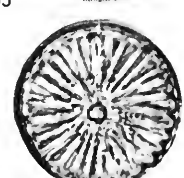
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Actinoptychus gründleri Schmidt.

(Figure 66.)

Actinoptychus gründleri Schmidt, 1874, pl. 1, fig. 22. Pantocsek, 1886, pl. 12, fig. 106; 1889, pl. 25, fig. 365. Wolle, 1894, pl. 92, figs. 3, 7. Schmidt, 1886, pl. 90, fig. 7.
Actinoptychus stella Schmidt, 1886, pl. 90, fig. 1.
Actinoptychus gallegosi Hanna and Grant, 1926, p. 120, pl. 11, fig. 6.
Actinoptychus pfitzeri Gründler, *in* Schmidt, 1875, pl. 29, fig. 1.

Geologic range. Eocene to Miocene.

Actinoptychus senarius Ehrenberg.

(Figure 67.)

Actinocyclus senarius Ehrenberg, 1838, p. 172, pl. 21, fig. 6.
Actinoptychus senarius Ehrenberg, 1841, p. 400, pl. 1, gr. 1, fig. 27; pl. 1, gr. 3, fig. 22 [fig. 21], [1843]. Hendey, 1937, p. 271. Lohman, 1941, p. 80, pl. 16, fig. 9. Hendey, 1964, p. 95.
Actinoptychus undulatus Ehrenberg. Schmidt, 1875, pl. 1, figs. 1-4, 6; 1886, pl. 109, fig. 1; 1888, pl. 132, fig. 16; 1890, pl. 153, fig. 25.
Actinoptychus undulatus (Bailey) Ralfs. Hanna and Grant, 1926, p. 124, pl. 12, fig. 4. Hustedt, 1929, p. 475, fig. 264.

Geologic range. Late Cretaceous to Recent.

Ecology. "Neritic, Bottom form. Frequently found in plankton. Of very wide distribution," according to Cupp (1943, p. 67). "Im Küstengebiet, selten im Küstenplankton, aller Meere verbreitet und häufig, auch hier und da in die Flussmündgungen hineingehend. Im Mittelmeergebiet weniger zahlreich als an den nördlichen Küsten Mitteleuropas," stated by Hustedt (1930, p. 476).

"This species is widely spread throughout north temperate seas and frequently is found in the plankton of deep water. It is very variable in appearance and size. The distribution of the areoles and the fineness of the

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Figure 65. *Actinoptychus bismarckii* Schmidt. Hypotype no. 3718 (CAS), from locality 1277 (CAS), Monterey, California. Diameter 0.1075 mm.

Figure 66. *Actinoptychus gründleri* Schmidt. Hypotype no. 3719 (CAS), from locality 1277 (CAS), Monterey, California. Diameter 0.2340.

Figure 67. *Actinoptychus senarius* Ehrenberg. Hypotype no. 3720 (CAS), from locality 27295-7 (CAS), Harris grade, Purisima Hills, Santa Barbara County, California. Diameter 0.0444 mm.

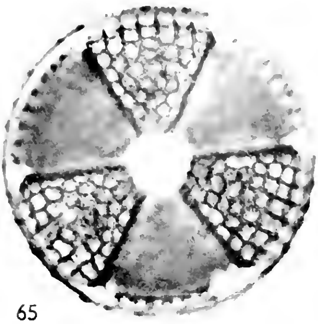
Figure 68. *Actinoptychus splendens* var. *incisa* (Grunow), new combination. Hypotype no. 3721 (CAS), from locality 1277 (CAS), Monterey, California. Diameter 0.0510 mm.

Figure 69. *Actinoptychus splendens* var. *incisa* (Grunow), new combination. Hypotype no. 3722 (CAS), from locality 1277 (CAS), Monterey, California. Diameter 0.0820 mm.

Figure 70. *Actinoptychus splendens* var. *incisa* (Grunow), new combination. Hypotype no. 3723 (CAS), from locality 1277 (CAS), Monterey, California. Diameter 0.0940 mm.

Figure 71. *Actinoptychus splendens* var. *incisa* (Grunow), new combination. Hypotype no. 3724 (CAS), from locality 1277 (CAS), Monterey, California. Diameter 0.1680 mm.

Figure 72. *Actinoptychus splendens* var. *angelorum* (Grunow), new combination. Hypotype no. 3724a (CAS), from locality 866 (CAS), Monterey, California. Diameter 0.105 mm.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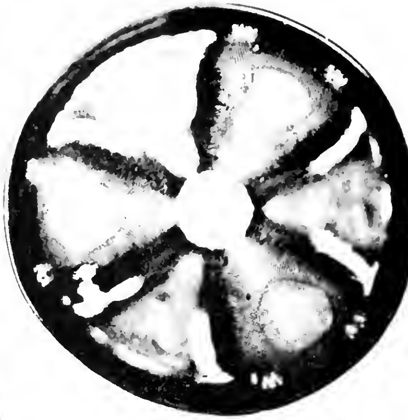
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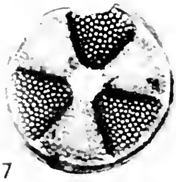
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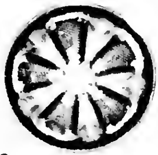
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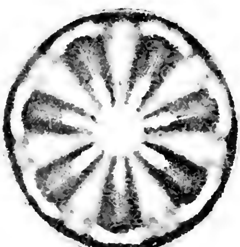
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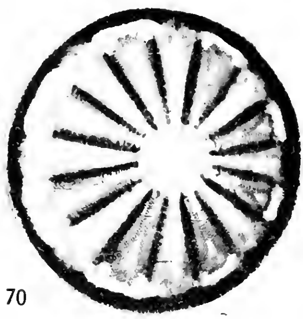
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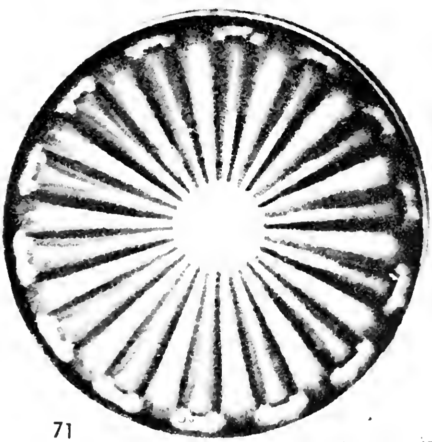
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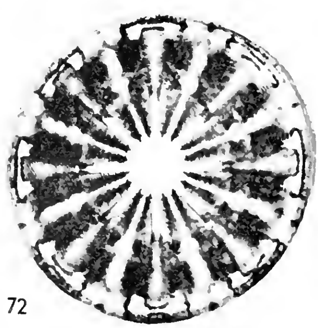
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markings varies almost from specimen to specimen," according to Hendey (1951, p. 32). Also, as stated by Hendey (1964, p. 95): "This species is cosmopolitan; it is widely spread throughout north temperate seas and common in the neritic plankton all around British coasts. Common also in oceanic plankton. It is never abundant but it is hardly ever absent from littoral gatherings taken at almost any time during the year."

Remarks. Valves discoid, with mostly six radial sectors, alternately raised and depressed. The raised sectors with short but stout processes (apicules) in the middle of the sector and at the inner edge of the margin. Sectors with coarse polygonal areolation. Secondary structure of fine puncta upon the inner surface of the areoles. Margin finely striate, with a ring of fine spinulae. Central space hyaline usually hexagonal. Considerable variation. Diameter of valves ranges from 0.0270 mm. to 0.0660 mm.

It is of interest to note that Hendey's proposal (1937) to reinstate the valid name *A. senarius* Ehrenberg, was also proposed in 1854 by Roper, p. 73.

Actinoptychus senarius var. **minutus** (Greville).

Actinoptychus minutus Greville, 1866, p. 5, pl. 1, fig. 12. Truan y Luard and Witt, 1888, p. 11, pl. 2, fig. 24.
Actinoptychus minutus Greville fa. *major* Forti, 1913, pp. 1587-1589, pl. 5, fig. 3.
Actinoptychus undulatus Ehrenberg, Schmidt, 1888, pl. 132, fig. 16.

Geologic range. Late Miocene to Pliocene.

Remarks. Valves discoid, usually with eight compartments alternate-

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Figure 73. *Actinoptychus splendens* var. *incisa* (Grunow), new combination. Hypotype no. 3725 (CAS), from locality 1277 (CAS), Monterey, California. Diameter 0.160 mm.

Figure 74. *Actinoptychus splendens* var. *solisi* Hanna and Grant. Hypotype no. 3726 (CAS), from locality 1277 (CAS), Monterey, California. Diameter 0.1300 mm.

Figure 75. *Actinoptychus splendens* var. *solisi* Hanna and Grant. Hypotype no. 3727 (CAS), from locality 1277 (CAS), Monterey, California. Diameter 0.1300 mm.

Figure 76. *Actinoptychus splendens* var. *solisi* Hanna and Grant. Hypotype no. 3728 (CAS), from locality 27295-25 (CAS), Harris grade, Purisima Hills, Santa Barbara County, California. Diameter 0.0754 mm.

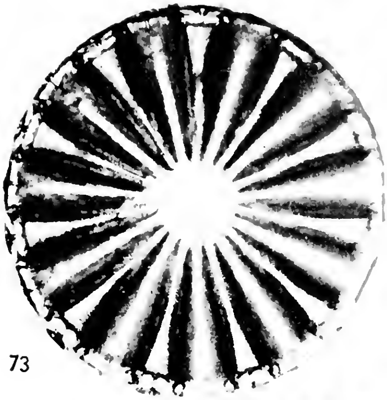
Figure 77. *Actinoptychus splendens* var. *solisi* Hanna and Grant. Hypotype no. 3729 (CAS), from locality 27295-7 (CAS), Harris grade, Purisima Hills, Santa Barbara County, California. Diameter 0.0470 mm.

Figure 78. *Actinoptychus stella* var. *clevi* (Schmidt), new combination. Hypotype no. 3730 (CAS), from locality 27295-102 (CAS), Harris grade, Purisima Hills, Santa Barbara County, California. Diameter 0.0820 mm.

Figure 79. *Actinoptychus vulgaris* var. *monicae* Grunow. Hypotype no. 3731 (CAS), from locality 866 (CAS), Monterey, California. Diameter 0.0810 mm.

Figure 80. *Actinoptychus vulgaris* var. *monicae* Grunow. Hypotype no. 3732 (CAS), from locality 866 (CAS), Monterey, California. Diameter 0.1080 mm.

Figure 81. *Actinoptychus vulgaris* var. *monicae* Grunow. Hypotype no. 3733 (CAS), from locality 866 (CAS), Monterey, California. Diameter 0.1800 mm.



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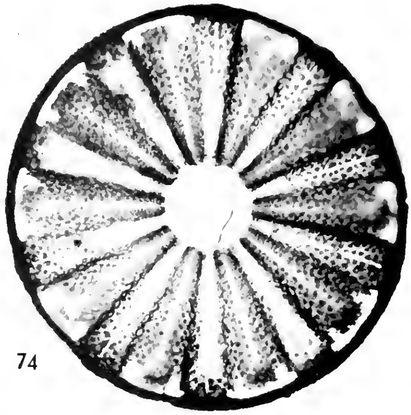

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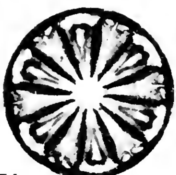

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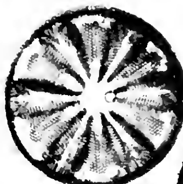

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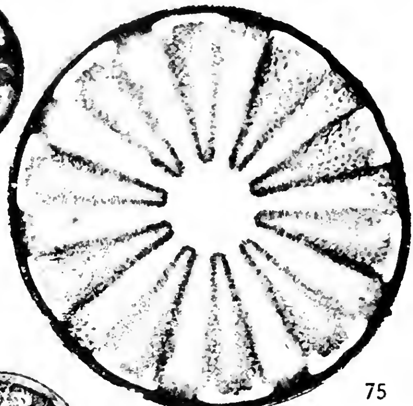

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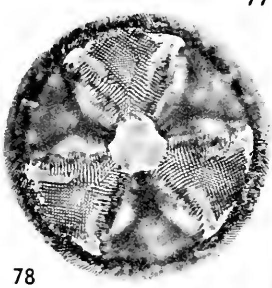

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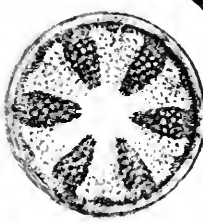

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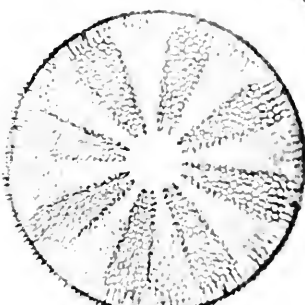

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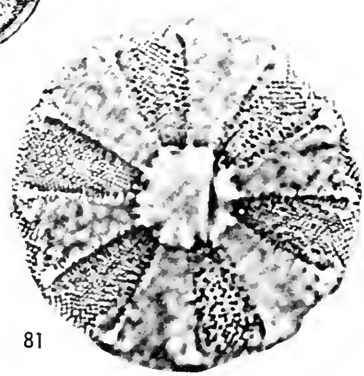


81

ly slightly raised and depressed. A central hyaline area with a cross can be seen if properly focused, which is characteristic of this variety.

Actinoptychus splendens var. **angelorum** (Grunow), new combination.

(Figure 72.)

Actinoptychus glabratus var. angelorum Grunow, *in* Van Huerck, 1883, pl. 120, fig. 9.

Geologic range. Late Miocene.

Remarks. Valves discoid, with alternately raised and depressed compartments, characterized by narrow hyaline spaces running from the central area to the inner margin and ending in a spine. In alternate compartments somewhat narrow hyaline spaces extend half way to the margin, the compartments ending in a pseudo-bracket-shaped hyaline area.

Actinoptychus splendens var. **incisa** (Grunow), new combination.

(Figures 68-71, 73.)

Actinoptychus incisa Grunow, *in* Schmidt, 1890, pl. 154, figs. 2, 3. Hanna and Gaylord, 1925, pl. 4, fig. 11.

Geologic range. Late Miocene to Pliocene.

Remarks. There is a complete intergradation of these forms.

Actinoptychus stella var. **clevei** (Schmidt), new combination.

(Figure 78.)

Actinoptychus clevei Schmidt, 1886, pl. 91, fig. 1. Aspeitia, 1911, p. 184, pl. 8, fig. 7.

Geologic range. Late Miocene.

Remarks. The little difference between the typical species of *A. stella* and *A. clevei* Schmidt is not of the specific magnitude, and so I have placed it as a variety of the species *A. stella*.

Actinoptychus splendens var. **solisi** Hanna and Grant.

(Figures 74-77.)

Actinoptychus solisi Hanna and Grant, 1926, p. 123, pl. 12, figs. 1-3.
Actinoptychus halionyx Grunow, Hanna, 1932, p. 169, pl. 2, fig. 4.
Actinoptychus splendens var. *halionyx* Grunow, *in* Van Heurck, 1883, pl. 119, fig. 3; pl. 120, figs. 3, 5.
Actinoptychus splendens var. *californica* Grunow, *in* Van Heurck, 1883, pl. 120, fig. 1.

Geologic range. Middle Miocene to Recent.

Ecology. "Wie die vorige Art im Küstengebiet aller Meere verbreitet und häufig. Die Varietät findet such lier und da unter der Art, besonders im Mittelmere," according to Hustedt (1929. p. 479).

Remarks. Valves discoid, alternately raised and depressed compartments; the raised sectors with a narrow hyaline line extending from the round hyaline central area to the margin of the valve and ending in a short spine. The areolation in the raised sectors is fairly strong. The depressed sectors with bracket-shaped hyaline areas near the margin. These individuals compare closely with the Maria Madre Island specimens.

