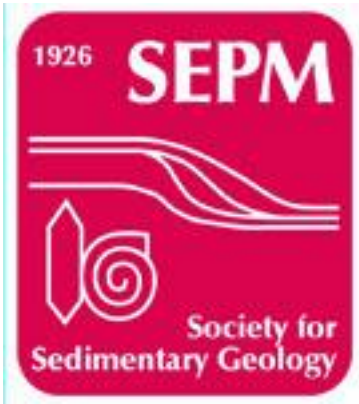

JOURNAL OF PALEONTOLOGY

A publication of THE SOCIETY OF ECONOMIC PALEONTOLOGISTS AND MINERALOGISTS *and* THE PALEONTOLOGICAL SOCIETY *with the generous support and cooperation of* THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS *and* THE GEOLOGICAL SOCIETY OF AMERICA

VOLUME 20 MARCH, 1946 NUMBER 2

DIATOMS OF THE MORENO SHALE

JOHN A. LONG,[1] DINGLEY P. FUGE[2] AND JAMES SMITH[3]

ABSTRACT—The latest definitely identified Cretaceous formation in California is a thick body of very distinctive shale, the Moreno formation, which outcrops in the San Joaquin Valley for a distance of 150 miles. It contains residual hydrocarbons in considerable amount. Megafossils are scarce, but certain zones contain incredible numbers of microfossils belonging to several groups. Those which have skeletons of silica have been studied more thoroughly than the calcareous forms and the present paper is the result of an exhaustive search of many samples for diatoms. A review of the literature which has dealt with any phase of the paleontology of the formation is included and this indicates that the Moreno is now the best known of any part of the California Cretaceous. A striking discovery in recent years was the finding of well-preserved skeletons of large reptiles such as plesiosaurs. The introduction contains information pertaining to the geological relationships, geographical extent and some of the physical aspects of the formation.

INTRODUCTION

Notes on the geology and general paleontology of the Moreno Shale

G. Dallas Hanna
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THE MORENO Shale is a well defined Upper Cretaceous stratigraphic unit extending along the west side of the San Joaquin valley, California, from Mount Diablo on the north nearly to Coalinga on the south. Beyond the southernmost exposures it has been identified in well sections as far as McLure Valley where the Tidewater Associated Oil Company cored over 100 feet of the upper part of the formation in West Slope well No. 1, Sec. 20, T. 24 S., R. 18 E., M.D.M., Kings County. It has been identified in wells a short distance outward from the outcrops but it dips steeply under the Valley and its extent in that direction is unknown. No trace of it appears on the east side along the foothills of the Sierra Nevada. Many wells in the southeast corner of the Valley have been drilled to basement without encountering it.

Lithologically, the shale is readily distinguished on outcrops as a very fine silt, generally weathering with a definitely purple tinge. Fresh exposures and well samples are usually dark chocolate brown

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to black, often somewhat "waxy" in texture due to a high content of residual hydrocarbon. The silts become somewhat coarser downward in the section and there is no sharp stratigraphic break at the contact with the formation below. The top of the latter, however, is usually mapped at the top of the first heavy brown sandstone member.

In some of the wells which have been drilled into and through the shale a short distance out from the margin of the Valley, the upper Moreno contact is very difficult to locate with certainty; Eocene sediments grade gradually downward into Cretaceous and the foraminiferal faunas show an intermingling in the border zone which is very puzzling.

The thickness of the Moreno is not uniform throughout its extent. In the Coalinga region careful measurements made by Messrs. J. J. Bryan and O. F. Kotick show 1100 feet. The maximum they found is in the vicinity of Ortigalito Creek where it reached over 4000 feet. Farther north it thins and then thickens again. Evidence of oil is not uncommon and one small field ("Oil City" nine miles north of Coalinga) has produced continuously from it since 1896, the first well there which showed oil having been drilled in 1890 (Arnold and Anderson, p. 180).

While the distinctiveness of the formation had been known to geologists for many years previously and some had mentioned it in print, the first broad description, map, and the name date from the work of Anderson and Pack (pp. 46–57). In selecting a type locality, they wisely chose the section exposed in Moreno Gulch, a water course cut deeply into the eastward slope of the Panoche Hills and located only about four miles north of the station which furnished the diatoms forming the subject of this report.

There is apparently a well-marked unconformity at the top of the shale in Moreno Gulch where it is overlain by a sand believed to be Martinez Eocene. At other places along the strike the immediately overlying formation varies in age from late alluvium to lower Eocene and there is a borderline zone which is very difficult to place. From 1941 to 1944 geologists attached to various oil companies have given this contact a great deal of study and general agreement as to the exact top of the Moreno has not been reached. The vertical distribution of a few species of Foraminifera and lateral variation in lithology of the contact zone have caused some of the difficulty. However, very little has been published on the subject.

Many new formation and "member" names have been proposed lately in attempts to subdivide the Moreno, but these have not appeared officially in print except in programs of geological meetings and abstracts.

In 1940 Allan Bennison submitted a thesis to the faculty of the University of California Department of Geological Sciences, in which he subdivided the Moreno north of Panoche Hills into several members. This thesis has not been published but other authors have adopted his names and some of them are in more or less current use. Several petroleum geologists who have mapped the area are inclined to believe the beds named, at least in part, are below the true Moreno as exposed and defined in Moreno Gulch and thus would not fall within the scope of the present review. However, references are cited because of the original supposition that they were Moreno. F. M. Anderson (1937, p. 1612) published the names in abstract form and A. S. Huey (p. 335) did likewise during the same year. Considerable information regarding some of the names was given in 1941 by F. M. Anderson (pp. 185–186) and by N. L. Taliaferro (pp. 132–134). The five names were listed by O. P. Jenkins in 1943.

In spite of repeated appearance of the various names in print, no proper or adequate descriptions or designations of type localities have been presented.

Max B. Payne read a paper at the April 18–19, 1941 meeting of the Cordilleran Section of The Geological Society of America, entitled "Moreno Shale, Panoche Hills, Fresno County, California," and an abstract of this appeared on page 19 of the preliminary list of titles and abstracts. Six new names were there proposed. The abstract was reprinted later in Bull. Geol. Soc. America, vol. 52, 1941, pp. 1953–1954 and from this the names were collected and published, without additional definition, by O. P. Jenkins.

This makes a total of 11 names sup-

posedly applying to the subdivision of the Moreno shale all of which have been rather indefinitely proposed. If the formation should need division it would seem that "Moreno" should be properly retained for the zone which has preserved diatoms in the Panoche Hills since this zone is the only portion which has been adequately defined paleontologically.

