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VI

THE DIATOMS OF SHARKTOOTH HILL, KERN COUNTY, CALIFORNIA

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Sharktooth Hill is located on the north side of Kern River in Sec. 25, T. 28S., R. 28E., M. D. M. It is shown on the U. S. Geological Survey's topographic map (Caliente Sheet) as an unnamed hill 642 feet high, and seven miles in an air line, northeast of Bakersfield.

The hill marks the westernmost exposure of Miocene rocks in this particular section. The uppermost layer near the top of the hill contains many marine shells, not well preserved. A few feet below this lies the stratum so prolific in bones and teeth of marine mammals and fishes. Because of the abundance of teeth of sharks in the layer, the hill has received the name indicated above. Below the layer containing the vertebrates there are shales extending to the base of the hill. The uppermost layers of these shales are somewhat sandy and contain few preserved fossils in this particular exposure. Further below, however, and about 30 feet below the bone layer there are pale-buff, diatom-shales containing ash as the chief impurity. Diatoms are present in great abundance and perfection of preservation. Some of the material may well be classed as an impure diatomite. The total thickness of the zone at this point cannot be determined because the base is obscured but the same layer in well sections not distantly removed has been found to have a thickness of 100 to 200 feet. The constituent organisms vary little from the base to the top. Besides diatoms, the shales contain silicoflagellates, sponges and radiolarians; these groups have not been carefully studied, as yet.

The geologic relationship of the Sharktooth Hill exposure has been presented in another paper[1] and it will suffice here to repeat that the formation belongs to the Temblor, middle Miocene as defined by Dr. F. M. Anderson.[2] The layer of bones referred to and the stratum of marine shells immediately overlying, constitute the type locality of "Zone C" of that author. We now know that beneath the beds here considered there are approximately 2500 feet of strata also classed as Temblor and even this does not include extreme basal Miocene of other sections.

The diatoms herein described have been exceedingly helpful in determining the stratigraphic relationship of this particular horizon and the Temblor formation in general. The same assemblage of common species in approximately the same relative abundance occurs at many places on the east side of the San Joaquin Valley both in surface outcrops and in well samples. One of these localities has been studied in detail and many of the records are incorporated herein. This exposure is found on the west side of Cottonwood Creek a few miles to the eastward of Sharktooth Hill. (See below for exact locality data.) It seemed desirable to add these records to offset any tendency the reader might have to consider these fossils purely local and transitory in their occurrence.

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[1] Hanna, Proc. Calif. Acad. Sci., ser. 4, vol. 19, no. 7, 1930, pp. 65-83.

[2] Proc. Calif. Acad. Sci., ser. 4, vol. 3, 1911, pp. 81-94.

The other records from near-by localities are omitted because of space limitations. It may be stated, however, that this layer has been identified in a north-south direction for about 20 miles on the east side of the great valley.

On the west side of the valley the horizon occurs widely distributed. It is especially accessible and well preserved to the right of the road leading from Coalinga to Oil City in Fresno County and immediately on top of the sandstone formation called "Vaqueros Reef" in some reports.[3] Here, the age of the diatomite has been listed as "Monterey" or "Santa Margarita" and the stratum was once called the "indicator bed."

Many excellent exposures occur in the coast ranges but the individual species cannot be recorded here without an undue expansion of the present paper. Each of these localities should receive separate study.

The diatoms of this particular horizon in California have not heretofore been critically studied. However, at least once before the Temblor has furnished a collection, which eventually fell into the hands of Tempere and Peragallo in Paris. Presumably the sample was collected in the search which was made for the source of the original float material noted in literature as "Santa Monica." Samples from many places and several zones were thus taken and sent to Europe under the name of this town where no fossil diatoms occur. Tempere & Peragallo's[4] list in which the Temblor records are found is somewhat difficult to interpret because they appear also to have incorporated some lots of upper Miocene species. In order to be certain of the determination, the California Academy of Sciences purchased in Paris a part of the original sample and slides have been made for comparison. These contain such highly distinctive forms as *Annellus californicus, Cymatogonia amblyoceras, Raphidodiscus marylandicus,* etc., and upper Miocene distinctive species are lacking. The sample probably came from the Santa Monica Mountains and certainly is equivalent in age to the material studied herein; this

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[3] Arnold & Anderson, U. S. Geol. Surv. Bull. 398, 1910, pp. 81-82.
[4] Diat. du Monde Entier, Ed. 2, 1908, pp. 60-62.

has been proved by means of other samples in the Academy collection from the same region, which were taken by experienced geologists and accurately located, stratigraphically.

To find the equivalent of this Temblor stratum elsewhere than in California it is necessary to go far but the correlation can be made with almost equal certainty. Early in the study, numerous species were noted which appeared to be very close to or identical with forms heretofore well known from the Miocene diatom deposits of Virginia, Maryland and New Jersey. In Maryland these deposits have been placed in the Calvert formation. Appeal was made to Dr. Remington Kellogg for material for use in comparison and he very kindly furnished me with a sample from Dunkirk, Calvert County, Maryland, collected by Dr. F. W. True. This has been of great help in determining critical species.

A careful analysis of age relationships of many American Miocene formations has been made by Dr. W. P. Woodring.[5] In this he placed the Calvert formation in the middle Miocene (p. 93). The Temblor was placed in the same part of the column (p. 97). It is believed that the present study has proved the equivalence in age of that part of the Calvert formation which contains the diatom deposits and the upper part of the Temblor as exposed on Kern River and elsewhere in California. The Calvert has been independently correlated with the Tortonian of the European standard section upon the basis of the plants and marine mammals by Berry[6] and Kellogg,[7] respectively. The latter has suggested from a subsequent study,[8] however, that both the Calvert and upper Temblor may be Helvetian and since Woodring's correlation of them with the Bowden (and Tortonian) was admittedly not positive the following table was proposed in my paper on the Geology of Sharktooth Hill. It has been shown recently that the Santa Margarita is merely a sandy phase of upper Monterey[8a]

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[5] Woodring, Miocene mollusks from Bowden, Jamaica. Pt. 2. Gastropods and discussion of results. Carnegie Inst. Washington, Publ. 385, 1928, pp. 1-108.

[6] Berry, U. S. Geol. Surv. Prof. Ppr. 98 F, 1916, pp. 61-70.

[7] Kellogg, Bull. Geol. Soc. America, vol. 35, 1924, pp. 763-764.

[8] Kellogg, R. Carnegie Inst. Washington, Publ. 346, art. 1, 1927, p. 5.

[8a] Barbat & Weymouth, Univ. Calif. Publ. Bull. Dept. Geol. Sci. vol. 21, 1931, pp. 25-36, pls. 4, 5, 2 text figs.

and since this is almost certainly Sarmatian in age, there is left to represent the Pontian in California, several borderline formations, the age of which has heretofore been somewhat doubtful. Some of these are: Reef Ridge formation; Harris [grade] diatomite; Intermediate zone of Newport, Malaga Cove and Los Angeles Basin generally. Most of these have not been well defined, paleontologically.

Correlation of California and European Miocene

SECTION	EUROPEAN STAGES	CALIFORNIA FORMATIONS
Upper	Pontian	Santa Margarita
Miocene	Sarmatian	Upper Monterey
Middle	Tortonian	Lower Monterey
Miocene	Helvetian	Upper Temblor
Lower	Burdigalian	Lower Temblor (Pyramid Hill Fauna)
Miocene	Aquitanian	Vaqueros

Attention is called to the fact that the correlation of the Sharktooth Hill exposure is made by means of identity of specialized and short range species. No further comment is necessary except to add that some of the same species of diatoms should be found in strata of the same age which are suitable for their preservation, wherever found, if due consideration be given to the life processes and wide geographic range of present-day forms of these small organisms. It is significant to note that many species recorded herein have likewise been found in Italy by Forti[9] in strata which he stated to be middle Miocene.

The literature pertaining to diatoms contains some very important papers dealing with the middle Miocene, elsewhere in the world, particularly the West Indies, east America, Spain,

[9] Forti, A. Atti R. Ist. Veneto, Sci. Lett. Art. vol. 72, pt. 2, 1913.

Italy and Hungary. In each of these localities there are some species which have been found in the Temblor. Here again samples have been available for comparison; some of these were obtained from generous correspondents and others were purchased as a part of the Tempere collection.

The use of these various collections has made the task of identification of species less burdensome and it is believed greater accuracy has thus been obtained than would otherwise have been possible. However, as in most other groups of fossils, there are certain genera of diatoms which are in taxonomic chaos and in these cases the species-names chosen may eventually prove to have been the wrong ones. Fortunately, however, this remark does not apply to most of the distinctive and abundant Temblor fossils. In order that these may be sifted from the less important ones the following list is given.

Most distinctive and important Temblor diatoms

*Actinocyclus ehrenbergii Ralfs
*Actinoptychus halionyx Grunow
*Actinoptychus kernensis Hanna
*Annellus californicus Tempere
*Biddulphia angulata Schmidt
*Coscinodiscus apiculatus Ehrenberg
*Coscinodiscus convexus Schmidt
*Coscinodiscus fulguralis Brun
Coscinodiscus meditatus Hanna
*Cymatogonia amblyoceras (Ehrenberg)
*Cymatosira andersoni Hanna
*Eupodiscus antiquus Cox
*Hyalodiscus frenguellii Hanna
*Navicula kernensis Hanna
Navicula mimicans Hanna
Perrya innocens Hanna
*Raphidodiscus marylandicus Christian
Rattrayella inconspicuua (Rattray)
*Rhaphoneis obesa Hanna
*Sceptroneis caduceus Ehrenberg
Stephanogonia polyacantha Forti
Stictodiscus kittonianus Greville
*Surirella tembloris Hanna
*Triceratium spinosum Bailey
Xystotheca hustedti Hanna
*Zygoceros (?) quadricornis Grunow

Not all of the above species are equally abundant, of course, but those marked with an asterisk (*) can usually be found in properly cleaned material after a few minutes search. Some of them are dominant in this Temblor horizon wherever found and are not known from upper Miocene strata; these are the most valuable marker-species. Since this paper is intended to be as exhaustive as possible for the deposit concerned, it naturally contains some forms which are either too rare or of too long geologic range to be useful in correlation or age determination at this time.

The present paper is based primarily on material from Sharktooth Hill but some records are incorporated from the locality on Cottonwood Creek a few miles to the east. Also there are a few *Rhaphoneis* listed from an exposure near Round Mountain. These three localities are entered in the records of the California Academy of Sciences as follows:

Locality 1063. A series of seven samples of diatomaceous shales from NE¼, Sec. 13, T. 29S., R. 29E., M. D. M., on the west side of Cottonwood Creek, Kern County, Calif.; G. D. Hanna and F. M. Anderson, Colls., April, 1927.

Locality 1068. A series of five samples of diatomaceous shales from the southeast side of Sharktooth Hill, Sec. 25, T. 28S., R. 28E., M. D. M., Kern County, Calif., G. D. Hanna, Coll., April, 1927.

Locality 1187. Diatomaceous ashy shale from Sec. 13, T. 28S., R. 28E., M. D. M., east side of 1340 Hill, about one mile west of Round Mountain, Kern County, Calif.; G. D. Hanna, Coll., April, 1927.

The last and any other locality records used have been considered for the sole purpose of elucidating the flora of the Sharktooth Hill strata and its equivalent elsewhere.

In preparing the collection for study the various species have been selected from strewings and mounted individually under measured covers. Synthetic resin (hyrax) has been used entirely as a mountant because this can now be procured practically without color, soluble in the usual solvents of balsam and possessing a refractive index of about 1.80. Moreover, test slides have not shown the slightest sign of deterioration in over four years. No known natural resin approaches this material in ease of manipulation and superior optical properties.

1. Actinocyclus ehrenbergii Ralfs

Plate 2, figs. 1, 2, 3

Actinocyclus ehrenbergii Ralfs in Pritchard, Hist. Infus. Ed. 4, 1861, p. 834. —Van Heurck, Syn. Diat. Belgique, 1880-1882, p. 215, pl. 123, fig. 7.—Rattray, Journ. Quekett Micr. Club, ser. 2, vol. 4, 1890, p. 171.—Wolle, Diat. N. America, 1890, pl. 85, fig. 9.

This large and handsome species is exceedingly abundant in the deposit on Sharktooth Hill. It is likewise widely distributed in beds of the same age. In an extension of the Sharktooth Hill horizon to the southeast a few miles a layer was found in which practically nothing else exists. Slides made from this particular sample are marvelous when the mounts are made in highly refractive resin; under low powers the play of prismatic colors is scarcely excelled by crystalline substances viewed with polarized light.

The references cited above are important but form an insignificant portion of the total literature on the species. Indeed, it is so variable that Rattray was obliged to use nine pages to cite the synonymy known to him in 1890. Ehrenberg conceived the idea of naming every individual he found with a different number of rays from any known to him and by careful search and great industry he was able to find the range extending from three to 120. This action stands as one of the greatest blunders in the study of diatoms. Rather than try to disentangle such a complex situation Ralfs renamed the entire mass, *Actinocyclus ehrenbergii* and the justice of this procedure has not been questioned by diatomists.

The species is exceedingly common in the Calvert formation of Maryland and Virginia and specimens from there formed the basis of a large number of Ehrenberg's names. By direct comparison, I am not able to detect any noteworthy difference between Maryland and California specimens. Authors have had much difficulty in distinguishing *A. ehrenbergii* from *A. ralfsii* (W. Smith). Some (as Grunow and Lagerstedt) have gone so far as to advocate their union and this may yet have to be done. In general the bright, hyaline, radial spaces are double in *ehrenbergii*, single in *ralfsii* but the character is apparently not constant.

2. Actinoptychus halionyx Grunow

Plate 2, fig. 4

Actinoptychus splendens halionyx GRUNOW in VAN HEURCK, Syn. Diat. Belgique, 1880-1882, pl. 119, fig. 3.—WOLLE, Diat. N. America, 1890, pl. 92, fig. 12.

"*Actinoptychus glabratus* GRUNOW?" SCHMIDT, Atlas Diat. pl. 153, 1890, fig. 12; "Peru Guano."

Actinoptychus solisi HANNA & GRANT, Proc. Calif. Acad. Sci. ser. 4, vol. 15, 1926, p. 123, pl. 12, figs. 1-3.

The mottled appearance of alternating segments in the Sharktooth Hill specimens is very similar to that shown in Ravet's photograph, reproduced by Van Heurck. His figure does not show the conspicuous hyaline areas at the outer ends of the non-maculate segments, so obvious in the photograph shown herewith, but this is believed to be due to a different focus of the microscope in the two cases. I am not able to find intergradation between these diatoms and the living, non-maculate *A. splendens* and therefore consider *halionyx* a distinct species. It seems now that *A. solisi* is a form of *halionyx* having somewhat bolder markings than usual.

3. Actinoptychus janischii Grunow

Plate 3, fig. 1

Actinoptychus janischii GRUNOW in VAN HEURCK, Syn. Diat. Belgique, 1880-1882, pl. 122, fig. 6; "Guano from Peru."—PANTOCSEK, Beit. Kennt. Bacill. Foss. Ungarns, pt. 1, 1886, p. 61, pl. 16, fig. 143; Hungarian Miocene deposits.—SCHMIDT, Atlas Diat. pl. 153, 1890, figs. 8-10, 21.

As Grunow pointed out, the most remarkable feature of this diatom is the fact that all segments are almost in a plane. Janisch is supposed to have found the diatom in Guano from Peru but until this report is corroborated it had best be held in doubt in view of the abundance of the species in Miocene deposits. It is fairly common at Sharktooth Hill but more so at some other localities stratigraphically equivalent such as 1063, on Cottonwood Creek a few miles east.

4. **Actinoptychus kernensis** Hanna, new species

Plate 3, figs. 2, 3

Valve large without undulations in the marginal zone; segments 12 (in holotype; not less than 8 nor more than 14 have been seen); segments are gentle undulations not separated by sharp flexures or dark or light radial lines (in some specimens the undulations of the segments scarcely perceptible); border striated; marginal zone very wide and marked with a coarse uneven reticulation, the radial arrangement being most perfect; irregular radial lines cover the disk (except for the hyaline central area), with cross lines forming a network; disk also covered with fine beads as in *A. splendens* and many other *Actinoptychus;* spines are scattered irregularly around the margin, without any definite number relation to the segments. Diameter (holotype), .1680 mm.; paratypes, .132, .089, and .060 mm.

Holotype: No. 3142; *paratypes:* Nos. 3143-3145 Mus. Calif. Acad. Sci. collected by G. D. Hanna at Loc. 1068 (C. A. S.) on the southeast side of **Sharktooth Hill, Kern County, California**; Temblor, middle Miocene.

Schmidt[10] figured a specimen from "Bolivia Guano" without name, which resembles the present form more than any other but when examined in detail there are many important structural differences. *A. vulgaris* is somewhat similar but the central hyaline area radiates outwardly, more or less, in alternating segments in that form; moreover, the boundaries of the segments are sharper defined, the marginal zone bears large hyaline areas as in *A. halionyx* shown herewith, and there is usually a mottled appearance to the valve under low powers.

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[10] Atlas Diat. pl. 132, 1888, fig. 5.

5. Actinoptychus perisetosus Brun

Plate 4, figs. 1, 2

Actinoptychus perisetosus Brun, Le Diatomiste, vol. 2, no. 16, 1894, p. 73 pl. 5, fig. 9; Japanese deposits.

Brun described this species as very variable and abundant in the fossil deposits of Japan. The Sharktooth Hill specimens do not agree with his figure in every minute detail but it is believed that the differences are inconsequential. The three large spines shown in his figure are more slender than they appear in ours but this is partly due to the fact that they are not all in perfect focus in the photographs. The species is very abundant in all collections made from the stratum on Sharktooth Hill and its equivalent at other places in that region.

The species bears superficial resemblance to the very abundant *A. undulatus* of many Miocene deposits but the lightly marked segments of the present form do not appear to be typical of *undulatus*. Nevertheless it seems probable that *perisetosus* is merely one of the many named variations of that long lived species.

6. Actinoptychus thumii Schmidt

Plate 4, figs. 3, 4

Actinoptychus stella thumii Schmidt, Atlas Diat. pl. 90, 1886, figs. 4, 5.—Pantocsek, Beit. Kennt. Bacill. Foss. Ungarns, pt. 1, 1886, p. 63, pl. 8, fig. 65.—Forti, Atti R. Ist. Veneto Sci. Lett. Art. vol. 72, pt. 2, 1913, pl. 15, figs. 6, 7; [as form *fenestrata*].

Schmidt's specimens came from "Szent Peter" in Hungary and "Tegel von Brünn," both probably middle or lower Miocene deposits. The Sharktooth Hill specimens are very close indeed and although Schmidt's figures indicate possible intergradation in his material I have observed no such tendency in the collection now being studied and therefore prefer to hold *thumii* distinct from *stella*. The form is probably a forerunner of the huge *grundleri* and its allies of later Miocene time. In the photographs herewith, the three blunt spines are not well shown because of the great depth of the diatom; some portions necessarily are out of focus because of the high magnification required to show the details of sculpture.

7. **Actinoptychus undulatus** (Bailey)

Actinocyclus undulatus Bailey, Amer. Journ. Sci. vol. 42, 1842, pl. 2, fig. 11. —Kützing, Bacill. 1844, p. 132, pl. 1, fig. 24.

Actinoptychus undulatus (Bailey), Ralfs in Pritchard, Hist. Infus. Ed. 4, 1861, p. 839, pl. 5, fig. 88.—Schmidt, Atlas Diat. pl. 1, 1874, figs. 1–4, 6.—Van Heurck, Syn. Diat. Belgique, 1881, pl. 22 *bis*, fig. 14; pl. 122, figs. 1–4.—Mann, Cont. U. S. Nat. Herb. vol. 10, pt. 5, 1907, p. 272.—Hanna & Grant, Proc. Calif. Acad. Sci. ser. 4, vol. 15, 1926, p. 124, pl. 12, fig. 4.—Hanna, Journ. Paleon. vol. 1, no. 2, 1927, p. 108.

In view of the uncertainty regarding the limits of variation of *A. undulatus* I am obliged to record it from the Sharktooth Hill deposit. The name may be used in too broad a sense but until a revision of the group is made, identification cannot be made with certainty.

8. **Annellus californicus** Tempere

Plate 4, figs. 5-9

Annellus californicus Tempere, in Tempere & Peragallo, Diat. du Monde Entier, Ed. 2, 1908, p. 60; "Santa Monica, Calif."—Azpeitia, Asoc. Esp. Prog. Cien. vol. 4, sec. 3, Cien. Nat. pt. 2, 1911, pp. 149-237, "Montemayor, Fernán-Núñez," Spain.

Annellus Tempere, Taylor, Notes on Diatoms, 1929, pp. 119, 180, 236, pl. 1, fig. 28.

This species is exceedingly common in the deposit exposed on Sharktooth Hill (Loc. 1068) and in many other places where the equivalent of this same series of strata is found. These other localities are widely distributed in California, some of them being: "North of Coalinga, immediately above the Temblor Reef Beds" (called "Vaqueros Reef" erroneously in U. S. Geological Survey Bulletins 398 and 603); "Smuggler's Cove, Santa Cruz Island, Calif."; near Point Dume, Los Angeles County, Calif.

The last mentioned locality may be the one from which Tempere's original material came although he gave it as from "Santa Monica." Definite proof of this statement can probably never be had and an analysis of the situation requires that we begin with the celebrated piece of float picked up a few miles south of Santa Monica.[11] When it was learned that the parent bed from which the float block had drifted was not in the immediate vicinity of Santa Monica a very great deal of search was made for it. California microscopists apparently examined every known outcrop of diatomaceous earth in the southern part of the state in their endeavor to supply the desires of students elsewhere for more material like the original find. Evidently those not thoroughly trained in the study of these organisms thought they had found the source bed whenever they found a stratum with well preserved fossils. In this manner the "Santa Monica float block" has been reported to have come from places all the way from Newport to Santa Maria. Unquestionably some of these amateurs distributed samples under the label "Santa Monica" which actually came from far from there, their motive being the sincere belief that they had the original source of the famous float.

Tempere's *Annellus* was found in only one of several samples (no. 112 of his collection) which he had under the locality "Santa Monica." It is certain that the genus was not represented in the original block and has not since been found in strata of known equivalent age. But now, that it has been found in many widely scattered places in the upper part of the Temblor, and often in abundance, it may be assumed with safety that Tempere's sample came from a locality of the same age. The nearest place to Santa Monica where such a deposit is located, so far as I have been able to determine, is near Point Dume, Los Angeles County. Several years ago Mr. Douglas Clark, geologist for the Southern Pacific Company, gave me a sample from there and *Annellus* was found in it soon after.

The genus is one of the most distinct among the diatoms. Tempere's original description, quoted below, is very inadequate and he never published a figure. "Valve á silice repliée sur ellemême sous form d'anneau tubulaire recouvert de grosses ponctuations régulièrement disposées. Diamétre de la valve: 70 à 15 μ; largeur: 30 à 40 μ. Pas rare dans le no. 112." This brief description is certainly insufficient to make the genus or species recognizable were it not for the striking

[11] See Hanna, Bull. Amer. Assoc. Petrol. Geol. vol. 12, no. 11, 1928, pp. 1109-1110, for an account of this.

form of the organism. Even so, I hesitated to adopt the name until after I had secured some of Tempere's original, cleaned material and from it made mounts of the form in question. There can be no doubt now as to what he had and I chose a specimen from his collection for illustration herewith. The structural details are given in the sectional drawing.

The genus appears to be as closely related to *Melosira* as any other. Such an open cylinder as this is otherwise unknown in the Diatomaceæ and a first thought may be that something is missing on one end. However, this cannot be because among hundreds which have been handled I have never found one that could not be strung, bead-like, on the glass hair of the mechanical finger. The collections in which the genus occurs contain nothing which could in any way be presumed to be detached caps, or partitions.[12]

This strange and striking organism had a short existence, geologically, and for this reason and because of its abundance when found it forms a valuable marker fossil of middle Miocene strata, the Temblor. It has not been found in lowermost diatomaceous shales near Coalinga, California (the Kreyenhagen of authors), and has also not been found any place in the type section of the Monterey. In the lower portion of this latter, however, where it might occur, the diatoms are not preserved.

9. **Arachnoidiscus manni** Hanna & Grant

Plate 5, fig. 1

Arachnoidiscus manni HANNA & GRANT, Proc. Calif. Acad. Sci. ser. 4, vol. 15, no. 2, 1926, p. 125, pl. 12, figs. 7-9.—HANNA, Journ. Paleo. vol. 1, no. 2, 1927, p. 109, pl. 17, fig. 5.

Arachnoidiscus ornatus montereiana SCHMIDT, Atlas Diat. pl. 73, 1882, figs. 7-9. (Not *A. ehrenbergii montereyana* SCHMIDT, Atlas Diat. pl. 68, 1881, fig. 2.)

Arachnoidiscus ornatus montereianus, HANNA & GAYLORD, Bull. Amer. Assoc. Petrol. Geol. vol. 9, no. 2, 1925, pl. 5, fig. 2.

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[12] The genus has recently been illustrated by Taylor, Notes on Diatoms, 1929, pl. 1, fig. 28, the locality being given as "Sta. Maria., Cal.", probably an error for "Santa Monica, Calif." Taylor failed to place the group definitely in his outline of the classification of diatoms on p. 119.

At one time it was thought that this species could be differentiated with a fair degree of constancy but after handling many hundreds, this now seems doubtful. Evidently Schmidt had reason for separating the fossil form from California Miocene from *A. ornatus* Ehrenberg but whether this was sufficient or not remains to be determined. It is to be noted that Ehrenberg did not figure *ornatus* and the first illustrations were given by Ralfs.[13] With these as a basis for determination it is found that most California fossils are heavier marked and the concentric divisions extend from margin to central area. The species *nicobaricus* of Ehrenberg[14] has usually been referred to *ornatus* as a synonym and it is found to be a much lighter marked form than specimens from California. The problem is further complicated by the fact that some of the early diatomists received both living and fossil material from "Monterey" and in their publications they did not differentiate. The living form is very common there and Mr. W. M. Grant has an abundance of specimens. On direct comparison with the fossils from the same place the differences noted above seem to be constant. However it seems possible that when a more thorough study shall have been made it will be necessary to reduce the number of names to one—*ornatus*.

The species is very rare in the Sharktooth Hill deposit.

10. **Asterolampra rotula** Greville

Plate 5, fig. 2

Asterolampra rotula GREVILLE, Trans. Micr. Soc. London, vol. 8, n. s. 1860, p. 111, pl. 3, fig. 5; "Monterey, California."—RATTRAY, Proc. Roy. Soc. Edinburgh, vol. 16, 1889, p. 195.—WOLLE, Diat. N. America, 1890, pl. 93, fig. 10.—DE TONI, Syl. Algarum, vol. 2, sect. 3, 1894, p. 1404.

The imperfect specimen referred to this Monterey species is the best that could be found in the Sharktooth Hill deposit. It is rare and no other representative of the genus or of *Asteromphalus* appears to be present.

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13 In Pritchard, Hist. Infus. Ed. 4, 1861, p. 842, pl. 15, figs. 18-21.

14 Mikrog. 1854, pl. 36 (not 30) fig. 35.

11. **Aulacodiscus brownei** Norman

Plate 5, fig. 3

Aulacodiscus brownei NORMAN in RALFS in PRITCHARD, Hist. Brit. Inf. Ed. 4, 1861, p. 844.—SCHMIDT, Atlas Diat. pl. 36, 1876, figs. 15, 16; pl. 105, 1886, fig. 6.—RATTRAY, Journ. Roy. Micr. Soc. 1888, p. 341.—WOLLE, Diat. N. America, 1890, pl. 88, fig. 10.—DE TONI, Syl. Alg. vol. 2, pt. 3, 1893, p. 1093.

This two spined *Aulacodiscus* was described from the upper Miocene at Monterey, California, where it is not uncommon. De Toni listed it as living and the similar, *A. probabilis* Schmidt, occurs in the Cretaceous of Simbirsk, Russia. The recent records may be taken with doubt owing to the circumstances of their collection and the specimen here being recorded may not be the same as those from Monterey because it shows some considerable differences in details. However, I do not have sufficient material to warrant separation at this time and it seems best to consider it the same. It was not found in the material from Sharktooth Hill but occurred at Loc. 1063 (C. A. S.) on Cottonwood Creek, a few miles to the east in a stratigraphically equivalent stratum.

12. **Auliscus bonus** Hanna, new species

Plate 5, figs. 4, 5

Valve small, almost circular, slightly convex, eyespots two with a few coarse punctæ on top; central area almost circular, hyaline; margin with a row of short semi-cellules, continuing inwardly as coarse, rugose, radial riblets. Diameter .0422 mm.

Holotype: No. 3155, Mus. Calif. Acad. Sci. collected by G. D. Hanna at Loc. 1068 C. A. S. on the southeast side of **Sharktooth Hill, Kern County, California**; Temblor, middle Miocene.

A. cœlatus Bailey is much larger than this little diatom and has much longer marginal markings; however the two are believed to belong to the same portion of the genus. The two figures shown are opposite valves of the same frustule and the different focus is obtained to show the characters of marginal and central area. No very close relative has been found in the literature although it displays no very striking or unusual details.

13. **Auliscus suppressus** Hanna, new species

Plate 5, fig. 6

Valve minute, circular, almost flat; border broad and heavy; two large "eyes" close to border; central circular space hyaline; disk with irregularly arranged, coarse, sparse, large beads; in addition a series of fine curved lines spread out from each "eye" and the sides are irregularly marked with lines and dots roughly radial in arrangement. Diameter, .0321 mm.

Holotype: No. 3156, Mus. Calif. Acad. Sci. collected by G. D. Hanna at Loc. 1068 (C. A. S.) southeast side of **Sharktooth Hill, Kern County, California**; Temblor, middle Miocene.

The species is probably allied to *A. loczyi* Pantocsek[15] Beit. from Hungarian Miocene but the available figures of that species do not show the fine lines mentioned. It is true that they can be seen only under favorable conditions, that is, by use of high aperture and mounting media of high refractive index. However, we cannot merely assume that the markings are present on *loczyi* when they are not shown.

The species is exceedingly small and apparently rare.

14. **Biddulphia angulata** Schmidt

Plate 5, figs. 7, 8

Biddulphia angulata Schmidt, Atlas Diat. pl. 141, 1889, figs. 7, 8; Nottingham, Maryland.—Wolle, Diat. N. America, 1890, pl. 6, fig. 7.

Odontella angulata (Schmidt), De Toni, Syl. Algarum, vol. 2, sect. 3, 1894, p. 869.

The diatoms here referred to *angulata* agree more closely with the figures of that species than any other of which illustrations have been found. There are some slight differences in details but hardly more than the specimens themselves display.

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[15] Beit. Kennt. Foss. Bacill. Ungarns, pt. 3, 1893, pl. 5, fig. 82.

January 8, 1932

The species is fairly common in the finer washings of the Sharktooth Hill deposit but they are almost always fractured or deformed by pressure.

15. **Cladogramma conicum** Greville

Cladogramma conicum GREVILLE, Trans. Micr. Soc. London, vol. 13, 1865, p. 97, pl. 8, figs. 1, 2.

A few specimens of a very convex *Cladogramma* were mounted from the lighter washings of material from Loc. 1063 on Cottonwood Creek, Kern County, Calif. *C. californicum,* as usually found in upper Miocene deposits, is a much flatter diatom.

16. **Coscinodiscus æginensis** Schmidt

Plate 5, fig. 9

Coscinodiscus æginensis SCHMIDT, Atlas Diat. pl. 113, 1888, figs. 13, 14.—RATTRAY, Proc. Roy. Soc. Edinburgh, vol. 16, 1889, p. 489.—DE TONI, Syl. Algarum, vol. 2, pt. 3, 1894, p. 1288.

Coscinodiscus apiculatus californica GRUNOW in SCHMIDT, Atlas Diat. pl. 113, 1888, figs. 13, 14.

Schmidt stated in the explanation of his plate 113 that Grunow called his diatom *"C. apiculatus californica"* but he was unable to associate the form with *apiculatus.* This view seems to be correct; the name *"californica"* even as a subspecies is not desirable because of the prior *"Coscinodiscus californicus"* of O'Meara.

The specimens found in the Sharktooth Hill deposit have a slightly smaller central hyaline area than Schmidt's figure but otherwise the resemblance is so close that indentification is believed to be warranted.

17. **Coscinodiscus apiculatus** Ehrenberg

Plate 6, fig. 1

Coscinodiscus apiculatus EHRENBERG, Ber. Akad. Wiss. Berlin, 1844, p. 77; Mikrog. 1854, pl. 18, fig. 43.—GRUNOW, Denk. Akad. Wiss. Wien, vol. 48, no. 2, 1884, p. 75.—SCHMIDT, Atlas Diat. pl. 64, 1877, figs. 5-10.—WOLLE, Diat. N. America, 1890, pl. 86, fig. 9.