Shadbolt (1854, Trans. Mic. Soc., p. 16) described *Actinophaenia splendens*, new genus and species as follows: "There is a very striking and beautiful discoid valve, tolerably abundant, of the same genus as one commonly found in the guano from Callao, but which, I conceive, as never yet had a generic name. It differs in essential characters both from the *Coscinodiscus* and *Actinocyclus*, and its position would probably be midway between them."

"It possesses a pseudonucleus, is minutely embellished with delicate markings similar to those seen in *Pleurosigma angulatum*, but in segments radiating from the center, so that, in all probability, the front view would exhibit slight undulations. The absence of any distinct division between the segments, however, separates it from *Actinocyclus*. I propose for this form the generic name *Actinophaenia*...glittering, with the specific designation *splendens*."

In the same volume, Roper discussed a form he found in the Thames, and says (p. 72): "Sparingly distributed, I have another large and beautiful disc (fig. 2) with sixteen septa, the surface of which is covered with faint cross striae, similar to those of *Pleurosigma;* and in that respect it resembles the valves from Natal, for which Mr. Shadbolt proposed the name of *Actinophaenia;* but I find this striation is no distinctive character, as all the specimens of *A. undulatus* (or *senarius*) that I have examined have the same peculiarity, and the septa are plainly discernible, especially with the parabolic condenser. In the lists I have applied to it provisionally the name of *Actinocyclus sedenarius*, as it approaches very nearly to Ehrenberg's figure of that species in the 'Berlin Transactions' for 1839, tab. 4, p. 2. The septa appear to have their origin from the smooth central portion or pseudo-nodule, and to terminate at slight elevations or openings at the margin of the disc, and in perfect specimens, those on one valve are opposite to the interspaces on the other. The front view exhibits slight traces of undulations, as in fig. 13, not in continuous wave lines, but rising to points at the extremities of the rays, giving the side view an appearance similar to that of a ridge-and furrow roof. The diameter varies from 1-288th to 1-187th of an inch."

Then Brightwell (1860, p. 94) stated: "19. *Actinophaenia splendens*, shadbolt. - Valve with two plates, one with very fine oblique markings, the other with much coarser markings, arranged in a somewhat pinnate manner. (Pl. VI, fig. 15) [18]."

A common species, varying greatly in size and number of segments. Brick fields, Caermarthen, Mr. Okeden. Very fine. Syn. —*Actinocyclus octodenarius*, and numerous other species of Ehrenberg: —*Actinocyclus duodenarius, sedenarius, octodenarius. Actinocyclus sedenarius*, Roper ('Micr.

Journ.,' vol. ii, pl. VI, fig. 2). --Mr. Roper's figure is unsatisfactory, giving only the fine markings. (Smith, "Syn. Brit. Diat.,' vol. ii, Appendix, p. 86). Professor Smith has published, with doubts as to their distinctness, the three species named above, which are certainly only varieties. It is unfortunate that he should have transferred these names from the genus *Actinoptychus*, in which they were placed by Ehrenberg, to that of *Actinocyclus*, thus creating the greatest confusion. Ehrenberg's *Actinoptychus duodenarius, sedenarius, bioctodenarius*, we believe to be totally different from the form in question."

A year later, Ralfs in Pritchard (1861, Infusoria, p. 849) described *A. splendens* (Shadbolt) as a species of *Actinoptychus*, as follows: "*A. splendens* (Shadbolt). - Compartments (12-20) obscurely cellulose, each with a median line, which terminates in a clavate intramarginal nodule or tooth; umbilicus hyaline, definite. =*Actinophaenis splendens*, Sh TM. iil p. 16; *Actinoptychus sedenarius*, E., Ro TM. ii. p. 74, pl. 6, f. 2. Common. Guano, England. In this species the alternate depressions of the compartments are often very slight; and the compartments being striated, frequently appear irregular, and are counted with difficulty. The species nevertheless has so peculiar an aspect that once known it is easily recognized. The rays are most distinct where they radiate from the hyaline umbilicus, at which part they sometimes appear thickened. In some specimens the nodules are confined to the alternate compartments."

The entire mix-up was supposed to be cleared up by Hustedt (1929, p. 478, fig. 265) by lumping *Actinophaenia splendens* Shadbolt, *Actinoptychus sedenarius* Ehrenberg, *Actinoptychus quatuordenarius* Ehrenberg, *Halionyx quinarius, senarius, septenarius, octonarius, nonarius, denarius, undenarius, vicenarius*, Ehrenberg, *Actinoptychus halionyx* Grunow, *Actinoptychus glabratus* Grunow, *Actinoptychus janischii* Grunow.

I question the validity of Hustedt's lumping because of Brightwell's (1890, p. 94) statement that: "Ehrenberg's *Actinoptychus duodenarius, sedenarius, bioctodenarius*, we believe to be totally different from the form in question." [which was *Actinophaenia splendens*, Shadbolt, who first described this species].

Also Mann (1907, p. 271) stated in a footnote "b", in regard to *Actinophaenia splendens* Shadbolt: "This name was originally published by Shadbolt in Trans. Micr. Soc. Lond. n.s. 2:16. 1854. The description is insufficient for a determination, but Brightwell's identification may be correct, inasmuch as he was contemporary worker and may have seen authentic material."

I have used the name *solisi* as a variety name for the form called *A. halionyx* because I do not think the variety name *halionyx* Grunow is valid. According to Hustedt (1929, p. 478), the original form of *Actinoptychus halionyx* Grunow is a synonym of *Actinoptychus splendens* (Shadbolt).

Grunow later illustrated a form which he called *Actinocyclus splendens* var. *halionyx* which was not the same as his original *A. halionyx* species. Therefore, in order to retain the variety *halionyx*, I have used the name *solisi* of Hanna and Grant in place of *A. halionyx*.

Actinoptychus vulgaris var. **monicae** Grunow.

(Figures 79-81.)

Actinoptychus vulgaris var. *monicae* GRUNOW, *in* Van Heurck, 1883, pl. 121, fig. 9; WOLLE, 1890, pl. 85, fig. 20.

GEOLOGIC RANGE. Late Miocene.

REMARKS. Valves discoid, with alternately raised and depressed compartments, the raised ones with one spine at the margin. Areolae well developed central hyaline area takes various shapes.

This variety is especially characterized by the hyaline spaces that are present in the depressed compartments at the margin of the valve. These are usually not connected. When properly focused, these depressed sectors appear to have many small beads submarginal and decrease toward the central hyaline area.

Subfamily ASTEROLAMPROIDEAE H. L. Smith, 1872 [12g, 12h]

Genus **Asteromphalus** Ehrenberg, 1844

Asteromphalus arachne (Brébisson) Greville.

Spatanidium arachne BRÉBISSON, 1857, p. 296, pl. 3, fig. 1.
Asteromphalus arachne (Brébisson) GREVILLE, 1860, p. 123.
Asteromphalus arachne Brébisson. SCHMIDT, 1876, pl. 38, fig. 4.

GEOLOGIC RANGE. Pliocene.

Asteromphalus brookei Bailey.

Asteromphalus brookei BAILEY, 1856, p. 2, pl. 1, fig. 1. SCHMIDT, 1876, pl. 38, figs. 21-23. RATTRAY, 1890, p. 209.

GEOLOGIC RANGE. Late Miocene to late Pliocene.

REMARKS. This species is characterized by compartments with inner ends obtusely rounded or truncate. The rays may be simple and the geniculations are not regular.

Asteromphalus darwinii Ehrenberg.

(Figure 82.)

Asteromphalus darwinii EHRENBERG, 1844, p. 200, pl. (June), fig. 1. GREVILLE, 1860, p. 116, pl. 4, figs. 12, 13.

GEOLOGIC RANGE. Late Miocene.

12g H. L. Smith, 1872, p. 17, as family Asterolampreae.

12h De-Toni, 1890, p. 919, new status and change in spelling.

Suborder AULACODISCINEAE Hendey, 1937 [12i]

Family EUPODISCACEAE Kützing, 1844 [12j, 12k]

Subfamily AULACODISCOIDEAE Pantocsek, 1886 [12l, 12m]

Genus **Aulacodiscus** Ehrenberg, 1845

Aulacodiscus brownei Norman.

(Figure 84.)

Aulacodiscus brownei NORMAN, *in* Pritchard, 1861, p. 844. RATTRAY, 1888, p. 341. HANNA, 1932, p. 175, pl. 5, fig. 3.

GEOLOGIC RANGE. Middle Miocene to Pliocene.

Aulacodiscus concentricus (Mann) Boyer.

(Figure 83.)

Tripodiscus concentricus MANN, 1907, p. 278, pl. 54, figs. 1, 2.
Aulacodiscus concentricus (Mann) BOYER, 1926, p. 76.

GEOLOGIC RANGE. Late Miocene.

REMARKS. Distinguished from *A. brownei* by its more concentric markings.

Aulacodiscus cornutus Brun.

Aulacodiscus cornutus BRUN, *in* Schmidt, 1882, pl. 170, fig. 2.

Aulacodiscus crux Ehrenberg.

Aulacodiscus crux EHRENBERG, 1844, p. 76. BOYER, 1926, p. 76. WOLLE, 1894, pl. 88, fig. 1.

Aulacodiscus kittoni Arnott.

Aulacodiscus kittoni ARNOTT, *in* Pritchard, 1861, p. 844, pl. 8, fig. 24. HUSTEDT, 1929, pp. 506-509, fig. 283. CUPP, 1943, p. 70, fig. 33, pl. 8, fig. 24.

GEOLOGIC RANGE. Late Miocene to Recent.

ECOLOGY. This species occurs in the littoral zone and is occasionally found in the plankton, according to Cupp (1943, p. 70).

REMARKS. The large rosette in the center portion of the valve surface is one of the most characteristic features of this species.

12i Hendey, 1937, p. 203.

12j Kützing, 1844, p. 137, as family Eupodisceae.

12k De-Toni, 1890, p. 916, new status and change in spelling.

12l Pantocsek, 1886, p. 55, as family Aulacodisceae.

12m Hustedt, 1930, p. 56, new status and change in spelling.

Aulacodiscus margaritaceus Ralfs.

Aulacodiscus margaritaceus RALFS, *in* Pritchard, 1861, p. 844. SCHMIDT, 1876, pl. 37, figs. 4-7; 1886, pl. 92, fig. 12; 1886, pl. 105, figs. 1-2, 4. RATTRAY, 1888, p. 351, pl. 6, fig. 3.

GEOLOGIC RANGE. Late Miocene to Recent.

Aulacodiscus simplex Rattray.

(Figure 85.)

Aulacodiscus simplex RATTRAY, 1888, p. 340.
Aulacodiscus decorus GREVILLE. SCHMIDT, 1876, pl. 33, fig. 9.

GEOLOGIC RANGE. Late Miocene.

Suborder AULISCINEAE Hendey, 1937 [12n]
Family AULISCACEAE Hendey, 1937 [12n]
Subfamily AULISCOIDEAE Heiden-Kolbe, 1928 [13, 14]

Genus **Auliscus** Ehrenberg, 1844

Auliscus albidus Brun.

(Figure 86.)

Auliscus albidus BRUN, *in* Schmidt, 1882, pl. 171, figs. 3, 4.
Auliscus albidus var. *baccata* BRUN, *in* Schmidt, 1882, pl. 171, fig. 5.

GEOLOGIC RANGE. Late Miocene.

Auliscus caelatus Bailey.

(Figure 87.)

Auliscus caelatus BAILEY, 1854, p. 6, pl. 1, figs. 3, 4. SCHMIDT, 1875, pl. 32, figs. 14, 15. RATTRAY, 1888, p. 25. HANNA AND GRANT, 1926, p. 129, pl. 13, fig. 8. HUSTEDT, 1928, p. 518, fig. 291.

GEOLOGIC RANGE. Late Miocene to Recent.

ECOLOGY. According to Hustedt (1928, p. 521), "Die Art ist zwar im ganzen europäischen Meeresgebiet verbreitet, aber viel seltener als *Aul. sculptus.*"

Auliscus caelatus var. **constricta** Rattray.

(Figures 88-91, 95.)

Auliscus caelatus var. *constricta* RATTRAY, 1888, p. 27, pl. 15, fig. 8. HUSTEDT, 1928, p. 519, fig. 293.

GEOLOGIC RANGE. Late Miocene to middle Pliocene.

12n Hendey, 1937, p. 203.

13 Heiden-Kolbe, 1928, p. 463, as a tribe Aulisceae.

14 Hendey, 1937, p. 203, new status and change of spelling.

Auliscus grunowi var. **californica** Grunow.

(Figures 92-94.)

Auliscus grunowi var. *californica* Grunow, *in* Schmidt, 1886, pl. 89, fig. 8; 1944, pl. 454, figs. 8, 9.
Auliscus grunowii var. *californica* Grunow, Rattray, 1888, p. 872.

Geologic range. Late Miocene.

Ecology. According to Hustedt (in Schmidt, 1944, pl. 454, figs. 8, 9), "Ich mache auf die Divergenz der radialen Streifen in den beiden Feldern der Querarea aufmerksam, während diese Punktreihen bei *Aul. pruinosus* von der Peripherie gegen das Zentrum stark konvergieren!"

Auliscus hardmanianus Greville.

Auliscus hardmanianus Greville, 1866, p. 6, pl. 2, 17. Rattray, 1888, p. 877. Schmidt, 1881, pl. 67, fig. 1; 1886, pl. 108, fig. 1. Mann, 1907, p. 282.

Geologic range. Late Miocene.

Auliscus incertus Schmidt.

(Figure 97.)

Auliscus incertus Schmidt, 1886, pl. 89, fig. 18, 19. Rattray, 1888, p. 883 (p. 23). Hustedt, 1928, p. 522, fig. 296.

Geologic range. Late Miocene.

Ecology. According to Hustedt (1928, p. 522) the species is found "Rezent nur von den Balearen bekannt (Weissflog), bedarf der Nachprufung."

Remarks. Valve elliptical with major axis about 1¼ times the minor axis. Transverse median area indistinct rising from central area to the processes. Markings are distinct striae, converging to the processes while the others are diverging. Others are straight along the minor axis, and still others convex towards the processes.

Figure 82. *Asteromphalus darwinii* Ehrenberg. Hypotype no. 3734 (CAS), from locality 866 (CAS), Monterey, California. Diameter 0.0500 mm.

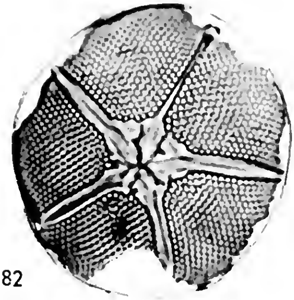
Figure 83. *Aulacodiscus concentricus* (Mann) Boyer. Hypotype no. 3735 (CAS), from locality 1277 (CAS), Monterey, California. Diameter 0.0705 mm.

Figure 84. *Aulacodiscus brownei* Norman. Hypotype no. 3736 (CAS), from locality 866 (CAS), Monterey, California. Diameter 0.1035 mm.

Figure 85. *Aulacodiscus simplex* Rattray. Hypotype no. 3737 (CAS), from locality 866 (CAS), Monterey, California. Diameter 0.1220 mm.

Figure 86. *Auliscus albidus* Brun. Hypotype no. 3738 (CAS), from locality 1277 (CAS), Monterey, California. Diameter 0.1154 mm.