F. M. Anderson first mentioned fossils in the shale in 1905 (p. 193). He listed and illustrated "*Sagrina*," a foraminifer, from near Coalinga similar to *Siphogenerinoides cretacea* Cushman and now known as *Siphogenerinoides whitei* Church (Hanna, 1925, p. 992; Taff and Hanna, 1926, pp. 812–814).[4] Since then more species of various groups have been identified from the formation than from any other single Cretaceous unit in California. Cushman and Campbell in 1935 (pp. 65–73, pl. 10, 11) listed and illustrated 20 forms of Foraminifera from samples (believed at that time to be Moreno but which some workers now think is Panoche) taken from a well drilled near Tracy and a year later described *Siphogenerinoides clarki* (Cushman and Campbell, 1936, pp. 91–92, pl. 13, figs. 9–12) from outcrop samples near Mt. Diablo. The occurrence of this species (or *S. whitei*) has been mentioned in various publications usually without specific name.

In 1943 A. S. Campbell (pp. 128, 129) listed 11 species of Foraminifera from matrix shale associated with the skeleton of the plesiosaur *Hydrotherosaurus alexandrae* Wells. The locality is not far from where the diatoms were collected which form the basis of the present report but about 775 feet lower in the section.

Anderson and Pack (pp. 46, 47), in the original description of the Moreno, mentioned a zone near the top which contains large numbers of diatoms. This is a striking member, particularly when seen from above, being pure white to light buff and about 100 feet thick. G. D. Hanna (1927) undertook a study of these diatoms in 1926 and collected his material at the type locality, Moreno Gulch. The primary object of the investigation was to determine if noticeable differences in the floras were apparent between this and the much younger Kreyenhagen and Miocene ones. Not many species were found in common. Later another locality a few miles to the southward of the first was investigated briefly and eight additional forms were recorded and discussed (Hanna, 1934).

In this work it was learned that the silicoflagellates were highly characteristic and good guide fossils for the siliceous shales of various ages in California and those of the Moreno (5 species) were published in 1928 (Hanna, 1928).

Diatomists in other parts of the world were attracted by the unusual nature of many of the species described by Hanna and requests for material were promptly filled. This resulted in the discovery of additional forms not previously known, some of which have been published.

Lefébure and Chenevière described *Kittonia hannai* in 1939 from material collected in Sec. 6, T. 15 S., R. 12 E., M.D.B. & M., Fresno County, California. In 1940 Leopoldo Rampi described and illustrated 16 species (11 new) of Archaeomonadaceae from some of the shale collected by Mr. Smith in connection with work on the present paper. Rampi did not give an exact locality and since only "Moreno U.S.A." is mentioned it seems desirable to point out that his sample came from Sec. 24, T. 14 S., R. 11 E., M.D.B. & M., Fresno County, California, Moreno shale, Upper Cretaceous.

The following forms were treated:

Archaeomonas inconspicua Deflandre
semplicia Rampi
mangini Deflandre
spinulosa Rampi
chiarugii Rampi
ambigua Rampi
membranosa Rampi
scrobiculata Rampi
vermiculosa Deflandre
cretacea Rampi
heteroptera Deflandre
smithi Rampi
Archaeomonadopsis frenguellii Rampi
incerta Rampi
elegante Rampi
Archaeöspaeridium dangeardianum Deflandre

[4] *S. cretacea* was formally described by J. A. Cushman (1929, p. 58, pl. 9, figs. 14, 15) from the Colon shale, Upper Cretaceous, Quebrada Honda, Venezuela. The California form was formally described as *Siphogenerinoides whitei* in 1941 from material collected very close to the exact outcrop which furnished the diatoms described in the following pages (Church, 1941, p. 182, fig. 67–37.)

In some of the sands and conglomerates north of Panoche Hills, there are large numbers of mollusks. Many of these were studied by Bennison but the identifications have not been published. The shales of the Moreno and the white calcareous concretions in them contain occasional ammonites, baculites, small pectens and *Acila;* these likewise have not been specifically identified.

Anderson and Pack, in the original description of the formation, mentioned the great abundance of microfossils but the only determinations made from their collections were the fishes *Chicolepis punctatus, Pomolobus? chicoensis, Erythrinolepis chicoensis* and *Echidnocephalus? pacificus* described as new from scales by T. D. A. Cockerell (1919).

C. L. Camp in 1942 (p. 10) mentioned the finding of two vertebrae of a fossil reptile in the Panoche Hills area by Herman G. Walker in 1918 to 1920. These apparently were the first remains of vertebrates, other than fishes to be found in the Cretaceous of California. In 1931, C. C. Church found three phalanges of a medium-sized reptile in Panoche strata a few hundred feet below the base of the Moreno shale. The locality is in Los Gatos Creek near Coalinga, Fresno County, California and the specimens are recorded as No. 7344 A-C, Calif. Acad. Sci. Type Coll. The finding of these small bones was sufficient evidence to warrant our urging Mr. Allan Bennison to search carefully near Gustine, California, where he was then a high-school student. It was not long until he had made important discoveries and it was through his early efforts that sufficient attention was attracted to the Moreno shale that well equipped exploration was subsequently undertaken by trained paleontologists. The history of the discoveries to date is given by Chester Stock (1939, see also anonymous photograph, 1939); C. L. Camp (1942) and S. P. Wells (1943).

As a result of the various activities the following mosasaurs were described in 1942: *Kolposaurus bennisoni* Camp; *Kolposaurus tuckeri* Camp; and *Plesiotylosaurus crassidens* Camp. The next year the plesiosaurs *Hydrotherosaurus alexandrae* Wells; *Morenosaurus stocki* Wells; *Aphrosaurus furlongi* Wells and *Fresnosaurus drescheri* Wells were described. Previously Hesse and Wells (1936) had announced the discovery of a duck-billed dinosaur from the Moreno but a detailed study of the fossil has not appeared. Anderson (1941b) published the new genus-name *Garzasaurus* in connection with some one of these Moreno reptiles but no diagnostic characters were given. Taliaferro (1944) has presented a resume of the geological relationships of the strata in which all of these reptiles were found.

While the manuscript of the present paper was in process of being edited and printed, there appeared another publication which deals in part with the Moreno shale (Goudkoff, 1945). This paper gives references to most of the previous work on the formation as well as those lower in the section. On fig. 2, the author gave a valuable correlation of the multitude of subdivisional names which have been proposed. He limited the Moreno proper to his own A, B and C zones, to which he applied and defined stage names "Cheneyan," "Upper Ciervian" and "Lower Ciervian" respectively.

Mr. James Smith became interested in the Moreno shale soon after the first papers on the diatoms appeared and made several collecting trips to Panoche Hills. Material in large quantity was collected. Subsequent preparation and the making of beautiful, individual mounts was carried on with enviable patience for several years. I had the good fortune to see his remarkable collection of slides after the photography was under way and was impressed by its great scientific value. Messrs. John A. Long and Dingley P. Fuge consented to undertake the taxonomic study of the collection and the following paper is the result of the work of these three men. Mr. N. Ingram Hendey of the British Museum rendered valuable assistance on numerous occasions and made the beautiful drawings which appear as figures. Being fully occupied with other duties my own connection with the investigation has been purely advisory, and this largely in regard to editorial matters.