There is some confusion in the published figures of *apiculatus* and *perforatus* and it may be that they cannot be separated in a large series. Both were described from Miocene deposits of Maryland or Virginia and have often been reported together. Typical *apiculatus* is abundant and usually well preserved in the Sharktooth Hill deposit and strata of equivalent age in other places in the same region.

18. Coscinodiscus convexus Schmidt

Plate 6, figs. 2, 3; plate 7, fig. 1

Coscinodiscus convexus Schmidt, Atlas Diat. pl. 60, 1877, fig. 15; Barbados.—Rattray, Proc. Roy. Soc. Edinburgh, vol. 16, 1889, p. 104.—De Toni, Syl. Algarum, vol. 2, sec. 3, 1894, p. 1271.

In the Sharktooth Hill deposit, the diatoms believed to be this species are much larger than those from Barbados but in other respects there is general agreement. Sometimes a specimen does have a rather imperfect central rosette, as the smaller figure herewith shows, and the absence of this is one of the distinguishing features of *convexus*. However, the diatom is far more convex than are such doubly marked species as *C. asteromphalus*. The convexity is so great that in the specimens photographed the margin is completely out of focus.

19. Coscinodiscus fulguralis Brun

Plate 7, fig. 2

Coscinodiscus fulguralis Brun, Mem. Soc. Phys. Hist. Nat. Genève, vol. 31, pt. 2, no. 1, 1891, p. 21, pl. 21, fig. 6; "Sendai" Japan, fossil deposit. —De Toni, Syl. Algarum, vol. 2, sect. 3, 1894, p. 1264.

This is a very delicate species and a perfect specimen was not found in the Sharktooth Hill deposit although it is abundant there. It is very large, almost flat and consistently has smaller beading than *C. gigas* Ehrenberg or *C. diorama* Schmidt to both of which it is related. There is some doubt as to the age of the diatoms reported from Japan and it seems very probable that some of the deposits may be as old as

Eocene while others are as young as Pliocene. On the authority of Schlumberger, Brun gave the latter age but this is extremely unlikely for all the material he described; there are too many extinct genera and species. Only in rare instances such as the present is a trace of the Japanese flora found in the California Temblor deposits.

20. **Coscinodiscus lineatus** Ehrenberg

Plate 8, figs. 1 2, 3

Coscinodiscus lineatus Ehrenberg, Abh. Akad. Wiss. Berlin, 1838, p. 129; 1841, p. 371, pl. 1, III, fig. 20, pl. 3, VII, figs. 7, 8.—Ehrenberg, Mikrog. 1854, pl. 18, fig. 33, pl. 22, fig. 6, pl. 35 A, XVI, fig. 3, XVII, fig. 7.—Van Heurck, Syn. Diat. Belgique, 1880-1881, p. 217, pl. 131, fig. 3.—Schmidt, Atlas, Diat. pl. 59, 1877, figs. 27-32.

This species is very abundant in the Sharktooth Hill deposit and strata of equivalent age elsewhere in the same general region. The specimens appear to belong to the typical species without a trace of marginal spines, originally described from east American Miocene deposits. The rows of beads often deviate from a true geometric 60° arrangement.

There is a temptation to call all circular diatoms with this true arrangement of the beads in three series of straight lines, *C. lineatus,* and undoubtedly a considerable number of erroneous determinations have thus been made. Even *Stephanopyxis lineatus* with the high marginal spines has been referred to *Coscinodiscus.* In spite of these difficulties the Temblor material here being considered appears to be indistinguishable from that from Calvert County, Maryland, supplied to me by Dr. Kellogg. I am not so certain that what has been called *lineatus* from the California upper Miocene deposits is that species in every case. The records in the literature indicate that the species is a very persistent one extending from "Eocene" of Denmark to the present time. Before accepting this as final a careful examination needs to be made of the group.

21. **Coscinodiscus marginatus** Ehrenberg

Plate 8, figs. 4, 5

Coscinodiscus marginatus Ehrenberg, Abh. Akad. Wiss. Berlin, 1841, p. 142. —Ehrenberg, Mikrog. 1854, pl. 18, fig. 44; pl. 33, XII, fig. 13; pl. 38B, XXII, fig. 8.—Schmidt, Atlas Diat. pl. 62, 1877, figs. 1-5, 9, 11, 12.—Wolle, Diat. N. America, 1890, pl. 112, fig. 8.—Mann, Cont. U. S. Nat. Herb. vol. 10, no. 5, 1907, p. 253, pl. 49, fig. 2.—Hanna & Grant, Proc. Calif. Acad. Sci. ser. 4, vol. 15, 1926, p. 139, pl. 15, fig. 5.

This heavy, coarsely marked diatom seems to have persisted through, unchanged from the middle Miocene to the present time. Many varietal names have been proposed for some of the variations encountered and they serve more to emphasize the need of a broad specific definition rather than any taxonomic need. Unless some of the variants prove to be reasonably constant through some geologic period of time or in a certain geographic area they have little value. The species reached its greatest development in the upper Miocene and certain layers of diatomite in California of this age are composed of it almost exclusively. In the middle Miocene, as at the Sharktooth Hill locality, the form is rare and constitutes an insignificant portion of the diatom flora; no large specimens were found, but otherwise those studied do not differ from upper Miocene forms.

22. **Coscinodiscus meditatus** Hanna, new species

Plate 9, fig. 1

Valve circular, almost flat, border narrow; beads largest nearest center where they are very sparse, decreasing in size slightly toward margin; marginal zone of about one-third radius covered with small beads arranged in close set radial rows, about every fourteenth row projecting much farther toward the center than the others. Diameter, .0541 mm.

Holotype: No. 3170, Mus. Calif. Acad Sci. collected by G. D. Hanna at Loc. 1068 (C. A. S.) **Sharktooth Hill, Kern County, California**; Temblor, middle Miocene.

This very striking species is common in the Sharktooth Hill deposit and at other localities in the vicinity where the same horizon is exposed. However, the silex seems to be brittle because unbroken specimens are hard to find. Only one species of diatom has apparently been described which bears a reasonably close resemblance; this is *Actinocyclus rotula* Brun[16] from a fossil deposit in Japan. That species has the short marginal rows of beads set diagonally to the radials and there are conspicuous spines at the marginal ends of the radials; moreover *rotula* is a true *Actinocyclus* with the conspicuous marginal bead; the California species does not possess a trace of this feature.

23. **Coscinodiscus monicæ** Grunow

Plate 9, fig. 2

Coscinodiscus janischii monicæ GRUNOW, Denk. Akad. Wiss. Wien, vol. 48' no. 2, 1884, p. 76.

Coscinodiscus monicæ GRUNOW, RATTRAY, Proc. Roy. Soc. Edinburgh, vol. 16, 1889, p. 115.—DE TONI, Syl. Algarum, vol. 2, sect. 3, 1894, p. 1278. —SCHMIDT, Atlas Diat. pl. 63, 1877, fig. 10 (without name; named in Fricke's Index, 1902).

The group of diatoms to which this species belongs is exceedingly difficult to differentiate. The beads are without secondary markings and the size seems to vary considerably. Schmidt's figure to which reference is here made has the central large beads separated from each other while in the specimen figured from Sharktooth Hill they touch. Otherwise the two are in close agreement.

24. **Coscinodiscus novozealandicus** Grove

Plate 9, fig. 3

Coscinodiscus superbus HARDMAN var. *novo-zelandica* GROVE in RATTRAY, Proc. Roy. Soc. Edinburgh, vol. 16, 1889, p. 459, pl. 16, pt. 2, fig. 15.— DE TONI, Syl. Algarum, vol. 2, sect. 3, 1894, p. 1208.

"*Coscinodiscus superbus* HARDMAN MS (*Cestodiscus*) var. *novæ seelandiæ* GROVE" in SCHMIDT, Atlas Diat. pl. 163, 1891, fig. 8; "Troublesome Gulley, Oamaru" New Zealand; pl. 148, 1890, fig. 7, [named on pl. 153, 1890].

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[16] Mem. Soc. Phys. Hist. Nat. Genève, vol. 31, no. 1, 1891, p. 6, pl. 17, fig. 5.

This species has been reported heretofore only from Oamaru, New Zealand strata of "Miocene" or "Oligocene" age; it is common in the Sharktooth Hill deposit. I can see no reason to associate the form as a subspecies with *C. superbus* from Barbardos (originally placed in the genus *Cestodiscus)*, because the two appear specifically different; specimens from both Barbados and Oamaru have been examined to determine this point. The New Zealand and California diatoms appear closer related to *C. elegans* than *superbus*. The genus *Cestodiscus* was founded on a *Coscinodiscus* with minute marginal spines and this is generally considered to be an unsound basis as Mann[17] has pointed out. Because of the heavy border, the small spines do not show distinctly in the photograph herewith but they are located at the ends of the main radial rows of beads. Under ordinary circumstances I believe in no alteration of a species- or genus-name from the original spelling of the author but in this case it seems best to correct the obvious error.

25. **Coscinodiscus oculus-iridis** Ehrenberg

Plate 9, fig. 4

Coscinodiscus oculus-iridis Ehrenberg, Abh. Akad. Wiss. Berlin, 1839, p. 147. —Ehrenberg, Mikrog. 1854, pl. 18, fig. 42; pl. 19, fig. 2.—Schmidt, Atlas Diat. pl. 60, 1877, fig. 17; pl. 63, figs. 4, 6-9; pl. 113, 1888, figs. 1, 3-5, 20.

How best to treat the diatoms belonging to the group centering about *C. oculus-iridis* is a problem very difficult to solve. There are many variants with which to contend and often it is impossible to form an accurate picture from the imperfect illustrations. In the present case, the diatoms of the Sharktooth Hill deposit are large and handsome but not very common. The beads forming the central rosette are always larger than those of the disk and the size of the hyaline space enclosed varies from nothing to that shown in the accompanying figure. The valves are decidedly more convex than are some living forms which have been referred to the species.

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[17] Cont. U. S. Nat. Herb. vol. 10, pt. 5, 1907, p. 246.

26. **Coscinodiscus pacificus** Grunow

Plate 10, fig. 1

Coscinodiscus oculus-iridis pacifica Grunow, Denk. Akad. Wiss. Wien, vol. 48, no. 2, 1884, p. 77.

Coscinodiscus pacificus Grunow in Rattray, Proc. Roy. Soc. Edinburgh, vol. 16, 1889, p. 563; [name for pl. 60, 1877, fig. 13, of Schmidt's Atlas Diat.].—Hanna & Grant, Proc. Calif. Acad. Sci. ser. 4, vol. 15, no. 2, 1926, p. 142, pl. 16, fig. 1.

Coscinodiscus radiatus Ehrenberg is a common and widely distributed diatom with a long geologic range. Normally it has no central rosette of large beads and the beading of the disk does not form perfect radial rows; no secondary markings are visible on the beads with ordinary dry lenses. *C. oculus-iridis,* on the other hand, has the central rosette and almost perfect radials, but still lacks secondary beading. Between these two extremes there is almost perfect intergradation and several of the intergrades have received names, *C. pacificus* being one of them.

27. **Coscinodiscus symbolophorus** Grunow

Coscinodiscus symbolophorus Grunow, Denk. Akad. Wiss. Wien, vol. 48, no. 2, 1884, p. 82, pl. 4, figs. 3-5.—Rattray, Proc. Roy. Soc. Edinburgh, vol. 16, 1889, p. 492.—Schmidt, Atlas Diat. pl. 138, 1889, figs. 1-3. —De Toni, Syl. Algarum, vol. 2, sect. 3, 1894, p. 1230.

Symbolophora; many species names of Ehrenberg; see Mann, Cont. U. S. Nat. Herb. vol. 10, pt. 5, 1907, p. 256.

This name of Grunow's has been generally accepted to include a very considerable number of names coined by Ehrenberg and included in his genus *"Symbolophora."* It appears to be impossible to disentangle the complicated synonymy the latter created and Grunow's action was undoubtedly the best to take. Most of Ehrenberg's names were founded on diatoms found in the Miocene of Virginia and Maryland and since then the species under one name or another has been reported from many fossil localities, widely distributed. The group apparently first appeared in the upper Cretaceous. It is very common in the Sharktooth Hill deposit and strata equivalent in age elsewhere in California.

28. **Cyclotella kelloggi** Hanna, new species

Plate 10, figs. 2, 3, 4

Valve flat, circular with a distinct border and a marginal zone crossed with heavy rounded radiating costæ; about every third to every fifth rib shorter than the remainder or broken into a few beads; remainder of disk covered with sparse, irregularly arranged but relatively large rounded beads. Diameter (holotype), .0392 mm.; (paratype no. 3176) .031+ mm.; (paratype no. 3177) .031.

Holotype: No. 3175; *paratype:* No. 3176, Mus. Calif. Acad. Sci. collected by G. D. Hanna at Loc. 1068 (C. A. S.) southeast side of **Sharktooth Hill, Kern County, California**; Temblor, middle Miocene. *Paratype:* No. 3177, from a depth of 4156 feet in Federal Exploration Company, Kinsella Well No. 1, Loc. 1221 (C. A. S.), Sec. 15, T. 22S., R. 24E., M. D. M., northwest of Bakersfield, Kern County, California; Miocene, possibly higher than Temblor.

Some figures of *C. transylvanica* Pantocsek, resemble this species in a general way but all differ in important details.[18] A closer species appears to be *C. calæ* Azpeitia[19] from the Miocene of Spain, but it likewise differs greatly in detail so that direct comparison scarcely seems necessary.

The species is very rare in the Sharktooth Hill deposit but has been found in abundance in a stratum of younger age a few miles out in the San Joaquin Valley. A nearly perfect specimen from there is figured herewith in order to make more complete the available information on the species. This latter individual has the marginal ribs somewhat shorter than those in the Sharktooth Hill specimens but this is believed to be due to the size of the disk; in other details it agrees very well with those from Sharktooth Hill. Specimens have been prepared from the type Monterey where they are not rare.

The species is named for Dr. Remington Kellogg in recognition of his work on the marine, vertebrate fossils of Sharktooth Hill.

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[18] See Fricke in Schmidt, Atlas Diat. pl. 223, 1900, fig. 21—Pantocsek, Beit. Kennt. Foss. Bacill. Ungarns, pt. 3, 1893, pl. 11, fig. 177.

[19] Assoc. Españona Prog. Cien. Cong. Zargoza, vol. 4, pt. 2, 1911, p. 200, pl. 1, figs. 5, 6.

In some respects this form resembles *"Cestodiscus (pulchellus var.?) hirtulus"* Grunow[20] from the Miocene of Trinidad. From the drawing, however it appears that the center of that species is provided with about seven angular spines and the occasional dark bars on the marginal zone may be spines. Both Rattray and De Toni put *hirtulus* under *Coscinodiscus* so it very likely bears no actual relationship to the present form.

29. Cymatogonia amblyoceras (Ehrenberg)

Plate 10, fig. 5

Triceratium amblyoceras EHRENBERG, Ber. Akad. Wiss. Berlin, 1844, p. 88.—EHRENBERG, Mikrog. 1854, pl. 18, fig. 51.—BRIGHTWELL, Quart. Journ. Micr. Sci. vol. 1, 1853, p. 250, pl. 4, fig. 14.—RALFS in Pritchard, Hist. Infus. ed. 4, 1861, p. 857.—WOLLE, Diat. N. America, 1890, pl. 77, fig. 3.—DE TONI, Syl. Algarum, vol. 2, sec. 3, 1894, p. 970.

Triceratium amblyoceras nankoorensis GRUNOW, Reise S. M. F. *Novara*, Bot. vol. 1, 1867, p. 103.—DE TONI, Syl. Algarum, vol. 2, sect. 3, 1894, p. 971.

Schuettia (?) *amblyoceras* (EHRENBERG), DE TONI, Syl. Algarum, vol. 2, sect. 3, 1894, pp. 1393, 1396.

Actinoptychus amblyoceras (EHRENBERG), SCHMIDT, Atlas Diat. pl. 1, 1874, fig. 25; pl. 155, 1890, fig. 13.—PANTOCSEK, Beit. Kennt. Diat. Foss. Ungarns, pt. 1, 1886, p. 60, pl. 13, fig. 110.—WOLLE, Diat. N. America, 1890, pl. 85, fig. 5.

Valve triangular, gently undulatory with a strong spine at one side of the bisector of each angle and close to the margin; sides gently concave; surface divided into six equal parts by lines formed by junction of lines of beads; these beads arranged in three sets of rows at 60° to each other; border very narrow; marginal area depressed and marked by finer beading than the disk.

Measurements

	Length of one side	Rows of beads in .01 mm.
No. 3178	.090 mm.	13
No. 3179	.1010 mm.	14
No. 3180	.1124 mm.	14
No. 3181	.0562 mm.	12

[20] Van Heurck, Syn. Diat. Belgique, 1880-2, pl. 126, fig. 3.

Plesiotypes: Nos. 3178-3181, Mus. Calif. Acad. Sci. collected by G. D. Hanna at Loc. 1068 (C. A. S.) on the southeast side of Sharktooth Hill, Kern County, California; Temblor Miocene.

This beautiful diatom is abundant in the Sharktooth Hill deposit and elsewhere in California in strata of equivalent age.

Because of the absence of a hyaline central area it was at first thought that the Sharktooth Hill specimens could be specifically separated from the east American *amblyoceras;* in the latter the central area is well developed. Examination of numerous collections from California shows that the area is not uniformly closed and may even be as large as in Maryland specimens. No other difference was noted which might be of use in separating the diatoms from the two coasts.

Three aberrant species have been reported living in tropical seas but the genus is best known from the fossil from Maryland and a fossil one from Hungary. None have been reported from upper Miocene or later deposits so far as my search of the literature has disclosed. The species have been assigned to various genera. They are obviously related to *Actinoptychus* but differ in failing to possess definite radial rays. Formerly they were put in *Triceratium* because of their shape but this disposition was certainly faulty. De Toni[21] created the genus *Schuettia* for the group but, as Van Heurck[22] pointed out, Grunow[23] had already proposed the name *Cymatogonia.* Since neither of these two names has come into general use it seems best to adopt the earlier; fortunately similar procedure throughout the genera of diatoms has thus far not proved acceptable.

30. **Cymatosira andersoni** Hanna, new species

Plate 10, fig. 6

Ovate, flat, border heavy, ends roundly pointed, sides gently curved; surface with large round beads, rather irregularly arranged but the central ones are nearly in longitudinal rows;

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[21] Syl. Algarum, vol. 2, sect. 3, 1894, p. 1395.
[22] Treat. Diat. 1896, p. 496.
[23] Bot. Centralbatt. vol. 15, no. 10, 1883, p. 299.

center always with a hyaline area; in edge view the diatoms grow in a chain somewhat looser than *Rhabdonema* but closer than in *Cymatosira lorenzianum*. Length, .0340 mm.; width, .010 mm.; 10 beads in .01 mm.

Holotype: No. 3182, Mus. Calif. Acad. Sci. collected by G. D. Hanna at Loc. 1068 (C. A. S.) southeast side of **Sharktooth Hill, Kern County, California**; Temblor, middle Miocene.

Very few species of *Cymatosira* have been discovered and this one differs radically from any of them. It is exceedingly abundant in the Sharktooth Hill deposit and its stratigraphic equivalent elsewhere in the same general region. The species seems to be closest to *C. biharensis* Pantocsek[24] from the Miocene of Hungary. Two fossil species from Japan, *debyi* and *japonica* Brun & Tempere,[25] are further removed.

The species is named for Dr. F. M. Anderson, long associated with the California Academy of Sciences and the original describer of the Temblor formation.

31. **Denticula lauta** Bailey

Plate 11, fig. 1

Denticula lauta Bailey, Smith. Cont. Knowl. vol. 7, 1855, p. 9, figs. 1, 2. (Feb. 1854).—Van Heurck, Syn. Diat. Belgique, 1881, pl. 49, figs. 1, 2.—Wolle, Diat. N. America, 1890, pl. 46, fig. 10; pl. 56, figs. 16-17.—Carter, Amer. Mon. Micr. Journ. vol. 12, no. 5, 1891, p. 97, pl. 1, fig. 19.

Eunotia sancti antonii Ehrenberg, Mikrog. 1854, pl. 33, XIII, figs. 9, 10; San Francisco Bay, Calif.; fossil deposit. (Not. pl. 34 V B, fig. 7, from "St. Antonio, Capverden, Afrika".)

Diatoms referred to this species are not common in the Sharktooth Hill deposit but occasional specimens may be found in the lighter washings. There is a portion of the Miocene higher in the column than this part of the Temblor where

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[24] Beit. Kennt. Foss. Bacill. Ungarns, pt. 2, 1889, p. 65, pl. 3, figs. 41, 42.

[25] Mem. Soc. Phys. Hist. Nat. Genève, vol. 30, no. 9, 1889, p. 36, pl. 7, figs. 18*a*, 18*b*, pl. 4, fig. 12.

Denticula is excessively abundant and this portion is thought to be stratigraphically equivalent to the outcrops on San Francisco Bay near Pinole. Bailey's and Ehrenberg's collections were obtained there and both had *Denticula* in abundance. My material from there is similar. Ehrenberg gave several figures from the locality and they are unmistakably the same as Bailey's species which has been accepted generally in diatom literature. The specimen illustrated herewith was illuminated with slightly oblique light giving the impression of asymmetry, as in *Nitzschia;* a true symmetrical arrangement is normal. I have not seen the minute beads shown in figures of some species of *Denticula.*

32. **Dimeregramma scutulum** Hanna, new species

Plate 11, fig. 2

Valve rounded on top, broad in the center, tapering to obtusely rounded ends; sides gently rounded; a zone of marginal beads on each side of the broad central space or pseudoraphe; these lateral zones consist of 23 straight transverse rows of three square beads each, except the rows near the ends which have two and then one; the beads are largest in the center and gradually become smaller toward each end; at each end there is a large roughly semicircular hyaline area. Length, .0330 mm.; width, .0133 mm.; 9 transverse rows of beads in .01 mm. in the center of the valve.

Holotype: No. 3184, Mus. Calif. Acad. Sci. collected by G. D. Hanna at Loc. 1068 (C. A. S.) southeast side of **Sharktooth Hill, Kern County, California**; Temblor, middle Miocene.

Only one specimen was found but owing to its small size the species may be more abundant in the finer washings. The literature contains many species of diatoms referred to the genus *Dimeregramma* but in most cases the drawings are on such a small scale that they cannot be identified satisfactorily.

33. **Dossetia lacera** (Forti)

Plate 11, fig. 3

Xanthiopyxis lacera Forti in Tempere & Peragallo, Diat. du Monde Entier, Ed. 2, 1909, p. 197; [name only].—Forti, Atti R. Ist. Veneto, Sci. Lett. Art. vol. 69, pt. 2, 1910, p. 1311.—Forti, Atti R. Ist. Veneto, Sci. Lett. Art. vol. 72, pt. 2, 1913, p. 1555, pl. 12, figs. 14-18.

This form was first described from the middle Miocene of Marmorita in Italy. It is fairly common in the Sharktooth Hill deposit and equivalent strata in California. The upper Miocene form, *D. temperei* Azpeitia, is generally distributed in the shales of this age in the state; it is a larger and heavier species and is much shorter in proportion to breadth.

The establishment of the genus *Dossetia* for such forms as this, seems to be entirely justifiable.[26]

34. **Eupodiscus antiquus** Cox

Plate 12, figs. 1, 2, 3, 4

Eupodiscus radiatus Bailey, var. *antiqua* J. D. Cox, in Kain & Schultze, Bull. Torrey Bot. Club, vol. 16, no. 8, 1889, p. 209.—Wolle, Diat. N. America, 1890, pl. 77, fig. 8.

Diatoms here referred to *E. antiquus* are abundant in the deposit on Sharktooth Hill and elsewhere in California in equivalent strata. The species is characterized by a heavy and upturned border zone bearing four post-like pillars. The disk in many cases presents "watch case milling" effect better than the specimen illustrated; again the pattern is less perfect, approaching a radiate or fasiculate arrangement. Neither more nor less than four pillars was observed in several hundred individual valves examined. Because the species is large, common, heavy, usually very well preserved and of exceedingly short geologic range so far as known, it makes a very valuable marker for the horizon in which it is found.

Measurements

Diameter	Beads in .01 mm.
.1426 mm.	3 (Plesiotype No. 3193)
.1820 mm.	2.5 (Plesiotype No. 3194)
.1156 mm.	2.5 (Plesiotype No. 3195)
.200 mm.	3 (Plesiotype No. 3196)

[26] See Azpeitia, Asoc. Española, Prog. Cien. Cong. de Zaragoza, vol. 4, pt. 2, 1911, pp. 202-203. Also Forti, last reference cited above.

Plesiotypes: Nos. 3193-3197, Mus. Calif. Acad. Sci. collected by G. D. Hanna at Loc. 1068 (C. A. S.) southeast side of Sharktooth Hill, Kern County, California; Temblor, middle Miocene.

The available information on *antiquus* is very meager. I cannot find that Cox published anything at all and Kain & Schultze only stated that: "while this species bears a general resemblance to *Eupodiscus radiatus,* the cellules are not radiate nor of equal size, but are much smaller towards the margin. General Cox has noted the same form in the Richmond deposits, and instead of considering it a distinct species, he prefers to consider it merely a variety." They were listing the diatoms from well borings at Atlantic City, New Jersey. Wolle's figure is not very satisfactory owing to his method of drawing. However, he did show a diatom with irregular beading and a heavy marginal zone with four post-like processes and it is probable that he had an authentic specimen. He mentioned Richmond, Virginia and the artesian well at Atlantic City but did not state from which the specimen illustrated came.

I have hesitated to identify the California material with a form so poorly diagnosed and certainly would not do so if there were not so many other things in common between the east and west coast deposits. Specimens from the eastern formations have not been available for comparison. Under such circumstances many taxonomists consider it the best policy to create new names with the risk that these may later become synonyms. This is supposed to cause less confusion in the literature than a misidentification, but in the present case it seems best to take a chance on this. It is extremely unfortunate that no satisfactory, well illustrated monograph of the east American deposits has appeared.

Even the genus *Eupodiscus* is of very doubtful application to either of the species, *antiquus* or *radiatus.* The type of the group is *Tripodiscus argus* Ehrenberg (selected by Boyer, Proc. Acad. Nat. Sci. Philadelphia, vol. 78, 1926 [1927] Suppl. p. 89), and it has been pointed out on more than one occasion that *radiatus* can hardly be considered congeneric.[27] Boyer even suggested the new genus-name *Baileya* for *radiatus* but unfortunately this had been used long ago for a genus of flowering plants.[28] The latest attempt to rectify matters was by Karsten[29] who proposed *"Eu-eupodiscus"* and cited *radiatus* alone. This is almost an impossible combination and probably was not intended to become a genus-name.

Until some really constructive information can be offered to clear up this nomenclatorial tangle it seems desirable to leave the California diatoms under *"Eupodiscus antiquus."*

35. Goniothecium rogersii Ehrenberg

Plate 11, figs. 4, 5, 6

Goniothecium rogersii EHRENBERG, Abh. Akad. Wiss. Berlin, 1841 [1843], pp. 401, 416 (or 128).—BAILEY, Amer. Journ. Sci. vol. 46, 1844, p. 301. —EHRENBERG, Mikrog. 1854, pl. 18, figs. 92, 93.—BRIGHTWELL, Quart. Journ. Micr. Sci. vol. 4, 1856, p. 107, pl. 7, figs. 43-46.

This is a common species in the Sharktooth Hill deposit. Originally it was described from Miocene deposits of Virginia or Maryland supposed to be equivalent in age.

My catalog contains the names of 23 species of *Goniothecium* all but seven being from Ehrenberg's writings. Of these 16, *rodgersii* may be the only valid name and the species has not heretofore been adequately figured. Like many of the diatoms belonging to this general group, great variability is found in the shape and size of the frustules and this fact led Ehrenberg to issue many names without consideration of other factors. The genus is very common in the upper Miocene of California, but numerous specimens examined do not appear to differ specifically from those from the Temblor, illustrated herewith by a representative selection.

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[27] Mann, A. Cont. U. S. Nat. Herb. vol. 10, no. 5, 1907, p. 278; and Boyer, op. cit.

[28] Harvey & Gray, ex Torrey, in Emory, Notes Mill. Reconnois, 1848.

[29] Karsten, in Engler, Pflanzenfam. Ed. 2, vol. 2, 1928, p. 226.

36. **Hemiaulus polymorphus** Grunow

Plate 11, fig. 7

Hemiaulus polymorphus GRUNOW, Denk. Akad. Wiss. Wien, vol. 48, 1884, p. 66.—GROVE & STURT, Journ. Quek. Micr. Club. vol. 3, ser. 2, 1887, p. 11.—SCHMIDT, Atlas Diat. pl. 143, 1889, figs. 11-13.—PANTOCSEK, Beit. Kennt. Foss. Bacill. Ungarns, pt. 2, 1889, p. 83.—WOLLE, Diat. N. America, 1890, pl. 25, figs. 23-25.—HANNA, Journ. Paleo. vol. 1, no. 2, 1927, p. 114, pl. 18, figs. 9, 10.

This exceedingly variable diatom is very rare in the deposit on Sharktooth Hill. Indeed, *Hemiaulus* by this time had almost ceased to exist although *polymorphus* was very abundant in Eocene time as represented by the Jutland deposits of Denmark, and the Kreyenhagen shale of California.

37. **Hercotheca mammillaris** Ehrenberg

Hercotheca mammillaris EHRENBERG, Ber. Akad. Wiss. Berlin, 1844, p. 269.—KÜTZING, Sp. Alg. 1849, p. 27.—EHRENBERG, Mikrog. 1854, pl. 33, XVIII, fig. 7.—RALFS in PRITCHARD, Hist. Infus. Ed. 4, 1861, p. 887, pl. 7, fig. 35.—GRIFFITHS & HENFREY, Microg. Dict. 1875, pl. 43, fig. 31.—WOLLE, Diat. N. America, 1890, pl. 64, figs. 22, 23.—DE TONI, Syl. Algarum, vol. 2, sect. 3, 1894, p. 1005.—VAN HEURCK, Treat. Diat. 1896, p. 427, fig. 147.—BOYER, Maryland, Geol. Surv. Miocene, 1904, p. 490.—HANNA, Journ. Paleo. vol. 1, no. 2, 1927, p. 114, pl. 18, fig. 11.

It is believed that numerous small oval diatoms with marginal spines found in the lighter washings from Locs. 1063 and 1068 are this species. A critical comparison with specimens from east American lower Miocene has not been made but it is not believed specific differences will be found.

38. **Hyalodiscus frenguellii** Hanna, new species

Plate 11, figs. 8, 9

Valve convex, constructed of heavy silica, thick at the edges; central disk large, almost flat, marked with very fine radial lines; outer zone narrow, covered with fine radial lines of beads; the beads are also arranged in diagonal curved rows meeting at an angle greater than 90°; at irregular intervals the radial rows are thickened producing larger and more conspicuous elongated dots.

Measurements

Diameter	Radial striæ in .01 mm., at inner edge of outer zone
.0968 mm.	21 (Holotype, No. 3190)
.0713 mm.	21 (Paratype, No. 3191)
.0539 mm.	21 (Paratype, No. 3192)

Holotype: No. 3190; *paratypes:* Nos. 3191, 3192, Mus. Calif. Acad. Sci. collected by G. D. Hanna at Loc. 1068 (C. A. S.) on the southeast side of **Sharktooth Hill, Kern County, California**; Temblor, middle Miocene.

This is a heavy species of *Hyalodiscus,* abundant in the Sharktooth Hill deposit. Its dark brown color on dry strewn slides makes it very conspicuous. The finer structure, however, is very difficult to resolve with dry objectives but can be seen with oblique light and 4 mm. apochromatics.

The central area appears rugose under low powers, some specimens showing a series of comparatively large bead-like elevations; the holotype, however, appears to possess an indistinct unevenness which disappears under high magnification.

Two species of *Hyalodiscus* have been recorded from the middle Miocene of the eastern United States, *lævis* and *stelliger.* The new species is not related closely to either of these; nor is it close to *H. reticulatus* Schmidt of the upper Miocene of California.

The species is named for Dr. Joaquin Frenguelli, the celebrated diatomist of the Argentine.

39. Leudugeria janischii (Grunow)

Epithemia ? LEUDUGER-FORTMOREL, Diat. Ceylon, Mém. Soc. Emul. St. Brieuc, 1879, p. 183, pl. 9, fig. 87.

Eunotiopsis janischiana GRUNOW, in CLEVE & MÖLLER, Diat. Ex. no. V, 1879, p. 4, no. 257; [name only].

Euodia janischii GRUNOW, in VAN HEURCK, Syn. Diat. Belgique, 1880-1882, pl. 127, figs. 1-4.—WOLLE, Diat. N. America, 1890, pl. 105, figs. 19-21.

Leudugeria epithemioides TEMPERE, Le Diatomiste, vol. 2, 1893, p. 17.

Leudugeria janischii GRUNOW, VAN HEURCK, Treat. Diat. 1896, p. 539, fig. 287.