Figure 87. *Auliscus caelatus* Bailey. Hypotype no. 3739 (CAS), from locality 866 (CAS), Monterey, California. Diameter 0.0580 mm.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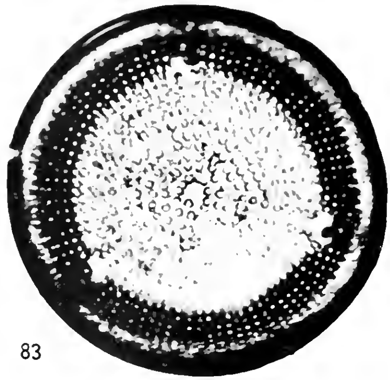
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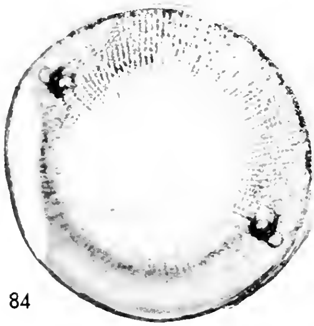
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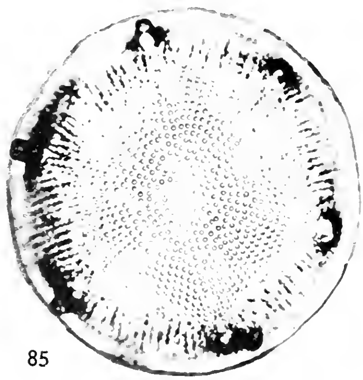
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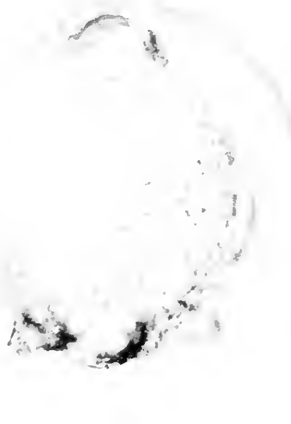
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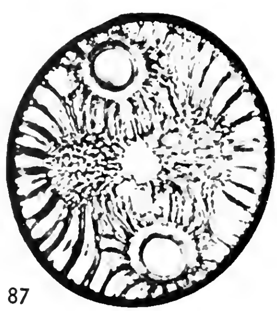
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Auliscus mirablis Grunow.

(Figures 96, 98, 99.)

Auliscus mirablis Grunow, 1863, p. 47, pl. 2, fig. 11. Schmidt, 1886, pl. 89, figs. 10-13. Rattray, 1888, p. 889.

Geologic range. Late Miocene.

Auliscus pruinosus Bailey.

(Figure 101.)

Auliscus pruinosis Bailey, 1854, p. 5, pl. 1, figs. 5-8. Rattray, 1888, p. 882 (p. 22). Hustedt, 1928, p. 511, fig. 286.

Geologic range. Late Miocene.

Ecology. Following Hustedt (1928, p. 521), "Nach Oestrup soll die Art im Holbaekfjord (Danemark) vorkommen. Sonst ist die im Küstengebiet Mittelamerikas häufige Form in den europäischen Meeren meines Wissens noch nicht beobachtet."

Auliscus punctatus Bailey.

(Figures 100, 102-108.)

Auliscus punctatus Bailey, 1853, p. 5, pl. 1, fig. 9. Greville, 1863, p. 49, pl. 3, fig. 15. Rattray, 1888, p. 869. Boyer, 1926, p. 91. Hustedt, *in* Schmidt, 1944, pl. 455, figs. 9-12.

Geologic range. Late Miocene to Recent.

Figure 88. *Auliscus caelatus* var. *constricta* Rattray. Hypotype no. 3740 (CAS), from locality 866 (CAS), Monterey, California. Diameter 0.0830 mm.

Figure 89. *Auliscus caelatus* var. *constricta* Rattray. Hypotype no. 3741 (CAS), from locality 1277 (CAS), Monterey, California. Diameter 0.0868 mm.

Figure 90. *Auliscus caelatus* var. *constricta* Rattray. Hypotype no. 3743 (CAS), from locality 1277 (CAS), Monterey, California. Diameter 0.0600 mm.

Figure 91. *Auliscus caelatus* var. *constricta* Rattray. Hypotype no. 3744 (CAS), from locality 1277 (CAS), Monterey, California. Diameter 0.0800 mm.

Figure 92. *Auliscus grunowi* var. *californica* Grunow. Hypotype no. 3745 (CAS), from locality 866 (CAS), Monterey, California. Diameter 0.0585 mm.

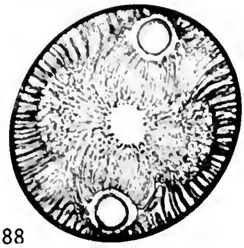
Figure 93. *Auliscus grunowi* var. *californica* Grunow. Hypotype no. 3746 (CAS), from locality 1277 (CAS), Monterey, California. Diameter 0.0658 mm.

Figure 94. *Auliscus grunowi* var. *californica* Grunow. Hypotype no. 3747 (CAS), from locality 1277 (CAS), Monterey, California. Diameter 0.0670 mm.

Figure 95. *Auliscus caelatus* var. *constricta* Rattray. Hypotype no. 3748 (CAS), from locality 866 (CAS), Monterey, California. Diameter 0.0600 mm.

Figure 96. *Auliscus mirabilis* Grunow. Hypotype no. 3749 (CAS), from locality 1277 (CAS), Monterey, California. Diameter 0.0630 mm.

Figure 97. *Auliscus incertus* Schmidt. Hypotype no. 3750 (CAS), from locality 1277 (CAS), Monterey, California. Diameter 0.0852 mm.



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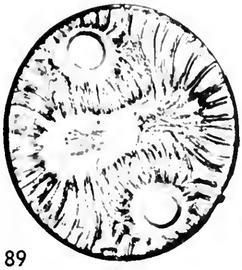

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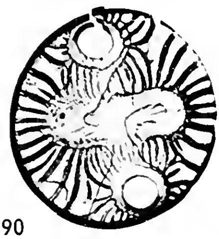

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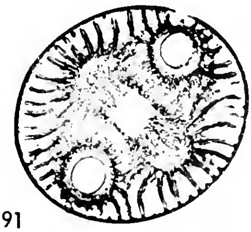

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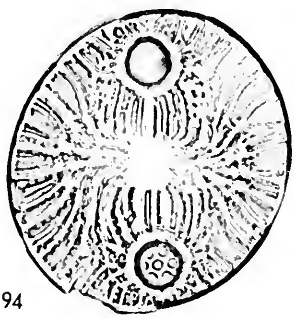

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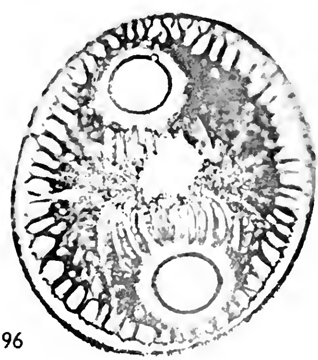

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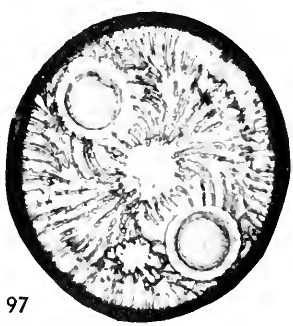


97

Remarks. This species is characterized by a closely punctate surface while *A. pruinosis* has a sparsely punctate surface.

Auliscus stockhardtii Janisch.

(Figures 109-112.)

Auliscus stockhardtii Janisch, 1861, p. 163, pl. 1, fig. 4. Schmidt, 1875, pl. 30, figs. 11-13; 1881, pl. 67, fig. 6.

Geologic range. Late Miocene.

Remarks. Valve subcircular with large apiculi near the processes and near the border.

Genus **Glyphodiscus** Greville, 1862

Glyphodiscus stellatus Greville.

(Figure 120a.)

Glyphodiscus stellatus Greville, Trans. Micr. Soc. London, vol. 10, n.s., 1862, p. 91, pl. 9, fig. 5. "Monterey Stone." Schmidt, Atlas, Diat., pl. 80, 1876, fig. 3; pl. 117, 1888, fig. 11. Wolle, Diat. N. Amer. 1894, pl. 76, figs. 8, 9.

Geologic range. Miocene.

Remarks. This is a very characteristic upper Miocene diatom in California.

Figure 98. *Auliscus mirablis* Grunow. Hypotype no. 3751 (CAS), from locality 1277 (CAS), Monterey, California. Diameter 0.0754 mm.

Figure 99. *Auliscus mirablis* Grunow. Hypotype no. 3752 (CAS), from locality 866 (CAS), Monterey, California. Diameter 0.0512 mm.

Figure 100. *Auliscus punctatus* Bailey. Hypotype no. 3753 (CAS), from locality 866 (CAS), Monterey, California. Diameter 0.0860 mm.

Figure 101. *Auliscus pruinosus* Bailey. Hypotype no. 3754 (CAS), from locality 866 (CAS), Monterey, California. Diameter 0.0677 mm.

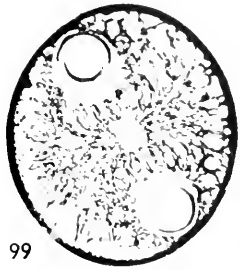
Figure 102. *Auliscus punctatus* Bailey. Hypotype no. 3755 (CAS), from locality 1277 (CAS), Monterey, California. Diameter 0.0830 mm.

Figure 103. *Auliscus punctatus* Bailey. Hypotype no. 3756 (CAS), from locality 866 (CAS), Monterey, California. Diameter 0.0948 mm.

Figure 104. *Auliscus punctatus* Bailey. Hypotype no. 3757 (CAS), from locality 1277 (CAS), Monterey, California. Diameter 0.1110 mm.

Figure 105. *Auliscus punctatus* Bailey. Hypotype no. 3758 (CAS), from locality 1277 (CAS), Monterey, California. Diameter 0.0844 mm.


98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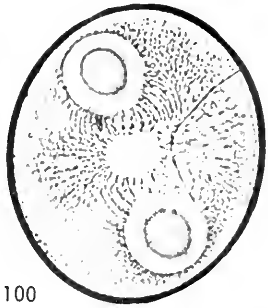
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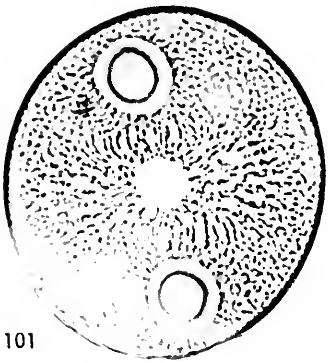
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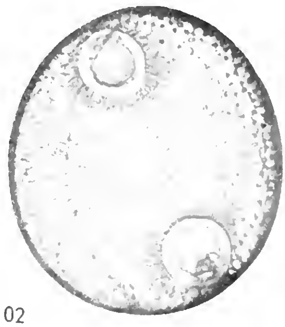
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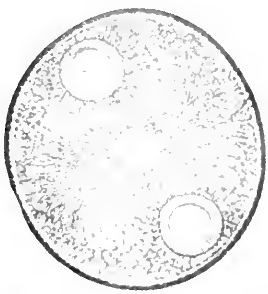
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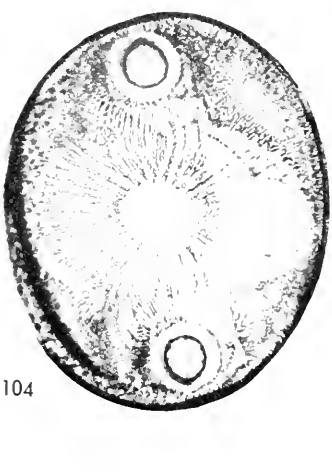
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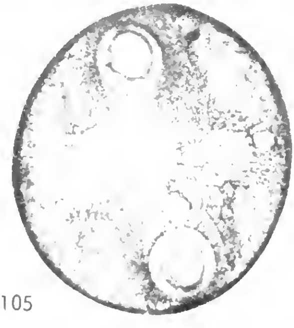

105

Suborder Biddulphineae Hustedt, 1930 [14a]
Family Biddulphiaceae Kützing, 1844 [15, 16]
Subfamily Biddulphioideae Schütt, 1896 [16a]

Genus **Biddulphia** Gray, 1831

Biddulphia aurita (Lyngbye) Brébisson and Godey.

(Figure 113.)

Diatoma auritum Lyngbye, 1819, p. 182, pl. 62, fig. D.
Biddulphia aurita (Lyngbye) Brébisson and Godey, 1838, p. 12. Hustedt, 1930, p. 846, fig. 501. Hendey, 1964, p. 103, pl. XXIV, fig. 6.

Geologic range. Late Miocene to Recent.

Ecology. According to Cupp (1943, p. 162), this species is most abundant in the Arctic and boreal seas, and considered it to be a neritic and littoral species.

This species is "usually in long chains attached to a substratum," according to Hendey (1964, p. 103).

Biddulphia aurita var. **obtusa** (Kützing) Hustedt.

(Figure 116.)

Biddulphia obtusa (Kützing) Ralfs, *in* Pritchard, 1861, p. 848, pl. 13, figs. 30-32.
Odontella obtusa Kützing, 1844, p. 137, pl. 18, figs. 8, 1-3, 6-8.
Biddulphia aurita var. *obtusa* (Kützing) Hustedt, 1930, pp. 848-849, fig. 502.
Biddulphia roperiana Greville, 1859, p. 163, pl. 8, figs. 11-13.

Figure 106. *Auliscus punctatus* Bailey. Hypotype no. 3759 (CAS), from locality 1277 (CAS), Monterey, California. Diameter 0.1120 mm.

Figure 107. *Auliscus punctatus* Bailey. Hypotype no. 3760 (CAS), from locality 1277 (CAS), Monterey, California. Diameter 0.1110 mm.

Figure 108. *Auliscus punctatus* Bailey. Hypotype no. 3761 (CAS), from locality 1277 (CAS), Monterey, California. Diameter 0.0966 mm.

Figure 109. *Auliscus stockhardtii* Janisch. Hypotype no. 3762 (CAS), from locality 1277 (CAS), Monterey, California. Diameter 0.1116 mm.

Figure 110. *Auliscus stockhardtii* Janisch. Hypotype no. 3763 (CAS), from locality 1277 (CAS), Monterey, California. Diameter 0.1496 mm.

Figure 111. *Auliscus stockhardtii* Janisch. Hypotype no. 3764 (CAS), from locality 1277 (CAS), Monterey, California. Diameter 0.0880 mm.

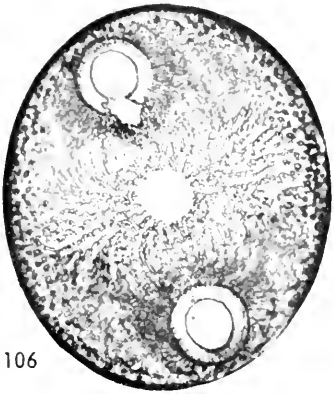
Figure 112. *Auliscus stockhardtii* Janisch. Hypotype no. 3765 (CAS), from locality 866 (CAS), Monterey, California. Diameter 0.0600 mm.

14a Hustedt, 1930, p. 56.

15 Kützing, 1844, p. 130, as a family Biddulphieae.

16 De-Toni, 1890, p. 910, change in spelling.

16a Schütt, 1896, p. 56.