The locality from which the collection was obtained is in the fourth eastward-flowing gulley shown on U. S. Geol. Survey Topographic Map, Panoche Quadrangle,

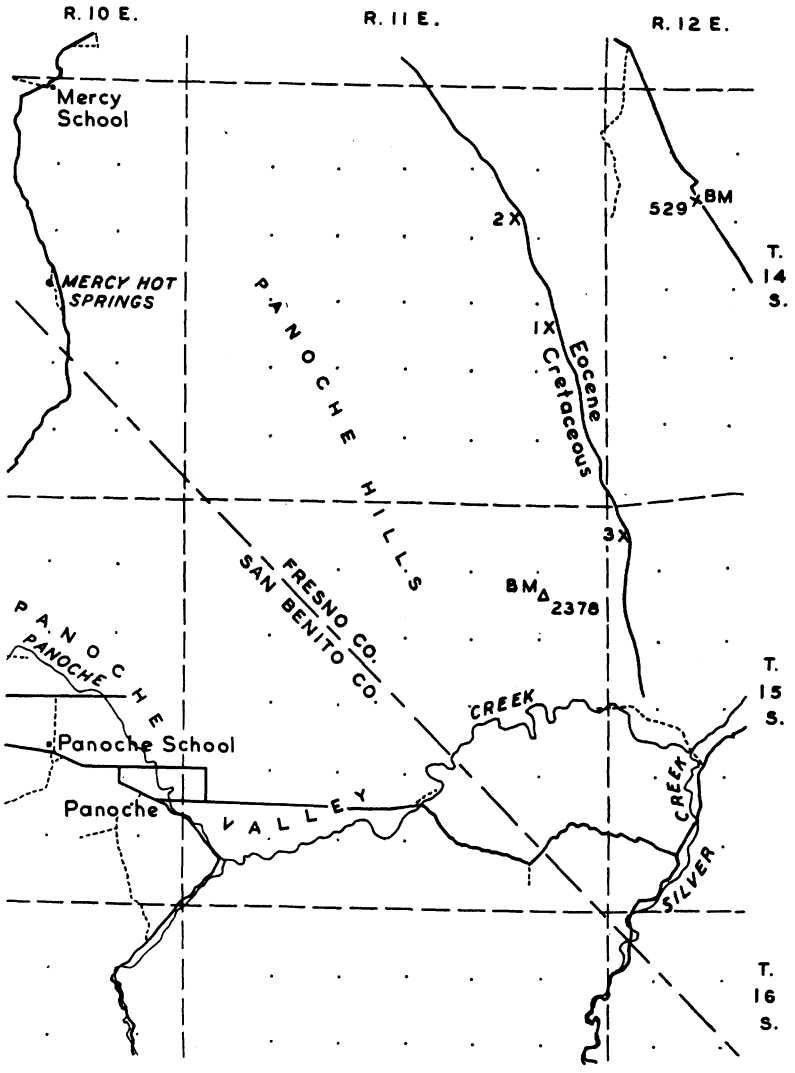


FIG. 1—Outline map from a portion of U. S. Geological Survey topographic sheet, Panoche Quadrangle, Fresno County, California, showing location of stations from which diatoms for this and preceding papers were obtained. Scale ½ inch = 1 mile. Cretaceous-Eocene boundary line approximate and adapted from map published by Anderson and Pack, U. S. Geol. Surv. Bull. 603, 1915.

1. Sec. 24, T. 14 S., R. 11 E., M. D. B. & M., from which the collections for the present study were made.

2. Sec. 11, T. 14 S., R. 11 E., M. D. B. & M., Moreno Gulch, the type locality of the Moreno formation, from which the material was obtained by Hanna, Calif. Acad. Sci. Occ. Pprs. 13, 1927, pp. 1–48, 5 pls.

3. Sec. 6, T. 15 S., R. 12 E., M. D. B & M., from which the material was obtained by Hanna, Journ. Paleo., vol. 8, no. 3, 1934, pp. 352–355, 1 pl., and Journ. Paleo., vol. 1, no. 4, 1928, pp. 259–263, 1 pl.

along the east flank of Panoche Hills, north of Panoche Creek, Sec. 24, T.14 S., R. 11 E., M.D.B. & M., western Fresno County California. The finding of so many additional species speaks well for the thoroughness of the present study but the authors would be the last to imply that the wonderful deposit is exhausted of novelties. The

map (fig. 1) shows the geographic position of the collecting station in the zone of diatomite.

The photographs of the diatoms were made by Mr. Smith and the slides have been deposited in the collection of type material in the California Academy of Sciences.

DESCRIPTIONS OF FOSSILS

John A. Long, Dingley P. Fuge and James Smith

ACTINODICTYON WEISSFLOGII UNCA, Long, Fuge and Smith, n. var.

Plate 13, figure 8

The occurrence of this rare diatom, whose typical form was reported by Pantocsek from Russia, is noteworthy.

The Moreno forms correspond closely to that illustrated by Pantocsek (1893, pl. 5, fig. 84) save that in them there is attached to each of the aulacodiscoid processes with which the clear channels terminate, a slender hook-shaped rod which is bent immediately backwards and lies along the furrow. Diameter .059 mm.

Several specimens have been observed with from five to seven channels and in each these hooks were a characteristic feature.

Holotype, No. 3345.

ACTINOPTYCHUS CHENEVIEREI Long, Fuge and Smith, n. sp.

Plate 13, figure 10

Valve circular with narrow hyaline margin and polygonal hyaline center. Sectors 10 in number, all closely beaded in decussating lines; an irregular network over the surface of each sector. The lower sectors have an indistinct pseudo-raphe and a narrow hyaline line near the circumference; the upper sectors have a pseudo-raphe and a single spine near the hyaline margin. Diameter .075 mm.

The species is named for Mon. E. Chenevière, of Montbéliard, France, who has discovered many rare diatoms.

Holotype, No. 3353,

ACTINOPTYCHUS GLABRATUS *incisus* Grunow

Plate 13, figure 9

Actinoptychus glabratus, var. *incisa* Grunow, 1883, in Van Heurck, Syn. Diat. Belgique pl. 120, fig. 8.—Schmidt, 1890, Atlas, Diat., pl. 154, fig. 2.

A large form agreeing closely with the plate in the "Atlas." In his synonymy of *Actinoptychus*, Mann (1907, p. 272) evidently preferred to regard *A. glabratus* as a variety of *A. splendens*. Diameter .200 mm.

Hypotype, No. 3346,

ACTINOPTYCHUS INDETERMINATUS Long, Fuge and Smith, n. sp.

Plate 13, figure 2

Valve circular with hexagonal, hyaline center; sectors six in number, separated from each other by somewhat indefinite boundaries, all closely beaded in decussating lines; beads irregular at the junction of the sectors. There is a small spine at each peripheral angle of the sectors. Diameter, .06 mm.