Leudugeria janischiana GRUNOW, FORTI, Atti R. Ist. Veneto, Sci. Lett. Art. vol. 72, pt. 2, 1913, p. 1648, (var. *subarcuata* TEMPERE, pl. 27, fig. 4).

A single specimen was found in the collection from Loc. 1063 on the west side of Cottonwood Creek, Kern County, California. The species is much more common in the upper part of the Miocene, as at Monterey, than in the Temblor. It has been reported living in tropical seas but the records need confirmation.

Forti has given valuable observations on the genus and revived the original spelling of the species-name as written on the slides distributed by Cleve & Möller. It is doubted if many taxonomists will agree that such procedure constitutes publication.

40. **Liradiscus rugulosus** Forti

Plate 12, figs. 5, 6

Liradiscus rugulosus FORTI, Atti R. Ist. Veneto, Sci. Lett. Art. vol. 72, pt. 2, 1913, p. 1559, pl. 12, fig. 23.

The specimen here referred to Forti's species conforms almost exactly in shape, as does *Liradiscus ovalis* Greville.[30] The specimen is strongly marked with uniformly scattered spines but lacks the peculiar lines connecting the spines found in *ovalis*. *L. rugulosus* seems also from the figure to be marked only with spines and these appear smaller but the difference does not appear sufficiently great to warrant specific separation. The species appears to be rare in the Sharktooth Hill deposit; only one good specimen was found but since it is a very small form, thorough search of the lighter washings might show that it is more abundant.

Typically, a *Liradiscus* should have the peculiar lines connecting the spines and probably this form should be referred to *Xanthiopyxis* but until more specimens can be studied it seems best not to change genera.

Macrora Hanna, new genus

Valve small, circular; margin heavy, crenulated and marked by large hyaline ovate areas; disk convex and marked by similar, large hyaline areas.

Genotype (monotypic): *Pyxidicula stella* Azpeitia.

[30] See Van Heurck, Treat. Diat. 1896, p. 511, fig. 260.

41. **Macrora stella** (Azpeitia)

Plate 12, fig. 7

Pyxidicula (??) *stella* AZPEITIA, Assoc. Esp. Prog. Cien. Cong. de Zargoza, vol. 4, pt. 2, sec. 3, 1911, pp. 150, 152, 213, pl. 1, fig. 1; Puente-Genil, Córdoba.

This form is rare in the Sharktooth Hill deposit (Loc. 1068) but was occasionally found in the finer washings. It would be overlooked in ordinary mounting procedure unless this be conducted with an objective of shorter focal length than 16 mm.

Azpeitia doubly questioned the placing of the species in *Pyxidicula;* he even expressed doubt as to its being a diatom, thinking perhaps it might belong to the Radiolaria. However, I have had an opportunity to study several specimens in all positions and can state confidently that the organism is a diatom; the huge hyaline areas are not pores. The relationship appears to be with *Stephanopyxis* but there is such radical divergence from all known species of that genus that I feel obliged to propose a new group name for it. The California specimens do not show any difference which can reasonably be used for specific separation, from the one figured from the Miocene of Spain by Azpeitia.

42. **Melosira geometrica** Hanna, new species

Plate 12, figs. 8, 9

Valve circular with heavy margin, disk convex with large beads arranged in hexagonal system, beads largest at center and decreasing regularly toward margin of disk; in zonal view sides are straight and marked with longitudinal rows of very fine beads. Diameter (holotype), .030 mm.; diameter (paratype), .0352 mm.; length, .0139 mm.

Holotype: No. 3200; *paratype:* No. 3201, Mus. Calif. Acad. Sci. collected by G. D. Hanna at Loc. 1068 (C. A. S.), southeast side of **Sharktooth Hill, Kern County, California**; Temblor, middle Miocene.

From the markings on the disk this species might be expected to fall in the genus *Endictya* but members of that group should have the beading on the girdle similar to or identical with that of the disk; in this form they are very different. It appears to be a true *Melosira* although no very close relative seems to have been described. It is common in the Sharktooth Hill deposit in the finer washings and was thought to be some form of *Stephanopyxis* during preparatory processes but careful handling of many valves with the mechanical finger did not confirm the supposition. In edge view the form was always conspicuous on dry, strewn slides due to the brown prismatic color formed by the fine markings.

43. **Melosira sulcata** (Ehrenberg)

Gallionella sulcata Ehrenberg, Ber. Akad. Wiss. Berlin, 1837, p. 61.—Ehrenberg, Infus. 1838, p. 170, pl. 21, fig. 5.—Ehrenberg, Mikrog. 1854, pl. 18, figs. 1*a-c;* pl. 20, II, fig. 27; pl. 25A, XVII, figs. 11-12.

Melosira sulcata (Ehrenberg), Kützing, Bacill. 1844, p. 55, pl. 2, fig. 7.—Schmidt, Atlas Diat. pl. 177, 1892, figs. 23-39.—Hanna & Grant, Proc. Calif. Acad. Sci. ser. 4, vol. 15, no. 2, 1926, p. 148, pl. 17, fig. 2.

Diatoms supposed to be this species are exceedingly abundant in the Sharktooth Hill deposit. Many variations (or species) are present, ranging from those with perfectly hyaline disks to those with radiating bars as in *M. sol* and *M. clavigera* and those with rosette centers. An adequate means of separation of these variations has not been proposed; they may all be forms of one plastic species. As the taxonomy of the group stands at present they are useless for correlation in geology.

44. **Navicula kernensis** Hanna, new species

Plate 13, fig. 1

Valve strongly convex, long and slender, ends pointed; raphe surrounded by a lanceolate hyaline area dilated in the center, more on one side than the other; outer zone marked with close set transverse, slightly radial ribs of uneven length, interrupted toward the outer ends by a strong, longitudinal bar upon which there is a thickening where each transverse bar crosses; terminal nodules heavy; central nodule strongly rounded, heavier on one side than the other. Length (holotype), .192 mm.; width, .040 mm.; nine striæ in .01 mm.; length (paratype), .220 mm.; width, .0485 mm.; nine striæ in .01 mm.

Holotype: No. 3202; *paratype:* No. 3203, Mus. Calif. Acad. Sci. collected by G. D. Hanna at Loc. 1068 (C. A. S.) on the southeast side of **Sharktooth Hill, Kern County, California;** Temblor, middle Miocene.

This heavy and striking species is common in the Sharktooth Hill deposit and its equivalent elsewhere in the same general region. The silica is evidently brittle because perfect specimens are scarce, yet fragments are found on practically every strewn slide.

Search of the literature for a named form to which this could be referred was without avail. Pantocsek described several species, *N. halionata* in particular, from the Miocene of Hungary which are similar in shape and in the possession of bars instead of lines of beads but in every case details are so different from the California specimens that separation must be maintained. Many of the early species to which the California form bears a superficial resemblance are so crudely drawn that recognition of them cannot be at all certain. This pertains particularly to *N. formosa* Gregory[31] which is better illustrated than many others. The resemblance of *kernensis* and *mimicans* to *formosa* is striking; Gregory suspected that the transverse bars were punctate and Boyer[32] has shown this to be the case. Moreover, the descriptions of *formosa* which have been seen indicate that the diatom is smaller and the markings are finer.

Some of the species similar to the present one and *mimicans* have been referred to the group *Caloneis* of Cleve which is now recognized as a distinct genus; in view of the fact that Boyer[33] selected *N. amphisbæna* as the genotype, such reference may not be permissible; further study is necessary to determine this point definitely and in the meantime it is perhaps better to place them in *Navicula*.

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[31] Gregory, W., Trans. Micr. Soc. London, vol. 4, 1856, p. 42, pl. 5, fig. 6.
[32] Boyer, C. S. The Diatoms of Philadelphia, 1916, pl. 21, fig. 18.
[33] Proc. Acad. Nat. Sci. Philadelphia, vol. 79, 1927, Suppl. p. 306.

45. **Navicula lyra** Ehrenberg

Plate 13, fig. 2

Navicula lyra Ehrenberg, Abh. Akad. Wiss. Berlin, 1841 (1843), p. 419, pl. 1, I, fig. 9*a*.—Wolle, Diat. N. America, 1890, pl. 16, figs. 6, 9, 14, 26. —Hanna & Grant, Proc. Calif. Acad. Sci. ser. 4, vol. 15, no. 2, 1926, p. 152, pl. 18, fig. 5.—Hanna, Journ. Paleo. vol. 1, no. 2, 1927, p. 116, pl. 20, fig. 3.

Navicula lyra recta Greville, Edinburgh, New Phil. Journ. n. s. vol. 10, 1859, pl. 4, fig. 3.—Schmidt, Atlas Diat. pl. 2, 1874, fig. 18.—Wolle, Diat. N. America, 1890, pl. 16, fig. 4.

This beautiful species is rare in the Sharktooth Hill deposit but it is just as well developed as living individuals today. It has had a long life and must be a form especially well fitted to adapt itself to its surroundings. Variation among the specimens mounted from the deposit is not great. No attempt has been made to place the fossils in any of the 35 or more subspecies which have been named because no useful purpose would appear to be served by following a trinomial or polynomial system of nomenclature. Eventually some of these forms may be desirable to meet the needs of geology but it is not felt that that time has yet arrived.

46. **Navicula marina** Ralfs

Plate 13, fig. 3

Navicula marina Ralfs, in Pritchard, Hist. British Infusoria, Ed. 4, 1861, p. 903; new name for *N. punctulata* W. Smith, not Ehrenberg.—Van Heurck, Syn. Diat. Belgique, 1880-1881, pl. 11, fig. 16.—Hanna & Grant, Journ. Paleo. vol. 3, no. 1, 1929, p. 96, pl. 13, figs. 6, 7; pl. 14, fig. 1.—Not *N. marina* Janisch & Rabenhorst, Diat. Honduras, 1863, p. 10, pl. 2, fig. 16.

Navicula punctulata W. Smith, Syn. British Diat., vol. 1, 1853, p. 52, pl. 16, fig. 151; Marine, Poole Bay and Seaford, Sussex, England.—Not *N. punctulata* Ehrenberg, Ber. Akad. Wiss. Berlin, 1842, p. 337; Mikrog., 1854, pl. 16, group 1, fig. 1; pl. 15A, fig. 34; pl. 15B, fig. 14.

Navicula granulata Brebisson, Van Heurck, Syn. Diat. Belgique, 1880-1881, pl. 11, fig. 15.—Not *N. granulata* Brebisson, in Donkin, Trans. Micr. Soc., vol. 6, n. s., 1858, p. 17, pl. 3, figs. 19 *a*, *b*.

Navicula schultzei Kain, Bull. Torrey Bot. Club, vol. 16, 1889, p. 75, pl. 89, fig. 2, Atlantic City, New Jersey, Miocene.

Navicula schultzei mexicana Schmidt, Atlas Diat., pl. 244, 1903, fig. 5.

Navicula schultzii Kain, Wolle, Diat. N. America, 1890, pl. 24, fig. 5.

Navicula schulzii Kain, Cleve, Kongl. Sv. Vet. Akad. Handl. vol. 27, no. 3, 1895, p. 45.

Navicula schulzii marylandica Cleve, Kongl. Sv. Vet. Akad. Handl. vol. 27, no. 3, 1895, p. 45.

Navicula schulzii californica Cleve, Kongl. Sv. Vet. Akad. Handl. vol. 27, no. 3, 1895, p. 45, pl. 1, fig. 26.

This species is common in the Sharktooth Hill deposit and its equivalent in the same general region. The specimen figured has slightly angulated sides, this being the most common form present, but shape is very variable and some individuals are plain ovate without a trace of angulation.

Measurements

Length	Width	Transverse rows of beads in .01 mm.
.090 mm.	.447 mm.	6 (Plesiotype No. 3205, figured)
.090 mm.	.0428 mm.	7

Finding this species in the Temblor was a surprise because it has already been reported from an Etchegoin, Pliocene, brackish water deposit in the San Joaquin Valley. Under the name "*Navicula schultzei* Kain" it has been reported from Miocene deposits of eastern North America.[34] Cleve added the subspecies, *marylandica,* from the same region and *californica* from California, but they do not appear to be sufficiently distinct for recognition.

47. **Navicula mimicans** Hanna, new species

Plate 13, fig. 4

Valve similar in structure to *N. kernensis* but shorter, broader and with a narrower hyaline zone on each side of the raphe; the transverse bars end inwardly in an almost even line; the lateral longitudinal line is not a bar but a mere thickening in the transverse bars and the line is much more distant from the margin than in *N. kernensis;* the central area is dilated more on one side than the other corresponding to an asymmetric thickening of the central nodule.

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[34] Kain & Schultze, Bull. Torrey, Bot. Club, vol. 16, 1889, p. 75, pl. 89, fig. 2.—Boyer, Maryland Geol. Surv. Miocene, 1904, p. 487.

Measurements

Length	Width	Striæ in .01 mm.
.1350 mm.	.0345 mm.	9 (Holotype No. 3206)
.0669 mm.	.0223 mm.	11 (Paratype No. 3207)
.1170 mm.	.0340 mm.	9 (Paratype No. 3208)

Holotype: No. 3206; *paratypes:* Nos. 3207, 3208, Mus. Calif. Acad. Sci. collected by G. D. Hanna at Loc. 1068 (C. A. S.) on the southeast side of **Sharktooth Hill, Kern County, California**; Temblor, middle Miocene.

This species is similar in structure to *N. kernensis* but connecting forms do not exist in the formation here being studied, although both are common. *N. mimicans* is always shorter and broader and the longitudinal lateral lines are always closer to the raphe. The measurements given represent the greater part of the range of variation. *N. kernensis* is much the more constant in size. (See under that form for remarks regarding relationships.)

48. **Navicula morricei** Hanna, new species

Plate 13, fig. 5

Valve flat, ovate, ends roundly pointed; transverse rows of beads slightly radial toward ends, interrupted on each side of the raphe by a zone of scattered beads; this zone corresponds in position to the lyre of *N. lyra,* the central nodule being dilated as in that species. Length (holotype), .120 mm.; width, .0580 mm.; 10 rows of beads in .01 mm. in center of valve, nine at ends.

Holotype: No. 3209, Mus. Calif. Acad. Sci. collected by G. D. Hanna at Loc. 1068 (C. A. S.) southeast side of **Sharktooth Hill, Kern County, California**; Temblor, middle Miocene.

The species is rare in the locality mentioned and because of the large size and fragile nature of the valves, perfect specimens are difficult to find. Those examined, however, have shown very little variation, either in size, shape, or character of markings.

Species belonging to this same group and sufficiently close to call for careful comparison are: *N. schaarschmidtii* Pantocsek,[35] with more rounded ends, smaller size (.076-.10 mm. long and .04–.048 mm. wide) and finer markings (10.5–12 rows of beads in .01 mm.); *N. neupaurii* Pantocsek[36] with more rounded ends, smaller size (.094 mm. long and .042 mm. wide) and finer markings (12 rows of beads in .01 mm).

The distinctions shown are believed to warrant specific separation of the California form from these. It is not at all unlikely that this species has passed at some time or other under the name *N. prætexta,* since there is a slight superficial resemblance; however, consultation of original sources of information pertaining to that species shows that the usual California upper Miocene forms referred to it have probably been correctly identified.[37] It is possible that the *prætexta* complex forms an intergrading series of variants similar to *N. lyra;* if so then *morricei* merely forms one of the links in the chain but sufficient material has not yet been studied to prove such intergradation.

This handsome diatom is named in honor of Mr. Charles Morrice, a modest and earnest worker whose justly earned fame is narrated in greater detail in the paper on the geology of Sharktooth Hill.[38]

49. **Navicula optima** Hanna, new species

Plate 13, fig. 6

Valve ovate, narrowly rounded at the ends, slightly convex; markings consist of distantly spaced bars, acutely radial, and extending from the raphe to the border except in the central area where three on each side are unequally shortened; this produces an imperfect stauros. Length (holotype), .0411 mm.; width, .0114 mm.; eight bars in .01 mm.

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[35] Beit. Kennt. Foss. Bacill. Ungarns, pt. 1, 1886, p. 28, pl. 14, fig. 121; Miocene, Hungary.

[36] Op. cit. p. 27, pl. 14, fig. 123; St. Peter, Hungary.

[37] See Hanna & Grant, Proc. Calif. Acad Sci. ser. 4, vol. 15, 1926, p. 154 for references to *N. prætexta.*

[38] Hanna, G. D., Proc. Calif. Acad. Sci. ser. 4, vol. 19, no. 7, 1930, pp. 65-83.

Holotype: No. 3210, Mus. Calif. Acad. Sci. collected by G. D. Hanna at Loc. 1068 (C. A. S.), southeast side of **Sharktooth Hill, Kern County, California**; Temblor, middle Miocene.

This minute but boldly marked form bears a strong resemblance to *N. tolmani* Hanna[39] from a still lower portion of the Tertiary section; the present species, however, lacks the tendency toward capitate ends and *N. tolmani* does not have the central bars shortened to produce a stauros.

On account of its small size most of the diatoms of the present species were probably lost in the finer washings during the cleaning processes; consequently it appeared to be rare.

Much uncertainty surrounds the identity of a vast number of the early described species of *Navicula;* lenses were comparatively imperfect and published drawings are on such a small scale that the essential characters cannot be determined therefrom. Moreover, mounting material no better than Canada balsam was known when many of the species were described. Two courses are open to the student of such organisms. One is to use an old name of some species which in general appearance and form somewhat resembles his but the exact characters of which he can only surmise. The other procedure is to describe his material as new and add another name to an already overburdened genus. Neither action is satisfying but the last seems to be the least objectionable of the two in the present case.

50. Navicula proserpinæ (?) Pantocsek

Plate 13, fig. 7

Navicula proserpinæ Pantocsek, Beit. Kennt. Foss. Bacill. Ungarns, pt. 3, p. 79, 1905, pl. 18, 1893, fig. 260; "Bodos, Transylvania," freshwater deposit.

A few specimens of this minute species were found in the Sharktooth Hill deposit. They may belong to an undescribed species but the identification at this time cannot be effected with certainty; the publication of the figure, however, is believed desirable in order to record the presence of such a form

[39] Journ. Paleo. vol. 1, no. 2, 1927, p. 117, pl. 20, fig. 5.

in this middle Miocene formation; it may have an important bearing on the history of the evolution of the genus *Navicula* which may be exclusively a Tertiary to recent group; Boyer[40] has suggested that it began with the lower Miocene.

The species bears a close resemblance to the figure of Pantocsek's *N. proserpinæ,* reported from a freshwater deposit; the few specimens found in the Sharktooth Hill material may have washed into the Miocene sea from a nearby lake or stream because they do not differ radically from many described freshwater forms.

51. **Navicula spectabilis** Gregory

Navicula spectabilis Gregory, Trans. Roy. Soc. Edinburgh, vol. 21, 1857, p. 481, pl. 9, fig. 10.—Schmidt, Atlas Diat. pl. 2, fig. 31, pl. 3, figs. 20-21, 29, 1875.—Mann, Cont. U. S. Nat. Herb. vol. 10, pt. 5, 1907, p. 356.—Hanna & Grant, Proc. Calif. Acad. Sci. ser. 4, vol. 15, 1926, p. 156, pl. 19, fig. 2.

A very few individuals of this species were detected in the collection made at Loc. 1063 (C. A. S.) on the west side of Cottonwood Creek a few miles east of Sharktooth Hill. It and its close relative, *N. lyra,* have lived without much change of structure or form from lower Miocene to the present and for this reason they are practically valueless for correlation purposes. They are very beautiful diatoms, nevertheless.

52. **Omphalotheca caput-medusæ** (Azpeitia)

Hercotheca ? caput-medusæ Azpeitia, Assoc. Esp. Prog. Cien. Cong. Zaragoza, vol. 4, sec. 3, Cien. Nat. pt. 2, 1911, p. 207, pl. 11, fig. 3; Miocene of Spain.

Diatoms similar to the one Azpeitia figured are present but rare in the Sharktooth Hill deposit (Loc. 1068). It appears that they would better be included under *Omphalotheca* than *Hercotheca* because of the convexity of the valves and the excessively long spines distributed over the valvular surface.

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[40] Maryland Geol. Surv. Miocene, 1904, p. 488.

53. **Periptera tetracladia** Ehrenberg

Plate 13, fig. 8

Periptera tetracladia EHRENBERG, Ber. Akad. Wiss. Berlin, 1844, p. 270.—KÜTZING, Spec. Algarum, 1849, p. 25.—EHRENBERG, Mikrog. 1854, pl. 33, XVIII, fig. 9.—RALFS in PRITCHARD, Hist. Infus. Ed. 4, 1861, p. 865, pl. 6, fig. 30.—GRIFFITHS & HENFREY, Microg. Dict. 1875, pl. 43, fig. 66.—VAN HEURCK, Syn. Diat. Belgique, 1880-1882, pl. 83*ter*, figs. 7-9.—PANTOCSEK, Beit. Kennt. Foss. Bacill. Ungarns, pt. 2, 1889, p. 74.—WOLLE, Diat. N. America, 1890, pl. 67, figs. 17-19.—CARTER, Amer. Mon. Micr. Journ. vol. 12, no. 6, 1891, p. 121, pl. 2, fig. 35.—DE TONI, Syl. Algarum, vol. 2, sect. 3, 1894, p. 1007. —BOYER, Maryland, Geol. Surv. Miocene, 1904, p. 490.—TEMPERE & PERAGALLO, Diat. du Monde Entier, 1908, p. 26.—AZPEITIA, Asoc. Española, Prog. Cien. Cong. Zaragoza, vol. 4, sec. 3*a*, Cien. Nat. pt. 2, 1911, pp. 59, 64, 156, 163, 164, 175.

No two individuals of this form have been seen which are exactly alike and evidently species-boundaries should be interpreted generously. Ehrenberg originally described it from the Miocene of Virginia or Maryland and it has been recognized in several other deposits of the same epoch.

It is fairly common in the lighter washings from the Sharktooth Hill samples; the spines are brittle and often partially or entirely broken off. The frustule is ovate in end view. Probably the most constant features are the shape and the zone of dots on the side of the frustule.

At present we have no means of merging this form with other nondescript "endocystoid" genera although it is possible that too many of these are recognized as valid. Van Heurck[41] placed the group under the much later genus-name *Pyrgodiscus* Kitton, 1885, but the procedure is not warranted even if the rules of nomenclature were not so violently violated.

54. **Perrya innocens** Hanna, new species

Plate 14, fig. 1

Valve very large, extremely thin and delicate, rounded on the sides, tapering abruptly at the ends; a large rounded wrinkle or wave extends longitudinally through the center of the valve; markings consist of a set of transverse bars, rather

[41] Treat. Diat. 1896, index.

coarse and irregularly defined in parts but fairly uniformly spaced and not resolvable into beads; between these major bars which extend almost across the valve there are shorter bars extending inwardly from the inferior margin (on the holotype) unequal distances; the number of these shorter bars between any two major bars is one, two or three, on the same valve; in no instance do they cross the mid-zone; even the major ribs are somewhat poorly and irregularly defined toward the superior margin. Length (holotype), .1860 mm. (original length about .260 mm.); width, .080 mm.; number of major bars in .01 mm. 4 to 5 depending upon the part of the valve upon which the measurement is taken.

Holotype: No. 3213, Mus. Calif. Acad. Sci. collected by G. D. Hanna at Loc. 1068 (C. A. S.) on the southeast side of **Sharktooth Hill, Kern County, California**; Temblor, middle Miocene.

The recognition of huge Nitzschias belonging to the group *Perrya* of Kitton is contrary to the views of Van Heurck[42] but is in accordance with the work of H. & M. Peragallo[43] who have given the group careful study. Structurally these forms appear to be too far removed from typical *Nitzschia* to be included in the same genus. The species described above is considerably different from all others in that there is not the slightest indication of the transverse bars breaking up into beads. Also the other described forms do not have the pronounced longitudinal wave shown in *innocens*.

There is considerable evidence to indicate that *Nitzschia* first appeared in lower Miocene strata and the progenitors of the present enormous number of living species were diverse and aberrant forms.

P. innocens is common in the Sharktooth Hill deposit and its equivalent elsewhere in California but the diatoms are so fragile that it is almost impossible to find unbroken specimens in any sample I have cleaned.

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[42] Treat. Diat. 1896, p. 408, fig. 130.

[43] Diat. Mar. de France, 1900, p. 297, pl. 76, fig. 2.

55. **Plagiogramma truanii** Pantocsek

Plate 14, fig. 2

Plagiogramma truanii PANTOCSEK, Beit. Kennt. Foss. Bacill. Ungarns, pt. 2, 1889, p. 62; Bory, Hungary; pt. 3, 1905, p. 87, pl. 15, 1892, fig. 224, pl. 24, fig. 351.—MANN, U. S. Nat. Mus. Bull. 100, vol. 6, pt. 1, 1925, p. 129.

The specimen figured herewith from Sharktooth Hill, Kern County, California (Loc. 1068 C. A. S.) is very close to the one described from the Miocene of Hungary in 1889. The ends of the California form have a slight tendency to become capitate, a character not shown in Pantocsek's figure; also he stated that there were 15 striæ in .01 mm. whereas the present form has 17. These are such minor differences that they can hardly be specific. The form is very rare at the locality mentioned. I doubt if the species can be held distinct from some living forms bearing earlier names but until a careful study shall have been made of the entire group it seems desirable to recognize the fossil form; there seems to be a conflict between two or more of the earlier names.

Raphidodiscus H. L. Smith

Melonavicula CHRISTIAN, Amer. Mon. Micr. Journ. vol. 7, 1886, p. 218; *nomen nudum.*—ANON., Journ. Roy. Micr. Soc. 1890, p. 79.

Raphidodiscus H. L. SMITH in CHRISTIAN, The Microscope, vol. 7, March, 1887, p. 67.—VORCE, "The Affinities of *Raphidodiscus*," The Microscope, vol. 9, no. 5, 1889, pp. 132-137, pl. 6.

Humbugodiscus DEBY, Nuova Notarisia, 1890, p. 240.

Rhaphidodiscus, VAN HUERCK, Treat. Diat. 1896, p. 236, pl. 35, figs. 913 *a*, *b*, text fig. 33. [Name spelled "*Raphidodiscus*" in explanation of pl. 35.]

This very distinct and remarkable form is apparently an excellent marker fossil of middle and possibly lower Miocene deposits the world over. It has been reported from Maryland, Virginia, Trinidad, Hungary and California. The earliest name is *Melonavicula* but this must be considered as a nomen nudum because when the diatom was finally made known with illustrations it appeared as *"Raphidodiscus."* A careful reading of Christian's article shows that he attributed the name to Prof. H. L. Smith. Van Heurck misspelled the name in his Treatise (p. 236) but corrected it in the explanation of his plate; nevertheless his error has often been repeated. Probably no diatom has been the cause of as much bitter feeling as this. Particularly some European diatomatists deplored the action of Christian and H. L. Smith; Deby went so far as to facetiously rename the genus, *Humbugodiscus!* As it turns out, the critics were in error. Unfortunately Christian's first specimen was lodged inside the rim of a *Melosira* but his figures show he had others which were not.

56. **Raphidodiscus marylandicus** Christian

Plate 14, figs. 3, 4

Melonavicula marylandica Christian, Amer. Mon. Micr. Journ., vol. 7, 1886, p. 218; *nomen nudum.*

Raphidodiscus marylandica Christian, The Microscope, vol. 7, 1887, p. 66, first fig.—Vorce, The Microscope, vol. 9, no. 5, 1889, p. 132, pl. 6, fig. 5.—Wolle, Diat. N. America, 1890, pl. 84, fig. 1.—De Toni, Syl. Algarum, vol. 2, sect. 1, 1891, p. 313.—Van Heurck, Treat. Diat. 1896, pl. 35, fig. 913*a*.

Raphidodiscus febigerii Christian, The Microscope, vol. 7, 1887, p. 66, 3 figs. —Vorce, The Microscope, vol. 9, 1889, p. 132, pl. 6, figs. 1, 2.—Wolle, Diat. N. America, 1890, pl. 84, figs. 3, 4.—De Toni, Syl. Algarum, vol. 2, sect. 1, 1891, p. 313.—Van Heurck, Treat. Diat. 1896, pl. 35, fig. 913*b*.

Raphidodiscus christianii Gascoyne in Vorce, The Microscope, vol. 9, 1889, p. 132, pl. 6, fig. 4.—Wolle, Diat. N. America, 1890, pl. 84, fig. 2. —De Toni, Syl. Algarum, vol. 2, sect. 1, 1891, p. 313.

Raphidodiscus bogus Ward in Vorce, The Microscope, vol. 9, 1889, p. 132. Disciform *Navicula*, Van Heurck, Treat. Diat. 1896, p. 236, fig. 33; Naparima, Trinidad.

Navicula disciformis Petticolas in Vorce, The Microscope, vol. 9, 1889, p. 132; *nomen nudum.* [Vorce stated that Petticolas had described *R. marylandica* under the above name but I have been unable to find such a description.]

Diploneis microtatos christianii Cleve, Kongl. Sven. Vet. Akad. Handl. vol. 26, no. 2, 1894, p. 96, pl. 2, fig. 1.—Fricke, Verz. Schmidt's Atlas Diat. 1903, p. 35.—Boyer, Maryland Geol. Surv. Miocene, 1904, p. 487, pl. 135, fig. 5.

Cocconeis febigerii "Brun," Schmidt, Atlas, Diat. pl. 193, 1894, fig. 58; "Richmond," Va.

The species is common in the Sharktooth Hill deposit and its stratigraphic equivalent elsewhere in California.

Measurements

Length	Width	Transverse rows of beads at dark oval line opposite central nodule in .01 mm.
.0555 mm.	.0515 mm.	13 (Plesiotype, No. 3215, fig'd)
.0480 mm.	.0448 mm.	12 (Plesiotype, No. 3216)
.0315 mm.	.0310 mm.	17 (Plesiotype, No. 3217)
.0382 mm.	.0382 mm.	13 (Plesiotype No. 3218, fig'd)

The synonymy has been worked out in as great detail as possible because the species is believed to be exceedingly important in correlation of geologic formations. It has been found in several localities in California and many places in the eastern part of the United States; the strata in which it has occurred are middle Miocene. A safe inference is that where the species appears the formation is approximately equivalent of the Temblor and Calvert formations in age.

I cannot agree with Cleve and Boyer that the form is merely a variety of *Navicula mikrotatos* Pantocsek.[44] This cannot be unless Pantocsek's figure be hopelessly misdrawn and this seems unlikely. The two undoubtedly belong to the same genus, however.

It likewise does not appear desirable to sink so distinctive a diatom in the great group *Navicula,* or any of its alleged subgenera such as *Diploneis;* it is far more distinctive than some of the admitted genera of Naviculoid diatoms.

In view of the many specific names which have been applied to the form, it seems that to promote stability the rules of nomenclature should be adhered to; this necessitates the adoption of Christian's name *marylandica.* Fortunately this has been most used in the literature.

Specimens from east American localities have been compared directly with these California forms and it does not appear desirable to make a separation. The differences are inconstant and trivial and are more than bridged by the individual variation among specimens from the same stratum.

Boyer[45] made this significant statement regarding the importance of the form from a stratigraphic standpoint: "This *Diploneis,* originally named *Rhaphidodiscus* [sic.] because

[44] Beit. Kennt. Foss. Bacill. Ungarns, pt. 1, 1886, p. 27, pl. 9, fig. 80.
[45] Maryland Geol. Surv. Miocene, 1904, p. 488.

when found it had been accidentally enclosed, as was proved later, in the rim of a *Melosira,* is of interest by reason of its orbicular form, although otherwise naviculoid. The *Naviculeæ* appear to be introduced in the Miocene deposits by this genus, several forms of which are rather common, while *Navicula* proper is scarcely seen until a later period."

57. **Rattrayella inconspicuua** (Rattray)

Plate 14, fig. 5; plate 15, figs. 1, 2

Eupodiscus inconspicuus Rattray, Journ. Roy. Micr. Soc., vol. 9, 1888, p. 911.—Boyer, Maryland Geol. Surv. Miocene, 1904, p. 498, pl. 135, figs. 6, 7; "Calvert formation, Maryland."

This highly interesting species from east American Miocene deposits is common in the diatomite exposed on Sharktooth Hill, Kern County, California, and equivalent strata elsewhere in the state. It is a fragile diatom but perfect specimens can often be found. The pattern of the large central hexagonal cells decreasing in size toward the margin is a very constant character. Boyer stated that the small marginal ocelli vary from three to 11; I have seen only eight on the Sharktooth Hill specimens. An important feature, however, is the fact that midway between the ocelli there are small blunt spines and this is the most valuable character of *Rattrayella.* It is true that the other known species of the genus, *oamaruensis* and *simbirskianus* are marked on the disk by radiating lines of small beads but in other circular diatoms such differences are not necessarily considered to be of generic value. Under no circumstances can the species remain in *Eupodiscus,* the genotype of which is the very different species, *argus.* Boyer remarked that possibly the form is the variety of *Eupodiscus radiatus* Bailey, called *antiqua* J. D. Cox, but very little is known regarding this subspecies. Certainly *inconspicuua* cannot be left in the same genus with *radiatus* for which the name *Eu-eupodiscus* has recently been proposed. Rattray's remark that the form shows no close affinity to *E. radiatus* is certainly true. I have made comparison with the Oamaru and Simbirsk

Rattrayellas and do not believe the difference in size and character of surface markings sufficient to warrant generic separation.