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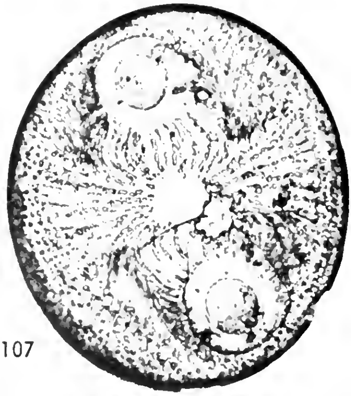

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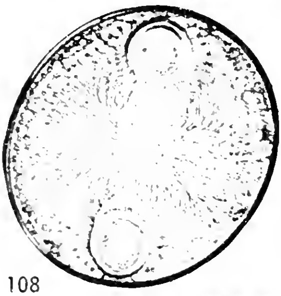

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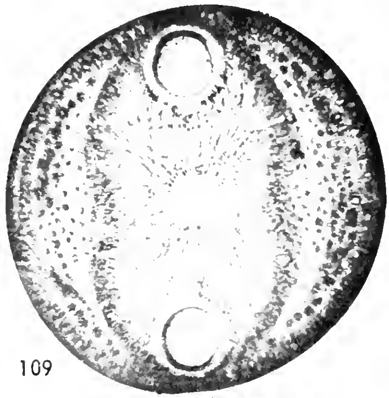

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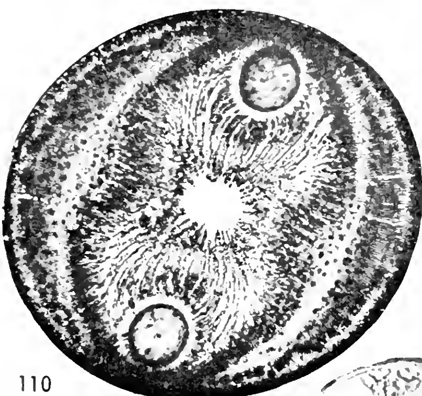

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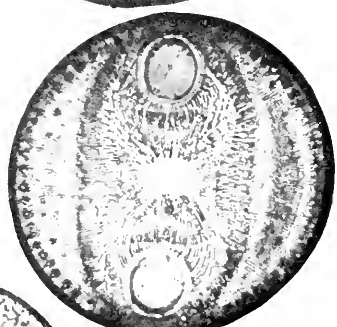
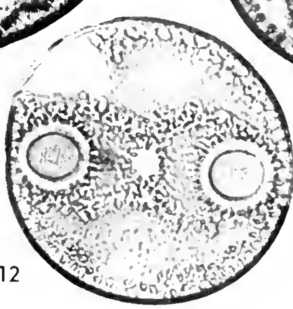




112

Geologic range. Late Miocene to Recent.

Ecology. A littoral coast form according to Hustedt (1930, p. 848.)

Remarks. Differs from *B. aurita* in the shortness of the processes, and in the absence of central spines.

Biddulphia rhombus (Ehrenberg) W. Smith

(Figure 118.)

Zygoceros rhombus Ehrenberg, 1839, p. 80, pl. 4, fig. 11 [1840].
Biddulphia rhombus (Ehrenberg) W. Smith, 1856, p. 49, pl. 45, fig. 320; pl. 61, fig. 320. Hustedt, 1930, p. 842, figs. 496, 497.

Geologic range. Late Miocene.

Ecology. This species is a characteristic inhabitant of the littoral zone. It is widely distributed and a neritic species according to Hendey (1964, p. 103).

Biddulphia tuomeyi (Bailey) Roper.

(Figures 117, 119, 120.)

Zygoceros tuomeyii Bailey, 1843, p. 138, pl. 3, figs. 3-9.
Biddulphia tuomeyii (Bailey) Roper, 1859, p. 8, pl. 1, figs. 1,2. Hustedt, 1928, p. 834, fig. 491.

Figure 113. *Biddulphia aurita* (Lyngbye), Brébisson and Godey. Hypotype no. 3766 (CAS), from locality 866 (CAS), Monterey, California. Length 0.0500 mm., breadth 0.0400 mm.

Figure 114. *Triceratium elegans* Greville. Hypotype no. 3767 (CAS), from locality 866 (CAS) Monterey, California. Length 0.0500 mm., breadth 0.0510 mm.

Figure 115. *Triceratium elegans* Greville. Hypotype no. 3768 (CAS), from locality 866 (CAS), Monterey, California. Length 0.0610 mm., breadth 0.0560 mm.

Figure 116. *Biddulphia aurita* var. *obtusa* (Kützing) Hustedt. Hypotype no. 3769 (CAS), from locality 866 (CAS), Monterey, California. Length 0.0355 mm., breadth 0.0260 mm.

Figure 117. *Biddulphia tuomeyi* (Bailey) Roper. Hypotype no. 3770 (CAS), from locality 866 (CAS), Monterey, California. Length 0.0930 mm., breadth 0.0590 mm.

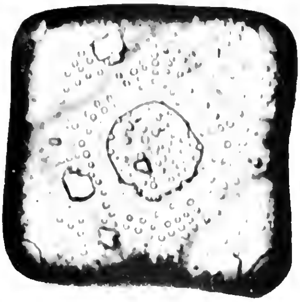
Figure 118. *Biddulphia rhombus* (Ehrenberg) W. Smith. Hypotype no. 3771 (CAS), from locality 866 (CAS), Monterey, California. Length 0.1110 mm., breadth 0.0510 mm.

Figure 119. *Biddulphia tuomeyi* (Bailey) Roper. Hypotype no. 3772 (CAS), from locality 866 (CAS), Monterey, California. Length 0.1600 mm., breadth 0.0690 mm.

Figure 120. *Biddulphia tuomeyi* (Bailey) Roper. Hypotype no. 3773 (CAS), from locality 866 (CAS), Monterey, California. Length 0.1330 mm., breadth 0.0370 mm.

Figure 120a. *Glyphodiscus stellatus* Greville. Hypotype no. 3120 (CAS), from locality no. 1277 (CAS), Monterey County, California. Diameter 0.0747 mm.

113



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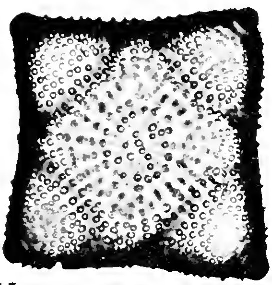

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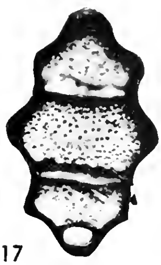

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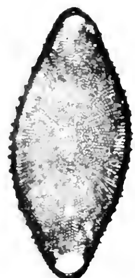

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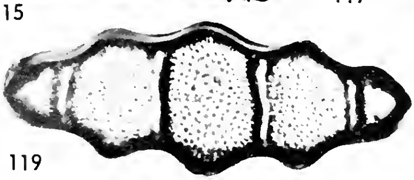

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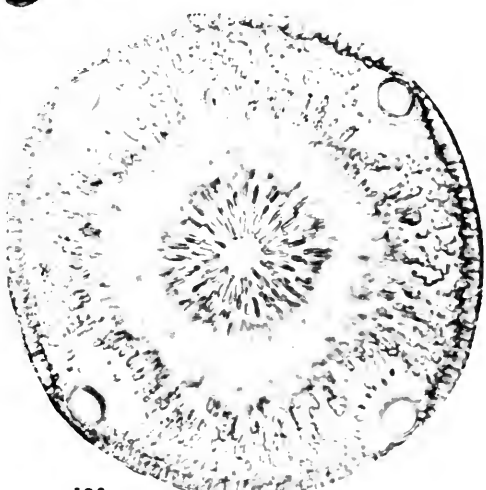


120a

Biddulphia tuomeyii Bailey, Van Heurck, 1882, pl. 98, figs. 2, 3.
Biddulphia tuomeyii (Bailey), Hanna and Grant, 1926, p. 133, pl. 14, fig. 7.

Geologic range. Late Cretaceous to Recent.

Ecology. "Litoral im Küstengebiet wärmerer Meere weit verbreitet und nicht selten," according to Hustedt (1930, p. 836).

Genus **Trigonium** Cleve, 1868

Trigonium arcticum (Brightwell) Cleve.

(Figure 121.)

Triceratium arcticum Brightwell, 1853, p. 250, pl. 4, fig. 11.
Trigonium arcticum (Brightwell) Cleve, 1886, p. 663. Hendey, 1937, p. 282, pl. 10, fig. 1.

Geologic range. Late Miocene to Recent.

Ecology. According to Hendey (1937, p. 282), this species is "A littoral diatom, not a true member of the plankton and commonly found epiphytic upon larger algae."

Trigonium arcticum var. **californica** (Grunow).

(Figures 123, 126.)

Triceratium arcticum var. *californica* Grunow, *in* Schmidt, 1882, pl. 79, figs. 5, 6.

Geologic range. Late Miocene to Recent.

Remarks. This variety is placed in the genus *Trigonium* following the re-establishment of that genus by Hendey (1937, pp. 280-282).

Figure 121. *Trigonium arcticum* (Brightwell) *Cleve*. Hypotype no. 3123 (CAS), from locality 866 (CAS), Monterey, California. Length 0.1360 mm.

Figure 122. *Triceratium montereyi* Brightwell. Hypotype no. 3775 (CAS), from locality 866 (CAS), Monterey, California. Length 0.1610 mm.

Figure 123. *Trigonium arcticum* var. *californica* (Grunow). Hypotype no. 3776 (CAS), from locality 866 (CAS), Monterey, California. Length 0.0720 mm.

Figure 124. *Triceratium favus* Ehrenberg. Hypotype no. 3777 (CAS), from locality 27295-162 (CAS), Harris grade, Purisima Hills, Santa Barbara County, California. Length 0.2400 mm.

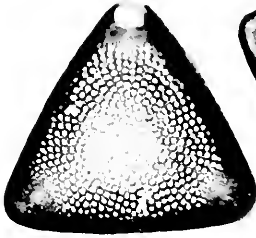
Figure 125. *Triceratium margaritiferum* Cleve. Hypotype no. 3777a (CAS), from locality 1277 (CAS), Monterey, California. Length 0.0540 mm.

Figure 126. *Trigonium arcticum* var. *californica* (Grunow). Hypotype no. 3778 (CAS), from locality 1277 (CAS), Monterey, California. Length 0.0770 mm.

Figure 127. *Triceratium montereyi* Brightwell. Hypotype no. 3779 (CAS), from locality 866 (CAS), Monterey, California. Length 0.3010 mm.

Figure 128. *Triceratium montereyi* Brightwell. Hypotype no. 3779 (CAS), from locality 866 (CAS), Monterey, California. Length 0.3010 mm. Same specimen as figure 127.

Figure 128a. *Triceratium quadrangulare* Greville. Hypotype no. 3781 (CAS), from locality 1278 (CAS), Monterey, California. Length 0.1260 mm.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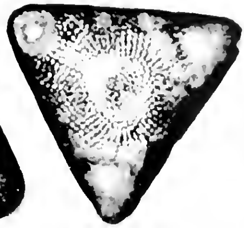
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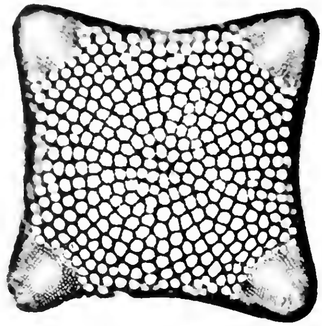
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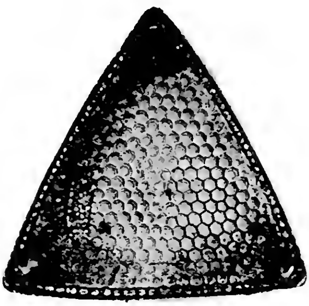
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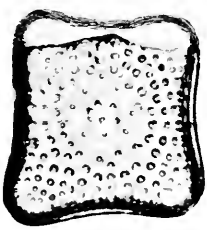
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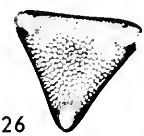
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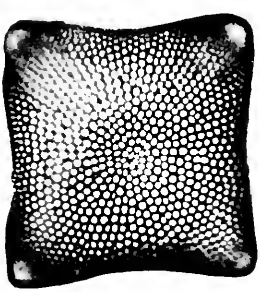
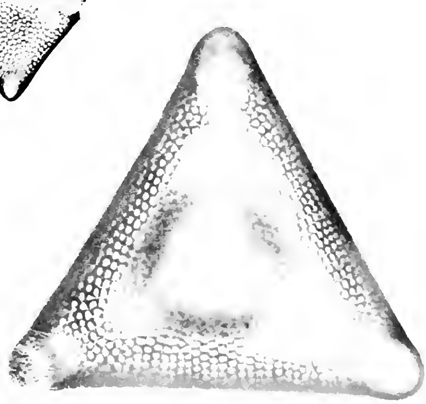

128a


128

Subfamily Triceratioideae Schütt, 1896 [17, 18]

Genus **Triceratium** Ehrenberg, 1840

The complex structure of the valve is profoundly different from anything observed in the genus *Biddulphia*. "The sides of the cell are usually straight, sometimes very slightly convex. The angles are furnished with a stout cornutate process. The valve surface is covered with a regular hexagonal loculation. The loculi are usually open upon the outer surface, while the lower wall or floor is furnished with poroids. The valve mantle is narrow. The girdle is always dimpled and finely punctate. Small spines are usually present on the valve surface at the point of confluence of the walls of the loculi; there are often developed at the margin of the valve and have the appearance of a palisade," according to Hendey (1937, p. 282).

Triceratium elegans Greville.

(Figures 114, 115.)

Amphitetras elegans Greville, 1866, pp. 8, 9, pl. 2, fig. 24.
Triceratium elegans Greville, *in* Schmidt, 1886, pl. 99, figs. 10-13.
Biddulphia elegans (Greville) Boyer, 1900, p. 717.
"Tr (Odontella) Grev. forma major."Grunow, *in* Van Heurck, pl. 109, fig. 1.

Geologic range. Late Miocene.

Triceratium favus Ehrenberg.

(Figure 124.)

Triceratium favus Ehrenberg, 1839, p. 159, pl. 4, fig. 10 [1841]. Hustedt, 1930, p. 798, figs. 462, 463. Hendey, 1937, pp. 283-284, pl. 10, figs. 2, 3.

Geologic range. Late Miocene to Recent.

Ecology. According to Hustedt (1928, p. 801) this species is "litoral in allen europäischen Meeren sehr verbreitet und häufig, oft weit flussaufwarts noch anzutreffen, ebenso in neritischen Plankton fast stets vorhanden."

Triceratium margaritiferum Cleve.

(Figure 125.)

Triceratium margaritiferum Cleve, 1881, p. 26, pl. 6, fig. 76. Schmidt, 1890, pl. 152, fig. 32.
Biddulphia penitens Hanna and Grant, 1926, p. 132, pl. 14, figs. 4, 5.

Geologic range. Late Miocene.

Triceratium montereyi Brightwell.

(Figures 122, 127, 128.)

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[17] Schütt, 1896, p. 56, as a subtribe Triceratinea.
[18] Hustedt, 1930, p. 56, new status and change of spelling.

Triceratium montereyi BRIGHTWELL, 1853, p. 251, pl. 4, fig. 18. MÖLLER, 1882, p. 143, pl. 22, figs. 9-11. WOLLE, 1894, pl. 102, fig. 2; pl. 107, figs. 6, 9.

GEOLOGIC RANGE. Late Miocene to Recent.

Triceratium quadrangulare Greville.

(Figure 128a.)

Triceratium quadrangulare GREVILLE, 1865, p. 10, pl. 2, fig. 26. SCHMIDT, 1885, pl. 81, fig. 3. WOLLE, 1894, pl. 106, fig. 8.

GEOLOGIC RANGE. Late Miocene.

Triceratium thumii Schmidt.

(Figure 129.)

Triceratium thumii SCHMIDT, 1886, pl. 93, fig. 2; 1888, pl. 126, fig. 1. PANTOCSEK, 1886, pl. 5, fig. 39.

GEOLOGIC RANGE. Late Miocene to Recent.

Genus **Lithodesmium** Ehrenberg, 1840

Lithodesmium californicum Grunow.

(Figure 130.)

Lithodesmium californicum GRUNOW, *in* Van Heurck, 1883, pl. 115, fig. 9. SCHMIDT, 1890, pl. 158, fig. 11.

GEOLOGIC RANGE. Late Miocene to early Pliocene.

Lithodesmium cornigerum Brun.

(Figure 131.)

Lithodesmium cornigerum BRUN, 1896, p. 239, pl. 24, figs. 15-17. HANNA, 1930, p. 189, pl. 14, figs. 9, 10.

GEOLOGIC RANGE. Early Pliocene to late Pliocene.