Holotype, No. 3347.

ACTINOPTYCHUS PACKI IMMACULATUS Long, Fuge and Smith, n. var.

Plate 13, figure 5

Valve circular, with hyaline center somewhat irregular in outline. The depressed sectors have close beading in regular decussate lines; one spine near the margin with hyaline space which forms the beginning of a pseudoraphe extending about half-way to the center. In the elevated sectors the beading is more irregular, especially towards the center; instead of spines, there are hyaline spaces corresponding in position to those in the depressed sectors. There are also triangular hyaline spaces near the margin, between each pair of sectors.

This form is equally common and somewhat larger than *A. packi* Hanna (1927, p. 12) and is distinguished from it by the entire absence of the maculate markings. When seen dry it is a much more diaphanous form. Diameter, .088 mm.

Holotype, No. 3349,

ACTINOPTYCHUS ROTULA Long, Fuge and Smith, n. sp.
Plate 13, figures 3, 4

Valve circular with narrow hyaline margin and large polygonal hyaline center. Compartments fourteen in number. In each depressed sector there is a distinct pseudo-raphe running from the circumference to the hyaline center. The beading is regular and somewhat coarse, arranged in lines crossing at right angles; the elevated sectors have similar but slightly finer beading, no pseudo-raphe and a line of slightly larger beads close to the margin. Spines absent. Diameter, holotype .050; paratype, .0425 mm.

A specimen has been observed with hyaline border to all the sectors except at the termination of the pseudo-raphe in the depressed sectors. Here, at the end of the pseudo-raphe, there is a suggestion of a minute process or spine. This variation is worthy of note but we do not regard it as sufficiently marked to create a new variety.

Holotype, (fig. 3), No. 3350, paratype, (fig. 4), No. 3351,

ACTINOPTYCHUS SIGNATUS Long, Fuge and Smith, n. sp.
Plate 13, figure 1

Valve circular with narrow hyaline margin and polygonal, hyaline center. All sectors, 10 in number, have close beading in lines crossing at right angles. Toward the outer part of the elevated sectors, which present a somewhat scabrous appearance, the beading is somewhat irregular. No indication of a pseudo-raphe appears in any sector. In all sectors, one fourth of the length of the radius from the circumference, there is a small hyaline space bearing one central bead or small spine, a characteristic feature of this species. There are no marginal processes of any kind. Diameter .0425 mm.

Holotype, No. 3352,

ACTINOPTYCHUS SUMMISSUS Schmidt

Actinoptychus summissus Schmidt, 1874, Atlas, Diat., pl. 1, fig. 13.

This form corresponds almost exactly with Schmidt's figure, which probably represents a recent example. In our specimen the markings seem somewhat more pronounced.

ACTINOPTYCHUS UNDULATUS Ehrenberg, var.

Actinoptychus undulatus, Schmidt, 1874, Atlas, Diat., pl. 1, fig. 6.

A variety, characterized by an unusual central space has been noted in the Moreno samples. The specimen illustrated by Schmidt came from Monterey.

ANAULUS CALIFORNICUS Long, Fuge and Smith, n. sp.
Plate 14, figure 2

Valve almost flat, subelliptical in shape, divided into three segments by transverse septa. Markings consist of small pearls. These are concentrically arranged about a clear center in the middle segment, and in a linear manner in the end segments. Length, .05, width, .0325 mm.

Holotype, No. 3354.

ANAULUS UNDALATUS Long, Fuge and Smith, n. sp.
Plate 14, figure 3

Valve narrowly lanceolate with rostrate ends and undulating sides, constricted where two septa cross the diatom, finely beaded all over the surface. Length, .044, width, .0096 mm.

Holotype, No. 3355.

ARACHNOIDISCUS EHRENBERGII Bailey
Plate 13, figure 6

Arachnoidiscus ehrenbergii, Schmidt, Atlas, Diat., pl. 68, 1881, figs. 3, 4.

Specimens of this form are occasionally met with in the Moreno shale. They are somewhat small, about .1425 mm. in diameter, and differ but slightly from the type form.

Hypotype, No. 3356.

ARACHNOIDISCUS INDICUS Ehrenberg
Plate 14, figure 9

Arachnoidiscus indicus, Schmidt, 1881, Atlas, Diat., pl. 68, 1890, figs. 6 & 7, pl. 147, fig. 9.

This species, which some regard as a variety of *A. ehrenbergii* is found only very rarely. The only specimen we have seen corresponds closely to the form illustrated by Schmidt. Diameter, .059 mm.

Hypotype, No. 3357.

AULACODISCUS ALLORGEI Chenevière
Plate 13, figure 13

Aulacodiscus allorgei Chenevière, Bull. Soc. Franc. de Microscopie, vol. 3, no. 3, 1934, p. 106, pl. 8, fig. 2.

This diatom, which occurs but rarely, seems identical with the one figured by M. Chenevière from the interesting Russian deposit of Kamischev. Diameter, .147 mm.

Hypotype, No. 3358.

AULACODISCUS ALTERNANS Long, Fuge and Smith, n. sp.
Plate 14, figure 11

Valve round; surface, rising only slightly to processes, which, however, are left on broad, prominent eminences by the slant of the surface between the processes to the border, thus leaving the alternate sectors of the diatom out of focus and creating a characteristic appearance; beyond the eminences on which the processes stand the drop to the border is sudden; border definitely striated; central space clear, subcircular; markings rounded and in contact, but in places compressed to oval shape; primary rays indistinct, merging to a narrow clear space at processes; processes of medium size, bulbous with truncate apex, four in number. Diameter, .230 mm.

Holotype, No. 3359.

AULACODISCUS AMERICANUS Long, Fuge and Smith, n. sp.
Plate 13, figure 11

Valve circular; surface rising gently from a depressed, subcircular, hyaline center until about half way to processes where it forms a pronounced ridge, thence almost flat to processes, and then descends steeply to a narrow hyaline border. Close to the central space the markings are rounded, but immediately become crowded and polygonal, running in radial lines to the margin. Processes 7 or 8 in number, almost erect, inserted near the outer side of a sub-circular, hyaline space about one-fourth of the radius from the circumference; furrows closed but obvious. Diameter, .25 m.

The above description is from an imperfect specimen, the only one as yet found of this attractive form.

Holotype, No. 3360.