Rhaphoneis Ehrenberg

EHRENBERG, Ber. Akad. Wiss. Berlin, 1844, p. 74. Genotype (selected by Boyer, Proc. Acad. Nat. Sci. Philadelphia, vol. 78, 1926 (1927), Suppl. p. 190): *Rhaphoneis amphiceros* Ehrenberg, Op. cit.; Mikrog. 1854, pl. 33, XIV, fig. 22 [type figure here selected]; pl. 33, XV, fig. 20; not pl. 18, fig. 82 [=*R. rhombus*].

The species of this genus are in a state of confusion from which they cannot be extricated until a review of all can be made. In the following records an attempt has been made to make the identifications conform to original sources of information. However, there must be some doubt in any present treatment of the group.

Regarding *Rhaphoneis* it is interesting to note that while the three species noted below as occurring rarely in the Sharktooth Hill horizon form a very inconspicuous portion of the finer washings, there is a diatom-bearing zone below this a short distance in which the genus is excessively abundant. The common species in this latter zone, however, are two others not found at the Sharktooth Hill exposure at all. The third species, *amphiceros,* is rare in the lower zone. The best exposure found of this lower zone is on the east side of the hill marked "1340" on the U. S. Geological Survey's topographic sheet, and situated on the west flank of Round Mountain.

58. **Rhaphoneis amphiceros** Ehrenberg

Plate 15, figs. 3, 4, 5

Rhaphoneis amphiceros EHRENBERG, Ber. Akad. Wiss. Berlin, 1844, p. 87.—EHRENBERG, Mikrog. 1854, pl. 33, XIV, fig. 22; XV, fig. 20; not pl. 18, fig. 82.—RALFS in PRITCHARD, Hist. Infus. Ed. 4, 1861, p. 791, pl. 14, fig. 21.—VAN HEURCK, Syn. Diat. Belgique, 1880-1882, p. 147, pl. 36, fig. 22.—WOLLE, Diat. N. America, 1890, pl. 37, fig. 20.—HANNA & GRANT, Proc. Calif. Acad. Sci. ser. 4, vol. 15, no. 2, 1926, p. 165, pl. 20, fig. 8.

January 8, 1932

I have referred to this species, the largest *Rhaphoneis* of the Sharktooth Hill deposit where it is not common. These fossils are not subject to great variation in shape and are broad in proportion to length, the sides being gently rounded. The beads vary considerably in size, and the transverse rows have a very gentle curve away from the center. This interpretation of Ehrenberg's type species is slightly at variance with his first figure (cited above) in which the sides are somewhat angulated. His next figures are more like mine. The discrepancies are believed to be due to specific differences. The selection here made is in general agreement with that of most later authors although some have called such forms "*R. gemmifera* Ehr." a species which Ehrenberg never figured. The proper interpretation seems to be to make the latter a synonym of *amphiceros*. In selecting the type of the genus Boyer cited all three of Ehrenberg's figures of *amphiceros* thereby failing to definitely fix the species. For this reason and to stabilize the nomenclature I have chosen his last two figures, excluding the first which I have referred to *R. rhombus*. This last is very common in some Pliocene localities in California but I have not yet found it in the deposit here being considered or its equivalent elsewhere. In order to aid in clearing the synonymy of *amphiceros* the notes given below have been made on *rhombus* and their publication at this time would seem to be desirable.[46]

Ehrenberg evidently figured more than one species among his original illustrations of *rhombus*. The one I have selected as type conforms to the usual interpretation although it does not have page priority. His first figures, called *rhombus* (pl. 18, figs. 84, 85), are certainly not rhombic and are not even obtusely angulated on the sides. By the present interpretation of type figures it becomes possible to retain the commonly used names for the diatoms to which they have usually been applied although Ehrenberg certainly had no very clear conception of specific limits in the group.

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[46] *Rhaphoneis rhombus* EHRENBERG, Ber. Akad. Wiss. Berlin, 1844, p. 87.—EHRENBERG Mikrog. 1854, pl. 33, XIII, fig. 19 [type figure, here selected]; not pl. 18, figs. 84, 85.
Rhaphoneis amphiceros EHRENBERG, Mikrog. 1854, pl. 18, fig. 82.

59. **Rhaphoneis elegans** Pantocsek & Grunow

Plate 15, figs. 5, 6, 7

Rhaphoneis gemmifera elegans PANTOCSEK & GRUNOW in PANTOCSEK, Beit. Kennt. Foss. Bacill. Ungarns, pt. 1, 1886, p. 34, pl. 2, fig. 21; pl. 20, fig. 179; pl. 27, fig. 264; pl. 30, fig. 317; "Felso"-Estregály Kékkö, Szakal, Szent-Péter," [Hungary]; "Naparima," [Trinidad Island].

Diatoms referred to this species are very abundant in the zone, outcropping on 1340 Hill just west of the top of Round Mountain, Loc. 1187 (C. A. S.) Kern County, California, Temblor Miocene. However it is less abundant there than *R. parilis.* The long drawn out ends and bold markings are characteristic and the three figures herewith cover practically the entire range of variation seen. Pantocsek's figures include practically the same range and all of his localities are supposed to be Miocene. The association of the name with *gemmifera* is not warranted if Roper's interpretation of Ehrenberg's species be assumed to be correct because intergrading specimens have not been shown to exist; furthermore, the extreme uncertainty regarding the original *gemmifera* would make any identification therewith doubtful.

60. **Rhaphoneis obesa** Hanna, new species

Plate 15, figs. 9, 10

Valve flat, very broad transversely with sides uniformly rounded; ends produced into gracefully tapering, rounded necks; beads in transverse rows curved gently away from the transverse diameter; pseudoraphe narrow but distinct. Length (holotype), .0385 mm.; width, .0180 mm.; 8 rows of beads in .01 mm.; length (paratype), .030 mm.; width, .0181 mm.; 8 rows of beads in .01 mm.

Holotype: No. 3228, Mus. Calif. Acad. Sci. collected by G. D. Hanna at Loc. 1068 (C. A. S.) on the southeast side of Sharktooth Hill, Kern County, California; Temblor, middle Miocene.

Paratype: No. 3229, Mus. Calif. Acad. Sci. collected by G. D. Hanna at Loc. 1063 (C. A. S.) **west side of Cottonwood Creek, Kern County, California**; Temblor Miocene.

The beads in this species are closer together in the rows than in *R. amphiceros;* also the rows have a greater curvature away from the transverse diameter. Moreover, the ends are more produced into narrow necks than in any of the described species of the genus except the one noted below from a slightly lower horizon in the Temblor.

61. **Rhaphoneis obesula** Hanna, new species

Plate 16, fig. 1

Rhaphoneis rhombus Ehrenberg, Mikrog. 1854, pl. 18, fig. 84, 85; Richmond Va. [Not pl. 33, XIII, fig. 19.]

Valve flat, almost as wide as long, sides rounded, ends produced into obtusely rounded apices; beads rather sparse, rows strongly curved away from the transverse axis; pseudoraphe distinct and broad in the center. Length, .020 mm.; width, .0155 mm.; 9 rows of beads in .01 mm.

Holotype: No. 3230, Mus. Calif. Acad. Sci., collected by G. D. Hanna at Loc. 1068 (C. A. S.) on the southeast side of **Sharktooth Hill, Kern County, California**; Temblor, middle Miocene.

This exceedingly obese form is very rare at this locality. It may perhaps be an extreme variant of *R. amphiceros* but no specimens were found to lead one to suppose the intergrades exist. The two figures of Ehrenberg cited come closer than any other which has been named.

62. **Rhaphoneis parilis** Hanna, new species

Plate 16, figs. 2, 3, 4

Valve flat, long and slender, tapering gracefully to the ends; sides very obtusely rounded; pseudoraphe practically obliterated; beads uniform in size throughout, rounded and separated uniformly from each other; transverse rows, straight or almost so and placed at right angles to the longitudinal axis.

Measurements

Length	Width	Transverse rows of beads in .01 mm.
.0429 mm.	.010 mm.	7 (Holotype No. 3231)
.0490 mm.	.010 mm.	7 (Paratype No. 3232)
.0344 mm.	.010 mm.	7 (Paratype No. 3233)
.060 mm.	.010 mm.	7 (Longest specimen seen)

Holotype: No. 3231; *paratypes:* Nos. 3232, 3233, Mus. Calif. Acad. Sci. collected by G. D. Hanna at Loc. 1187 (C. A. S.), on east side of hill marked "1340" on U. S. Geol. Surv. map, **west flank of Round Mountain, Kern County, California;** Temblor, middle Miocene.

This is an exceedingly common species in the stratum outcropping on "1340" Hill. It and the following species constitute a large percentage of all the diatoms in this fairly rich layer.

The figures illustrate about all of the variation noted among hundreds of individuals studied. A few may be a little longer or shorter but the proportions and markings are remarkably constant. I can find no named species in the literature to which these diatoms can be referred with certainty. Some might lump them into the complex assemblage which has gone under the name *gemmifera* Ehrenberg[47] but this procedure appears to be decidedly undesirable. Ehrenberg never figured it and his description might fit many species or even genera. Kützing[48] did not figure it; and Roper[49] apparently identified and figured a Thames River specimen as *gemmifera*. Whether this was correct or not, will probably never be known unless Ehrenberg's original specimen be found. Roper himself did not feel confident of the identification. Under the circumstances it appears necessary to accept his interpretation of Ehrenberg's name and our fossils are certainly not the same as the Thames River one he illustrated. This latter is larger, has curved transverse lines of beads, more beads in the central rows, is less elongate and has a definite pseudoraphe. These differences appear to be so constant that the Temblor diatoms cannot be called Roper's "*gemmifera*."

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[47] Ehrenberg, Ber. Akad. Wiss. Berlin, 1844, p. 87.
[48] Kützing, Species Algarum, 1848, p. 49.
[49] Trans. Micr. Sci. vol. 2, 1854, p. 75, pl. 6, fig. 7.

63. Sceptroneis caduceus Ehrenberg

Plate 16, figs. 5, 6, 7

Sceptroneis caduceus EHRENBERG, Ber. Akad. Wiss. Berlin, 1844, p. 254.—BAILEY, Amer. Journ. Sci. vol. 48, no. 2, 1845, p. 326, pl. 4, fig. 11. "Bermuda tripoli" [Nottingham, Md.].—EHRENBERG, Mikrog. 1854, pl. 33, XVII, fig. 15; Rappahannock, Cliff, Virginia.—(?) GREGORY, Trans. Roy. Soc. Edinburgh, vol. 21, 1857, p. 59, pl. 6, fig. 106.—RALFS in PRITCHARD, Hist. Infus. Ed. 4, 1861, p. 772, pl. 4, fig. 11. —GRUNOW, Verh. K. K. Zool. Bot. Gesell. vol. 12, 1862, p. 354.—CARRUTHERS in GRAY, Handbook Brit. Fr. Water Weeds or Algæ, 1864, p. 79.—RABENHORST, Flora Europæa Algarum, 1864, p. 299.—GRUNOW, Hedwigia, vol. 5, 1866, p. 146.—VAN HEURCK, Syn. Diat. Belgique, 1880-1882, p. 147, pl. 37, fig. 5.—PANTOCSEK, Beit. Kennt. Foss. Bacill. Ungarns, pt. 1, 1886, pp. 18, 36; St. Peter and Felso-Esztergaly, Hungarian Miocene.—KAIN & SCHULTZE, Bull. Torrey Bot. Club, vol. 16, 1889, p. 76; [Atlantic City, New Jersey]; Miocene.—WOLLE, Diat. N. America, 1890, pl. 37, fig. 13.—MÖLLER, Lichtdrucktafeln, 1891, pl. 2, row 5, fig. 36; "Nottingham," Md.; pl. 29, row 5, fig. 2, same place.—DE TONI, Syl. Algarum, vol. 2, sect. 2, 1892, p. 646.—VAN HEURCK, Treat. Diat. 1896, p. 331, pl. 10, fig. 399, text fig. 87.—BOYER, Maryland Geol. Surv. Miocene, 1904, p. 489, pl. 135, fig. 12; Calvert formation in Maryland, many localities given.—PERAGALLO, Diat. Mar. France, 1901, p. 331, pl. 82, fig. 37, pl. 83, fig. 36; Richmond, Va.—FORTI, Nuova Notarisia, vol. 19, 1908, p. 131; Bergonzano, Italy.—TEMPERE & PERAGALLO, Diat. du Monde Entier, Ed. 2, p. 78, 1908, Atlantic City, New Jersey; p. 117, 1909, "Santa Cruz, Colorado" [probably Santa Ynez, Calif.]; p. 128, 1909, Nottingham, Md.; p. 225, 1910, Bergonzano, Reggio d'Emilio, Italy, Miocene; p. 335, 1912, Patuxtent River, Md.; p. 374, 1913, (Popės Creek, Md.).—FORTI, Atti. R. Ist. Veneto, Sci. Lett. Art. vol. 72, pt. 2, 1913, p. 1653; [Separate, "Cont. Diat." XIII, p. 119].

Sceptroneis caduceus abbreviata FORTI, Atti. R. Ist. Veneto, Sci. Lett. Art. vol. 72, pt. 2, 1913, p. 1653, pl. 19, fig. 4; "Bergonzano, Rhegii Lepidi" Italy; Middle Miocene.

Styloneis caduceus EHRENBERG, Ber. Akad. Wiss. Berlin, 1845, p. 55. The genus-name is a typographical error according to Ehrenberg, Mikrog. 1854, Exp. pl. 33.

Rhaphoneis hungarica PANTOCSEK, Beit. Kennt. Foss. Bacill. Ungarns, pt. 1, 1886, pp. 17, 34, pl. 3, fig. 30; not pl. 25, fig. 224; "Szakal," Hungary; Miocene; pt. 2, p. 63; Nagy-Kurtos, Hungary, Miocene.

This is one of the most abundant species in the Sharktooth Hill deposit and its stratigraphic equivalent elsewhere in California. There is very great variation in the size and shape of the valves but the size of the bold square markings and the radial beads on the capitate end are remarkably constant.

The records of Gregory (1857) and Van Heurck (1896) showing the species to be living, need confirmation. Tempere & Peragallo (1909) listed it from "Santa Cruz Colorado," a locality which has given a great deal of trouble. Originally it was given as "Santa Suez, California" and it seems that the best interpretation to make is "Santa Ynez, California." Thus far the locality has not been verified as Santa Cruz, city, county or island although much time has been spent in searching for it.[50]

The species has been reported from many east American Miocene localities and from several other places in the world, all of which are supposed to be of approximately the same age. No definite record of it has been found in any upper Miocene locality anywhere. Pantocsek's first figure of *Rhaphoneis hungarica* is undoubtedly a *Sceptroneis* and probably *caduceus* but his second figure is entirely different; his name should be retained for the last.

Ehrenberg's original figure and many specimens from Maryland and Virginia are longer and more slender than the longest shown herewith; however, in a large series there appears to be sufficiently close intergradation to warrant retaining the name for the California material.

64. **Stephanogonia actinoptychus** (Ehrenberg)

Mastogonia actinoptychus Ehrenberg, Abh. Akad. Wiss. Berlin, 1844, p. 269. —Ehrenberg, Mikrog. 1854, pl. 18, figs. 109 *a*, *b;* pl. 33, XIII, fig. 16.

Stephanogonia actinoptychus (Ehrenberg), Van Heurck, Syn. Diat. Belgique, 1880-1882, pl. 83ter, figs. 2-4.—Pantocsek, Beit. Kennt. Foss. Bacill. Ungarns, pt. 2, 1889, p. 76, pl. 13, fig. 221.

Forms supposed to be this species are common in the lighter washings of samples from the Temblor, particularly from Loc. 1063, on the west side of Cottonwood Creek a few miles east of Sharktooth Hill. The genera *Stephanogonia* and *Masto-*

[50] See Hanna, G. D. Journ. Paleo. vol. 4, no. 2, 1930, pp. 182-184, for a more complete account of the difficulties connected with the "Santa Cruz" locality.

gonia have not been adequately differentiated; the early figures are not very satisfactory and a careful study of both groups is needed. The species are most common in middle Miocene strata.

65. Stephanogonia polyacantha Forti

Plate 16, fig. 8

Stephanogonia polyacantha FORTI, Atti R. Ist. Veneto, Sci. Lett. Art. vol. 72, pt. 2, 1913, p. 1560, pl. 12, fig. 11; [separate, "Cont. Diat." XIII, p. 26, pl. 2, fig. 11]; "Middle Miocene, Marmorito, Alexandria, Piedmont," Italy.

Stephanogonia polyacantha inermis FORTI, Atti R. Ist. Veneto, Sci. Lett. Art. vol. 72, pt. 2, 1913, p. 1561, pl. 12, fig. 12; [separate, p. 27, pl. 2, fig. 12]; "Middle Miocene, Bergonzano, Reggio d'Emilia," Italy.

Stephanogonia actinoptychus polyacantha TEMPERE & PERAGALLO, Diat. du Monde Entier, Ed. 2, 1909, p. 197; (name only).—FORTI, Atti R. Ist. Veneto, vol. 69, 1910, p. 1310; [separate, "Cont. Diat." XI, p. 62].

Stephanogonia cincta PANTOCSEK, FORTI, Nuova Notarisia, vol. 19, 1908, p. 132. —TEMPERE & PERAGALLO, Diat. du Monde Entier, Ed. 2, 1909, p. 197.—FORTI, Atti R. Ist. Veneto, vol. 69, 1910, p. 1310.—TEMPERE & PERAGALLO, Diat. du Monde Entier, Ed. 2, 1910, p. 225.— Not *Stephanogonia cincta* PANTOCSEK, Beit. Kennt. Foss. Bacill. Ungarns, pt. 2, 1889, p. 76, pl. 9, fig. 161; "Nagy-Kürtös, Szakal."

This large and striking species is fairly common in the Sharktooth Hill deposit (Loc. 1068) and on Cottonwood Creek (Loc. 1063). Forti described it from beds of probably equivalent age in Italy. Besides being by far the largest known *Stephanogonia* it is further characterized by the presence of the scattered rounded beads and the absence of pronounced spines around the internal disk. It is very fragile and perfect specimens are difficult to find. Tempere & Peragallo were first to use the name *polyacantha* but without descriptive matter of any kind. Therefore the species must be credited to Forti who claimed it properly.

The outer zone with radial ribs resembles strongly the "veil" of *Coscinodiscus sol,* a living species.

One very large specimen mounted on the same slide as the one figured herewith is .1154 mm. in diameter.

66. **Stephanopyxis lineata** (Ehrenberg)

Plate 16, figs. 9, 10, 11

"*Stephanodiscus ? lineatus* (=*Peristephania lin.* ?)" EHRENBERG, Mikrog. 1854, pl. 33, XIII, fig. 22; "San Francisco, Calif."

Stephanopyxis ambigua GRUNOW, Denk. Akad. Wiss. Wien, vol. 48, 1884, p. 91.

Peristephania entycha EHRENBERG, Mikrog. 1854, pl. 35B, IV, fig. 14 [?].

Stephanopyxis lineata (Ehrenberg), FORTI, Nuova Notarisia, 1912, p. 83.—FORTI, Atti R. Ist. Veneto, Sci. Lett. Art. vol. 72, pt. 2, 1913, p. 1547, pl. 11, figs. 21, 23, pl. 12, fig. 3.

Forti deserves credit for resurrection of this important species. Undoubtedly it has been confused with *Coscinodiscus lineatus* because the markings on the disk of the two are similar. The high spines on the margin and the abrupt deflection at that point in the *Stephanopyxis* certainly distinguish them. Ehrenberg's specimen came from a deposit on San Pablo Bay, a portion of San Francisco Bay and I have the species in abundance from there. The age of that deposit has not yet been certainly determined but it is Miocene, and probably somewhat higher in the section than the Sharktooth Hill material yet lower than the type Monterey shale. Ehrenberg's placing of the species in *Stephanodiscus* may have been a slip of the pen; his genus *Peristephania* has not been accepted.

The species is common in the Sharktooth Hill deposit and it is believed that the zonal view here shown for the first time will aid in clearing up the confusion which has surrounded it.

67. **Stictodiscus kittonianus** Greville

Plate 16, fig. 12

Stictodiscus kittonianus GREVILLE, Trans. Micr. Soc. London, n. s. vol. 9, 1861, p. 77, pl. 10, figs. 2, 3.—SCHMIDT, Atlas Diat. pl. 74, 1882, figs. 16, 18.—WOLLE, Diat. N. America, 1890, pl. 75, fig. 9.

Stictodiscus is exceedingly rare in the Sharktooth Hill deposit and only the above species is represented. The very common upper Miocene *S. californicus,* is entirely absent. The original locality for *kittonianus* was "Nottingham Maryland" a deposit which is believed to be very nearly the equivalent of the California Temblor.

68. **Surirella tembloris** Hanna, new species

Plate 16, figs. 13, 14

Valve ovate, slightly pyriform, with a narrow lanceolate central area bordered by a zone of irregular transverse bars; marginal zone with radiating, broad bars on which fine beading is visible under high aperture. Length (holotype No. 3242, .0954 mm.; (paratype No. 3243) .1080 mm.; (paratype No. 3244) .0910 mm.

Holotype: No. 3242; *paratype:* No. 3243, Mus. Calif. Acad. Sci. collected by G. D. Hanna at Loc. 1063 (C. A. S.), Sec. 13, T. 29S., R. 29E., M. D. M., west side of **Cottonwood Creek, Kern County, California,** middle Miocene. *Paratype:* No. 3244 from Loc. 1068 (C. A. S.), southeast side of **Sharktooth Hill, Kern County, California**; same formation.

This species is similar to *S. alternans* Schmidt[51] from the Miocene of Richmond, Virginia but this last has a broader central area bounded by a zone of regular, radial, beaded bars.

69. **Triceratium americanum** Ralfs

Triceratium amblyceros Ehrenberg, Brightwell, Quart. Journ. Micr. Sci. vol. 1, 1853, p. 250, pl. 4, fig. 14; not of Ehrenberg.

Triceratium americanum Ralfs in Pritchard, Hist. Infus. Ed. 4, 1861, p. 855. —Schmidt, Atlas Diat. pl. 76, 1882, fig. 28; not fig. 3.—Hanna, Journ. Paleo. vol. 1, no. 2, 1927, p. 122, pl. 21, fig. 3.

This species is common at Loc. 1063 on Cottonwood Creek, a few miles east of Sharktooth Hill; specimens cannot be separated specifically from those recently reported (1927) from Phoenix Canyon near Coalinga, California, in strata believed to be considerably lower in the Tertiary.

It was stated in my paper cited above that Schmidt figured two forms under the name *americanum,* a coarsely beaded one (his fig. 3) and the one here accepted as *americanum.* It is believed that the coarsely marked specimen is the same as was

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[51] Atlas Diat. pl. 211, 1897, fig. 30.

recently named *"Biddulphia jordani"*[52] from Maria Madre Island, Mexico. It so happens that this name is preoccupied by *"Triceratium jordani"* Truan & Witt.[53]

70. Triceratium condecorum Brightwell

Plate 17, figs. 1, 3

Triceratium condecorum BRIGHTWELL, Quart. Journ. Micr. Sci. vol. 1, 1853, p. 250, pl. 4, fig. 12.—SCHMIDT, Atlas, Diat. pl. 76, 1882, fig. 27.—PANTOCSEK, Beit. Kennt. Foss. Bacill. Ungarns, pt. 1, 1886, p. 52, pl. 27, fig. 256.—WOLLE, Diat. N. America, 1890, pl. 102, fig. 6.

This small species originally came from "Nottingham Maryland" and has been found widely distributed in Miocene strata elsewhere. The name was originally used by Ehrenberg in 1844[54] according to Chase but essentially as a nomen nudum, and most authors cite the species as of Brightwell who gave the first figure. In most illustrations the sides are shown slightly more convex than the California specimens but since this seems to be a trivial difference and all other details are essentially the same the identification appears to be warranted.

The proposal to place such diatoms as this in which processes are lacking in the angles, in Cleve's genus *Trigonium* has not been adopted by many diatomists. Likewise, the placing of all Tricerati in *Biddulphia* does not appear acceptable. I have accordingly followed general custom and use the name *Triceratium*.

T. americanum Ralfs differs from *condecorum* in having the marginal beads arranged in radial rows. Both species are found fairly commonly in the lighter washings of the Sharktooth Hill deposit and strata of the same age in the same general area.

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[52] Hanna & Grant, Proc. Calif. Acad. Sci. ser. 4, vol. 15, no. 2, 1926, p. 131, pl. 14, fig. 3.
[53] Diat. Jeremie, Hayti, 1888, p. 23, pl. 7, fig. 12.
[54] Ber. Akad. Wiss. Berlin, 1844, p. 272.

71. **Triceratium spinosum** Bailey

Plate 17, figs. 4, 5

Triceratium spinosum Bailey, Amer. Journ. Sci. vol. 46, 1844, p. 139, pl. 3, fig. 12.—Ralfs in Pritchard, Hist. Infus. Ed. 4, 1861, p. 853, pl. 6, fig. 19.—Wolle, Diat. N. America, 1890, pl. 25, fig. 22; pl. 77, figs. 4, 9, 10; pl. 102, figs. 2, 5.

Triceratium tridactylum Brightwell, Quart. Journ. Micr. Sci. vol. 1, 1853, p. 248, pl. 4, fig. 3.—Schmidt, Atlas Diat. pl. 87, 1885, fig. 12.—Wolle, Diat. N. America, 1890, pl. 105, fig. 1.

Biddulphia spinosa (Bailey), Brockmann, Abh. Senckenbergischen Naturforschenden Gesellschaft, vol. 41, 1928, pl. 2, fig. 17.

This striking species was first found in Miocene, east American deposits. It is not uncommon in California samples from Sharktooth Hill and equivalent strata elsewhere in that general region.

72. **Triceratium subrotundatum** Schmidt

Plate 17, fig. 2

Triceratium subrotundatum Schmidt, Atlas Diat., pl. 93, 1886, fig. 1; Nottingham, Maryland.—Wolle, Diat. N. America, 1890, pl. 102, fig. 3; pl. 112, fig. 7.—Tempere & Peragallo, Diat. du Monde Entier, Ed. 2, 1912, p. 331.

Biddulphia (?) *subrotundata* (Schmidt), Boyer, Proc. Acad. Nat. Sci. Phila. vol. 52, 1900, (1901) p. 720.—Forti, Atti R. Ist. Veneto, Sci. Lett. Art. vol. 72, pt. 2, 1913, p. 1637, pl. 21, figs. 1, 2, [fa. *italica*]; "Bergonzana, Rhegii Lepidi et Monte Gibbio," Italy.

A large but delicate form without angular processes was found occasionally at Loc. 1063 (C. A. S.), on the west side of Cottonwood Creek several miles east of Sharktooth Hill. A considerable number of imperfect specimens was seen and several were mounted. The only previous records appear to be from the Miocene deposits of eastern North America and from Italy in strata which appear to be approximately equivalent in age to those here being considered. Forti has given an excellent account of the relationship of the species. Boyer stated that except in outline, the species scarcely differed from *Coscinodiscus,* but this is doubtful; affinity seems to be with *T. favus.*

73. **Tropidoneis primoris** Hanna, new species

Plate 17, fig. 6; plate 18, figs. 1, 2

In girdle view, frustule slightly truncate, about three times as long as broad indented at the transverse median line where the central nodule is extended laterally about one-third the distance to the inner margin; ends of valves rounded above; connecting zone narrow with straight sides; markings consisting of transverse rows of beads, uniformly spaced throughout. Length (holotype), .1240 mm., width, .040 mm.; length (paratype), .1184 mm.; width, .0137 mm., (one valve); 24 transverse rows of beads in .01 mm.

Holotype: No. 3248; *paratype:* No. 3249, Mus. Calif. Acad. Sci. collected by G. D. Hanna at Loc. 1068 (C. A. S.) southeast side of **Sharktooth Hill, Kern County, California**; Temblor, middle Miocene.

The valves of this species are exceedingly compressed laterally, so that looked at in girdle view the diatom has hardly any thickness at all; this condition is believed to be in part due to pressure in the formation from which the collection was obtained. The diatoms are very delicate and diaphanous so that they are easily destroyed in cleaning operations; nevertheless a considerable number of individuals was seen. Often the valves are warped in preservation thus making it difficult to focus all parts at once in photography. *Tropidoneis membranacea* (Cleve)[55] appears to be closer to this than any described species of the genus but that form lacks the laterally dilated central nodule, and the frustule is almost twice as large. The markings are very nearly the same size and would be difficult to resolve without high aperture lenses and a highly refractive mounting medium.

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[55] *Amphiprora membranacea* Cleve, Bih. till Sven. Vet. Akad. Handl. vol. 1, no. 11, 1873, p. 12, pl. 2, fig. 18; Java Sea.—Cleve Kongl. Sven. Vet. Akad. Handl. vol. 26, no. 2, 1894, p. 24.—Mann, U. S. Nat. Mus. Bull. 100, vol. 6, pt. 1, 1925, p. 174.

74. Xanthiopyxis acrolopha Forti

Xanthiopyxis acrolopha FORTI, Nuova Notarisia, vol. 23, 1912, p. 84.—TEMPERE & PERAGALLO, Diat. du Monde Entier, Ed. 2, 1915, p. 331.—FORTI, Cont. Diat. XIII. Atti R. Ist. Veneto, Sci. Lett. Art., vol. 72, pt. 2, 1913, p. 1556 (22), pl. 12 (2), figs. 22, 24, 27, 28, 30-37.—HANNA, Journ. Paleo. vol. 1, no. 2, 1927, p. 124, pl. 21, figs. 10, 11.

Further down in the Tertiary on the west side of the San Joaquin Valley this species is very common but on the east side in the Temblor it has been found only once. This was at Loc. 1063 (C. A. S.) on the west side of Cottonwood Creek, a few miles east of Bakersfield.

75. Xanthiopyxis globosa Ehrenberg

Plate 18, fig. 3

Xanthiopyxis globosa EHRENBERG, Ber. Akad. Wiss. Berlin, 1844, p. 273.—RALFS in PRITCHARD, Hist. Infus. Ed. 4, 1861, p. 827.—DE TONI, Syl. Algarum, vol. 2, sect. 3, 1894, p. 1155.—FORTI, Cont. Diat. XIII, Atti R. Ist. Veneto, Sci. Lett. Art. vol. 72, pt. 2, 1913, p. 1557 (23), pl. 12 (2), figs. 39-49.

Forti's application of Ehrenberg's descriptive name seems satisfactory although the species had not previously been illustrated. The valves are so convex that good photographs are hardly possible and I have therefore furnished a drawing, admittedly somewhat diagrammatic. The species is apparently confined to middle and perhaps lower Miocene strata. It is replaced in upper Miocene by *X. umbonata* Greville although the latter is not believed to be a direct descendant. The precursor of *umbonata* is believed to be a large cap shaped form in which the usual sharp spines of the well known species are represented by mere rounded nodules. This latter form is not uncommon in the Temblor strata here being considered but is not now formally described because of lack of suitable type material. *X. globosa* is fairly common in the lighter washings from Locs. 1063 and 1068 (C. A. S.). It is characterized by the bold angular spines. In zonal view it does not have the constriction which seems always to be present in *Omphalotheca.*

The deposit likewise contains a circular form about the same size and shape as this but with many more and smaller spines. Also there is an ovate one with spines as large and arranged about the same as in the present species; these do not appear to have been described and are omitted here because of the lack of sufficient, well preserved specimens.

76. **Xanthiopyxis maculata** Hanna, new species

Plate 18, fig. 4

Valve composed of two ovals joined together by a broad isthmus; border without spines or beads and surface hyaline, marked only by faint maculations irregular in shape and size and visible only under extremely favorable illumination. Length, .050 mm.; width, .0161 mm.

Holotype: No. 3251, Mus. Calif. Acad. Sci. collected by G. D. Hanna at Loc. 1068 (C. A. S.), southeast side of **Sharktooth Hill, Kern County, California**; Temblor, middle Miocene.

This is the third species of this striking, constricted form of *Xanthiopyxis*. The others are *X. panduræformis* Pantocsek[56] with the "variety" *soleiformis* Forti[57] and *X. specticularis* Hanna.[58] The present species is nearer *panduræformis* but lacks the bold heavy markings of that form from the Miocene of Hungary, Spain and Italy.

77. **Xanthiopyxis marginata** Hanna, new species

Plate 18, fig. 5

Valve circular, hyaline, with the exception of a single row of massive spines just inside the margin; these spines are angular at the base, rounded at the tips and set unequal distances apart. Diameter, .0296 mm.