REMARKS. This diatom is shaped like a three-bladed propeller and it is probably one of the most distinctive diatoms from California fossil deposits. It seems to be an excellent indicator of Pliocene age inasmuch as it has been found in Pliocene rocks on the only four other occasions when found. It has not been found in the Monterey shale at its type area or at any other place.

Lithodesmium minusculum Grunow.

(Figure 132.)

Lithodesmium minusculum GRUNOW, *in* Van Heurck, 1883, pl. 16, figs. 1-5.
Lithodesmium minusculum forma *major* GRUNOW, *in* Van Heurck, 1883, pl. 116, fig. 6.

GEOLOGIC RANGE. Late Miocene to early Pliocene.

Subfamily ISTHMOIDEAE Schütt, 1896 [19, 20]

Genus **Isthmia** Agardh, 1832

Isthmia nervosa Kützing.

Isthmia nervosa KÜTZING, 1844, p. 137, pl. 19, fig. 5. CUPP, 1943, p. 166, fig. 116. HENDEY, 1964, p. 110, pl. XXV, fig. 3.

GEOLOGIC RANGE. Late Miocene to Recent.

ECOLOGY. This is an epiphytic littoral species. It occurs in the "plankton as tychopelagic species; widespread, but never abundant. Usually found in colder waters," according to Cupp (1943, p. 167).

Family ANAULACEAE Schütt, 1896 [21, 22]

Subfamily ANAULOIDEAE Heiden-Kolbe, 1928 [22a]

Genus **Porpeia** Bailey, 1961

Porpeia quadriceps Bailey.

(Figure 133.)

Porpeia quadriceps Bailey, RALFS *in* Pritchard, 1861, p. 850, pl. 6, fig. 6. MANN, 1907, p. 315. HANNA AND GRANT, 1926, p. 164, pl. 20, figs. 6, 7.

Porpeia quadriceps Bailey var. *intermedia* GRUNOW, *in* Van Heurck, 1882, pl. 95 bis, figs. 13, 14.

GEOLOGIC RANGE. Late Miocene.

Genus **Anaulus** Ehrenberg, 1844

Analus mediterraneus var. **intermedia** Grunow.

(Figure 134.)

Analus mediterraneus var. *intermedia* GRUNOW, *in* Van Heurck, 1882, pl. 102, fig. 9. HUSTEDT, 1930, p. 893, fig. 535.

GEOLOGIC RANGE. Late Miocene.

ECOLOGY. Inhabits littoral coasts of warm seas, according to Hustedt, (1930, p. 893).

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19 Schütt, 1896, p. 56, as a tribe Isthmiinae.

20 Hustedt, 1930, p. 56, new status and change of spelling.

21 Schütt, 1896, p. 56, as a tribe Anauleae.

22 Hustedt, 1930, p. 56, new status and change of spelling.

22a Heiden-Kolbe, 1928, p. 464.

Family Chaetoceraceae H. L. Smith, 1872 [23, 24]

Subfamily Chaetoceroideae Kolbe, 1927 [25]

Genus **Chaetoceros** Ehrenberg, 1844

Chaetoceros cinctus Gran.

(Figure 135.)

Chaetoceros cinctus Gran, 1897, p. 24, pl. 2, figs. 23-27.
Chaetoceros incurvus Bailey, 1854, p. 9, figs. 30-32.

Geologic range. Early Pliocene to Recent.

Ecology. According to Cupp (1943, p. 142) this is a neritic and south temperate species.

Chaetoceros subsecundus (Grunow) Hustedt.

(Figure 136.)

Syndendrium diadema Ehrenberg, 1854, pl. 35A, group 18, fig. 13.
Chaetoceros subsecundus (Grunow) Hustedt, 1930, p. 709, fig. 404.

Geologic range. Early Pliocene to Recent.

Ecology. According to Hustedt (1930, p. 710), this species is "Neritisch an den Küsten Europas bis ins Nördliche Eismer, auch im Mittelmeer von Pavillard und Forti beobachtet."

Genus **Periptera** Ehrenberg, 1845

Periptera species.

(Figures 137, 138.)

Geologic range. Early Pliocene to middle Pliocene.

Remarks. The central elevated area of the ovate valve bears about two to five thick but sharp spines. Long, sharp spines are also present along the narrow border.

This differs from the commonly known *Periptera tetracladia* in which the narrower central area lacks spines.

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23 H. L. Smith, 1872, p. 14, as a family Chaetocereae.

24 De-Toni, 1890, p. 920, change of spelling.

25 Kolbe, 1927, p. 31.

Figure 129. *Triceratium thumii* Schmidt. Hypotype no. 3782 (CAS), from locality 1277 (CAS), Monterey, California. Length 0.2253 mm.

Figure 130. *Lithodesmium californicum* Brun. Hypotype no. 3783 (CAS), from locality 866 (CAS), Monterey, California. Length 0.0520 mm.

Figure 131. *Lithodesmium cornigerum* Brun. Hypotype no. 3784 (CAS), from locality 27295-29 (CAS), Harris grade, Purisima Hills, Santa Barbara County, California. Length 0.0617 mm.

Figure 132. *Lithodesmium minusculum* Grunow. Hypotype no. 3785 (CAS), from locality 27295-7 (CAS), Harris grade, Purisima Hills, Santa Barbara County, California. Length 0.0362 mm.

Figure 133. *Porpeia quadriceps* Bailey. Hypotype no. 3786 (CAS), from locality 866 (CAS), Monterey, California. Length 0.1290 mm., breadth 0.0385 mm.

Figure 134. *Anaulus mediterraneus* var. *intermedia* Grunow. Hypotype no. 3787 (CAS), from locality 866 (CAS), Monterey, California. Length 0.0543 mm., breadth 0.0190 mm.

Figure 135. *Chaetoceros cintus* Gran. Hypotype no. 3788 (CAS), from locality 27295-7 (CAS), Harris grade, Purisima Hills, Santa Barbara County, California. Length 0.0261 mm.

Figure 136. *Chaetoceros subsecundus* (Grunow) Hustedt. Hypotype no. 3789 (CAS), from locality 27295-3 (CAS), Harris grade, Purisima Hills, Santa Barbara County, California. Length 0.0330 mm.

Figures 137, 138. *Periptera* new species. Hypotypes nos. 3790, 3791 (CAS), from locality 27295-122 (CAS), Harris grade, Purisima Hills, Santa Barbara County, California. Length 0.0262 mm.

Figure 139. *Xanthiopyxis diaphana* Forti. Hypotype no. 3792 (CAS), from locality 27295-3 (CAS), Harris grade, Purisima Hills, Santa Barbara County, California. Length 0.0445 mm., breadth 0.0329 mm.

Figure 140. *Xanthiopyxis diaphana* Forti. Hypotype no. 3793 (CAS), from locality 27295-3 (CAS), Harris grade, Purisima Hills, Santa Barbara County, California. Length 0.0438 mm., breadth 0.0229 mm.

Figures 141, 142. *Xanthiopyxis diaphana* Forti. Hypotype no. 3794 (CAS) from locality 27295-3 (CAS), Harris grade, Purisima Hills, Santa Barbara County, California. Length 0.0326 mm., breadth 0.0208 mm.

Figure 143. *Xanthiopyxis diaphana* Forti. Hypotype no. 3795 (CAS), from locality 27295-3 (CAS), Harris grade, Purisima Hills, Santa Barbara County, California. Length 0.0500 mm., breadth 0.0220 mm.

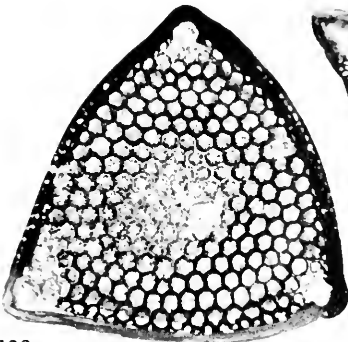
Figure 144. *Xanthiopyxis lacera* Forti. Hypotype no. 3796 (CAS), from locality 27295-7 (CAS), Harris grade, Purisima Hills, Santa Barbara County, California. Length 0.0700 mm., breadth 0.0479 mm.

Figure 145. *Xanthiopysis lacera* Forti. Hypotype no. 3797 (CAS), from locality 866 (CAS), Monterey, California. Length 0.0500 mm.

Figure 146. *Xanthiopyxis oblonga* Ehrenberg. Hypotype no. 3798 (CAS), from locality 866 (CAS), Monterey, California. Length 0.0370 mm., breadth 0.0170 mm.

Figures. 147, 148. *Xanthiopyxis oblonga* Ehrenberg. Hypotypes nos. 3799, 3800 (CAS), from locality 866 (CAS), Monterey, California. Length 0.0390 mm., breadth 0.0150 mm.

Figure 149. *Xanthiopyxis oblonga* Ehrenberg. Hypotype no. 3801 (CAS), from locality 866 (CAS), Monterey, California. Length 0.0230 mm.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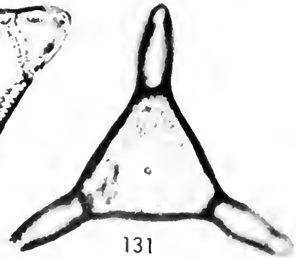
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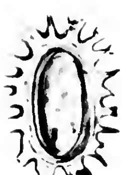
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Genus **Xanthiopyxis** Ehrenberg, 1845

Xanthiopyxis cingulata Ehrenberg.

Xanthiopyxis cingulata Ehrenberg, 1854, pl. 33, group 17, fig. 18. Hanna and Grant, 1926, pl. 21, no. 9 .

Geologic range. Late Miocene to late Pliocene.

Remarks. Valves circular with spines uniformly distributed over the surface and projecting outwardly from the border.

Xanthiopyxis diaphana Forti.

(Figures 139-143.)

Xanthiopyxis diaphana Forti, 1913, p. 1554, pl. 2, figs. 13, 19, 26.

Geologic range. Early Pliocene to middle Pliocene.

Remarks. This species is characterized by convex, hyaline, and ovate valves. The border is narrow and is entirely devoid of spines or beads.

Xanthopyxis lacera Forti.

(Figures 144, 145.)

Xanthiopyxis lacera Forti, 1913, p. 1555, pl. 2, figs. 14-18.

Geologic range. Late Miocene to early Pliocene.

Xanthiopyxis oblonga Ehrenberg.

(Figures 146-149.)

Xanthiopyxis oblonga Ehrenberg, 1854, pl. 33, gr. 17, fig. 17. Forti, 1913, p. 1554, pl. 2, fig. 38.

Geologic range. Late Eocene to Recent.

Xanthiopyxis ovalis Lohman.

(Figures 150-152.)

Xanthiopyxis ovalis Lohman, 1938, p. 91, pl. 20, fig. 6; pl. 22, fig. 12.

Geologic range. Pliocene.

Remarks. This species is characterized by a distinct oval-shaped valve, and by spines never projecting beyond the margin of the valve. According to Lohman (1938, p. 91) this species is confined to the Pliocene.

Xanthiopyxis umbonata (Greville).

(Figure 153.)

"*Xanthiopyxis ? umbonatus* n. sp., Grev.", 1886, p. 2, pl. 1, fig. 5.
Xanthiopyxis ? umbonata Greville, 1894, p. 1156.

GEOLOGIC RANGE. Late Miocene.

REMARKS. This species was originally described from the "Monterey deposit" by Greville.

Xanthiopyxis sp. A.

(Figures 154, 154a.)

GEOLOGIC RANGE. Early Pliocene to middle Pliocene.

REMARKS. Valves are ovate, convex, with the central hyaline area having a central blunt protuberance. Short, sharp spines surround the central zone in a somewhat radial pattern, decrease toward the border and do not project beyond the border.

Xanthiopyxis sp. B.

(Figure 156.)

GEOLOGIC RANGE. Early Pliocene to middle Pliocene.

REMARKS. Valves are ovate, convex, with a hyaline center area marked with a few irregularly arranged beads. The narrow border is marked with a single row of beads.

Xanthiopyxis sp. C.

(Figures 157, 158.)

GEOLOGIC RANGE. Early Pliocene.

REMARKS. Valves convex, hyaline and ovate. The border is characterized by a row of beads.

Xanthiopyxis sp. D.

(Figures 155, 155a.)

GEOLOGIC RANGE. Miocene to Pliocene.

REMARKS. This dome-shaped species with dense spines is common in collections of the above stated geologic range.

Family RUTILARIACEAE Pantocsek, 1889[26, 27]

Subfamily RUTILARIODEAE Boyer, 1916[28]

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26 Pantocsek, 1889, p. 74, as a family Rutilariae.

27 De-Toni, 1894, p. 1020, change of spelling.

28 Boyer, 1916, p. 13.

Genus **Rutilaria** Greville, 1863

Rutilaria epsilon (Kitton) Greville.

(Figure 159.)

Nitzschia epsilon Kitton, 1863, p. 228 [as synonym].
Rutilaria epsilon (Kitton) Greville, 1863, p. 228, pl. 9, fig. 1. Hanna, 1928, pl. 8, fig. 3.

Geologic range. Late Miocene.

Suborder Rhizosoleniineae Hendey, 1964 [29]
Family Bacteriastraceae Lebour, 1930 [30, 31]
Subfamily Bacteriastroideae Hendey, 1937 [32]

Genus **Bacteriastrum** Shadbolt, 1854

Bacteriastrum delicatulum Cleve.

Bacteriastrum delicatulum Cleve, 1897, p. 298, fig. 15. Schmidt, 1920, pl. 328, fig. 609.

Geologic range. Early Pliocene to Recent.

Ecology. According to Hendey (1964, p. 139), this is "An oceanic form, common in temperate waters."

Bacteriastrum varians Lauder.

Bacteriastrum varians Lauder, 1863, p. 8, pl. 3, figs. 1-6. Hendey, 1937, p. 308.

Geologic range. Early Pliocene to Recent.

Ecology. This oceanic species is found commonly in tropical waters, according to Hendey (1937, p. 308).

Suborder Fragilariineae Hendey, 1964 [33]
Family Fragilariaceae Kützing, 1844 [34, 35]
Subfamily Fragilarioideae Schütt, 1896 [36]

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29 Hendey, 1964, p. 57.
30 Lebour, 1930, p. 23, as a family Bacteriastraceae.
31 Hendey, 1937, p. 204, new status and change of spelling.
32 Hendey, 1937, p. 204
33 Hendey, 1964, p. 57
34 Kützing, 1844, pp. 32, 42, as a family Fragilarieae.
35 De-Toni, 1890, p. 893, new status and change of spelling.
36 Schütt, 1896, p. 117.

Genus **Glyphodesmis** Greville, 1862

Glyphodesmis sigmoideus Hanna and Grant.

Glyphodesmis sigmoideus Hanna and Grant, 1926, p. 145, pl. 16, fig. 10.

Geologic range. Late Miocene.

Glyphodesmis williamsonii (W. Smith) Grunow.

(Figure 160.)

Himantididium ? williamsonii, W. Smith, 1856, p. 14, pl. 33, fig. 287.
Glyphodesmis williamsonii (W. Smith). Grunow, 1880, pl. 36, fig. 14; Hustedt, 1931, p. 124, figs. 646 a-c.

Geologic range. Late Miocene.

Ecology. According to Hustedt (1931, p. 125) this species is "Im Litoral der europäischen Küsten überall verbreitet, aber nur im Mittelmeergebiet häufiger vorkommend."

Genus **Opephora** Petit, 1880

Opephora schwartzii (Grunow) Petit.

(Figures 161-165.)

Fragilaria schwartzii Grunow, 1863, p. 143.
Opephora schwartzii (Grunow) Petit, *in* Pelletan, 1889, p. 88; Boyer, 1916, pl. 10, figs. 16, 19.

Geologic range. Late Miocene to Recent.

Ecology. According to Hendey (1964, p. 159), this species is a "Marine littoral, not common, but occurring on the west coasts of the British Isles."