AULACODISCUS ARCHANGELSKIANUS Witt
Plate 14, figure 13

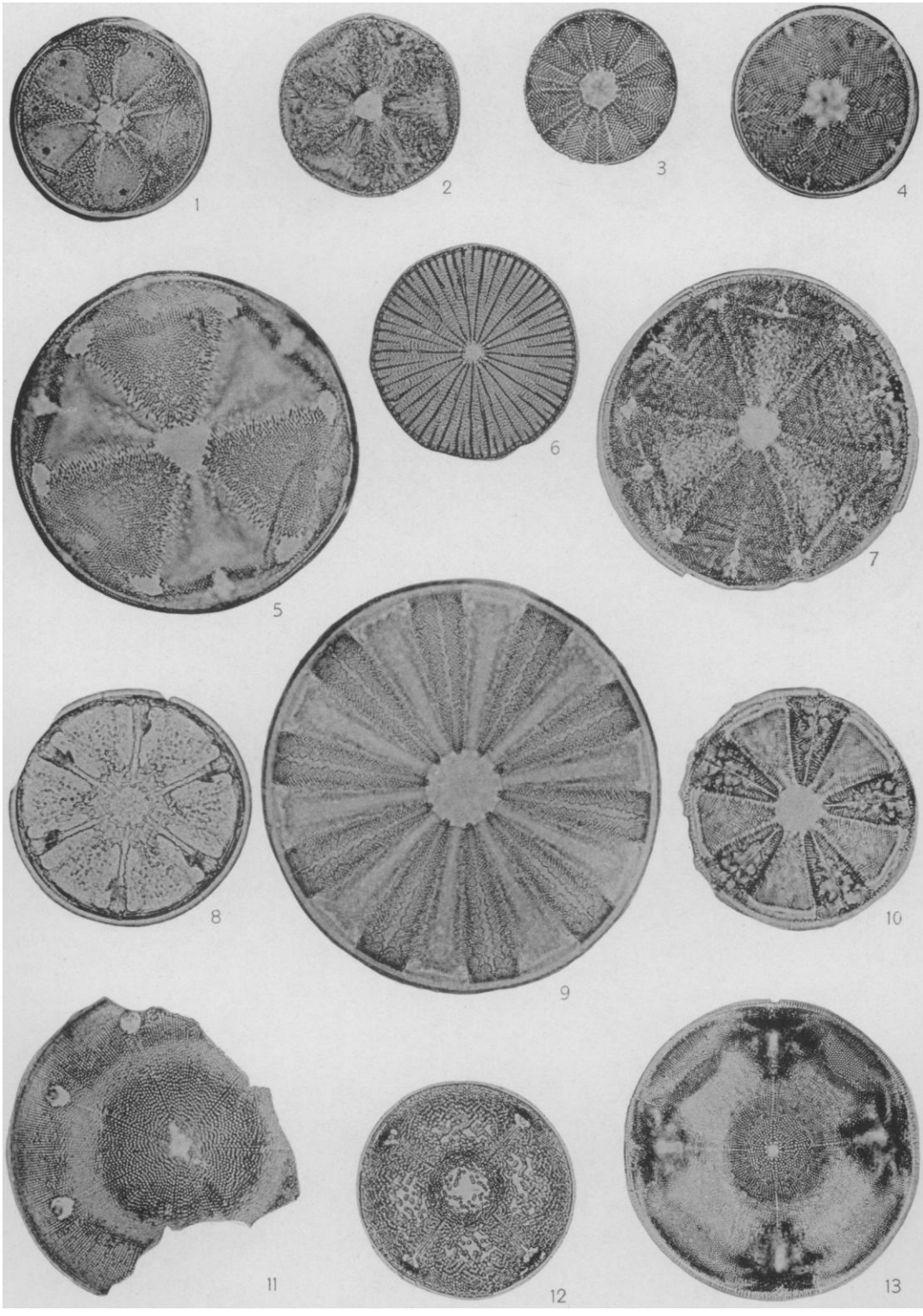
Aulacodiscus archangelskianus Witt, 1886, Verhandl., Russ. Kais. Mineral. Gesellschaft, St. Petersburg, ser. 2, vol. 22, pp. 137–177, pl. 6, fig. 11.—Schmidt, 1886, Atlas, Diat., pl. 101, figs. 7, 11.—Hanna, 1927, Calif. Acad. Sci. Oc. Pprs. 13, p. 14, pl. 1, figs. 6, 7; (as *A. pugnalis*). —Hanna, Journ. Paleo. Vol. 8, no. 3, 1934, p. 353, pl. 48, fig. 7.

In the Moreno shale there seem to be two distinct varieties of *Aulacodiscus archangelskianus* Witt. In one, the markings fill the valve except at the center, and are definitely disposed in radiating rows, generally in contact, and at times compressed into an oval shape. The processes vary in number from three to eight. This seems identical with *archangelskianus* Witt. Diameter, .178 mm.

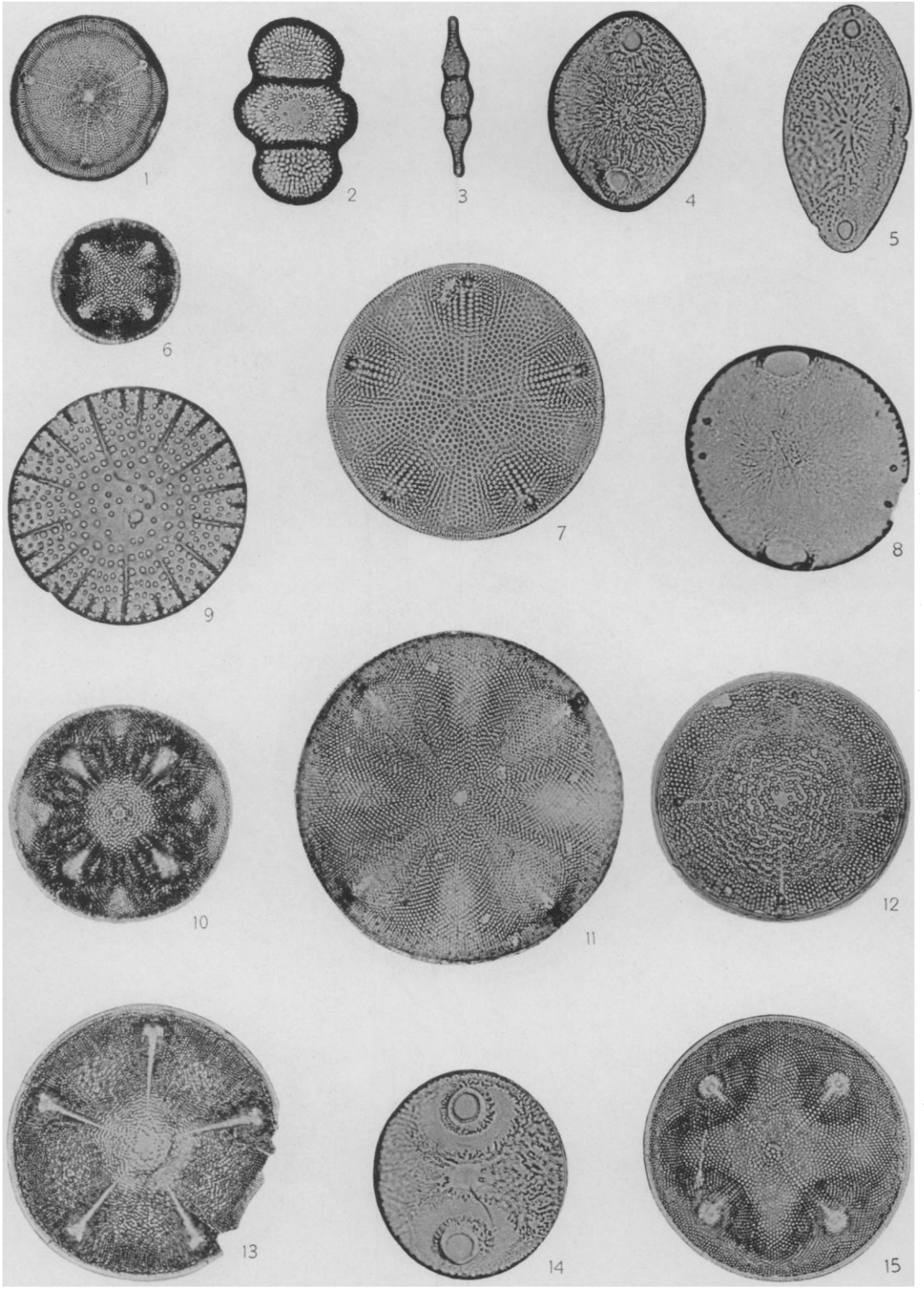
Hypotype, No. 3361.