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[56] Beit. Kennt. Foss. Bacill. Ungarns, pt. 1, 1886, p. 43, pl. 29, fig. 297.
[57] Atti R. Ist. Veneto Sci. Lett. Art. vol. 72, pt. 2, 1913, p. 1552.
[58] Journ. Paleo. vol. 1, no. 2, 1927, p. 124, pl. 17, fig. 10.

Holotype: No. 3252, Mus. Calif. Acad. Sci. collected by G. D. Hanna at Loc. 1068 (C. A. S.) southeast side of **Sharktooth Hill, Kern County, California,** Temblor, middle Miocene.

No species of diatom with which I am familiar approaches this sufficiently close to permit direct comparison. Unfortunately the best mounted specimen is slightly tipped so that one side of the circle of spines is out of focus in the photograph, but it is believed the characters are sufficiently well displayed, nevertheless, to permit description. The species is fairly common in the lighter washings.

78. **Xanthiopyxis oblonga** Ehrenberg

Xanthiopyxis oblonga Ehrenberg, Mikrog. 1854, pl. 33, XVII, fig. 17.—Cleve, Journ. Quekett Micr. Club, ser. 2, vol. 2, 1885, p. 175, pl. 13, fig. 18.—Forti, Cont. Diat. XIII, Atti R. Ist. Veneto, Sci. Lett. Art. vol. 72, pt. 2, 1913, p. 1554 (20), pl. 12 (2), fig. 38.—Hanna & Grant, Proc. Calif. Acad. Sci. ser. 4, vol. 15, 1926, p. 170, pl. 21, fig. 11.—Hanna, Journ. Paleo. vol. 1, no. 2, 1927, p. 124.

These oblong *Xanthiopyxis* seem to be most common in the middle Miocene the world over. During the latter part of this epoch, in formations such as the Monterey shale, they are much scarcer and two species, *acrolopha* and *cingulata* may not be present at all. *X. oblonga* occurs in the Temblor frequently and was noted particularly in the lighter washings from Loc. 1063, several miles east of Bakersfield.

Xystotheca Hanna, new genus

Diatom ovate, biddulphoid with a round auliscoid spot at each end and irregular rugose flat zones radiating to the median line.

Genotype (monotypic): *Xystotheca hustedti* Hanna, new species.

79. **Xystotheca hustedti** Hanna, new species

Plate 18, figs. 5, 6

Valve ovate, slightly convex, almost flat on top, heavily marked with bold irregularly shaped rugosities extending from the narrow margin toward the long median line; in the holotype these rugose areas are patches of no regular shape and arranged roughly in transverse or radiating zones; at each end there is a conspicuous auliscoid eye-spot surrounded by a narrow ring.

Measurements

	Holotype No. 3253	Paratype No. 3254
Length	.0714 mm.	.0268 mm.
Width	.0350 mm.	.0188 mm.

Holotype: No. 3253, Mus. Calif. Acad. Sci. collected by L. G. Hertlein at Loc. 1170 (C. A. S.) **Smugglers Cove, Santa Cruz Island, California**; Temblor Miocene; *paratype:* No. 3254, collected by G. D. Hanna at Loc. 1068 (C. A. S.) southeast side of **Sharktooth Hill, Kern County, California**; Temblor Miocene.

This strange form does not fall readily into any known genus of diatoms. It possesses the shape of some biddulphoid species but has none of the other characters of the members of that heterogenous group. The "eye spots" are similar to those of *Auliscus* but all other characters are very different from any member of that group. I have selected the holotype from Santa Cruz Island Miocene because the species is there beautifully developed. The paratype came from Sharktooth Hill and is a smaller individual with the rugose markings less patchy; nevertheless I believe the two to be the same species because the two deposits contain so many other fossils in common, such as *Annellus californicus, Raphidodiscus marylandicus, Cyclotella kelloggi,* etc.

The species is named for Dr. Frederick Hustedt, the eminent diatomist of Bremen, Germany.

80. Zygoceros (?) quadricornis Grunow

Plate 18, figs. 8, 9

Zygoceros (?) *quadricornis* GRUNOW in VAN HEURCK, Syn. Diat. Belgique, 1880-1882, pl. 105, figs. 5, 6, 7; Nottingham, Maryland.

Zygoceros quadricornis GRUNOW, PANTOCSEK, Beit. Kennt. Foss. Bacill. Ungarns, pt. 1, 1886, p. 49, pl. 26, fig. 248.—WOLLE, Diat. N. America, 1890, pl. 64, figs. 8, 9.—DE TONI, Syl. Algarum, vol. 2, sect. 3, 1894, p. 888.—TEMPERE & PERAGALLO, Diat. du Monde Entier, Ed. 2, p. 132, 1909, Nagy-Curtos, Hungary; p. 278, 1911, San Luis Obispo County, California; p. 417, 1913, Palogla, Hungary.

Biddulphia quadricornis (GRUNOW), BOYER, Proc. Acad. Nat. Sci. Philadelphia, vol. 52, 1900 [1901]; p. 713.

This strange species is common in the Sharktooth Hill deposit and elsewhere in strata of the same age in California. Tempere & Peragallo's San Luis Obispo record is probably acceptable because rocks of the same age are found in that county but it should be added that they have included the species in a list which was obviously made from a mixed collection. The list contains uppermost Miocene species which we know definitely do not occur in Temblor strata and also Temblor species which do not occur in the Monterey.

Grunow originally questioned the placing of the species in the genus *Zygoceros* and it is believed he was justified although subsequent authors have expressed no such doubt. Probably a new genus should be erected for it, but it is so delicate that better preserved material than I have seen is needed before so doing. Evidently Grunow had only fragments and his drawings are not good. Pantocsek's are much better. The photographs herewith are of mere fragments but it is believed that they help to give the characters of the form. The most conspicuous and best preserved portion of the diatom is a heavy square of silica, the sides being slightly convex; at each corner there projects a long heavy spine (often broken); the plane of the square is covered with a delicate beading in partial radial arrangement; from the opposite side of the square there projects a funnel-like veil with a narrow border at the outer margin; this veil is supported with light ribs projecting from the square but not reaching to the outer margin.

I have found the species in material from Dunkirk, Maryland, kindly supplied to me by Dr. Remington Kellogg and believe the California forms do not differ specifically in spite of Grunow's drawings.

The characters of the species seem to ally it more with *Stephanopyxis* than with *Biddulphia, Zygoceros* probably being a synonym of the latter. However, there is some discrepancy in the selection of the type species of *Zygoceros* which makes a serious complication and we need not go into this at the present time.

January 8, 1932

Plate 2

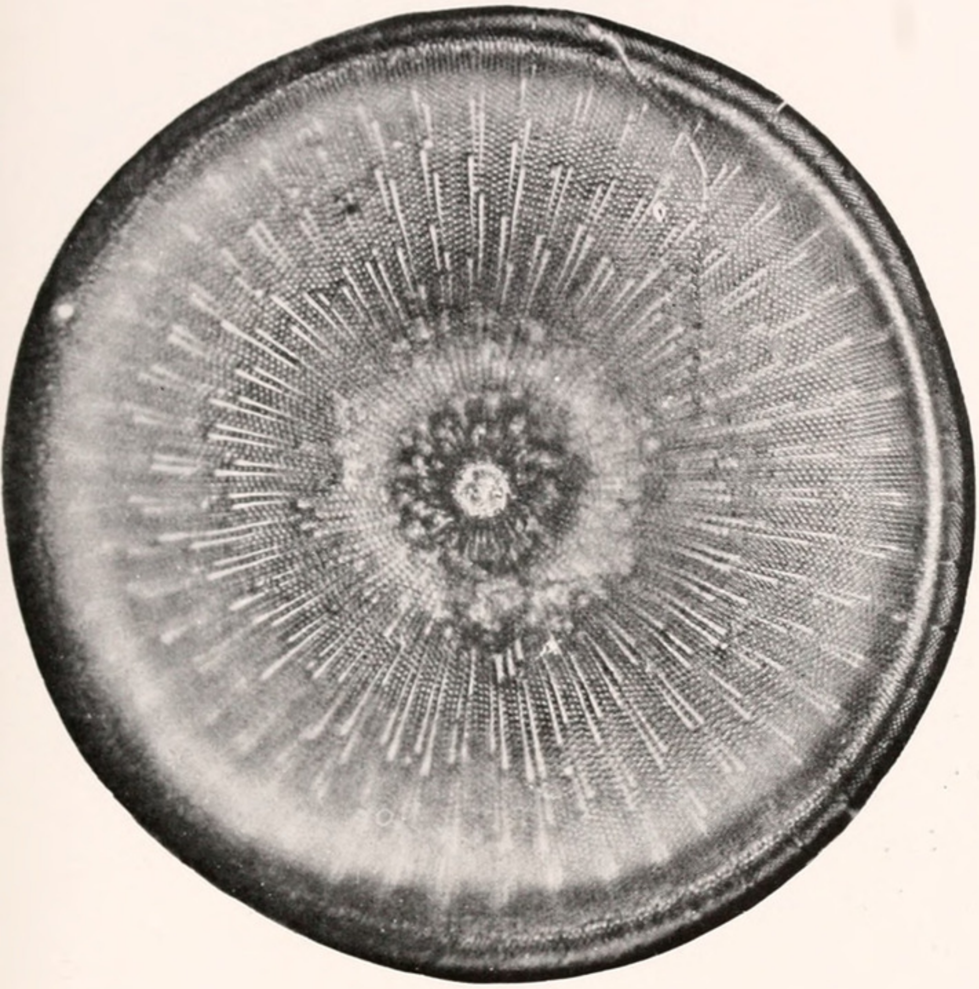
Fig. 1. *Actinocyclus ehrenbergii* Ralfs. Plesiotype, No. 3138, C. A. S.; × 500; diameter, .1780 mm.; 7 beads in .01 mm. near center, 9 near margin.

Fig. 2. *Actinocyclus ehrenbergii* Ralfs. Same specimen as Fig. 1 photographed with a lower focus to show depressed central area.

Fig. 3. *Actinocyclus ehrenbergii* Ralfs. Plesiotype, No. 3139, C. A. S.; × 693; diameter, .0649 mm.; 7 beads in .01 mm.

Fig. 4. *Actinoptychus halionyx* Grunow. Plesiotype, No. 3140 C. A. S.; × 575; diameter, .095 mm.

[All of the diatoms illustrated on this plate are from Calif. Acad. Sci. Loc. 1068, southeast side of Sharktooth Hill, Kern County, California; Temblor Miocene.]



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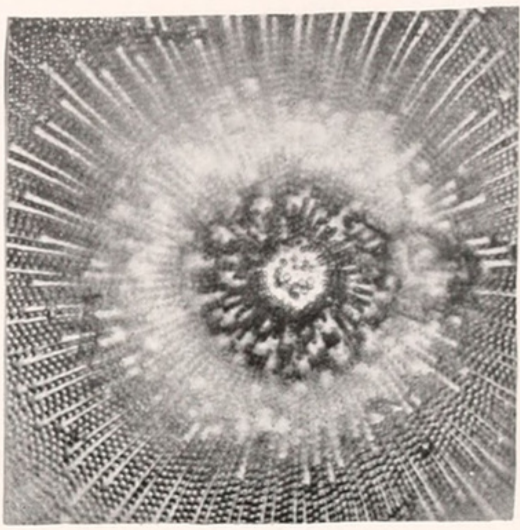

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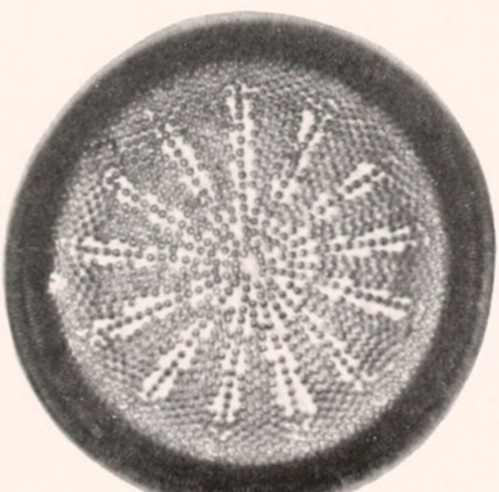

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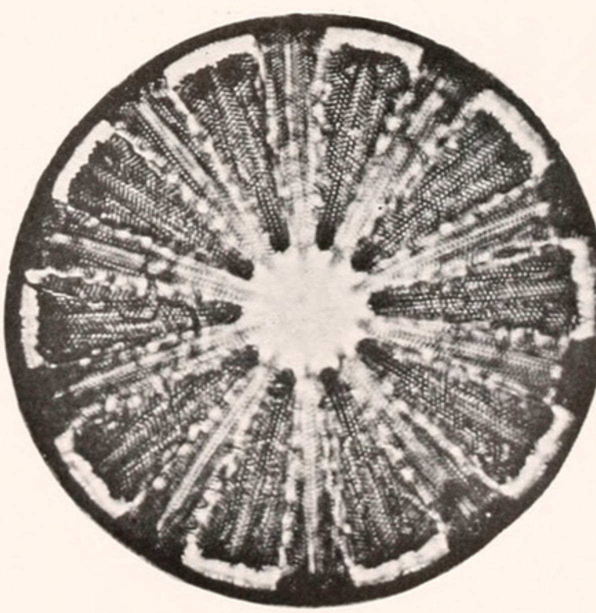

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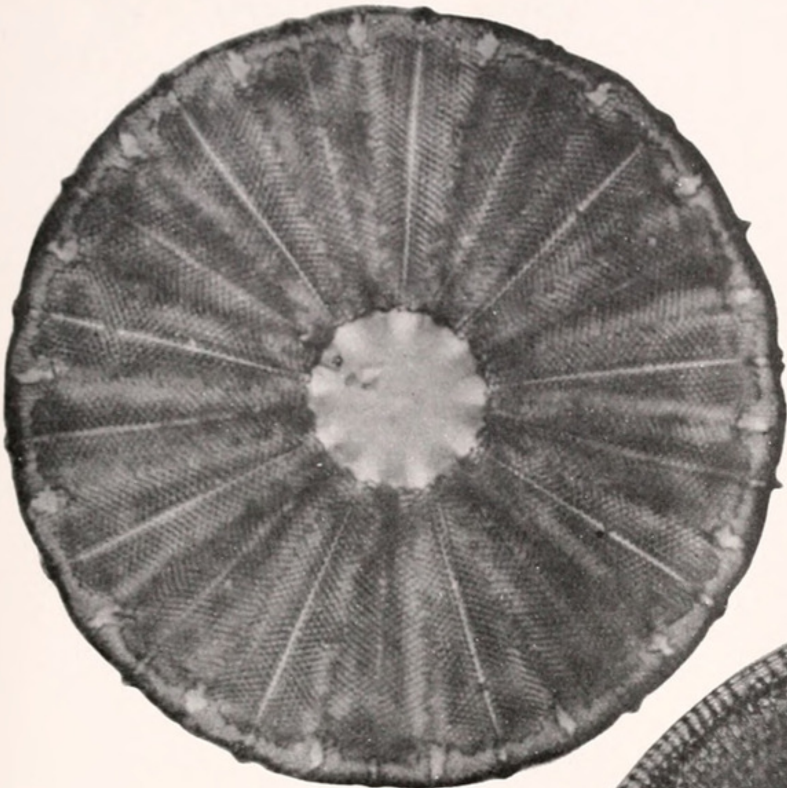
Plate 3

Fig. 1. *Actinoptychus janischii* Grunow. Plesiotype, No. 3141, C. A. S.; × 870; diameter, .084 mm.; from Calif. Acad. Sci. Loc. 1063, west side of Cottonwood Creek, Kern County, California, Sec. 13, T. 29S.; R. 29E., M. D. M.; Temblor Miocene.

Fig. 2. *Actinoptychus kernensis* Hanna, n. sp. Holotype, No. 3142, C. A. S.; × 550; diameter, .1680 mm.; showing one set of segments and border in focus.

Fig. 3. *Actinoptychus kernensis* Hanna, n. sp. Holotype, same specimen as Fig. 2; showing other set of segments in focus; from Calif. Acad. Sci. Loc. 1068, southeast side of Sharktooth Hill, Kern County, California; Temblor Miocene.



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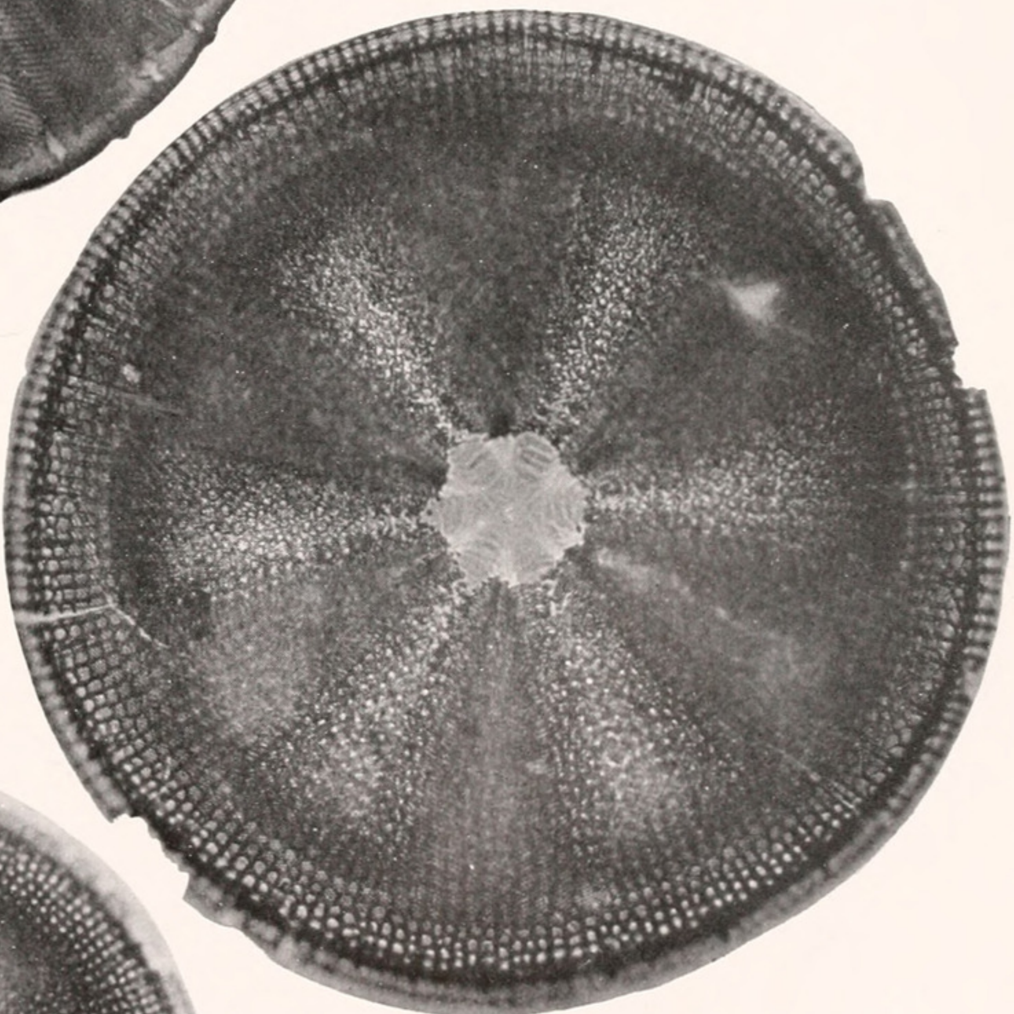

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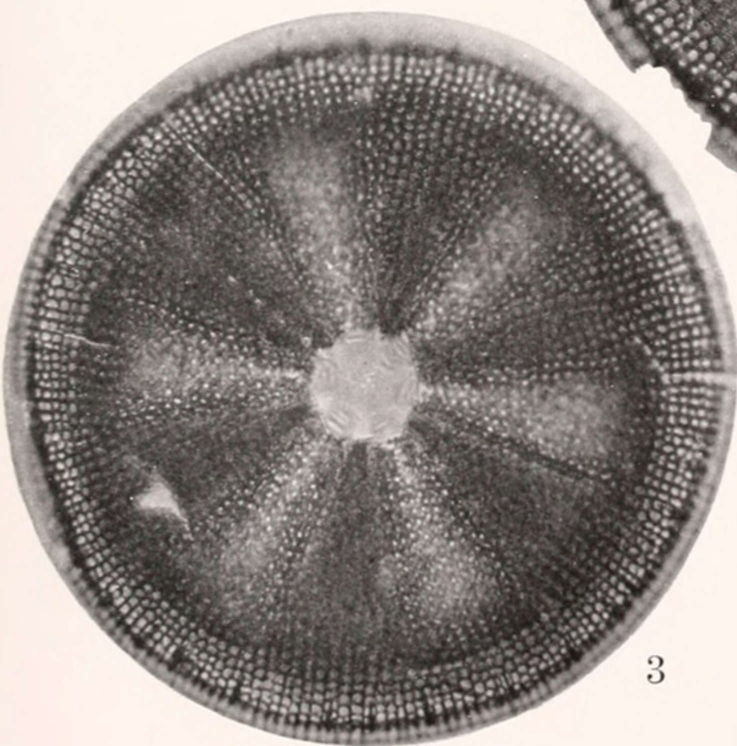


3

Plate 4

Fig. 1. *Actinoptychus perisetosus* Brun. Plesiotype, No. 3146, C. A. S.; × 1050; diameter, .0621 mm.; showing heavily marked segments in focus; from Calif. Acad. Sci. Loc. 1068, southeast side of Sharktooth Hill, Kern County, California; Temblor Miocene.

Fig. 2. *Actinoptychus perisetosus* Brun. Same specimen as Fig. 1; showing lightly marked segments in focus.

Fig. 3. *Actinoptychus thumii* Schmidt. Plesiotype, No. 3147, C. A. S.; × 600; diameter, .060 mm.; showing heavily marked segments in focus;, from Calif. Acad. Sci. Loc. 1068, southeast side of Sharktooth Hill Kern County, California; Temblor Miocene.

Fig. 4. *Actinoptychus thumii* Schmidt. Same specimen as Fig. 3; × 1000; showing lightly marked segments in focus.

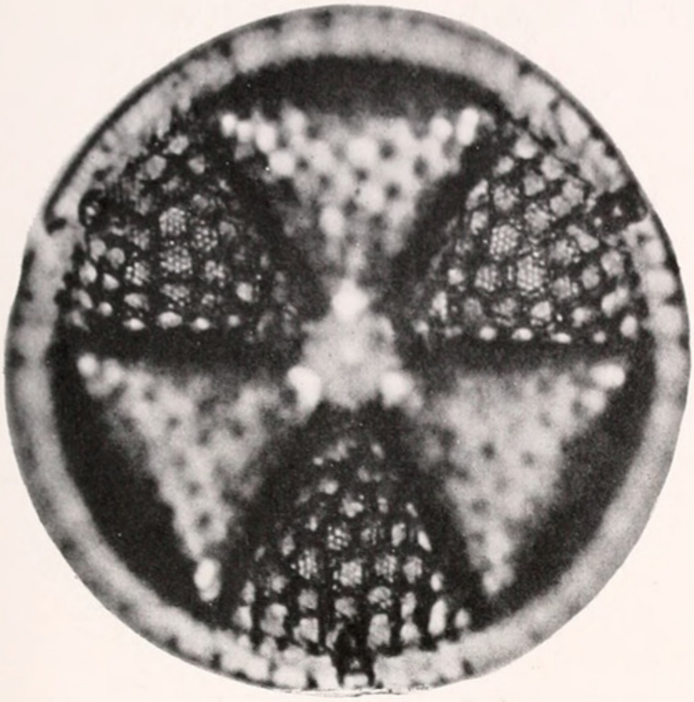
Fig. 5. *Annellus californicus* Tempere. Plesiotype, No. 3148, C. A. S.; × 725; diameter, .0525 mm.; side view of cylinder; from Calif. Acad. Sci. Loc. 1063, west side Cottonwood Creek, Kern County, California; Temblor Miocene.

Fig. 6. *Annellus californicus* Tempere. Plesiotype, No. 3149, C. A. S.; × 725; diameter, .520 mm.; end view of cylinder; from same locality as Fig. 5.

Fig. 7. *Annellus californicus* Tempere. Plesiotype, No. 3150, C. A. S.; × 555; diameter, .1080 mm.; side view of cylinder somewhat crushed; from Calif. Acad. Sci. Loc. 1068, southeast side of Sharktooth Hill, Kern County, California; Temblor Miocene.

Fig. 8. *Annellus californicus* Tempere. Plesiotype, No. 3151, C. A. S.; × 260; diameter, .0720 mm.; end view of cylinder; from Tempere's original material labelled and listed as from "Santa Monica, California," but which may have come from the Temblor Miocene of the Santa Monica Mountains.

Fig. 9. *Annellus californicus* Tempere. Diagrammatic longitudinal section to show structure.



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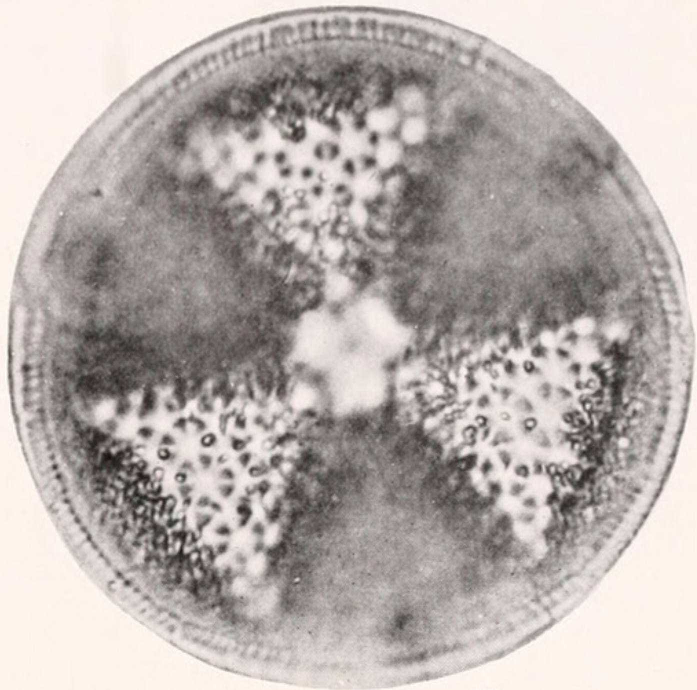

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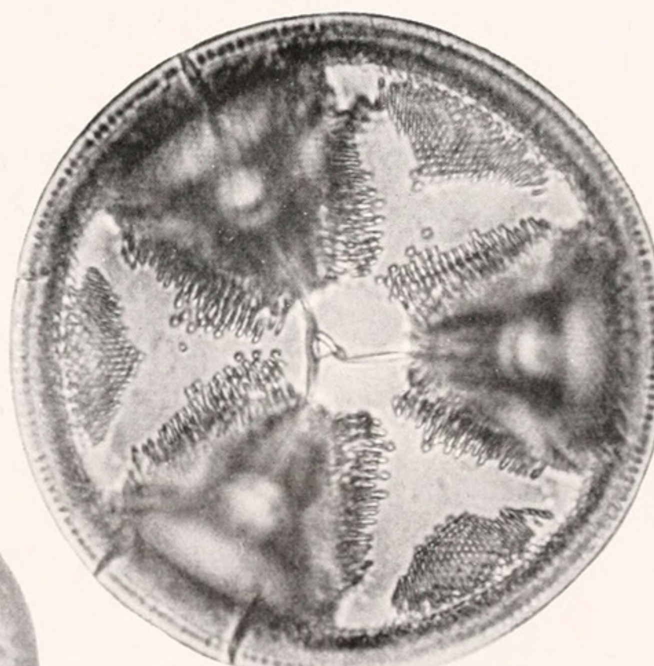

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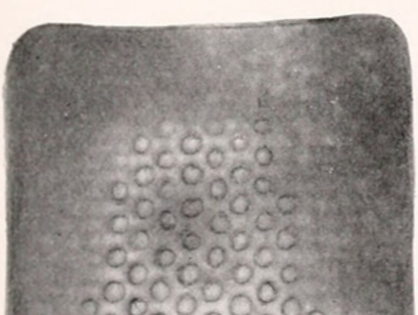

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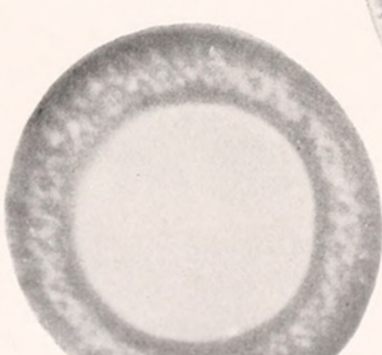

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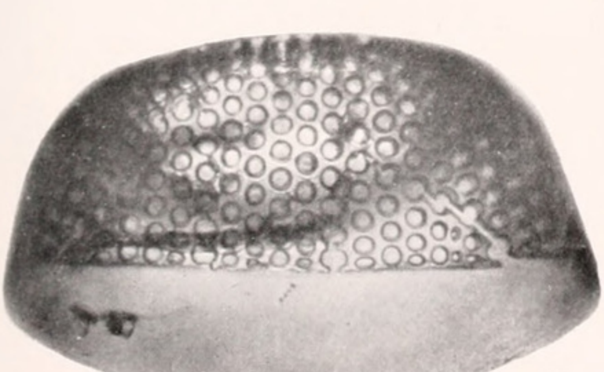

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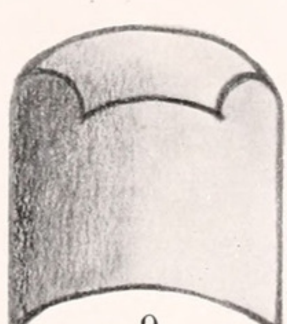

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Plate 5

Fig. 1. *Arachnoidiscus manni* Hanna & Grant. Plesiotype, No. 3152, C. A. S.; × 407; diameter, .1515 mm.; from Calif. Acad. Sci. Loc. 1068, southeast side of Sharktooth Hill, Kern County, California; Temblor Miocene.

Fig. 2. *Asterolampra rotula* Greville. Plesiotype, No. 3153, C. A. S.; × 440; diameter, .0876 mm.; from Calif. Acad. Sci. Loc. 1068, southeast side of Sharktooth Hill, Kern County, California; Temblor Miocene.

Fig. 3. *Aulacodiscus brownei* Norman. Plesiotype, No. 3154, C. A. S.; × 950; diameter, .0378 mm.; from Calif. Acad. Sci. Loc. 1063, west side Cottonwood Creek, Kern County, California, Sec. 13, T. 29S., R. 29E., M. D. M.; Temblor Miocene.

Fig. 4. *Auliscus bonus* Hanna, n. sp. Holotype, No. 3155, C. A. S.; × 880; diameter, .0422 mm.; from Calif. Acad. Sci. Loc. 1068, southeast side of Sharktooth Hill, Kern County, California; Temblor Miocene.

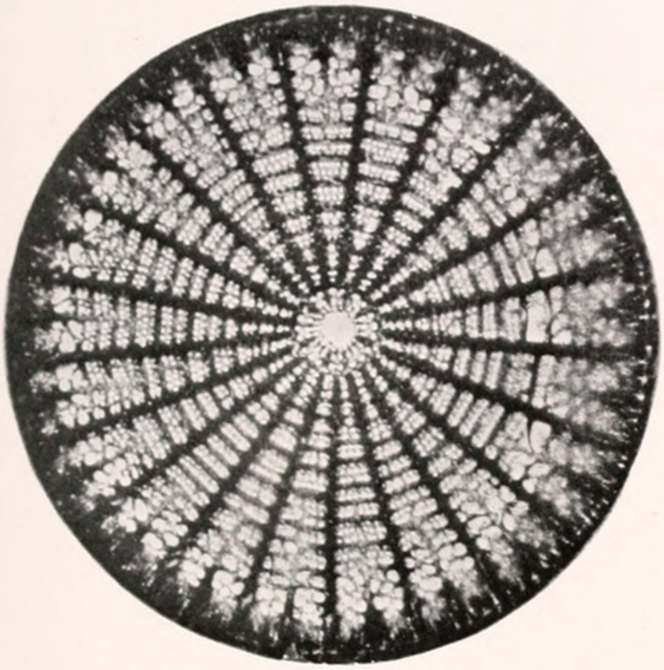
Fig. 5. *Auliscus bonus* Hanna, n. sp. Holotype, No. 3155, C. A. S.; × 880; diameter, .0422 mm.; opposite valve from Fig. 4; from Calif. Acad. Sci. Loc. 1068, southeast side of Sharktooth Hill, Kern County, California; Temblor Miocene.

Fig. 6. *Auliscus suppressus* Hanna, n. sp. Holotype, No. 3156, C. A. S.; × 934; diameter, .0321 mm.; from Calif. Acad. Sci. Loc. 1068, southeast side of Sharktooth Hill, Kern County, California; Temblor Miocene.