Genus **Plagiogramma** Greville, 1859

Plagiogramma antillarum Cleve.

(Figures 166, 167.)

Plagiogramma antillarum Cleve, 1878, p. 10, pl. 3, fig. 16; Mann, 1925, p. 129, pl. 29, fig. 1.

Geologic range. Late Miocene.

Ecology. Found living in chains.

Plagiogramma attenuatum Cleve.

(Figure 168.)

Plagiogramma attenuatum Cleve, 1878, p. 10, pl. 3, fig. 18; Mann, 1925, p. 129, pl. 29, fig. 2.

Geologic range. Late Miocene.

Figures 150, 151. *Xanthiopyxis ovalis* Lohman. Hypotypes nos. 3802, 3803 (CAS), from locality 27295-122 (CAS), Harris grade, Purisima Hills, Santa Barbara County, California. Length 0.0336 mm.

Figure 152. *Xanthiopyxis ovalis* Lohman. Hypotype no. 3804 (CAS), from locality 27295-7 (CAS), Harris grade, Purisima Hills, Santa Barbara County, California. Length 0.0257 mm.

Figure 153. *Xanthiopyxis umbonata* (Greville). Hypotype no. 3805 (CAS), from locality 866 (CAS), Monterey, California. Length 0.0421 mm.

Figure 154. *Xanthiopyxis* new species A. Hypotype no. 3806 (CAS), from locality 27295-7 (CAS), Harris grade, Purisima Hills, Santa Barbara County, California. Length 0.0378 mm.

Figure 154a. *Xanthiopyxis* new species A. Hypotype no. 3807 (CAS), from locality 27295-7 (CAS), Harris grade, Purisima Hills, Santa Barbara County, California. Length 0.0426 mm.

Figures 155, 155a. *Xanthiopyxis* new species D. Hypotypes nos. 3808, 3809 (CAS), from locality 27295-7 (CAS), Harris grade, Purisima Hills, Santa Barbara County, California. Length 0.0400 mm.

Figure 156. *Xanthiopyxis* new species B. Hypotype no. 3810 (CAS), from locality 27295-7 (CAS), Harris grade, Purisima Hills, Santa Barbara County, California. Length 0.0230 mm., breadth 0.0100 mm.

Figure 157. *Xanthiopyxis* new species C. Hypotype no. 3811 (CAS), from locality 27295-7 (CAS), Harris grade, Purisima Hills, Santa Barbara County, California. Length 0.0272 mm., breadth 0.0083 mm.

Figure 158. *Xanthiopyxis* new species C. Hypotype no. 3812 (CAS), from locality 27295-7 (CAS), Harris grade, Purisima Hills, Santa Barbara County, California. Length 0.0162 mm., breadth 0.0032 mm.

Figure 159. *Rutilaria epsilon* (Kitton) Greville. Hypotype no. 3095 (CAS), from locality 866 (CAS), Monterey, California. Length 0.1516 mm., breadth 0.0250 mm.

Figure 160. *Glyphodesmis williamsonii* (W. Smith) Grunow. Hypotype no. 3813 (CAS), from locality 866 (CAS), Monterey, California. Length 0.0860 mm.

Figure 161. *Opephora schwartzii* (Grunow) Petit. Hypotype no. 3814 (CAS), from locality 866 (CAS), Monterey, California. Length 0.0610 mm., breadth 0.0140 mm.

Figure 162. *Opephora schwartzii* (Grunow) Petit. Hypotype no. 3815 (CAS), from locality 27295-7 (CAS), Harris grade, Purisima Hills, Santa Barbara County, California. Length 0.0282 mm.

Figure 163. *Opephora schwartzii* (Grunow) Petit. Hypotype no. 3816 (CAS), from locality 866 (CAS), Monterey, California. Length 0.0310 mm.

Figure 164. *Opephora schwartzii* (Grunow) Petit. Hypotype no. 3817 (CAS), from locality 866 (CAS), Monterey, California. Length 0.0432 mm.

Figure 165. *Opephora schwartzii* (Grunow) Petit. Hypotype no. 3818 (CAS), from locality 866 (CAS), Monterey, California. Length 0.0452 mm.

Figures 166, 167. *Plagiogramma antillarum* Cleve. Hypotypes nos. 3819, 3820 (CAS), from locality 866 (CAS), Monterey, California. Length 0.0910 mm., breadth 0.0170 mm.

Figure 168. *Plagiogramma attenuatum* Cleve. Hypotype no. 3821 (CAS), from locality 866 (CAS), Monterey, California. Length 0.1800 mm.

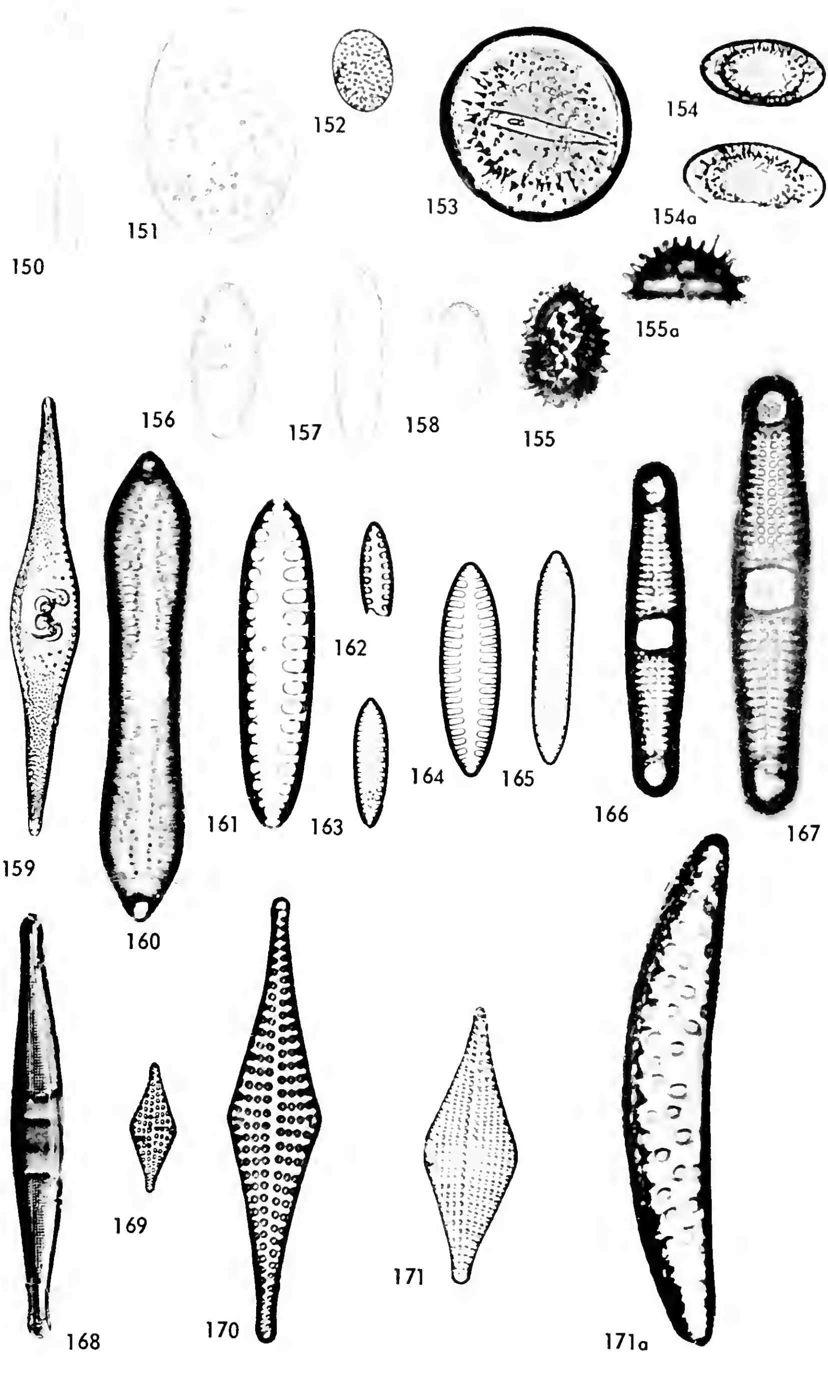
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Figure 169. *Rhaponeis amphiceros* var. *angularis* (Lohman). Hypotype no. 3822 (CAS), from locality 27295-7 (CAS), Harris grade, Purisima Hills, Santa Barbara County, California. Length 0.0383 mm.

Figure 170. *Rhaphoneis amphiceros* var. *angularis* (Lohman). Hypotype no. 3823 (CAS), from locality 27295-7 (CAS), Harris grade, Purisima Hills, Santa Barbara County, California. Length 0.0750 mm.

Figure 171. *Rhaphoneis elegans* Pantocsek and Grunow. Hypotype no. 3824 (CAS), from locality 27295-122 (CAS), Harris grade, Purisima Hills, Santa Barbara County, California. Length 0.0336 mm.

Figure 171a. *Leudugeria janischii* (Grunow). Hypotype no.3824a (CAS), from locality 866 (CAS), Monterey, California.

Genus **Rhaphoneis** Ehrenberg, 1845

Rhaphoneis amphiceros var. **angularis** (Lohman).

(Figures 169, 170.)

Rhaphoneis angularis Lohman, 1938, pl. 22, figs. 6-8.
Rhaphoneis amphiceros Ehrenberg, Peragallo, 1901, pl. 83, fig. 19.
Rhaphoneis rhombus Ehrenberg, Hanna, 1951, p. 283, fig. 2 (6).

Geologic range. Early Pliocene to late Pliocene.

Rhaphoneis amphiceros var. **elongata** Peragallo.

Rhaphoneis amphiceros var. *elongata* Peragallo, 1901, pl. 33, fig. 10.

Geologic range. Early Pliocene.

Rhaphoneis elegans Pantocsek and Grunow.

(Figure 171.)

Rhaphoneis gemmifera var. *elegans* Pantocsek and Grunow, *in* Pantocsek, 1886, p. 34, pl. 2, fig. 21; pl. 20, fig. 179; pl. 27, fig. 264; pl. 30, fig. 317.
Rhaphoneis elegans Pantocsek and Grunow, Hanna, 1932, p. 213, pl. 15, figs. 5-7.

Geologic range. Middle Miocene to early Pliocene.

Remarks. This species is distinguished by the straight rows of punctae and the expanded central portion of the valve.

Rhaphoneis parlis Hanna.

Rhaphoneis parlis Hanna, 1932, p. 214, pl. 16, figs. 2-4. Lohman, 1948, p. 182, pl. 11, fig. 10.

Geologic range. Early Miocene to middle Pliocene.

Genus **Thalassionema** Hustedt, 1932

According to Hendey (1964, p. 165), " The genus *Thalassionema* has often been attributed to Grunow because of the explanatory note made by him upon pl. 43 of Van Heurck's Synopsis (1880-85) under *Thalassiothrix nitzschioides* Grun. which was as follows: - 'On pourrait peut-être en créer un nouveau genre nommé *Thalassionema*.

"Owing to the fact that Grunow did not definitely accept this as a new genus, his publication of this name must be ruled as invalid. The authority is attributed to Hustedt who gave a full generic description followed by a description of *Thalassionema nitzschioides*."

Thalassionema nitzschioides (Grunow).

Synedra nitzschioides GRUNOW, 1862, p. 403.
Thalassionema nitzschioides (Grunow) PERAGALLO, 1901, p. 320, pl. 83, figs. 17, 18; HUSTEDT, 1932, p. 244, fig. 725.
"*Thalassiothrix ?? nitzschioides* Grun (Synedra Grun 1.c)", *in* Van Heurck, 1881, pl. 43, figs. 7-10.

GEOLOGIC RANGE. Early Pliocene to Recent.

ECOLOGY. This is a neritic and north temperate species, according to Cupp (1943, p. 183).

Subfamily TABELLARIOIDEAE Kützing, 1844 [37, 38]

Genus **Rhabdonema** Kützing, 1844

Rhabdonema biquadratum Brun.

(Figures 172-175.)

Rhabdonema biquadratum BRUN, 1889, p. 52, pl. 1, fig. 5. SCHMIDT, 1899, pl. 218, figs. 2-6. HANNA, 1928, pl. 8, fig. 1.

GEOLOGIC RANGE. Late Miocene.

Rhabdonema japonicum var. **sparsicostatum** Tempère and Brun.

(Figure 176.)

Rhabdonema japonicum var. *sparsicostatum* TEMPÈRE AND BRUN, 1889, p. 53. SCHMIDT, 1899, pl. 218, figs. 13-18.

GEOLOGIC RANGE. Late Miocene.

Genus **Leudugeria** Tempère, 1893

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37 Kützing, 1844, pp. 119, 126, as a family Tabellariceae.

38 Karsten, 1905, p. 396, new status and change of spelling.

Leudugeria janischii (Grunow).

(Figure 171a.)

Epithema ? sp. LEUDUGER FORTMOREL, Cat. Diat. Ceylon, 1879, p. 23, pl. 9, fig. 87.
Leudugeria janischii GRUNOW, *in* Van Heurck, Treat. Diat. 1896, p. 539, fig. 287.
Euodia janischii GRUNOW, *in* Van Heurck, Diat. Belgique, 1883, pl. 127, figs. 1-4.
Leudugeria epithemoides TEMPÈRE, Le Diatomiste, vol. 2, p. 17, 1893.

GEOLOGIC RANGE. This species was first discovered living in the western Pacific and southward, but it is also found frequently in the upper Miocene of California.

Genus **Entopya** Ehrenberg, 1848

Entopya australis var. **gigantea** (Greville).

(Figures 177-180.)

Gephyra gigantea GREVILLE, 1866, p. 122, pl. 11, figs. 7, 8.
Entopya australis var. *gigantea* (Greville), FRICKE, *in* Schmidt, 1902, pl. 230, figs. 1-11.

GEOLOGIC RANGE. Late Miocene.

Suborder ACHNANTHINEAE Hendey, 1964 [39]
Subfamily COCCONEIOIDEAE Kützing, 1844 [40, 41]

Genus **Cocconeis** Ehrenberg, 1838

Cocconeis decipiens Cleve.

(Figure 181.)

Cocconeis decipiens CLEVE, 1873, p. 14, pl. 1, fig. 6. HUSTEDT, 1933, pp. 353-354, fig. 808.
Cocconeis sigma PANTOCSEK, 1886, p. 32, pl. 8, fig. 68.
Cocconeis dirupta var. *sigma* CLEVE, 1895, p. 176.
Cocconeis oculus catis Brun, HANNA, 1951, p. 284, fig. 3 (13).

GEOLOGIC RANGE. Pliocene to Recent.

ECOLOGY. According to Hustedt (1933, p. 354), this is a "Litorale Meeresform, rezent bisher nur selten beobachtet; im Gebiet Europas bei Olenij im Weissen Meer!"

Cocconeis triumphis Hanna and Grant.

(Figure 182.)

Cocconeis triumphis HANNA AND GRANT, 1926, p. 135, pl. 14, figs. 11-13.

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[39] Hendey, 1964, p. 57.

[40] Kützing, 1844, p. 70, as a family Cocconeideae.

[41] Kolbe, 1927, p. 29, new status and change of spelling.

Cocconeis vitrea Brun.

(Figures 183, 184.)

Cocconeis vitrea Brun, 1891, p. 19, pl. 18, fig. 2. Cleve, 1894, p. 177. Schmidt, 1894, pl. 194, figs. 10, 11.

Geologic range. Late Miocene.

Suborder Naviculineae Hendey, 1964 [42]
Family Naviculaceae Kützing, 1844 [43, 44]
Subfamily Naviculoideae Schütt, 1896 [45]

Genus **Navicula** Bory, 1822

Navicula hennedyi W. Smith.

(Figures 187, 188.)