EXPLANATION OF PLATE 13

FIGS. *1*—*Actinoptychus signatus* Long, Fuge and Smith, n. sp. Holotype, Diam., .0425 mm. (p. 95)
2—*Actinoptychus indeterminatus* Long, Fuge and Smith, n. sp. Holotype, Diam., .06 mm. (p. 94)
3, 4—*Actinoptychus rotula* Long, Fuge and Smith, n. sp., *3*, Paratype, Diam., .0425 mm.; *4*, Holotype, Diam., .050 mm. (p. 95)
5—*Actinoptychus packi* Hanna, var. *immaculatus* Long, Fuge and Smith, n. var. Holotype, Diam., .088 mm. (p. 94)
6—*Arachnoidiscus ehrenbergii* Bailey. Diam., .135 mm. (p. 95)
7—*Actinoptychus packi* Hanna. Diam., .120 mm. (p. 94)
8—*Actinodictyon weissflogii* Pautosek, var. *unca* Long, Fuge and Smith, n. var. Holotype, Diam., .059 mm. (p. 94)
9—*Actinoptychus glabratus incisus* Grunow. Diam., .200 mm. (p. 94)
10—*Actinoptychus chenevierei* Long, Fuge and Smith, n. sp. Holotype, Diam., .075 mm. (p. 94)
11—*Aulacodiscus americanus* Long, Fuge and Smith, n. sp. Holotype, Diam., .250 mm. (p. 96)
12—*Aulacodiscus archangelskianus pugnalis* Hanna. Diam., .135 mm. (p. 96)
13—*Aulacodiscus allorgei* Cheneviere. Diam., .147 mm. (p. 96)
All specimens from Sec. 24, T. 14 S., R. 11 E., M.D.M., Fresno County, California.



Long, Fuge and Smith—Cretaceous Diatoms



Long, Fuge and Smith—Cretaceous Diatoms

AULACODISCUS ARCHANGELSKIANUS PUGNALIS Hanna
Plate 13, figure 12

Aulacodiscus pugnalis Hanna, Oc. Pprs. Calif. Acad. Sci. 13, 1927, p. 14, pl. 1, figs. 6, 7.—Hanna, 1934, Journ. Paleo. Vol. 8, p. 353, pl. 48, fig. 7 (as *A. archangelskianus*).

In this form the markings are not definitely radiate, but comparatively sparse, rounded and discrete. They are also larger than those of the type. The processes generally number three or four. Diameter .135 mm.

After creating the species *pugnalus* for this form Hanna later united it to *archangelskianus*. Having regard to the considerable difference in appearance, we consider it to be a distinct variety of Witt's species.

Hypotype, No. 3362.

AULACODISCUS BROWNEI Norman
Plate 14, figure 12

Aulacodiscus brownei, Schmidt, Atlas, Diat., pl. 36, 1876, figs. 15, 16, pl. 105, 1886, fig. 6.—Rattray, Journ. Roy. Micr. Soc. Vol. 8, 1888, p. 341.

It is with a little hesitation we refer two forms to this species. Each has four processes. This number, according to Rattray, is permissible for *brownei*, but the definite concentric arrangement of the markings which is so characteristic a feature in the commoner, two-processed forms, is not as definite here; consequently there is some uncertainty as to the accuracy of our diagnosis. Diameter, .080 mm.

Hypotype, No. 3363.

AULACODISCUS CELLULOSUS INFLATUS Long, Fuge and Smith, n. var.
Plate 14, figure 7

The form figured by Schmidt (1888, pl. 124, fig. 3) is very close, if not identical with this. This differs from the type from Oamaru in its contour. Here the surface is flat save along the line of processes where the rise is distinct and terminates in definite inflations. Processes four or five. An apparently identical form appears in material from Kamichev, Russia. Diameter, .135 mm.

Holotype, No. 3364.

AULACODISCUS ERECTUS Long, Fuge and Smith, n. sp.
Plate 14, figure 15

Valve circular; a flat quadrangular figure with concave margin occupies the center of the valve, its angles halfway between the processes and its concavities facing the processes. The edges of this figure rise gently but distinctly to the zone of processes and then slope more gently to the border. This contour gives a characteristic stelliform appearance to the valve. Markings consist of a central rosette whence angular cells proceed in a radiating manner to the border

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EXPLANATION OF PLATE 14

FIGS. *1*—*Aulacodiscus striatus* Long, Fuge and Smith, n. sp. Holotype, Diam., .080 mm. (p. 98)
2—*Anaulus californicus* Long, Fuge and Smith, n. sp. Holotype, Length, .05 mm.; width, .0325 mm. (p. 95)
3—*Anaulus undulatus* Long, Fuge and Smith, n. sp. Holotype, Length, .044 mm.; width .0096 mm. (p. 95)
4—*Auliscus priscus* Long, Fuge and Smith, n. sp. Holotype, Diam., .0525×.0425 mm. (p. 99)
5—*Auliscus scutulum* Long, Fuge and Smith, n. sp. Holotype, Diqm., .065×.0325 mm. (p. 100)
6—*Aulacodiscus sagittarius* var. *distentus* Long, Fuge and Smith, n. var. Holotype, Diam., .083 mm. (p 98)
7—*Aulacodiscus cellulosus inflatus* Long, Fuge and Smith, n. var. Holotype, Diam., 135 mm. (p. 97)
8—*Auliscus hendeyi* Long, Fuge and Smith, n. sp. Holotype, Diam., .050 mm. (p. 99)
9—*Arachnoidiscus indicus* Ehrenberg. Hypotype, Diam., .059 mm. (p. 95)
10—*Aulacodiscus sagittarius* Long, Fuge and Smith, n. sp. Holotype, Diam., .142 mm. (p. 98)
11—*Aulacodiscus alternans* Long, Fuge and Smith, n. sp. Holotype, Diam., .230 mm. (p. 96)
12—*Aulacodiscus brownei* Norman. Diam., .080 mm. (p. 97)
13—*Aulacodiscus archangelskianus* Witt. Diam., .178 mm. (p. 96)
14—*Auliscus bubo* Long, Fuge and Smith, n. sp. Holotype, Diam., .050 mm. (p. 99)
15—*Aulacodiscus erectus* Long, Fuge and Smith, n. sp. Holotype, Diam., .160 mm. (p. 97)

All specimens from Sec. 24, T. 14 S., R. 11 E., M.D.M., Panoche Hills, Fresno County, California.