Fig. 7. *Biddulphia angulata* Schmidt. Plesiotype, No. 3157, C. A. S.; × 1875; diameter, .0320 mm.; from Calif. Acad. Sci. Loc. 1068, southeast side of Sharktooth Hill, Kern County, California; Temblor Miocene.

Fig. 8. *Biddulphia angulata* Schmidt. Plesiotype, No. 3158, C. A. S.; × 1000; diameter, .0250 mm.; from Calif. Acad. Sci. Loc. 1068, southeast side of Sharktooth Hill, Kern County, California; Temblor Miocene.

Fig. 9. *Coscinodiscus æginensis* Schmidt. Plesiotype, No. 3159, C. A. S.; × 875; diameter, .0788 mm.; from Calif. Acad. Sci. Loc. 1068, southeast side of Sharktooth Hill, Kern County, California; Temblor Miocene.



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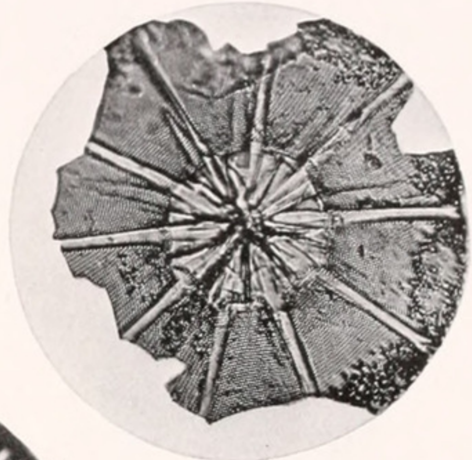

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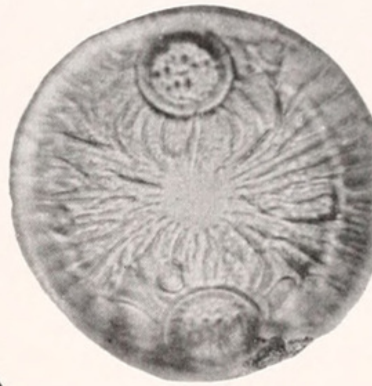

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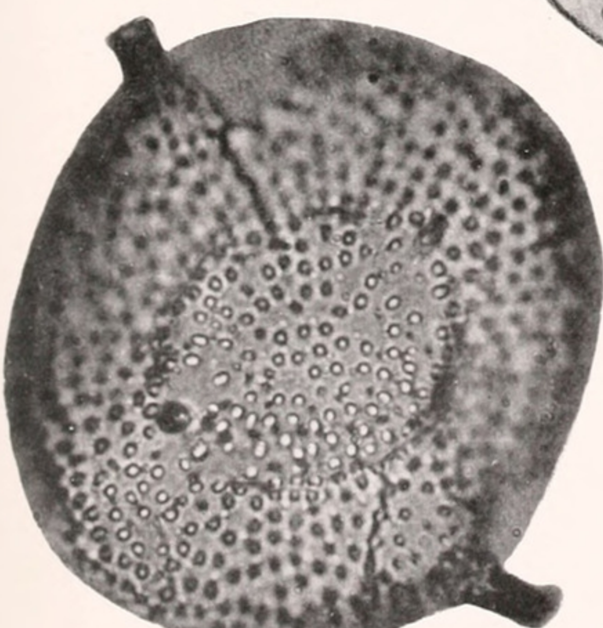

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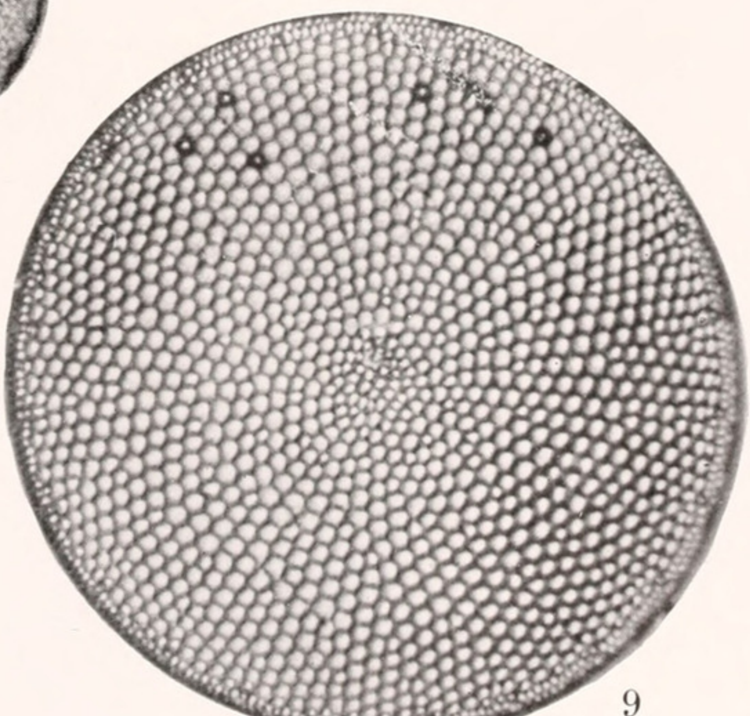

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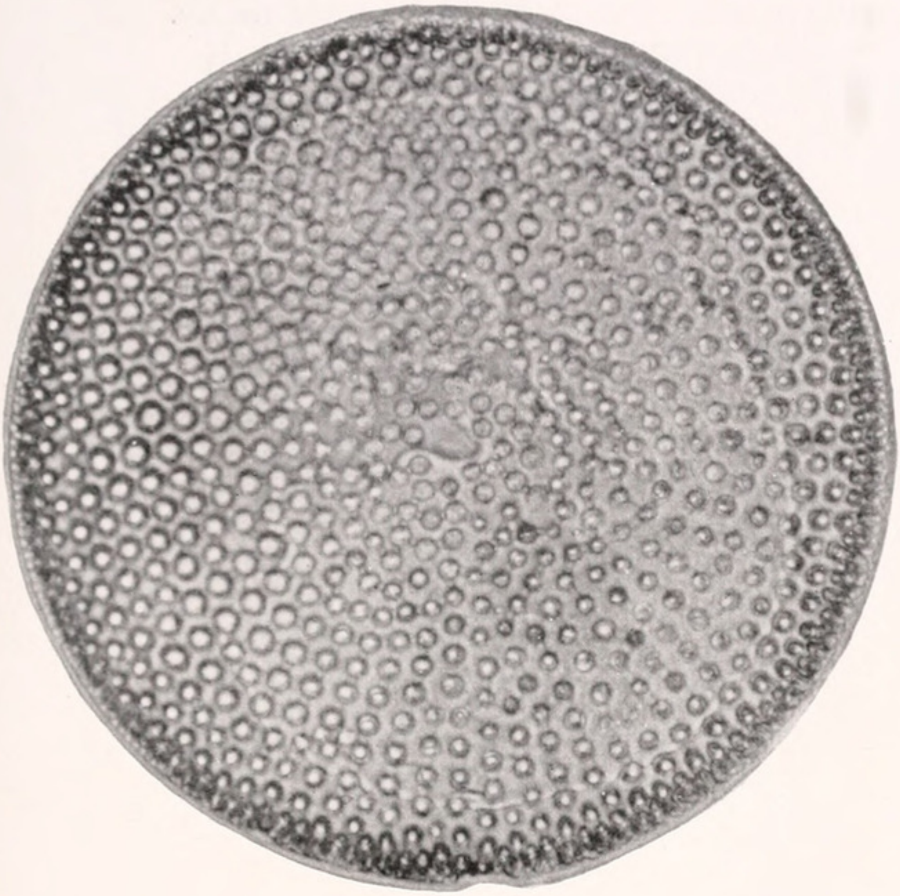
Plate 6

Fig. 1. *Coscinodiscus apiculatus* Ehrenberg. Plesiotype, No. 3160, C. A. S.; × 532; diameter, .1540 mm.

Fig. 2. *Coscinodiscus convexus* Schmidt. Plesiotype, No. 3161, C. A. S.; × 330; diameter, .2760 mm.

Fig. 3. *Coscinodiscus convexus* Schmidt. Plesiotype, No. 3163, C. A. S.; × 1600; fragment showing secondary sculpture.

[All of the diatoms illustrated on this plate are from Calif. Acad. Sci. Loc. 1068, southeast side of Sharktooth Hill, Kern County, California; Temblor Miocene.]



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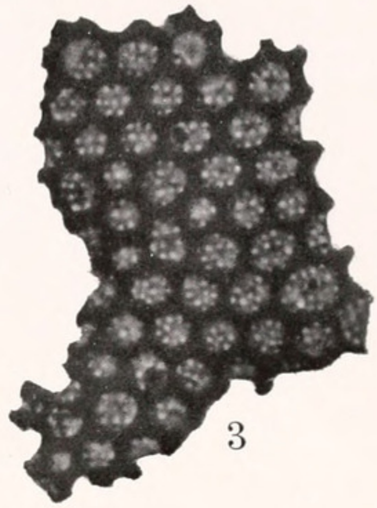

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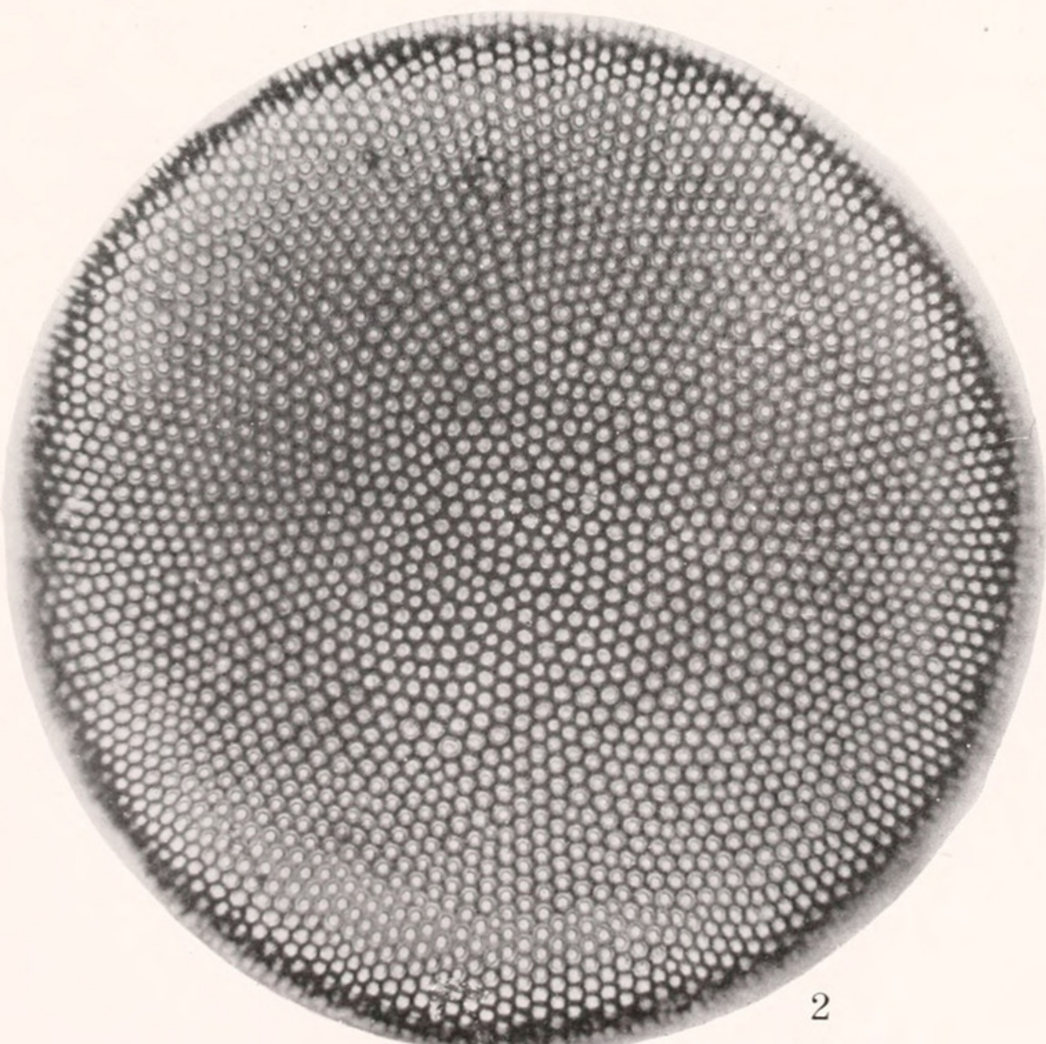

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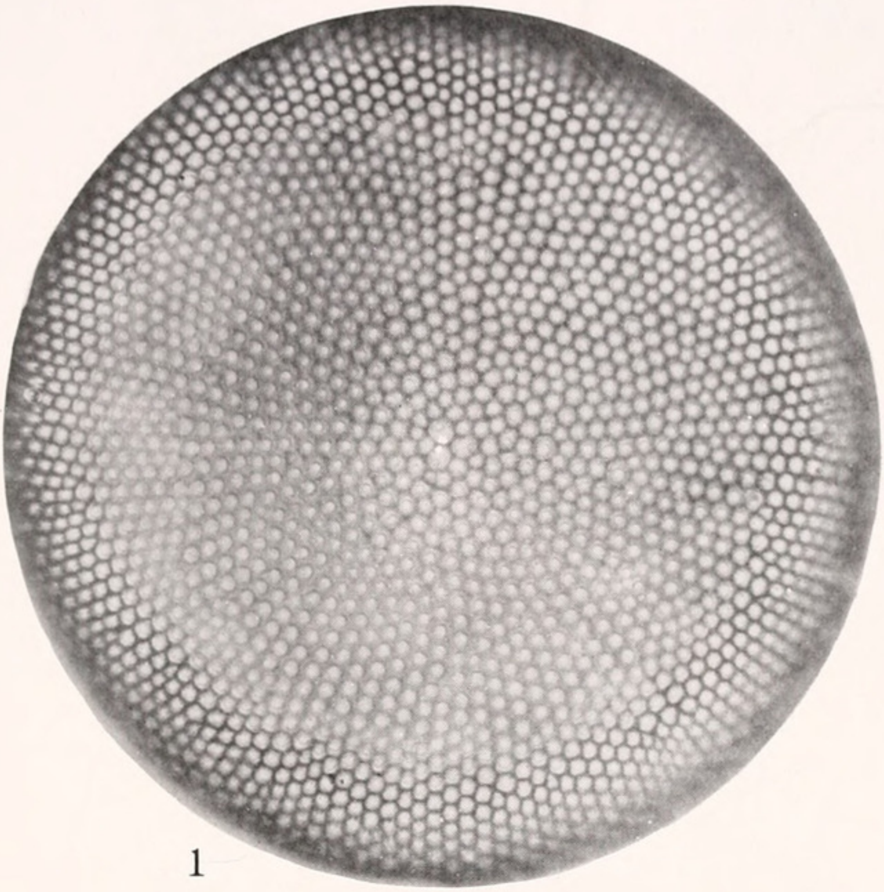
Plate 7

Fig. 1. *Coscinodiscus convexus* Schmidt. Plesiotype, No. 3162, C. A. S.; × 345; diameter, .232 mm.

Fig. 2. *Coscinodiscus fulguralis* Brun. Plesiotype, No. 3164, C. A. S.; × 308; diameter, .2912 mm.

[The diatoms illustrated on this plate are from Calif. Acad. Sci. Loc. 1068, southeast side of Sharktooth Hill, Kern County, California; Temblor Miocene.]



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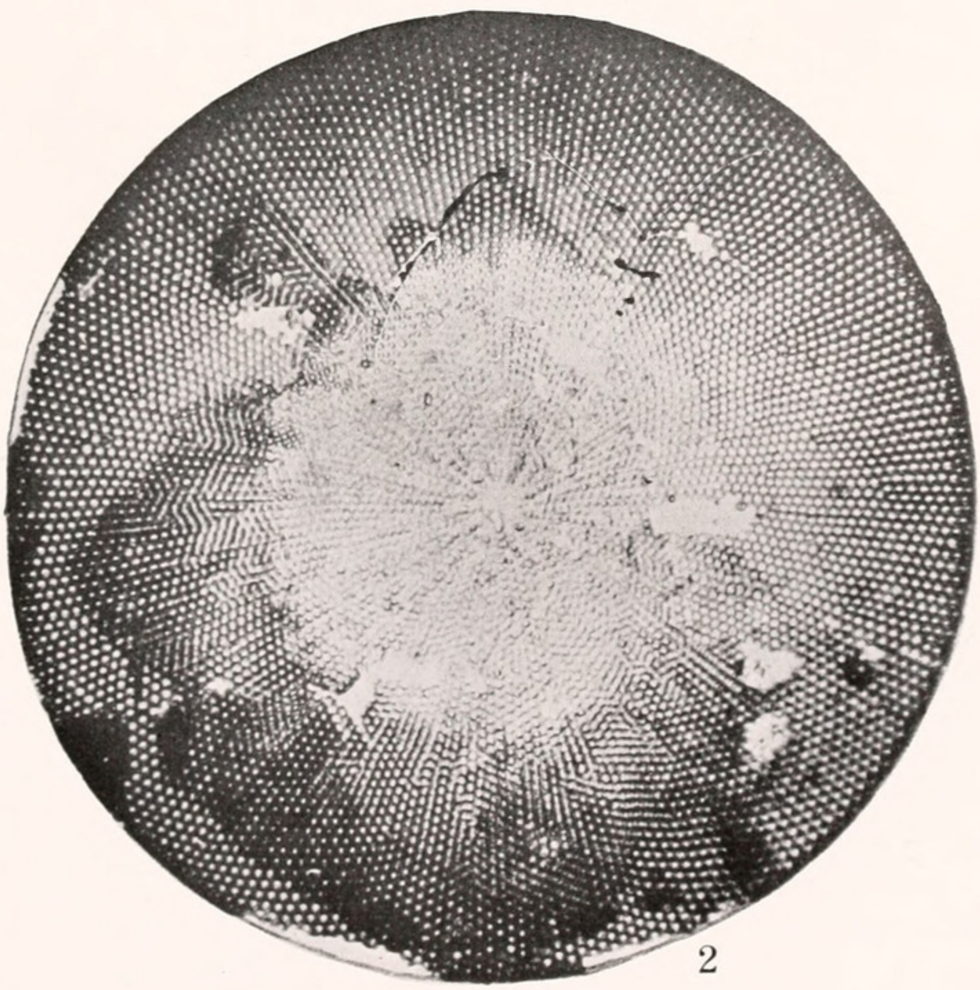

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Plate 8

Fig. 1. *Coscinodiscus lineatus* Ehrenberg. Plesiotype, No. 3165, C. A. S.; × 1600; diameter, .0412 mm.

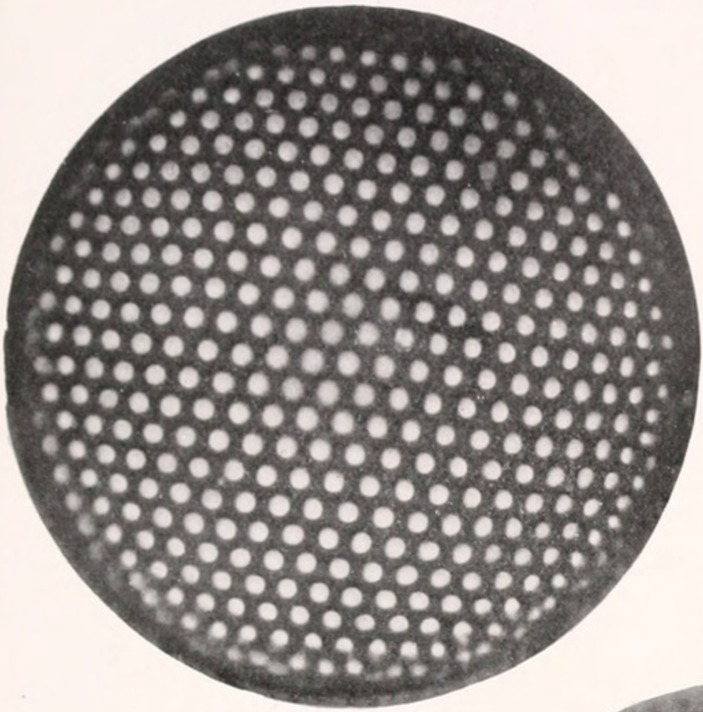
Fig. 2. *Coscinodiscus lineatus* Ehrenberg. Plesiotype, No. 3166, C. A. S.; × 1600; diameter, .040 mm.

Fig. 3. *Coscinodiscus lineatus* Ehrenberg. Plesiotype, No. 3167, C. A. S.; × 1600; diameter, .0420 mm.

Fig. 4. *Coscinodiscus marginatus* Ehrenberg. Plesiotype, No. 3168, C. A. S.; × 714; diameter, .0840 mm.

Fig. 5. *Coscinodiscus marginatus* Ehrenberg. Plesiotype, No. 3169, C. A. S.; × 433; diameter, .1040 mm.

[All of the diatoms illustrated on this plate are from Calif. Acad. Sci. Loc. 1068, southeast side of Sharktooth Hill, Kern County, California; Temblor Miocene.]



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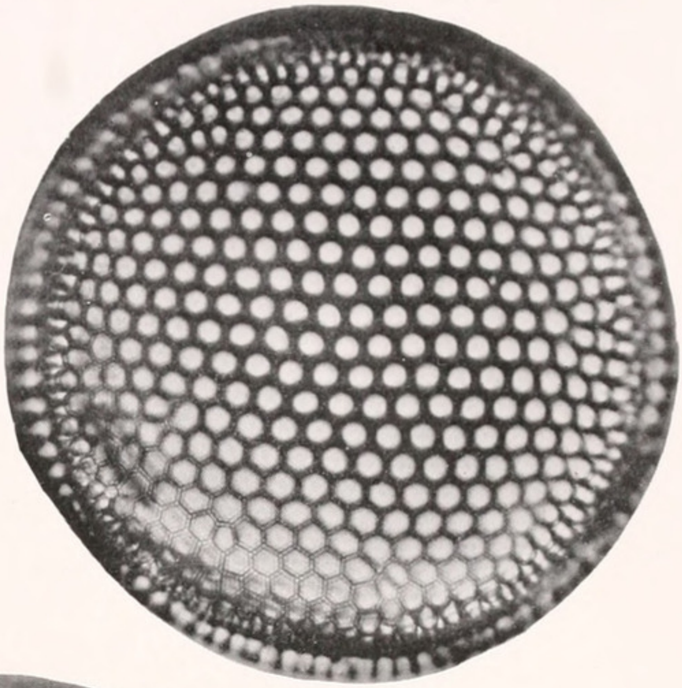

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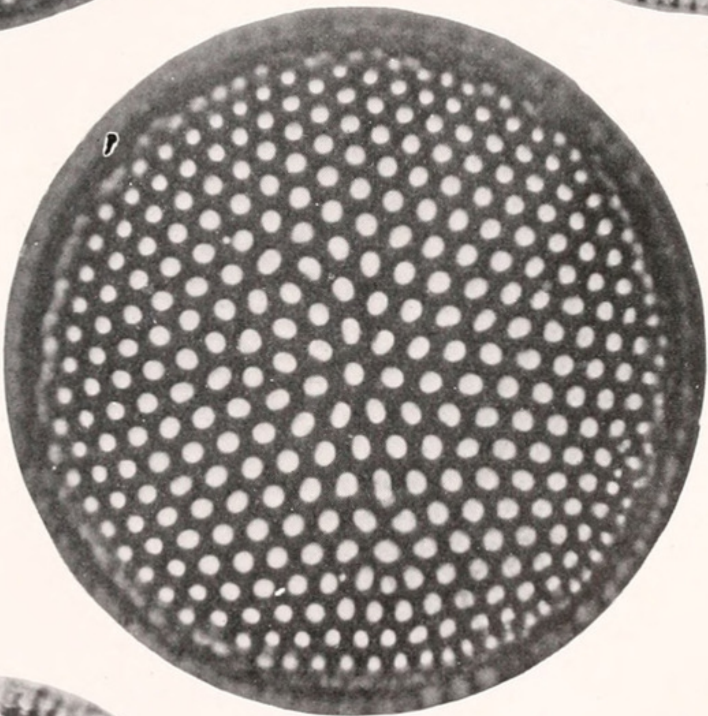

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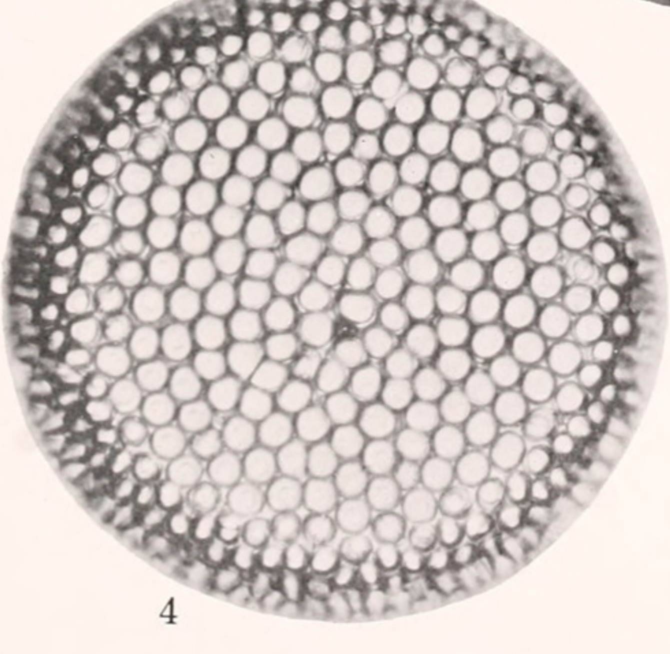

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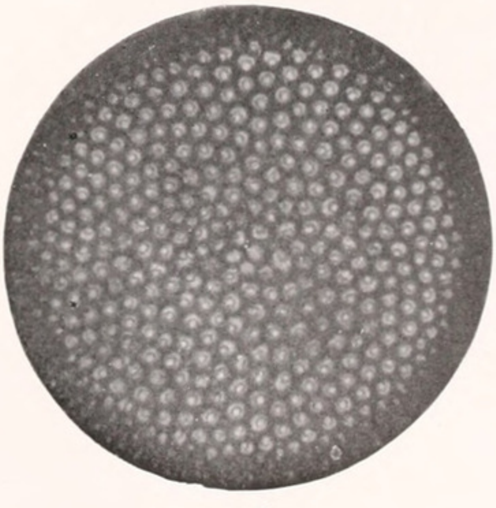

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PLATE 9

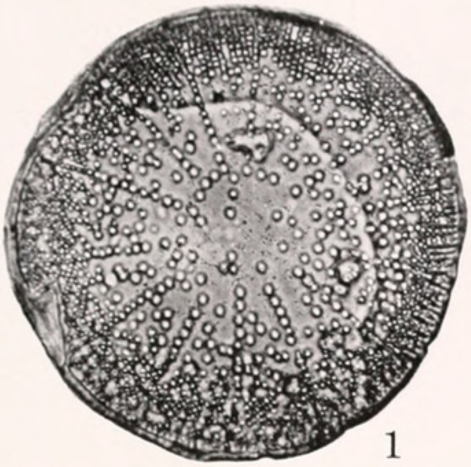
Fig. 1. *Coscinodiscus meditatus* Hanna, n. sp. Holotype, No. 3170, C. A. S.; × 775; diameter, .0541 mm.

Fig. 2. *Coscinodiscus monicæ* Grunow. Plesiotype, No. 3171, C. A. S.; × 430; diameter, .160 mm.

Fig. 3. *Coscinodiscus novozealandius* Grove. Plesiotype, No. 3172, C. A. S.; × 1485; diameter, .0465 mm.; 6 beads in .01 mm.

Fig. 4. *Coscinodiscus oculus-iridis* Ehrenberg. Plesiotype, No. 3173, C. A. S.; × 365; diameter, .240 mm.; 3 beads in .01 mm. near margin.

[All of the diatoms illustrated on this plate are from Calif. Acad. Sci. Loc. 1068, southeast side of Sharktooth Hill, Kern County, California; Temblor Miocene.]



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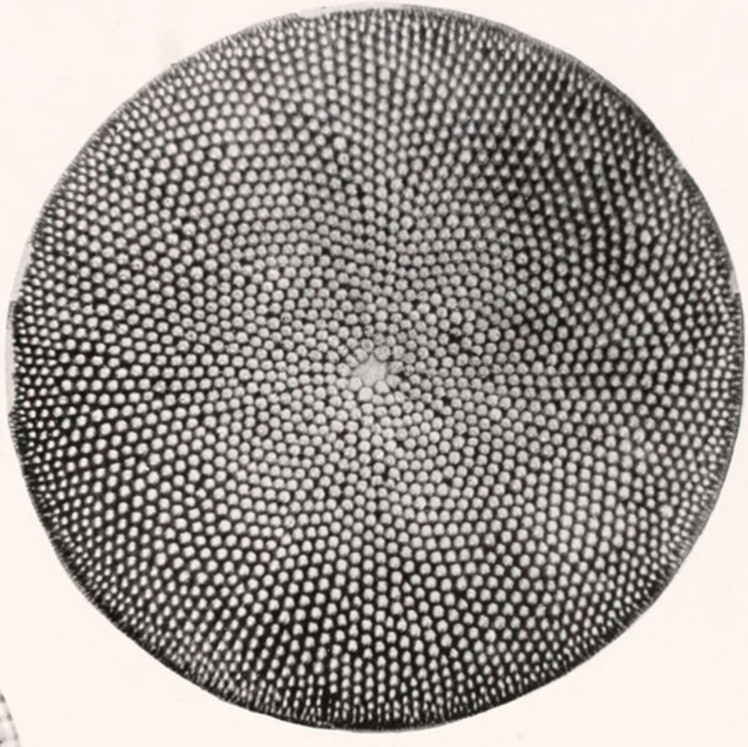

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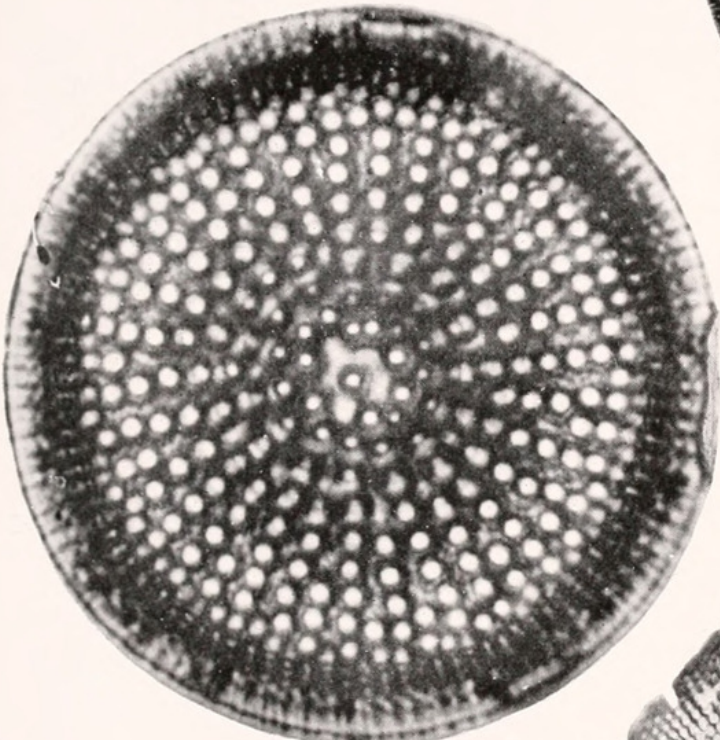

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Plate 10

Fig. 1. *Coscinodiscus pacificus* Grunow. Plesiotype, No. 3174, C. A. S.; × 450; diameter, .160 mm.

Fig. 2. *Cyclotella kelloggi* Hanna, n. sp. Holotype, No. 3175, C. A. S.; × 1734; diameter, .0392 mm.

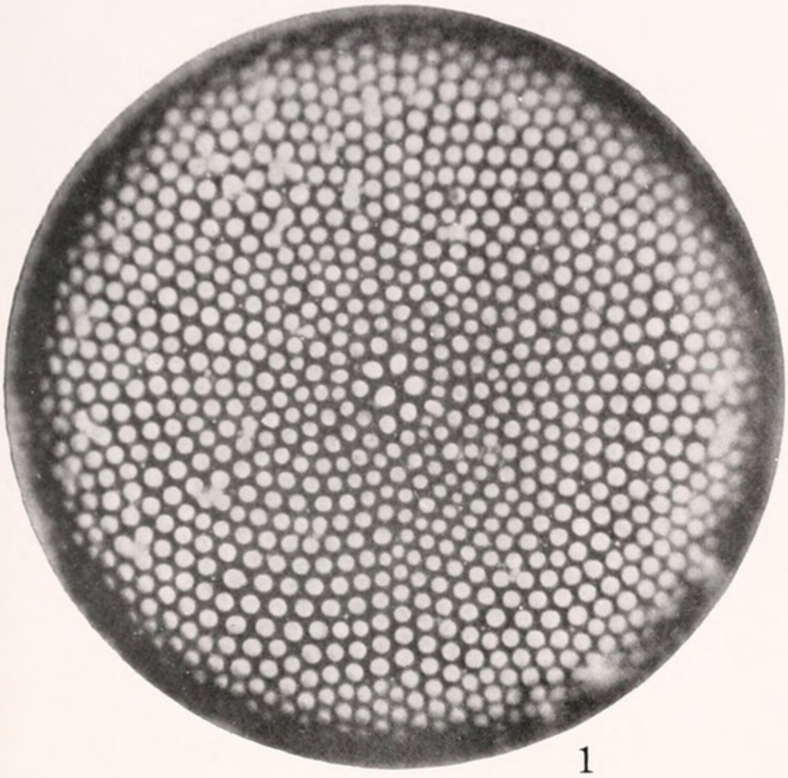
Fig. 3. *Cyclotella kelloggi* Hanna, n. sp. Paratype, No. 3176, C. A. S.; × 1870; diameter, .031+ mm.