Navicula hennedyi W. Smith, 1856, p. 93. Schmidt, 1875, pl. 3, fig. 18. Cleve, 1894, p. 57. Hustedt, 1964, pp. 453-454, figs. 1516, b, c, e-h.

Geologic range. Late Miocene to Recent.

Ecology. According to Hendey (1964, p. 213) this species is "A common littoral species on almost all European coasts."

Remarks. This species is distinguished by its broad lateral areas, semi-lanceolate, with parallel interior margins.

Navicula hennedyi var. **californica** (Greville) Cleve.

(Figure 186.)

Navicula californica Greville, 1859, p. 248, pl. 5, fig. 5.
Navicula hennedyi var. *californica* (Greville) Cleve, 1895, p. 58.
Navicula hennedyi forma *californica* (Greville) Cleve, Hustedt, 1964, p. 458, fig. 1520 [The figure is labeled "*Navicula Hennedyi* var. *californica*."]

Navicula hennedyi var. **granulata** Grunow.

(Figure 185.)

Navicula hennedyi var. *granulata* Grunow, *in* Schmidt, 1874, pl. 3, fig. 3.
"*Navicula Hennedyi* forma *granulata* Grunow, *in* A. S. Atl." Hustedt, 1964, p. 458, figs. 1519, a, b.

Geologic range. Late Miocene.

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42 Hendey, 1964, p. 58.

43 Kützing, 1844, pp. 70, 88, as a family Naviculaea.

44 Rabenhorst, 1853, pp. ix, 9, 36, change of spelling.

45 Schütt, 1896, pp. 57, 122.

Navicula lyra Ehrenberg.

(Figures 189, 190, 192.)

Navicula lyra Ehrenberg, 1843, p. 419, pl. 1, fig. 9a. Hendey, 1937, p. 344.

Geologic range. Oligocene to Recent.

Ecology. Lebour (1930, p. 209) records this species from "Brackish water." It has been recorded from "on the mud" in Chichester Harbour, by Hendey (1951, p. 50). He states (1957, p. 69) that this species is widely distributed in tropical and temperate seas. According to Hendey (1964, p. 209) this species is "Common littoral species on all British coasts and all coasts of the countries bordering the North Sea. The species favours a fairly high salinity and clean seawater, without pollution or excess organic material."

Remarks. In reference tothe taxonomy of this species, Hendey (1937, p. 345) states that "in dealing with this species the multiplication of varieties and forms serves no useful purpose, and that we are called upon to regard the problem from a wider aspect."

Figure 172. *Rhabdonema biquadratum* Brun. Hypotype no. 3825 (CAS), from locality 866 (CAS), Monterey, California. Length 0.0930 mm., breadth 0.0320 mm.

Figurf 173. *Rhabdonema biquadratum* Brun. Hypotype no. 3826 (CAS), from locality 866 (CAS), Monterey, California. Length 0.0870 mm.

Figure 174. *Rhabdonema biquadratum* Brun. Hypotype no. 3827 (CAS), from locality 866 (CAS), Monterey, California. Length 0.1236 mm., breadth 0.0340 mm.

Figure 175. *Rhabdonema biquadratum* Brun. Hypotype no. 3828 (CAS), from locality 866 (CAS), Monterey, California. Length 0.1420 mm.

Figure 176. *Rhabdonema japonicum* var. *sparsicosatum* Tempère and Brun. Hypotype no. 3829 (CAS), from locality 866 (CAS), Monterey, California. Length 0.059 mm.

Figure 177. *Entopya australis* var. *gigantea* (Greville). Hypotype no. 3830 (CAS), from locality 866 (CAS), Monterey, California. Length 0.1700 mm.

Figure 178. *Entopya australis* var. *gigantea* (Greville). Hypotype no. 3830 (CAS), from locality 866 (CAS), Monterey, California. Length 0.1700 mm. Same specimen as figure 177.

Figure 179. *Entopya australis* var. *gigantea* (Greville). Hypotype no. 3831 (CAS), from locality 1277 (CAS), Monterey, California. Length 0.1460 mm.

Figure 180. *Entopya australis* var. *gigantea* (Greville). Hypotype no. 3832 (CAS), from locality 866 (CAS), Monterey, California. Length 0.163 mm.

Figure 181. *Cocconeis decipiens* Cleve. Hypotype no. 3833 (CAS), from locality 866 (CAS), Monterey, California. Length 0.1074 mm.

Figure 182. *Cocconeis triumphis* Hanna and Grant. Hypotype no. 3834 (CAS), from locality 866 (CAS), Monterey, California. Length 0.1341 mm.


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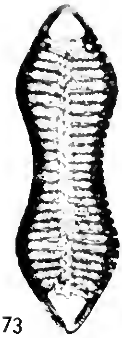
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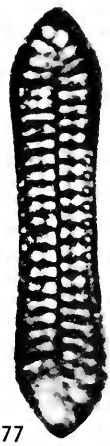
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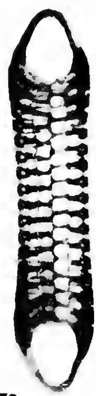
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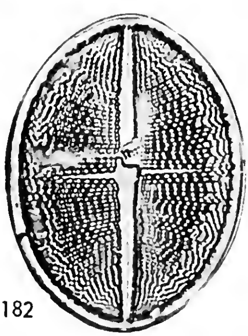
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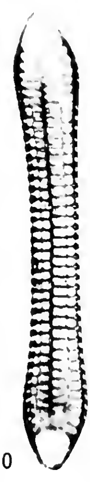
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Navicula optima Hanna.

(Figure 193.)

Navicula optima Hanna, 1932, p. 202, pl. 13, fig. 6.

Geologic range. Oligocene to Recent.

Navicula powellii var. **vidovichi** (Grunow) Cleve.

(Figure 194.)

Navicula vidovichi Grunow, 1863, p. 150, pl. 13, fig. 4. Hanna and Grant, 1926, p. 158, pl. 19, fig. 5.
Navicula powellii var. *vidovichi* (Grunow) Cleve, 1894, p. 63.

Geologic range. Late Miocene to Recent.

Navicula praetexia (Ehrenberg) Gregory.

(Figures 195-197.)

Pinnularia praetexia Ehrenberg, 1840, p. 214.
Navicula praetexia (Ehrenberg) Gregory, 1857, p. 481, pl. 1, fig. 11, Schmidt, 1875, pl. 3, figs. 31-34. Cleve, 1894, p. 55.

Geologic range. Late Miocene to Recent.

Ecology. According to Hendey (1964, p. 213) this species is "Littoral on the coasts of Scotland, Norway, west coast of Ireland and occasionally in the North Sea."

Navicula praetexia var. **abundans** Schmidt.

(Figures 198, 199.)

Navicula praetexia var. *abundans* Schmidt, pl. 129, fig. 8.
"*Navicula abundans* Schmidt." Hanna, 1928, p. 8, fig. 5.

Geologic range. Late Miocene.

Navicula spectabilis Gregory.

(Figure 191.)

Navicula spectabilis Gregory, 1857, p. 481, pl. 9, fig. 10. Hustedt, 1964, pp. 474-475, fig. 1532.
Navicula spectabilis Greville var. ? Schmidt, 1874, pl. 2, fig. 31; pl. 3, fig. 29.

Geologic range. Middle Miocene to late Miocene.

Navicula spectabilis var. **excavata** (Greville) Cleve.

(Figure 200.)

Navicula excavata Greville, 1866, p. 130, pl. 12, fig. 15.
Navicula spectabilis var. *excavata* (Greville) Cleve, 1895, p. 61. Hustedt, 1964, p. 478, figs. 1536, a, b.
Navicula oswaldii var. *hungarica* Pantocsek, 1889, pl. 25, fig. 370.

Geologic range. Late Miocene.

Genus **Diploneis** Ehrenberg, 1844

Diploneis bombus (Ehrenberg) Cleve.

Pinnularia bombus EHRENBERG, 1844, p. 84.
Diploneis bombus (Ehrenberg) CLEVE, 1894, p. 90. HENDEY, 1951, p. 58, pl. 8, figs. 7, 8; HENDEY, 1964, p. 227, pl. XXXII, fig. 2.

GEOLOGIC RANGE. Pliocene to Recent.

ECOLOGY. Hendey (1951, p. 12) reports this species from the "mud flora in Chichester Harbour" (diatoms living upon the surface of mud or slime and well within the influence of sunlight). On page 8 of the same paper, he lists this species as being "solitary" in habit.

Diploneis crabro Ehrenberg.

(Figure 201.)

Diploneis crabro EHRENBERG, 1844, p. 85. CLEVE, 1894, pp. 100-102. HANNA, 1951, p. 284, fig. 3 (8). HENDEY, 1964, p. 225, pl. XXXII, figs. 1-3.

GEOLOGIC RANGE. Late Miocene.

ECOLOGY. According to Hendey (1964, p. 225), this species is "A marine species favouring a high salinity."

REMARKS. Valves solitary, panduriform, strongly costate with elliptic cuneate segments. The very narrow furrows are bordered by a line of large puncta. The central nodule is quadrate or subcircular extended to produce parallel horns.

Diploneis exemta (Schmidt) Cleve.

(Figure 202.)

Navicula exemta SCHMIDT, 1875, pl. 11, figs. 28, 29.
Diploneis exemta (Schmidt) CLEVE, 1894, p. 86.

GEOLOGIC RANGE. Late Miocene.

Diploneis major Cleve.

(Figures 203, 204.)

Diploneis major CLEVE, 1894, p. 96.
Navicula smithii SCHMIDT, 1875, pl. 7, figs. 18, 19, 21, 22.

GEOLOGIC RANGE. Late Miocene to Recent.

Diploneis ornata (Schmidt) Cleve.

(Figure 205.)

Navicula ornata SCHMIDT, 1881, pl. 69, fig. 5. HANNA, 1928, pl. 8, fig. 6.
Diploneis ornata (Schmidt) CLEVE, 1894, p. 102.

GEOLOGIC RANGE. Late Miocene.

Diploneis ornata var. **spinifera** (Schmidt) Cleve.

(Figures 206-208, 210, 211.)

Navicula ornata var. *spinifera* Schmidt, 1882, pl. 174, fig. 25.
Diploneis ornata var. *spinifera* (Schmidt) Cleve, 1894, p. 102.

Geologic range. Late Miocene.

Diploneis smithi (Brébisson) Cleve.

Navicula smithi Brébisson, *in* W. Smith, 1856, p. 92.
Diploneis smithi (Brébisson) Cleve, 1894, p. 96. Hustedt, 1937, p.647, fig. 1051.

Geologic range. Late Miocene to Recent.

Ecology. Hustedt (1937, p. 650) states that this species is "Im allen Meeren verbreitet und häufig, auch in schwach salzigen Gewässern des Binnenlandes hier und da auftretend, insbesondere in der Nähe der Küstengebiete. Euryhalin." According to Hendey (1964, p. 225), this species is "A widely-spread species, common in brackish and marine conditions."

Diploneis taschenbergeri (Schmidt) Hustedt.

(Figure 209.)

Navicula taschenbergeri Schmidt, 1892, pl. 174, fig. 9.
Diploneis taschenbergeri (Schmidt), Hustedt, 1937, p. 715, fig. 1090.

Geologic range. Late Miocene.

Figure 183. *Cocconeis vitrea* Brun. Hypotype no. 3835 (CAS), from locality 1277 (CAS), Monterey, California. Length 0.0700 mm., breadth 0.064 mm.

Figure 184. *Cocconeis vitrea* Brun. Hypotype no. 3836 (CAS), from locality 866 (CAS), Monterey, California. Length 0.0620 mm., breadth 0.0430 mm.

Figure 185. *Navicula hennedyi* var. *granulata* Grunow. Hypotype no. 3837 (CAS), from locality 866 (CAS), Monterey, California. Length 0.0550 mm., breadth 0.0340 mm.

Figure 186. *Navicula hennedyi* var. *californica* (Greville) Cleve. Hypotype no. 3838 (CAS), from locality 866 (CAS), Monterey, California. Length 0.0510 mm.

Figure 187. *Navicula hennedyi* W. Smith Hypotype no. 3839 (CAS), from locality 866 (CAS), Monterey, California. Length 0.0710 mm.

Figure 188. *Navicula hennedyi* W. Smith. Hypotype no. 3840 (CAS), from locality 866 (CAS), Monterey, California. Length 0.0700 mm.

Figure 189. *Navicula lyra* Ehrenberg. Hypotype no. 3841 (CAS), from locality 866 (CAS), Monterey, California. Length 0.0700 mm., breadth 0.0260 mm.

Figure 190. *Navicula lyra* Ehrenberg. Hypotype no. 3842 (CAS), from locality 866 (CAS), Monterey, California. Length 0.0745 mm., breadth 0.0450 mm.

Figure 191. *Navicula spectabilis* Gregory. Hypotype no. 3843 (CAS), from locality 866 (CAS), Monterey, California. Length 0.0720 mm.

Figure 192. *Navicula lyra* Ehrenberg. Hypotype no. 3844 (CAS), from locality 866 (CAS), Monterey, California. Length 0.0970 mm., breadth 0.0440 mm.


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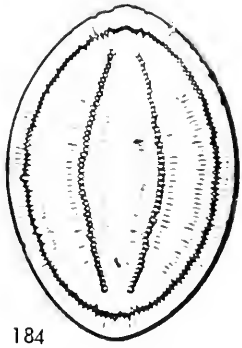
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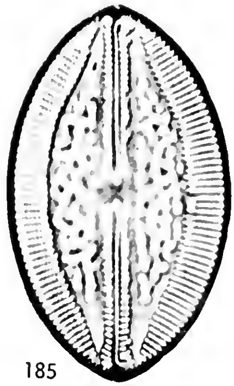
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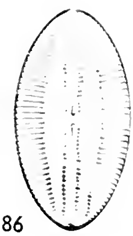
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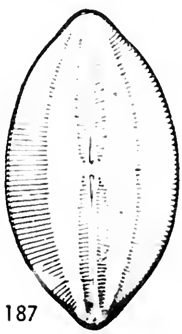
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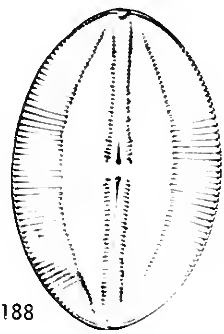
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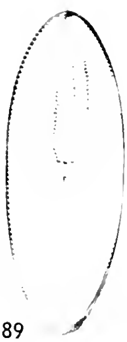
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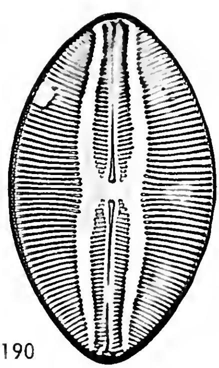
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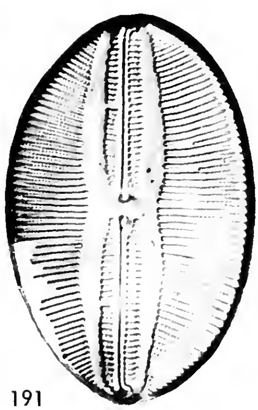
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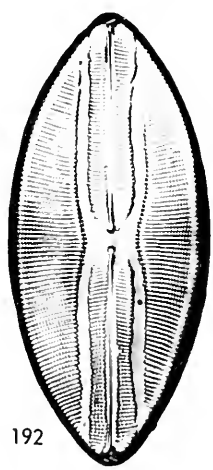
192

Family Bacillariaceae Lagerstedt, 1876 [46]
Subfamily Nitzschioideae Grunow, 1862 [47, 48]

Genus **Nitzschia** Hassall, 1845

Nitzschia pliocena (Brun), new combination.

(Figures 212, 213.)

Fragilaria pliocena Brun, 1891, p. 28, pl. 14, fig. 7. Reinhold, 1937, p. 104, pl. 12, fig. 18.