Near the margin these cells become slightly smaller and then terminate in a row of oblong cells surrounded by a clear border. Primary rays well marked, becoming open near the processes. Processes four in number, of moderate size, placed about one fourth of the radius within the valve and set in an unusual manner, almost erect, but pointing slightly toward the center of the valve. Diameter, .160 mm.

Holotype, No. 3365.

AULACODISCUS LAHUSENII MARGINALIS Witt

Aulacodiscus lahusenii marginalis Witt, 1886, Verhandl. Russ. Kais, Mineral. Gesellschaft St. Petersburg, ser. 2, vol. 22, pp. 137–177, pl. 7, fig. 3—Schmidt, 1886, Atlas, Diat., pl. 101, fig. 4.

The specimen that has been found corresponds closely to the illustrations cited above except that it has more of the irregular pearls in the center.

AULACODISCUS MORENOENSIS Long, Fuge and Smith, n. sp.
Plate 18, figure 3

Valve round; surface sunken at center, rising to the zone of processes to form a distinct narrow ridge, pentagonal in shape (when the processes are five), beyond this dropping to a flat margin. Within the processes the markings consist of discrete rounded puncta, irregularly arranged within but becoming radiate as they approach the zone of processes; beyond the raised area the markings are smaller and arranged in radiating striae. Primary rays distinct at the outer third; clear space at process evident but small. Processes long, narrow, cylindrical, from three to eight in number. Diameter, .080 mm.

This diatom is not uncommon, but the valve is evidently delicate for it is usually much corroded. The description and illustration are taken from one of the rare, uncorroded specimens.

Holotype, No. 3366.

AULACODISCUS RELLAE Hanna and Grant

Aulacodiscus rellae Hanna and Grant, Proc. Calif. Acad. Sci., ser. 4, vol. 15, 1926, pl. 13, figs. 5, 6.

This diatom has considerable points of resemblance to *A. barbadensis* Ralfs and *A. notatus* Grove and Sturt. The suggestion has been made that both should be united under *A. barbadensis*, but we concur in regarding them as definitely distinct.

AULACODISCUS SAGITTARIUS Long, Fuge and Smith, n. sp.
Plate 14, figure 10

Valve round; in contour, flat at center, rising boldly to the zone of processes. Between the processes the area is more or less concave and the raised portion drops sharply to a broad flat border. At the center, markings form a large rosette with clear central space. The markings themselves consist of rounded cellules in contact with each other, larger on the furrows, smaller below the raised area; margin with well-marked striae. The processes are of medium size, three or four in number with the proximal portion the smaller. Primary rays well marked, broadening to a "V" shaped clear space at the base. Diameter, .142 mm.

Holotype, No. 3367.

AULACODISCUS SAGITTARIUS DISTENTUS Long, Fuge and Smith, n. var.
Plate 14, figure 6

In var. *distentus* the raised area is barely concave between the processes, and gives the impression of a cushion-shaped structure placed upon a flat valve. Diameter, .083 mm.

The diatom will find a place in Rattray's group *"inflati."*

Holotype, No. 3368.

AULACODISCUS STRIATUS Long, Fuge and Smith, n. sp.
Plate 14, figure 1

Center slightly depressed, rising gently to the zone of processes whence it drops in a sharp curve to the margin; no compartments between the processes; center clear, angular; markings compressed, oval out to the zone of processes where they become smaller and round and form conspicuous radiate striae to the margin. Primary rays distinct, their markings in contact until they widen to a broad V-shaped space at the processes. Processes three in number, cylindrical. Diameter, .080 mm.

Holotype, No. 3369.

AULISCUS BUBO Long,
Fuge and Smith, n. sp.
Plate 14, figure 14

The surface slopes gently from the central space to the margin. There is a hyaline center almost square in shape, the ocelli, two in number, are round and of medium size, around each ocellus there is a narrow crescent of irregular puncta and within this, towards the center a much larger hyaline crescent. The rest of the surface is set with irregular striae which appear to consist of confluent puncta.

The valve is subcircular, measuring .0525 mm. by .05 mm.

Holotype, No. 3370.

AULISCUS DILECTUS Long, Fuge and
Smith, n. sp.
Plate 15, figure 14

Valve, circular; surface slightly convex save where it rises gently to the ocelli. The markings consist of delicate, curved striae passing from the central area to the border and the ocelli; in places, chiefly near the ocelli, these may be resolved into dots with a high power. Between the ocelli and the center there is a rectangular, subhyaline marking which appears to be caused by the suppression of some of the striae rather than by any great difference in the valve contour. Ocelli two, subcircular. Between the ocelli, near the border but not symmetrically placed are two large rounded markings about one fifth of the diameter of the ocelli; each consists of a hyaline lacuna in the valve surface in the center of which stands a pearl. Diameter, .04 mm. to .10 mm.; holotype, .095 mm.

This diatom is closely related to *Auliscus vallatus*.

Holotype, No. 3371.

AULISCUS HARDMANIANUS MACULOSUS
Long, Fuge and Smith, n. var.
Plate 15, figure 4

This diatom, which resembles in general appearance that illustrated by Greville (1865, pl. 11, fig. 17) and Schmidt (1881, pl. 67, fig. 1; 1886, pl. 89, fig. 4) differs from the type in the considerable prominence of the obconical areas and also in the fact that all the striae consist of lines of fine, clear dots. These are easily made out with a high magnification. Diameter, .059 mm.

Holotype, No. 3372.

AULISCUS HENDEYI Long, Fuge and
Smith, n. sp.
Plate 14, figure 8

Valve subcircular, three-fourths of the surface flat with a gentle slope to the border. The markings proceed from an ill-defined central point and consist of fine striations which are roughly radiate in disposition and which do not resolve into puncta. A row of coarse apiculi surrounds the margin except where broken by the ocelli; also on each side near the margin and roughly midway between the ocelli are two small but perfectly distinct puncta or apiculi. The ocelli are two in number, elliptical and hyaline and set at the extreme margin. Diameter, .05 mm.

Holotype, No. 3379.