Fig. 4. *Cyclotella kelloggi* Hanna, n. sp. Paratype, No. 3177, C. A. S.; × 1518; diameter, .031 mm.; from Calif. Acad. Sci. Loc. 1221, Federal Exploration Company, Kinsella Well No. 1, Sec. 15, T. 22S., R. 24E., M. D. M., Tulare County, California; depth 4156 feet; Temblor (?) Miocene.

Fig. 5. *Cymatogonia amblyoceras* (Ehrenberg). Plesiotype, No. 3178, C. A. S.; × 550; length of one side, .090 mm.; 13 rows of beads in .01 mm.

Fig. 6. *Cymatosira andersoni* Hanna, n. sp. Holotype, No. 3182, C. A. S.; × 1800; length, .0340 mm.; width, .01 mm.; 10 beads in .01 mm.

[All of the diatoms illustrated on this plate except figure 4 are from Calif. Acad. Sci. Loc. 1068, southeast side of Sharktooth Hill, Kern County, California; Temblor Miocene.]



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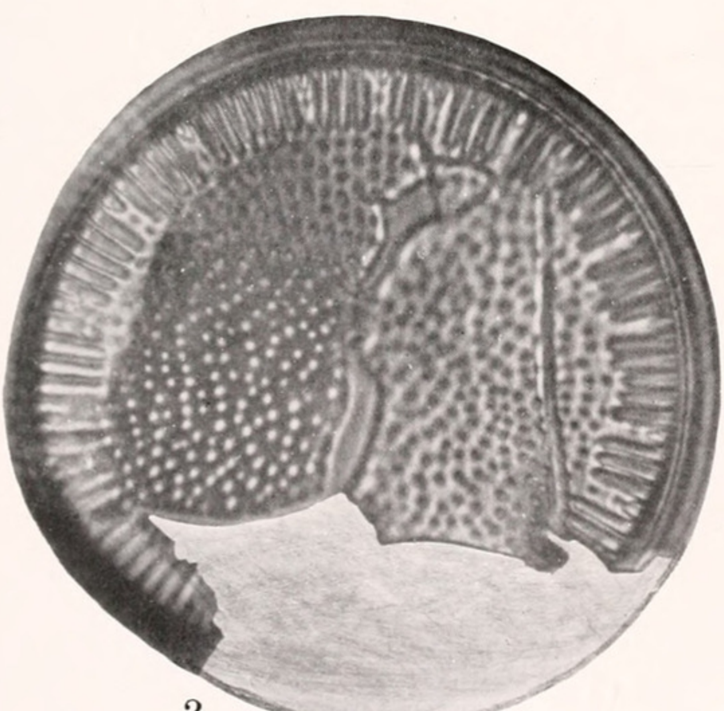

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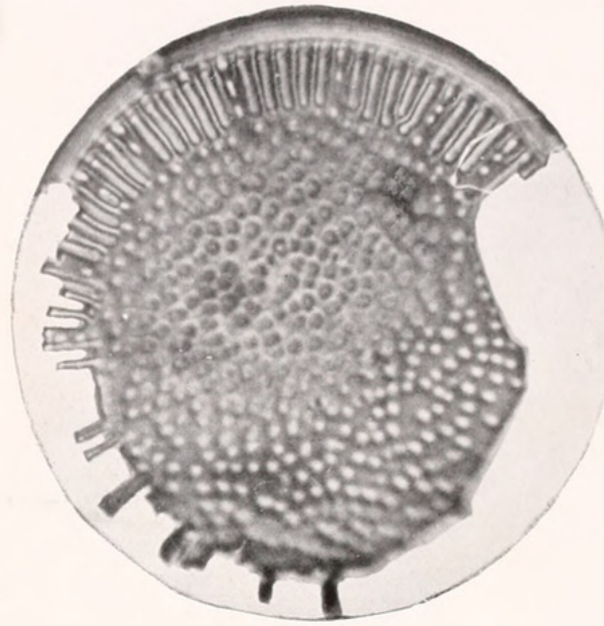

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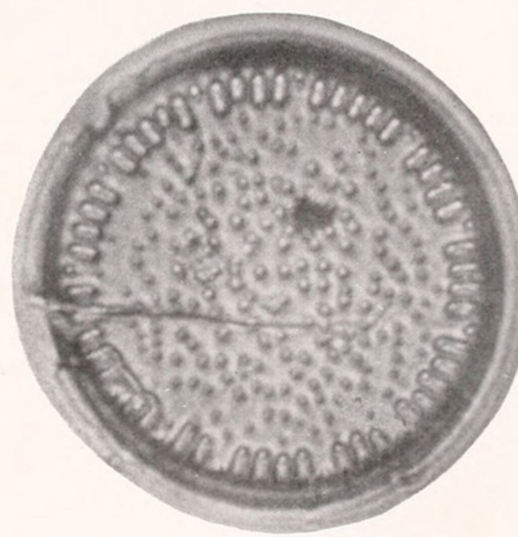

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January 8, 1932

Plate 11

Fig. 1. *Denticula lauta* Bailey. Plesiotype, No. 3183, C. A. S.; × 2000; length, .0216 mm.; width, .0062 mm.

Fig. 2. *Dimeregramma scutulum* Hanna, n. sp. Holotype, No. 3184, C. A. S.; × 1818; length, .0330 mm.; width, .0133 mm.; 9 beads in .01 mm.

Fig. 3. *Dossetia lacera* (Forti). Plesiotype, No. 3185, C. A. S.; × 406; length, .0592 mm.; the dark markings on the disk are sharp spines, out of focus in this view.

Fig. 4. *Goniothecium rogersii* Ehrenberg. Plesiotype, No. 3186, C. A. S.; × 717; length, .0530 mm.; width, .0420 mm.

Fig. 5. *Goniothecium rogersii* Ehrenberg. Plesiotype, No. 3187, C. A. S.; × 900; length, .0735 mm.; width, .0444 mm.

Fig. 6. *Goniothecium rogersii* Ehrenberg. Plesiotype, No. 3188, C. A. S.; × 940; length, .0532 mm.; width, .0428 mm.

Fig. 7. *Hemiaulus polymorphus* Grunow. Plesiotype, No. 3189, C. A. S.; × 842; diameter, .0285 mm.; height, .0220 mm.; 5 rows of beads in .01 mm.

Fig. 8. *Hyalodiscus frenguellii* Hanna, n. sp. Holotype, No. 3190, C. A. S.; × 620; diameter, .0968 mm.

Fig. 9. *Hyalodiscus frenguellii* Hanna, n. sp. Same specimen as figure 8, × 1600; enlarged to show details of sculpture.

[All of the diatoms illustrated on this plate are from Calif. Acad. Sci. Loc. 1068, southeast side of Sharktooth Hill, Kern County, California; Temblor Miocene.]


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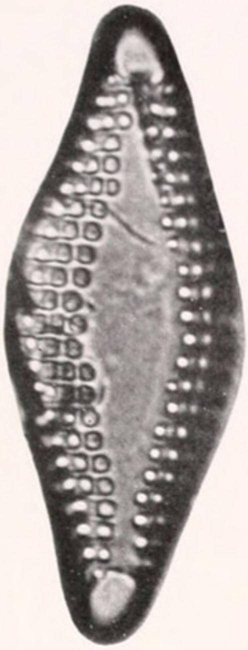
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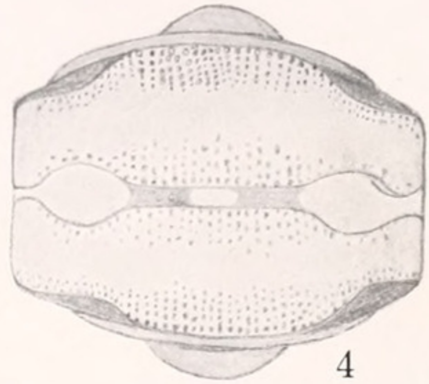
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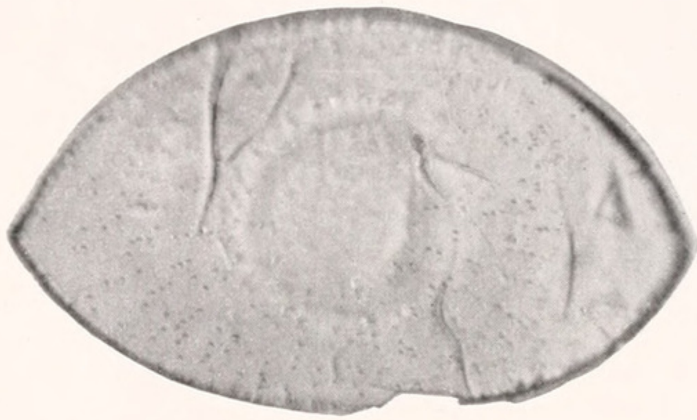
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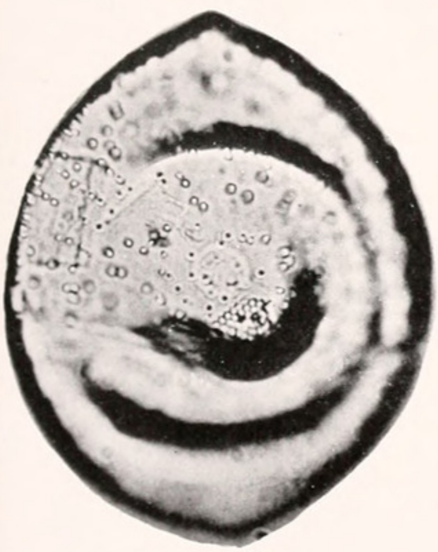
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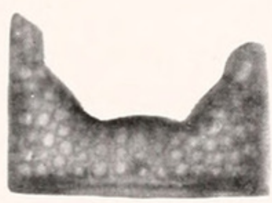
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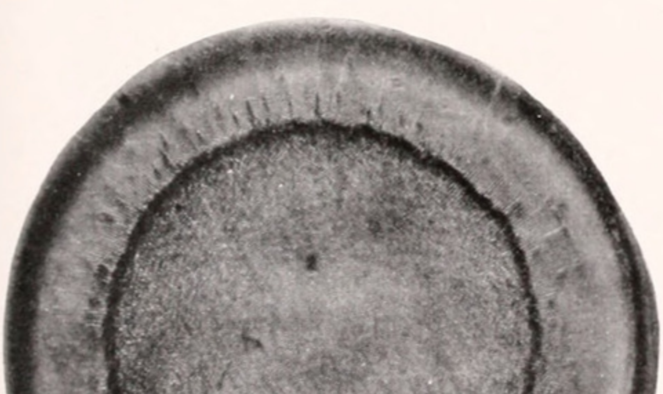
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Plate 12

Fig. 1. *Eupodiscus antiquus* Cox. Plesiotype, No. 3193, C. A. S.; × 533; diameter, .1426 mm.; 3 beads in .01 mm.

Fig. 2. *Eupodiscus antiquus* Cox. Same specimen as figure 1 with a lower focus.

Fig. 3. *Eupodiscus antiquus* Cox. Diagrammatic cross section through spines.

Fig. 4. *Eupodiscus antiquus* Cox. Diagrammatic side view of border at one of the spines.

Fig. 5. *Liradiscus rugulosus* Forti. Plesiotype, No. 3198, C. A. S.; × 1200; length, .0274 mm.; width, .0153 mm.

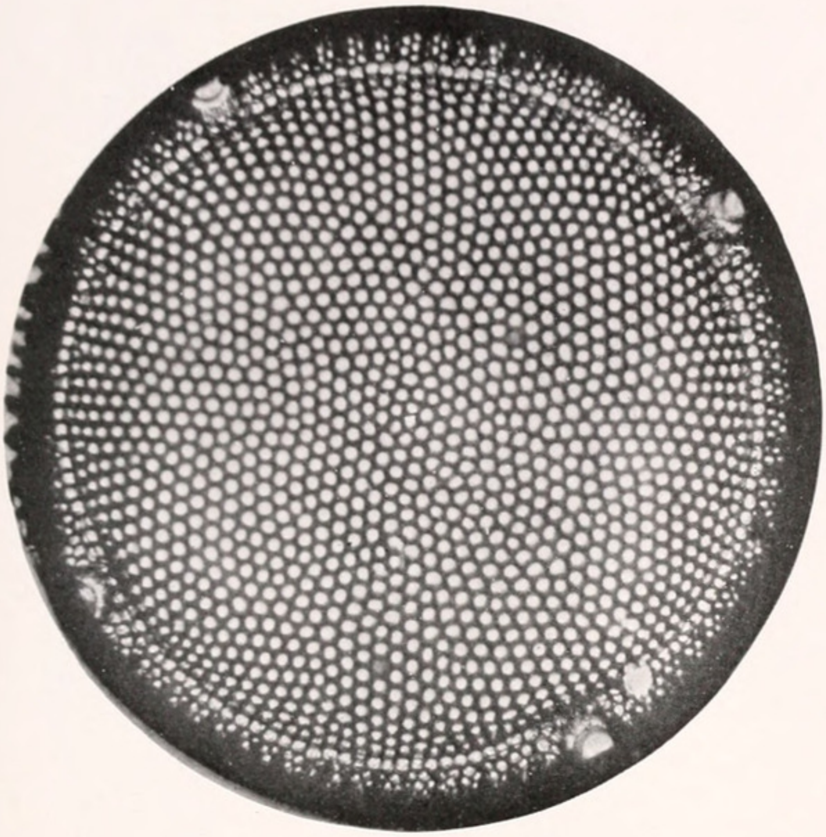
Fig. 6. *Liradiscus rugulosus* Forti. Diagrammatic side view omitting spines.

Fig. 7. *Macrora stella* (Azpeitia). Plesiotype, No. 3199, C. A. S.; × 3290; diameter, .0152 mm.

Fig. 8. *Melosira geometrica* Hanna, n. sp. Holotype, No. 3200, C. A. S.; × 1300; diameter, .030 mm.

Fig. 9. *Melosira geometrica* Hanna, n. sp. Paratype, No. 3201, C. A. S.; × 1275; diameter, .0352 mm.; length, .0139 mm.

[All of the diatoms illustrated on this plate are from Calif. Acad. Sci. Loc. 1068, southeast side of Sharktooth Hill, Kern County, California; Temblor Miocene.]



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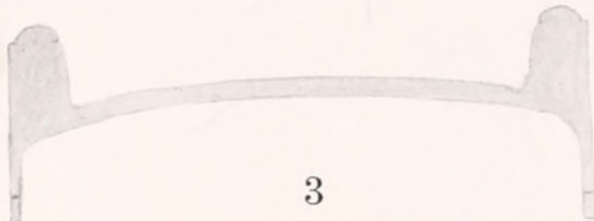

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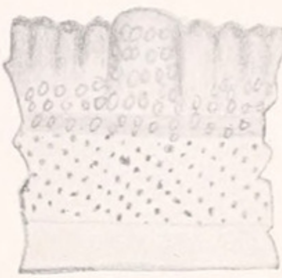

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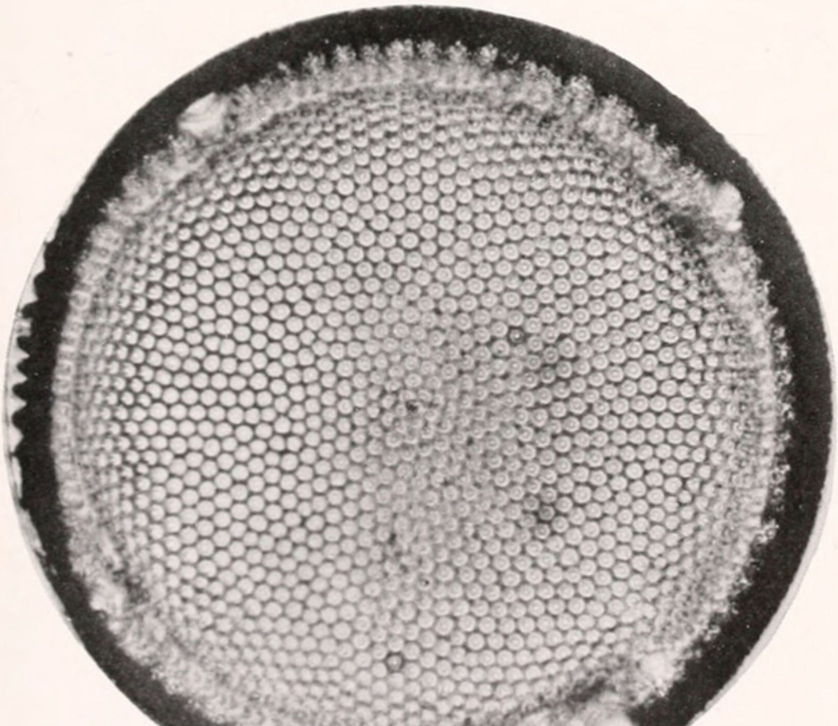

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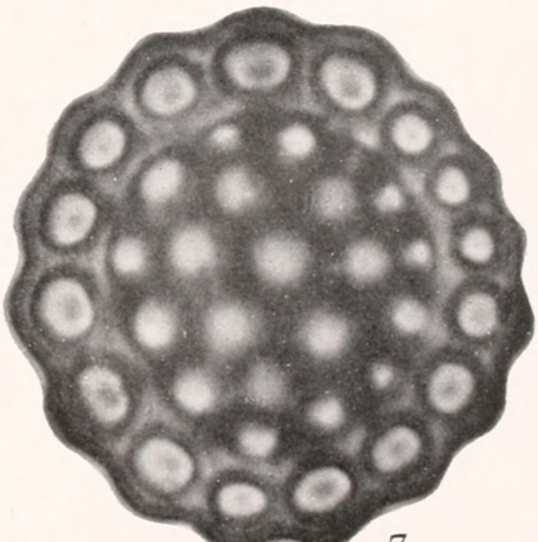

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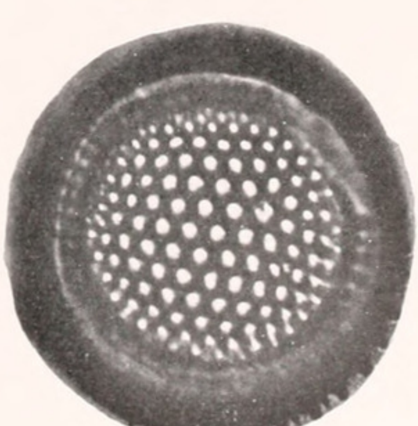

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Plate 13

Fig. 1. *Navicula kernensis* Hanna, n. sp. Holotype, No. 3202, C. A. S.; × 470; length, .192 mm.; width, .040 mm.; 9 costæ in .01 mm.

Fig. 2. *Navicula lyra* Ehrenberg. Plesiotype, No. 3204, C. A. S.; × 536; length, .1640 mm.; width, .060 mm.; 11 rows of beads in .01 mm.

Fig. 3. *Navicula marina* Ralfs. Plesiotype, No. 3205, C. A. S.; × 722; length, .090 mm.; width, .0447 mm.; 6 rows of beads in .01 mm.

Fig. 4. *Navicula mimicans* Hanna, n. sp. Holotype, No. 3206, C. A. S.; × 666; length, .1350 mm.; width, .0345 mm.

Fig. 5. *Navicula morricei* Hanna, n. sp. Holotype, No. 3209, C. A. S.; × 766; length, .120 mm.; width, .0580 mm.; 10 rows of beads in .01 mm. in center, 9 at ends.

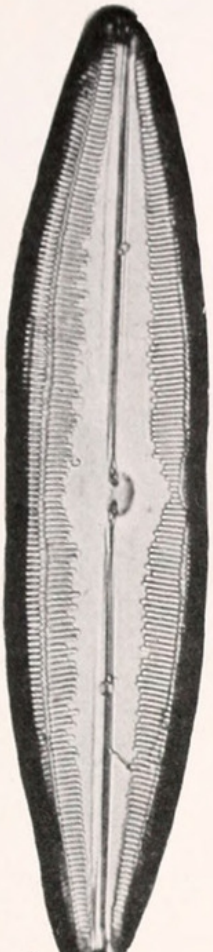
Fig. 6. *Navicula optima* Hanna, n. sp. Holotype, No. 3210, C. A. S.; × 1500; length, .0411 mm.; width, .0114 mm.; 8 costæ in .01 mm.

Fig. 7. *Navicula proserpinæ* (?) Pantocsek. Plesiotype, No. 3211, C. A. S.; × 945; length, .0570 mm.; width, .0125 mm.; 15 costæ in .01 mm.

Fig. 8. *Periptera tetracladia* Ehrenberg. Plesiotype, No. 3212, C. A. S.; × 2000; diameter, .0263 mm.

Fig. 9. *Periptera tetracladia* Ehrenberg. Diagrammatic cross-section of frustule.

[All of the diatoms illustrated on this plate are from Calif. Acad. Sci. Loc. 1068, southeast side of Sharktooth Hill, Kern County, California; Temblor Miocene.]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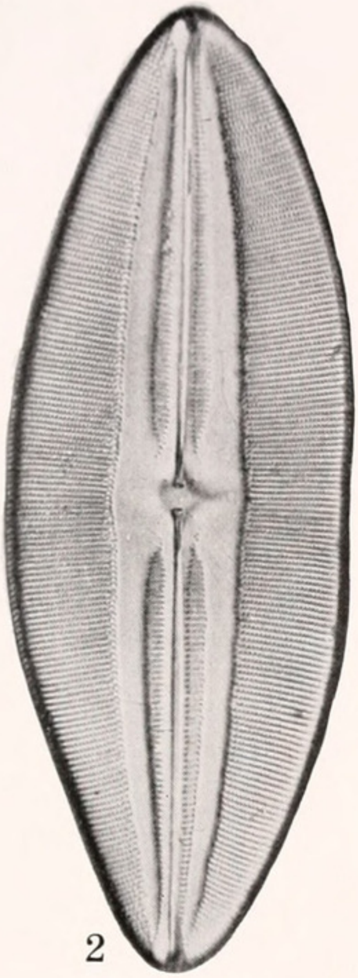
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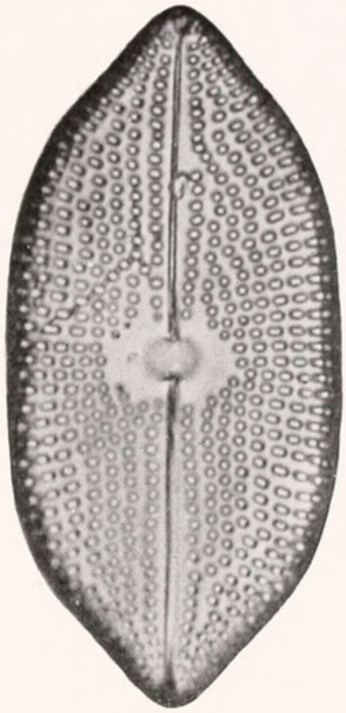
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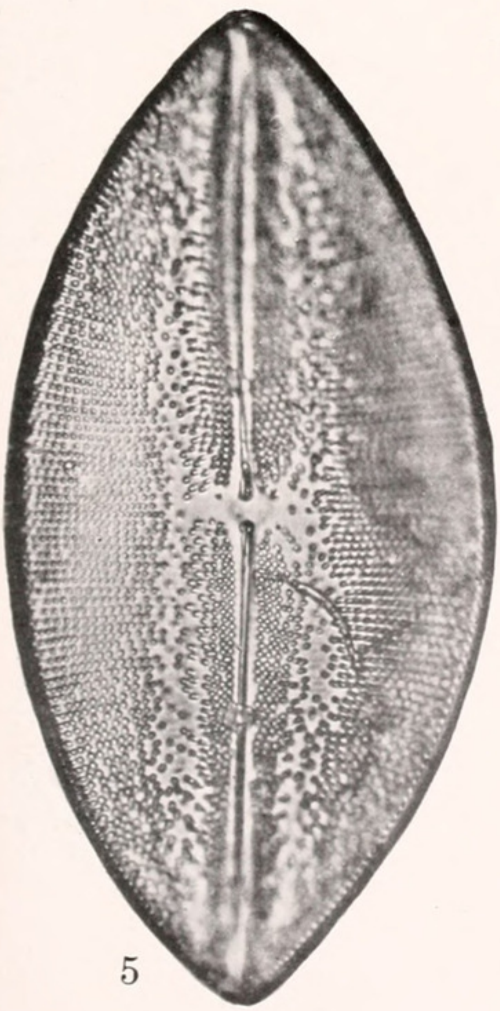
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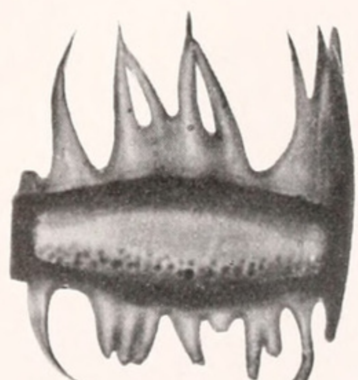
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Plate 14

Fig. 1. *Perrya innocens* Hanna, n. sp. Holotype, No. 3213, C. A. S.; × 365; length, .1860 mm., (originally .260 mm.); width, .080 mm.; 4 to 5 major striæ in .01 mm.

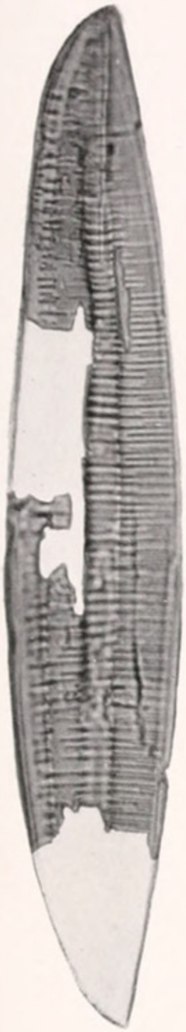
Fig. 2. *Plagiogramma truanii* Pantocsek. Plesiotype, No. 3214, C. A. S.; × 2043; length, .0548 mm.; width, .0122 mm.; 17 beads in .01 mm.

Fig. 3. *Raphidodiscus marylandicus* Christian. Plesiotype, No. 3215, C. A. S.; × 1027; length, .0555 mm.; width, .0515 mm.; 13 transverse rows of beads in .01 mm. in center of valve.

Fig. 4. *Raphidodiscus marylandicus* Christian. Plesiotype, No. 3218, C. A. S.; × 1000; length, .0382 mm.; width, .0382 mm.; 13 rows of beads in .01 mm. in center of valve.

Fig. 5. *Rattrayella inconspicuua* (Rattray). Plesiotype, No. 3219, C. A. S.; × 700; diameter, .1376 mm.; 3 cells in .01 mm. in center of valve.

[All of the diatoms illustrated on this plate are from Calif. Acad. Sci. Loc. 1068, southeast side of Sharktooth Hill, Kern County, California; Temblor Miocene.]



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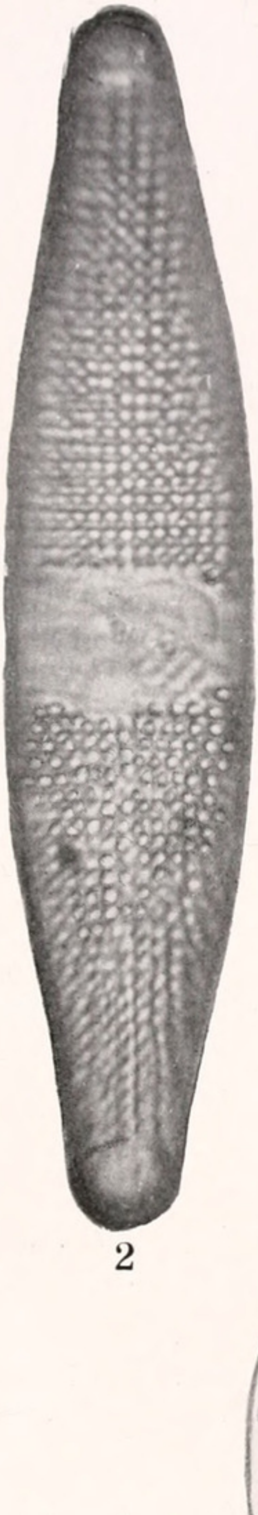

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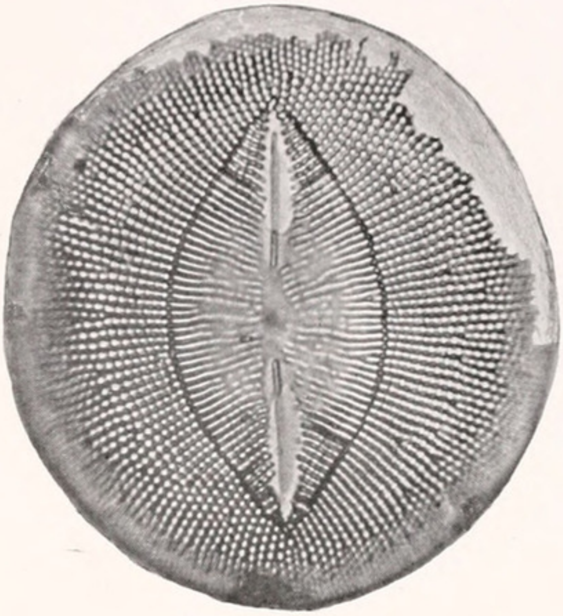

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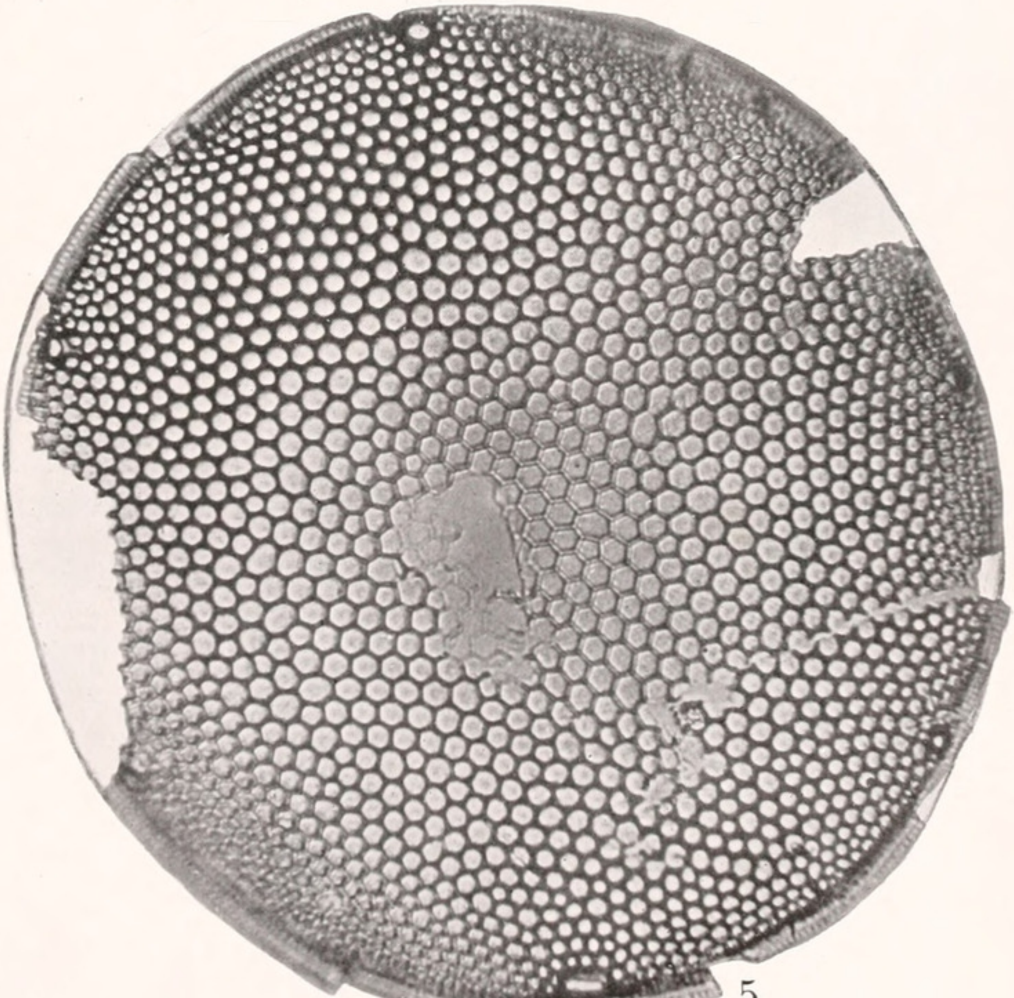

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Plate 15

Fig. 1. *Rattrayella inconspicuua* (Rattray). Plesiotype, No. 3220, C. A. S.; × 735; diameter, .0966 mm.; loc. 1068.