Geologic range. Early Pliocene to middle Pliocene.

Genus **Mastogloia** Thwaites, 1856

Mastogloia splendida (Gregory) Cleve.

(Figures 214-216.)

Cocconeis splendida Gregory, 1857, p. 493, pl. 9, fig. 29.
Mastogloia splendida (Gregory) Cleve. Hustedt, 1933, p. 463, fig. 883. Hendey, 1964, p. 237.
Orthoneis splendida (Gregory) Grunow, 1868, p. 15. Hanna and Grant, 1926, p. 160, pl. 19, fig. 6.

Geologic range. Late Miocene to early Pliocene.

Figure 193. *Navicula optima* Hanna. Hypotype no. 3845 (CAS), from locality 866 (CAS), Monterey, California. Length 0.0465 mm.

Figure 194. *Navicula powelli* var. *vidovichi* (Grunow) Cleve. Hypotype no. 3846 (CAS), from locality 866 (CAS), Monterey, California. Width 0.0130 mm.

Figure 195. *Navicula praetexta* (Ehrenberg) Gregory. Hypotype no. 3847a (CAS), from locality 27295-128 (CAS), Harris grade, Purisima Hills, Santa Barbara County, Length 0.2430 mm.

Figure 196. *Navicula praetexta* (Ehrenberg) Gregory. Hypotype no. 3847 (CAS), from locality 866 (CAS), Monterey, California. Width 0.0130 mm.

Figure 197. *Navicula praetexta* (Ehrenberg) Gregory. Hypotype no. 3848 (CAS), from locality 866 (CAS), Monterey, California. Length 0.0960 mm.

Figure 198. *Navicula praetexta* var. *abundans* Schmidt. Hypotype no. 3096 (CAS), from locality 866 (CAS), Monterey, California. Length 0.1380 mm.

Figure 199. *Navicula praetexta* var. *abundans* Schmidt. Hypotype no. 3849 (CAS), from locality 866 (CAS), Monterey, California. Length 0.1468 mm.

Figure 200. *Navicula spectabilis* var. *excavata* (Greville) Cleve. Hypotype no. 3850 (CAS), from locality 866 (CAS), Monterey, California. Length 0.1000 mm., breadth 0.0620 mm.

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46 Lagerstedt, 1876, p. 205.

47 Grunow, 1862, p. 321, 545, as a subfamily Nitzschieae.

48 Schütt, 1896, p. 142, new status and change of spelling.

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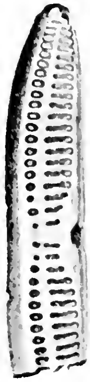

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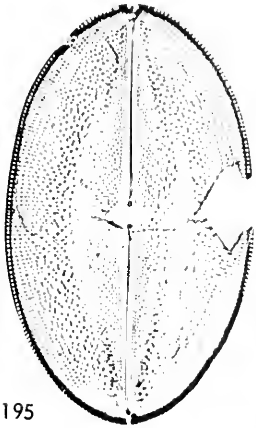

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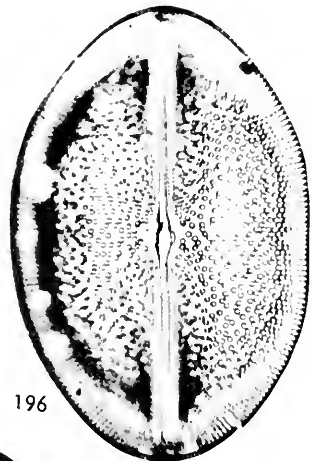

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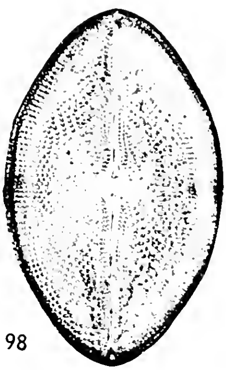

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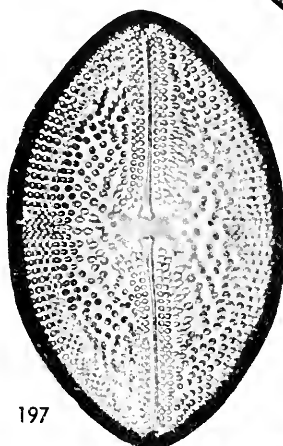

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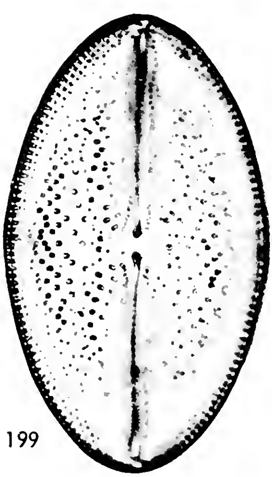

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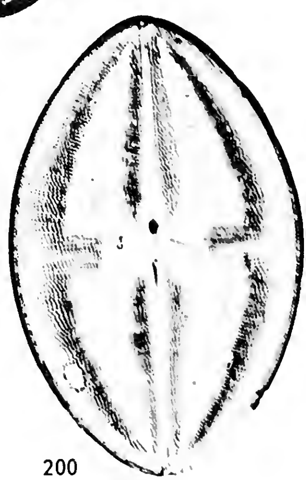

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Genus **Rouxia** Brun and Heribaud, 1893

Rouxia californica Peragallo.

(Figure 217.)

Rouxia californica PERAGALLO, *in* Tempère and Peragallo, 1910, p. 245. HANNA, 1930, p. 186-188, pl. 14, figs. 6, 7.

GEOLOGIC RANGE. Late Miocene.

ECOLOGY. "The presence of a species of the genus *Rouxia* at Lompoc, California, among a definitely pelagic flora, indicates that the entire genus may have been pelagic," according to Hanna (1930, p. 187.)

Family EPITHEMIACEA Grunow, 1860 [49, 50]
Subfamily EPITHEMIOIDEA Hustedt, 1914 [51]

FIGURE 201. *Diploneis crabro* Ehrenberg. Hypotype no. 3851 (CAS), from locality 866 (CAS), Monterey, California. Length 0.0990 mm.

FIGURE 202. *Diploneis exemta* (Schmidt) Cleve. Hypotype no. 3117 (CAS), from locality 866 (CAS), Monterey, California. Length 0.1200 mm.

FIGURE 203. *Diploneis major* Cleve. Hypotype no. 3852 (CAS), from locality 866 (CAS), Monterey, California. Length 0.0600 mm.

FIGURE 204. *Diploneis major* Cleve. Hypotype no. 3853 (CAS), from locality 866 (CAS), Monterey, California. Length 0.0550 mm.

FIGURE 205. *Diploneis ornata* (Schmidt) Cleve. Hypotype no. 3097 (CAS), from locality 1277 (CAS), Monterey, California. Length 0.1266 mm., breadth 0.0400 mm.

FIGURE 206. *Diploneis ornata* var. *spinifera* (Schmidt) Cleve. Hypotype no. 3854 (CAS), from locality 1277 (CAS), Monterey, California. Length 0.1600 mm.

FIGURE 207. *Diploneis ornata* var. *spinifera* (Schmidt) Cleve. Hypotype no. 3855 (CAS), from locality 1277 (CAS), Monterey, California. Length 0.1130 mm.

FIGURE 208. *Diploneis ornata* var. *spinifera* (Schmidt) Cleve. Hypotype no. 3092 (CAS), from locality 1277 (CAS), Monterey, California. Length 0.2136 mm., breadth 0.0896 mm.

FIGURE 209. *Diploneis taschenbergeri* (Schmidt) Hustedt. Hypotype no. 3856 (CAS), from locality 866 (CAS), Monterey, California. Length 0.1270 mm.

FIGURE 210. *Diploneis ornata* var. *spinifera* (Schmidt) Cleve. Hypotype no. 3857 (CAS), from locality 866 (CAS), Monterey, California. Length 0.1620 mm.

FIGURE 211. *Diploneis ornata* var. *spinifera* (Schmidt) Cleve. Hypotype no. 3118 (CAS), from locality 866 (CAS), Monterey, California. Length 0.1520 mm.

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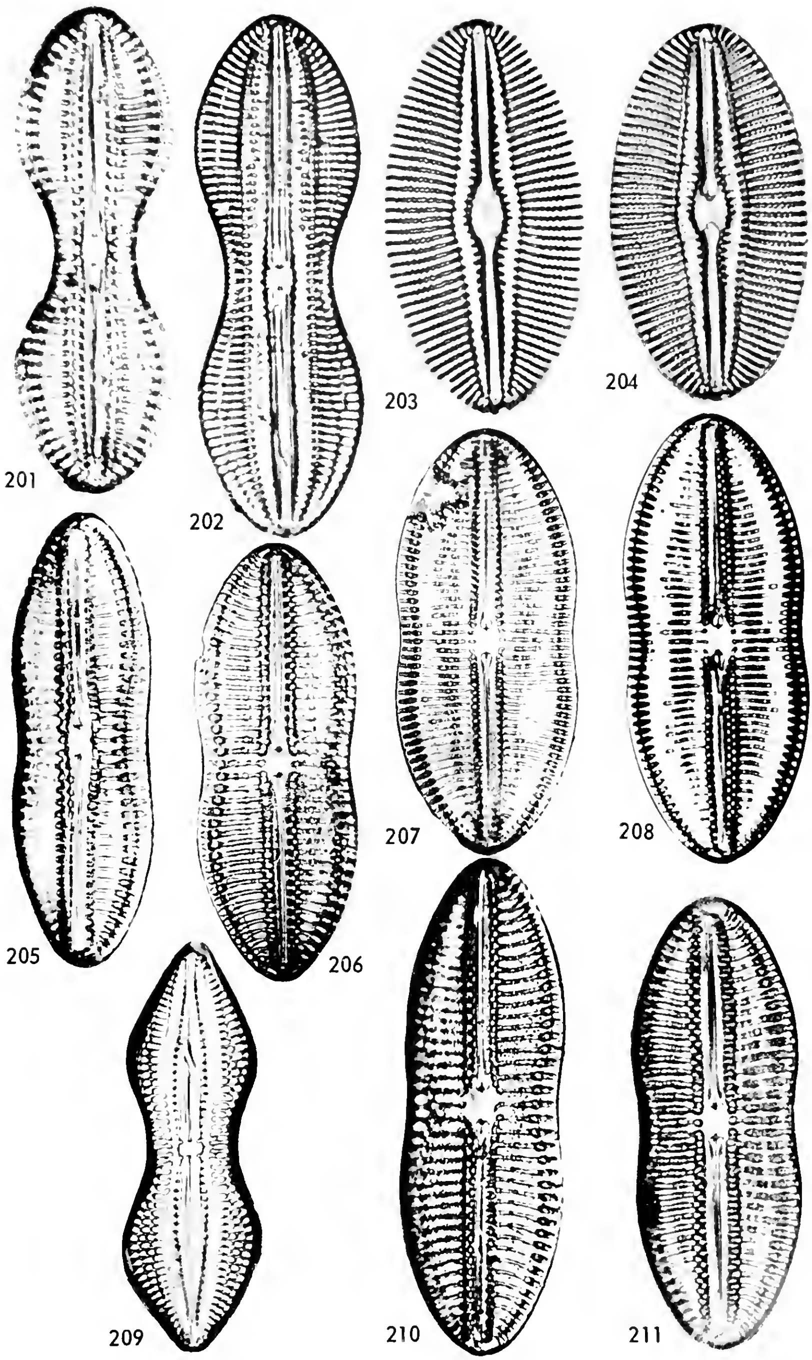
[49] Grunow, 1860, p. 508, as a family Epithemieae.

[50] Kolbe, 1927, pp. 29, 90, change in spelling.

[51] Hustedt, 1914, pp. 28, 108.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Genus **Denticula** Kützing, 1844

Denticula hustedtii Simonsen and Kanaya.

Denticula hustedtii Simonensen and Kanaya, 1961, p. 500, pl. 1, figs. 19-25.

Geologic range. Late Miocene to middle Pliocene.

Ecology. This genus has only one living representative which is found in the plankton in cold waters.

Remarks. Distinctive secondary pseudosepta are present.

Denticula kamtschatica Zabelina.

Denticula kamtschatica Zabelina, 1934, p. 16, figs. 7-9. Jousé, 1959, pl. 4, fig. 19.

Geologic range. Middle Pliocene.

Remarks. Distinguished by very delicate transapical striae (30 plus in 0.01 mm.) and by obscure oblique rows.

Denticula lauta Bailey.

Denticula lauta Bailey, 1854, p. 9, figs. 1, 2. Hanna, 1932, p. 188, pl. 11, fig. 1, Kanaya, 1959, p. 112, pl. 10, figs. 7-9, 15.

Geologic range. Early Miocene to middle Pliocene.

Remarks. Distinguished by the presence of distinct oblique rows, and by about 24 to 26 transapical striae in 0.01 mm.

Denticula nicobarica Grunow.

Denticula nicobarica Grunow, 1868, p. 97, pl. 1a, fig. 5. Van Heurck, 1811, pl. 49, fig. fig. 3.

Geologic range. Early Pliocene.

Remarks. Distinguished by the very coarse puncta, and by about 15-17 transapical striae in 0.01 mm.

Figure 212. *Nitzschia pliocena* (Brun), new combination. Hypotype no. 3858 (CAS), from locality 27295-29 (CAS), Harris grade, Purisima Hills, Santa Barbara County, California. Length 0.0512 mm.

Figure 213. *Nitzschia pliocena* (Brun), new combination. Hypotype no. 3859 (CAS), from locality 27295-29 (CAS), Harris grade, Purisima Hills, Santa Barbara County, California. Length 0.0700 mm.

Figure 214. *Mastogloia spendida* (Gregory) Cleve. Hypotype no. 3094 (CAS), from locality 866 (CAS), Monterey, California. Length 0.0900 mm., breadth 0.0720 mm.

Figure 215. *Mastogloia spendida* (Gregory) Cleve. Hypotype no. 3094a (CAS), from locality 866 (CAS), Monterey, California. Length 0.0860 mm.

Figure 216. *Mastogloia spendida* (Gregory) Cleve. Hypotype no. 3895 (CAS), from locality 866 (CAS), Monterey, California. Length 0.1580 mm.

Figure 217. *Rouxia californica* M. Peragallo. Hypotype no. 3896 (CAS), from locality 866 (CAS), Monterey, California. Length 0.0872 mm., breadth 0.0061 mm.

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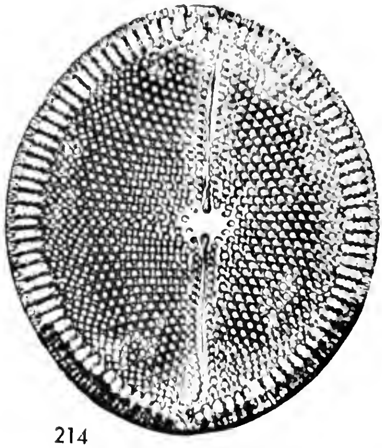

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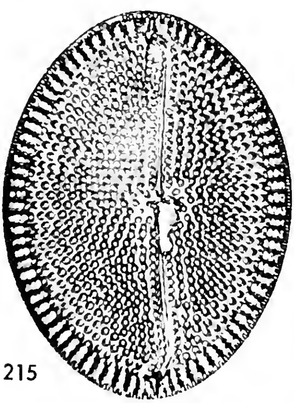

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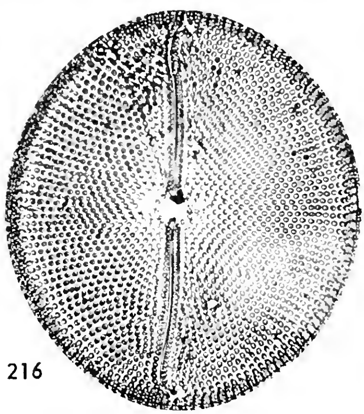

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