Fig. 2. *Rattrayella inconspicuua* (Rattray). Plesiotype, No. 3221, C. A. S.; × 710; diameter, .10 mm.; loc. 1068.

Fig. 3. *Rhaphoneis amphiceros* Ehrenberg. Plesiotype, No. 3222, C. A. S.; × 1116; length, .060 mm.; width, .0293 mm.; 7 beads in .01 mm.; loc. 1063.

Fig. 4. *Rhaphoneis amphiceros* Ehrenberg. Plesiotype, No. 3223, C. A. S.; × 1250; length, .0435 mm.; width, .0238 mm.; 8 beads in .01 mm.; loc. 1063.

Fig. 5. *Rhaphoneis amphiceros* Ehrenberg. Plesiotype, No. 3224, C. A. S.; × 1733; length, .030 mm.; width, .0175 mm.; 8 beads in .01 mm.; loc. 1063.

Fig. 6. *Rhaphoneis elegans* Pantocsek & Grunow. Plesiotype, No. 3225, C. A. S.; × 1185; length, .0363 mm.; width, .0158 mm.; 5.5 beads in .01 mm.; loc. 1187.

Fig. 7. *Rhaphoneis elegans* Pantocsek & Grunow. Plesiotype, No. 3226, C. A. S.; × 1170; length, .0470 mm.; width, .0170 mm.; 5 beads in .01 mm.; loc. 1187.

Fig. 8. *Rhaphoneis elegans* Pantocsek & Grunow. Plesiotype, No. 3227, C. A. S.; × 1185; length, .0668 mm.; width, .0196 mm.; 5 beads in .01 mm.; loc. 1187.

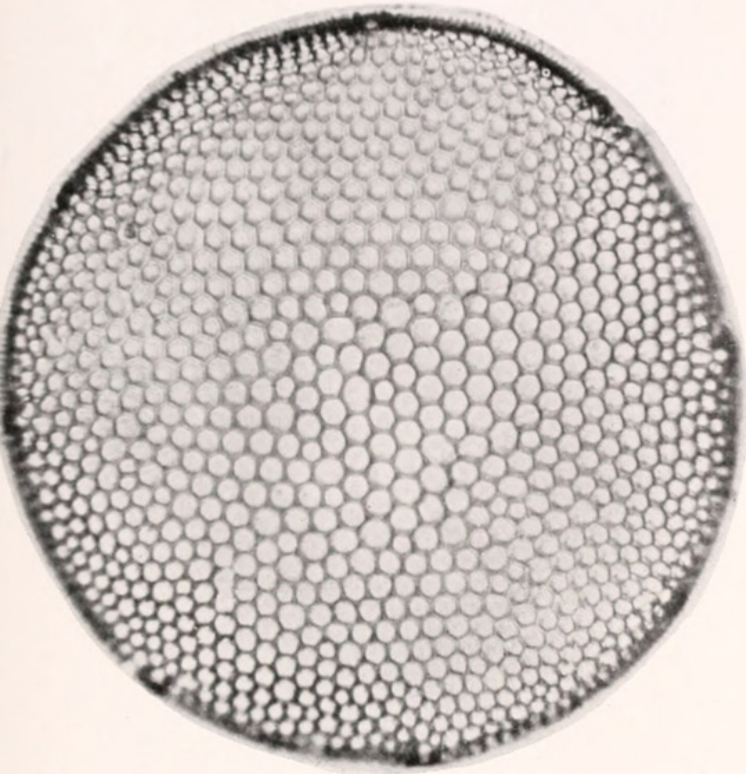
Fig. 9. *Rhaphoneis obesa* Hanna, n. sp. Holotype, No. 3228, C. A. S.; × 1235; length, .0385 mm.; width, .0180 mm.; 8 beads in .01 mm.; loc. 1068.

Fig. 10. *Rhaphoneis obesa* Hanna, n. sp. Paratype, No. 3229, C. A. S.; × 1533; length, .030 mm.; width, .0181 mm.; 8 beads in .01 mm.; loc. 1063.

[Loc. 1063; on west side of Cottonwood Creek, Sec. 13, T. 29S., R. 29E., M. D. M., Kern County, California; Temblor Miocene.]

[Loc. 1068; on southeast side of Sharktooth Hill, Kern County, California; Temblor Miocene.]

[Loc. 1187, near top of 1340 Hill on west side of Round Mountain, Kern County, California; Temblor Miocene.]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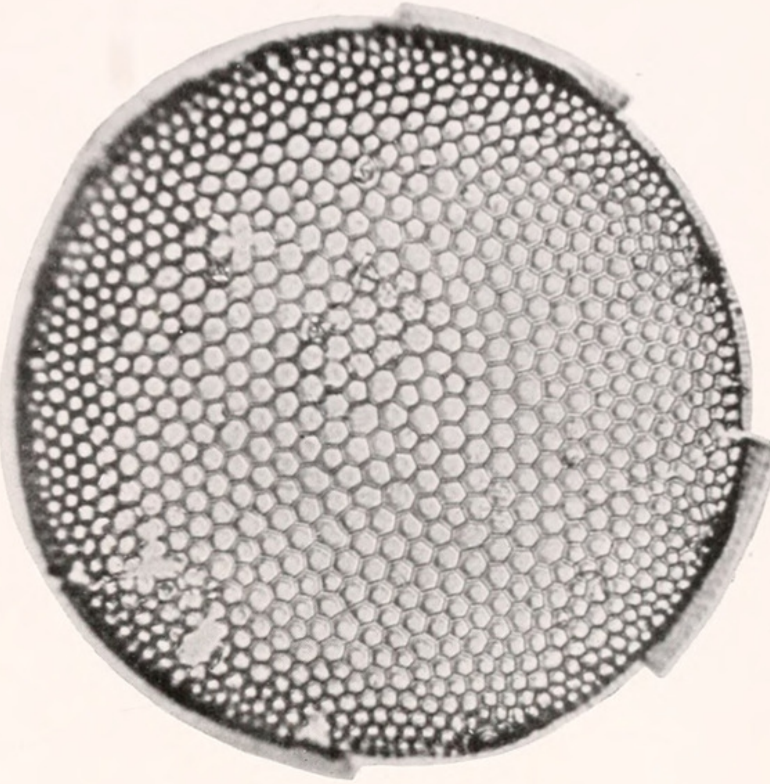
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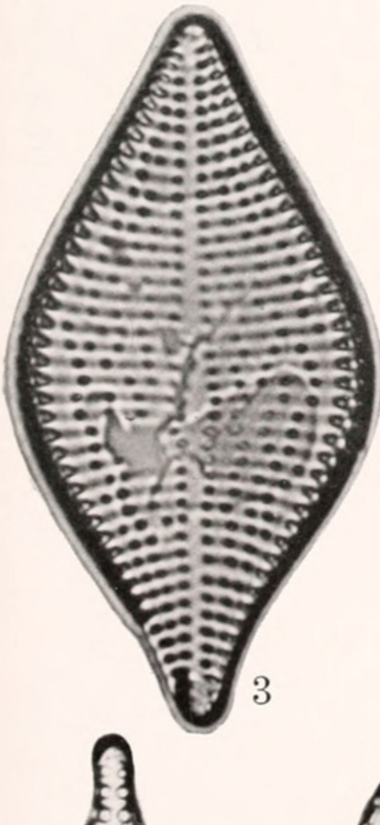
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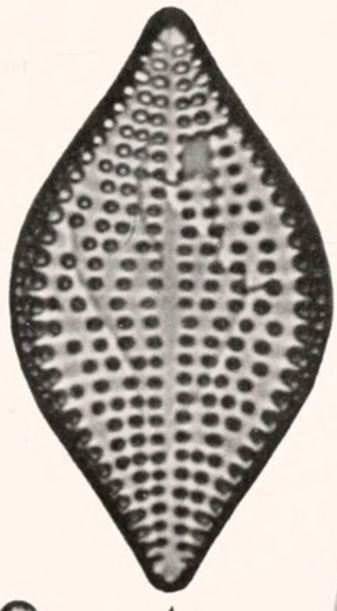
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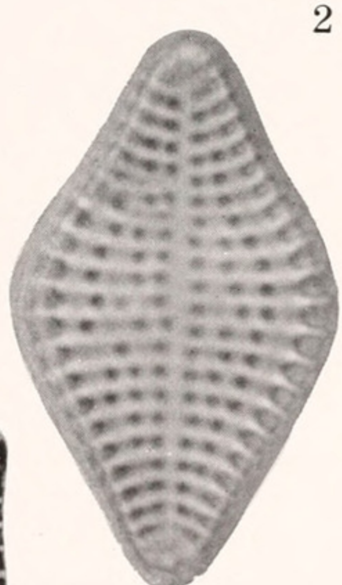
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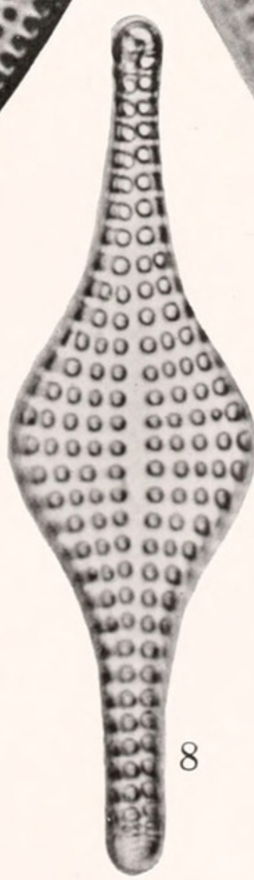
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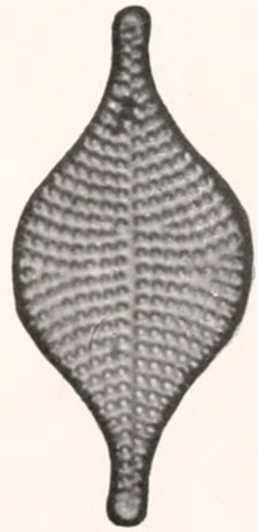
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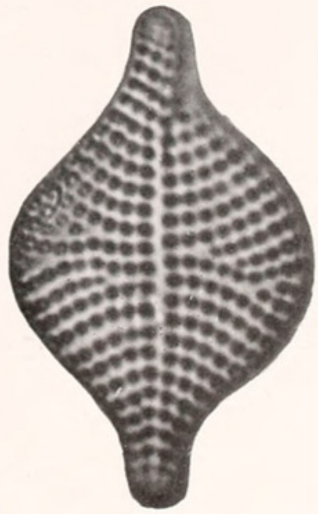
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Plate 16

Fig. 1. *Rhaphoneis obesula* Hanna, n. sp. Holotype, No. 3230, C. A. S.; × 1750; length, .020 mm.; width, .0155 mm.; 9 rows of beads in .01 mm.; loc. 1068.

Fig. 2. *Rhaphoneis parilis* Hanna, n. sp. Holotype, No. 3231, C. A. S.; × 1140; length, .0429 mm.; width, .010 mm.; 7 rows of beads in .01 mm.; loc. 1187.

Fig. 3. *Rhaphoneis parilis* Hanna, n. sp. Paratype, No. 3232, C. A. S.; × 1140; length, .0490 mm.; width, .010 mm.; 7 rows of beads in .01 mm.; loc. 1187.

Fig. 4. *Rhaphoneis parilis* Hanna, n. sp. Paratype, No. 3233, C. A. S.; × 1140; length, .0344 mm.; width, .010 mm.; 7 rows of beads in .01 mm.; loc. 1187.

Fig. 5. *Sceptroneis caduceus* Ehrenberg. Plesiotype, No. 3234, C. A. S.; × 450; length, .10 mm.; width, .020 mm.; 3 transverse rows of beads in .01 mm.; loc. 1068.

Fig. 6. *Sceptroneis caduceus* Ehrenberg. Plesiotype, No. 3235, C. A. S. × 463; length, .1466 mm.; width, .0170 mm.; loc. 1068.

Fig. 7. *Sceptroneis caduceus* Ehrenberg. Plesiotype, No. 3236, C. A. S.; × 463; length, .2048 mm.; width, .0167 mm.; loc. 1068.

Fig. 8. *Stephanogonia polyacantha* Forti. Plesiotype, No. 3237, C. A. S.; × 622; diameter, .0868 mm.; loc. 1068.

Fig. 9. *Stephanopyxis lineata* (Ehrenberg). Plesiotype, No. 3238, C. A. S.; × 420; diameter, .0875 mm.; loc. 1068.

Fig. 10. *Stephanopyxis lineata* (Ehrenberg). Plesiotype, No. 3239, C. A. S., × 420; diameter, .066 mm.; loc. 1068.

Fig. 11. *Stephanopyxis lineata* (Ehrenberg). Plesiotype, No. 3240, C. A. S.; × 420; diameter, .070 mm.; loc. 1068.

Fig. 12. *Stictodiscus kittonianus* Greville. Plesiotype, No. 3241, C. A. S.; × 700; diameter, .050 mm.; loc. 1068.

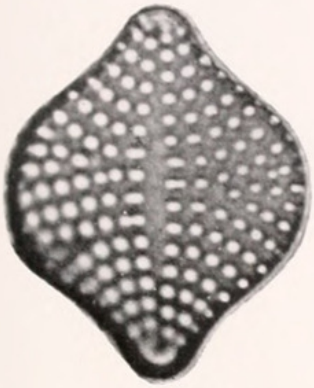
Fig. 13. *Surirella tembloris* Hanna, n. sp. Holotype, No. 3242, C. A. S.; × 932; length, .0954 mm.; width, .040 mm.; 4 marginal costæ in .01 mm.; loc. 1063.

Fig. 14. *Surirella tembloris* Hanna, n. sp. Paratype, No. 3243, C. A. S.; × 555; length, .1080 mm.; width, .0504 mm.; loc. 1063.

[Loc. 1063; on west side of Cottonwood Creek, Sec. 13, T. 29S., R. 29E., M. D. M., Kern County, California; Temblor Miocene.]

[Loc. 1068; on southeast side of Sharktooth Hill, Kern County, California; Temblor Miocene.]

[Loc. 1187; near top of 1340 Hill on west side of Round Mountain, Kern County, California; Temblor Miocene.]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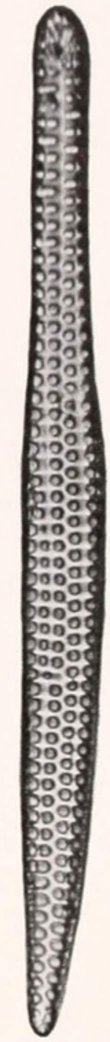
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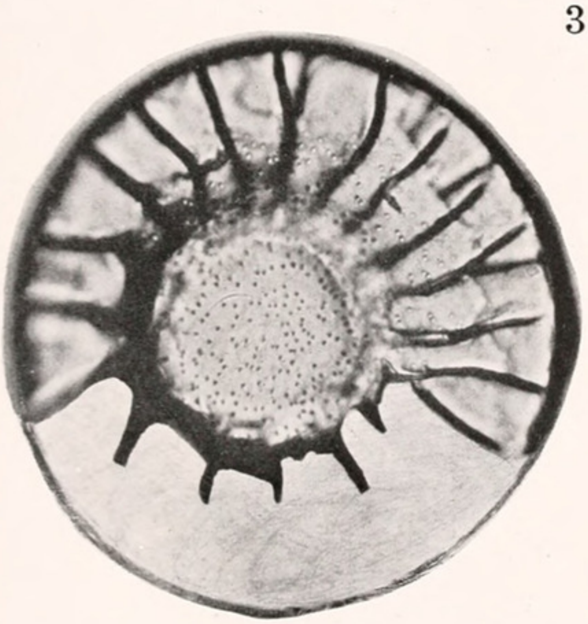
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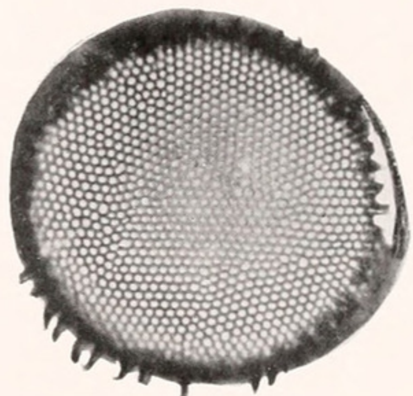
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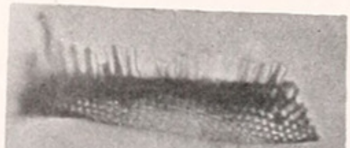
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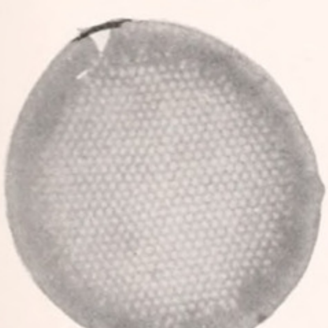
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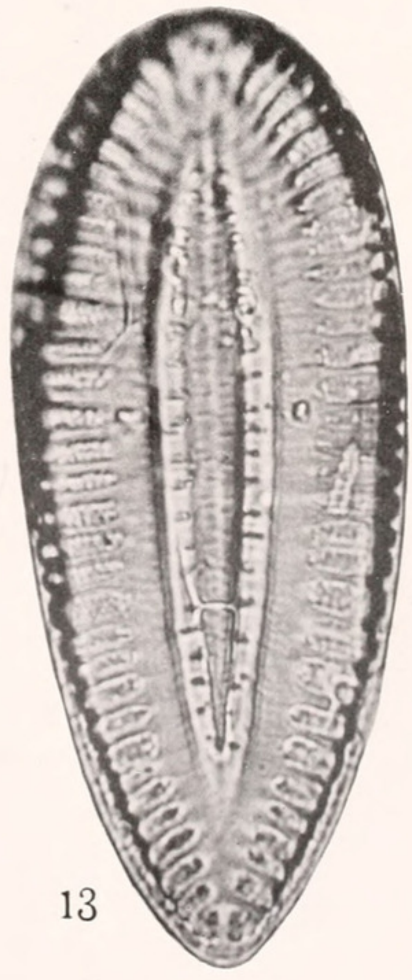
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Plate 17

Fig. 1. *Triceratium condecorum* Brightwell. Plesiotype, No. 3245, C. A. S.; × 1308; length of one side, .0382 mm.; loc. 1068.

Fig. 2. *Triceratium subrotundatum* Schmidt. Plesiotype No. 3257, C. A. S.; × 450 mm.; length of one side, .0888 mm.; loc. 1063.

Fig. 3. *Triceratum condecorum* Brightwell. Plesiotype, No. 3246, C. A. S.; × 1635; length of one side, .0422 mm.; loc. 1063.

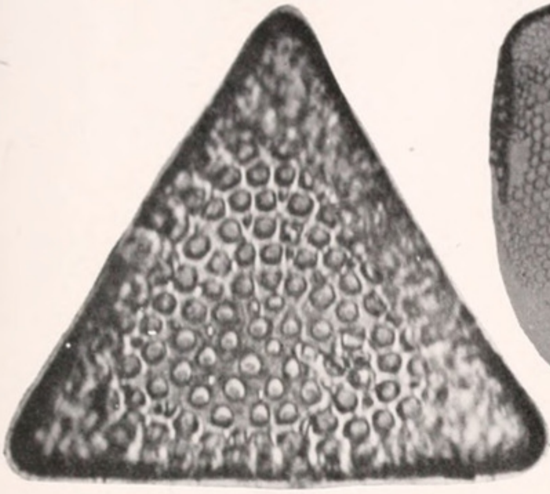
Fig. 4. *Triceratium spinosum* Bailey. Plesiotype, No. 3247, C. A. S.; × 1175; length of one side, .0930 mm.; 6 beads in .01 mm. on disk; loc. 1068. Three long curved setæ placed asymmetrically on the valve are out of focus and are indicated on the photograph as large black dots; the marginal spines are likewise out of focus.

Fig. 5. *Triceratium spinosum* Bailey. Same specimen as figure 3 with a different focus to show the marginal zone.

Fig. 6. *Tropidoneis primoris* Hanna, n. sp. Paratype, No. 3249, C. A. S.; × 2000; length, .1184 mm.; width, .0137 mm.; 24 rows of beads in .01 mm.; loc. 1068.

[Loc. 1063; west side of Cottonwood Creek, Sec. 13, T. 29S., R. 29E., M. D. M., Kern County, California; Temblor Miocene.]

[Loc. 1068; southeast side of Sharktooth Hill, Kern County, California; Temblor Miocene.]



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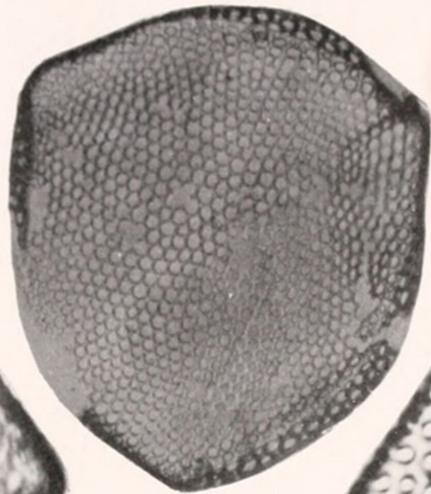

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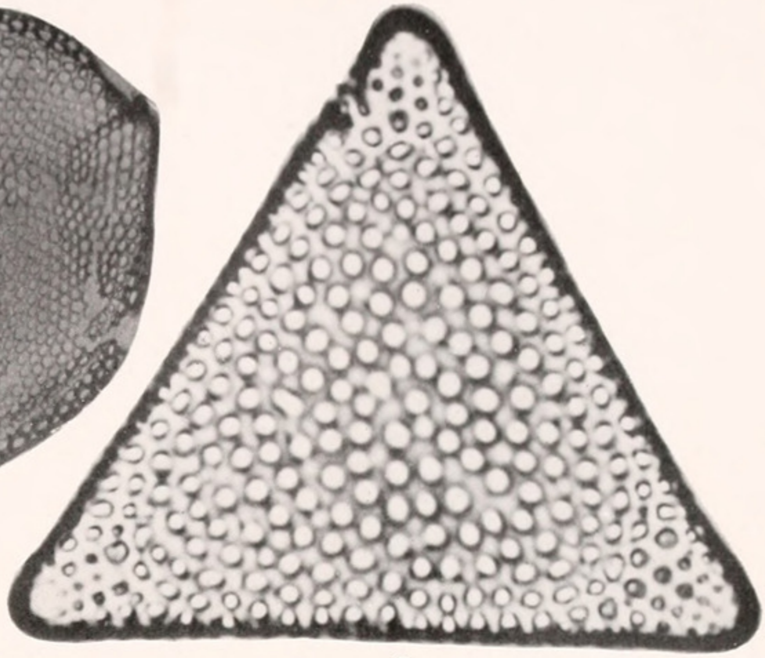

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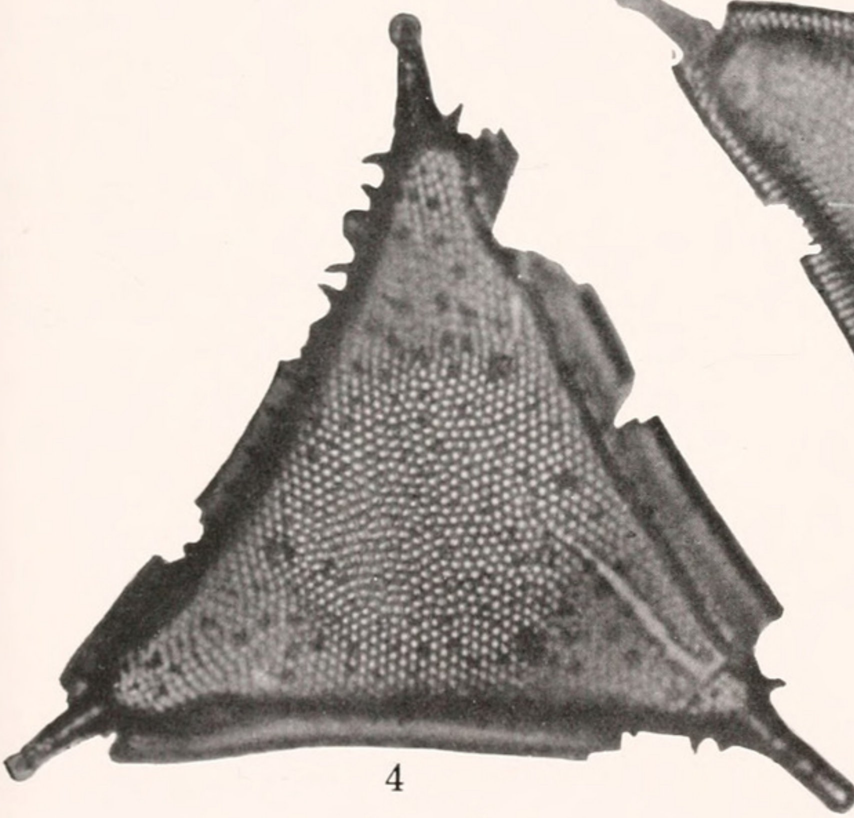

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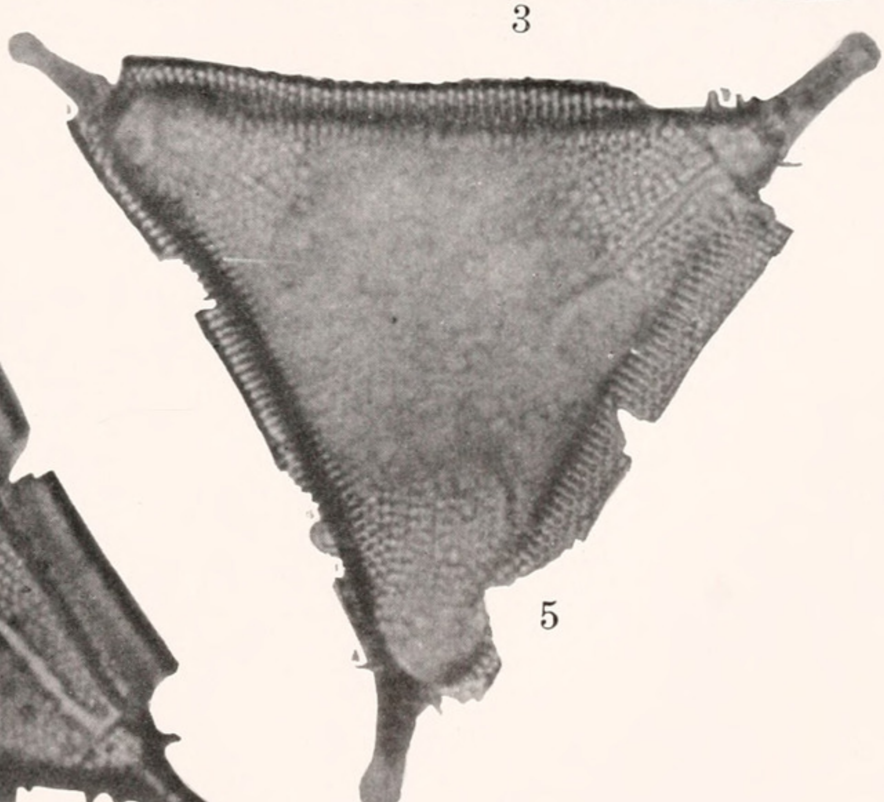

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PLATE 18

Fig. 1. *Tropidoneis primoris* Hanna, n. sp. Holotype, No. 3248, C. A. S.; × 693; length, .1240 mm.; width, .040 mm.; loc. 1068.

Fig. 2. *Tropidoneis primoris* Hanna, n. sp. Paratype, No. 3249, C. A. S.; × 565; length, .1184 mm.; width, .0137 mm.; 24 rows of beads in .01 mm.; loc. 1068.

Fig. 3. *Xanthiopyxis globosa* Ehrenberg. Plesiotype, No. 3250, C. A. S.; × 1000; diameter, .0250 mm.; loc. 1068.

Fig. 4. *Xanthiopyxis maculata* Hanna, n. sp. Holotype, No. 3251, C. A. S.; × 1820; length, .050 mm.; width, .0161 mm.; loc. 1068.

Fig. 5. *Xanthiopyxis marginata* Hanna, n. sp. Holotype, No. 3252, C. A. S.; × 1200; diameter, .0296 mm.; loc. 1068.

Fig. 6. *Xystotheca hustedti* Hanna, n. sp. Holotype, No. 3253, C. A. S.; × 817; length, .0714 mm.; width, .0350 mm.; from Calif. Acad. Sci. Loc. 1170, Smuggler's Cove, Santa Cruz Island, California; Temblor Miocene.

Fig. 7. *Xystotheca hustedti* Hanna, n. sp. Paratype, No. 3254, C. A. S.; × 1305; length, .0268 mm.; width, .0188 mm.; loc. 1068.

Fig. 8. *Zygoceros* (?) *quadricornis* Grunow. Plesiotype, No. 3255, C. A. S.; × 1411; distance across side of square, .0170 mm.; loc. 1063. Vertical (valval) view showing markings inside of square and projecting riblets supporting portion of funnel-like sides; only one of four corner-spines intact.

Fig. 9. *Zygoceros* (?) *quadricornis* Grunow. Plesiotype, No. 3256, C. A. S.; width at narrowest part, .0129 mm.; loc. 1068. Girdle view; one spine and one margin of valve reconstructed.

[Loc. 1063; on west side of Cottonwood Creek, Sec. 13, T. 29S., R. 29E., M. D. M., Kern County, California; Temblor Miocene.]

[Loc. 1068; on southeast side of Sharktooth Hill, Kern County, California; Temblor Miocene.]

[Loc. 1187; near top of 1340 Hill on west side of Round Mountain, Kern County, California; Temblor Miocene.]


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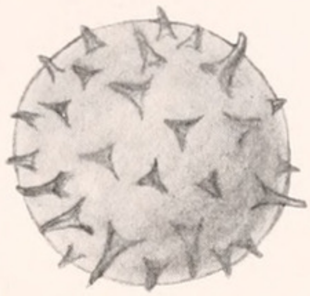
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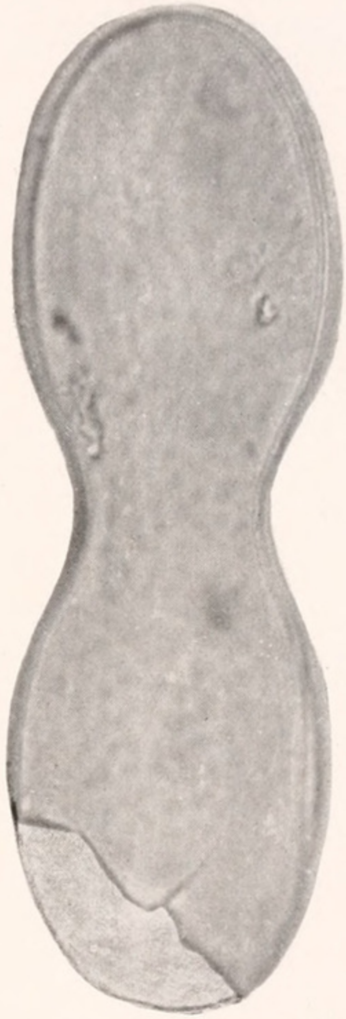
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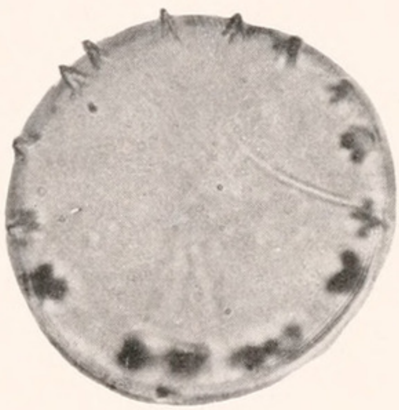
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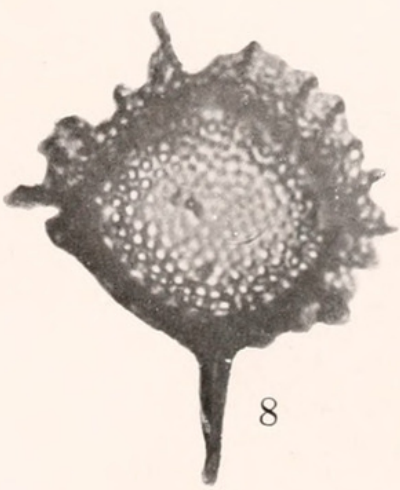
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