The species is named for N. Ingram Hendey, F.R.M.S., of the British Museum (Natural History) who has generously given much help in the preparation of this paper.

AULISCUS PALEACEUS Long, Fuge and
Smith, n. sp.
Plate 15, figure 2

Valve, circular; the central portion is flat with slight rise to the ocelli, dropping gently at about the outer third to the border. There is a small hyaline center. The markings consist of striations of fine dots irregularly placed, of which many, especially in the central area, anastomose and give a granular appearance to the valve. Ocelli two in number, subcircular and hyaline. Diameter, .0425 mm.

Holotype, No. 3373.

AULISCUS PRISCUS Long, Fuge and
Smith, n. sp.
Plate 14, figure 4

Valve broadly elliptical, surface almost flat with ocelli slightly raised; center hyaline with a few scattered puncta; surface irregularly striated with signs of convergence to the ocelli which are two in number, round, hyaline and surrounded with a few irregular apiculi. Diameters, .0525 mm. and .0425 mm.

Holotype, No. 3374.

AULISCUS SCUTULUM Long, Fuge and Smith, n. sp.
Plate 14, figure 5

Valve narrowly elliptical; surface rising in a gentle curve from the margin to a small, circular, hyaline center. There is a row of fine dots around the margin; the other markings consist of broken rows of rather coarse puncta, very sparsely distributed, which run from the center to the margin; other similar dots are interspersed as they approach the border. The subcircular ocelli are two in number, symmetrically placed near the ends and each is surrounded by a ring of fine puncta. Length, .065; width, .0325 mm.

Holotype, No. 3375.

AULISCUS SPISSUS Long, Fuge and Smith, n. sp.
Plate 15, figure 1

Valve circular; two round finely dotted ocelli, each with one central punctum. The surface is densely but finely striated, radially near the margin, and more irregularly towards the center. Surface apiculate except for two lunate spaces near the margin, between the ocelli. Diameter, .046 mm.

Holotype, No. 3376.

AULISCUS TRIOCULATUS Long, Fuge and Smith, n. sp.
Plate 15, figure 7

Valve circular; the central area flat and sloping gently towards the margin. There is a small hyaline center bearing a few scattered puncta whence puncta crowd into irregular lines radiate towards the margin, curving towards the ocelli. Towards the margin the lines of puncta become finer. Ocelli three in number, circular, hyaline, set a short distance within the border. Diameter, .0675 mm.

Holotype, No. 3377.

AULISCUS WHARTONI Long, Fuge and Smith, n. sp.
Plate 15, figure 13

Valve circular; surface almost flat but rising to the processes. The markings consist of close lines of fine beads which proceed from the indistinct center, where the beads are more irregular. These lines run radially or subradially to the margin, and also in a curved manner to the processes. Ocelli two in number, themselves closely beaded and almost suborbicularly triangular in shape. Diameter, .085 mm.

Holotype, No. 3378.

This form is named for Dr. Charles G. Wharton of Los Angeles, who gave valued assistance in collecting the material upon which this paper is based.

BIDDULPHIA APICULATA Long, Fuge and Smith, n. sp.
Plate 15, figure 3

Valve subcircular, in general appearance resembling *Lampriscus*. At the margin three ocelli alternate with three large apiculi. Markings consist of close, fine striae roughly radiate over the surface, but curving somewhat around the ocelli. Over this is a thin reticulum with numerous apiculi. Diameter, .025 mm.

Holotype, No. 3380.

BIDDULPHIA GUROWII Pantocsek

Biddulphia gurowii Pantocsek, 1893, Beit. Kennt. Foss. Bac. Ungarns, pt. 3, pl. 24, fig. 366.

A form which seems in every way identical with this has been observed in the Moreno shale. It should be noted that Pantocsek's species was found in the Russian deposits at Kusnetzk.

BISSULPHIA IMPRESSA Long, Fuge and Smith, n. sp.
Plate 15, figure 8

Valve rounded in outline; from a flat border there rises an oval mound upon which the two typical cerataulloid processes are placed. The markings consist of fine striae which can be resolved into dots under high magnification. These striae radiate from the center and cover the whole valve including the processes. There are no spines or apiculi, but a number of dark spots are disposed irregularly upon the raised portion. Diameter, .070 mm.

This diatom evidently finds its place in the group known as *Cerataulus*.

Holotype, No. 3381.

BIDDULPHIA LACUNOSA Long, Fuge and Smith, n. sp.
Plate 15, figure 10

Valve elliptico-rostrate in shape, almost flat, terminated by biddulphoid processes; surface covered with faint striations which are interrupted by four lunate hyaline spaces; the inner pair leave an almost circular striated portion at the center of the valve, and the outer pair lie close to the processes. The central portion bears one or more spines. Length, .040, width, .0175 mm.

Holotype, No. 3445.

The specimen from which the photograph and description were made was accidentally lost. Another has been selected as holotype which differs in no essential respects from the original except that it is slightly larger. Length, .0452 mm.

BIDDULPHIA LONGAEVA Long, Fuge and Smith, n. sp.
Plate 15, figure 11

Valve elliptical with pointed ends; surface almost flat, divided into three parts by narrow channels. The large middle part has a hyaline center with lines of sparse pearls distributed in a roughly radial manner, the pearls being especially scarce near the center. The terminal portions of the valve have closer lines of pearls growing smaller in size as they approach the biddulphoid processes at the ends of the valve. Length, .1125, width, .0675 mm.

Holotype, No. 3382.

BIDDULPHIA ? PERPLEXA Long, Fuge and Smith, n. sp.
Plate 15, figure 5

Valve widely elliptical with rounded ends; surface almost flat, divided into three parts by two straight channels. The central part is finely striated in indefinite radial lines. Each channel has close puncta on each side. The end portions of the valve are also finely striated but not radially. The processes were missing but judging by the fracture, they were large. Length, .060, width, .0425 mm.

This form can only be placed provisionally in *Biddulphia* since the only specimen observed was imperfect and no trace of the processes remained. One of the "channels" was curtailed about two thirds across the valve. This was possibly an individual rather than a specific character.

Holotype, No. 3383.

BIDDULPHIA PRIMORDINALIS Long, Fuge and Smith, n. sp.
Plate 17, figure 19

Valve oblong with four definite protrusions on each of which is situated a slightly raised process, divided by costae into three parts. Processes finely dotted, the rest of the valve bearing irregularly scattered, coarser puncta. Length .1254, width at central processes, .070 mm.

Holotype, No. 3384.

BIDDULPHIA SUBORBICULATA Long, Fuge and Smith, n. sp.
Plate 15, figure 6

Valve suborbicular, obscurely three-sided; flat from the center to a distance of about half the diameter where there is a broad ridge on whose outer edge stand three ceratauloid processes which reach the border; between the processes the border is flat and on the same plane as the center of the valve. At the center of the valve stands a punctum surrounded by a small granular, oval space from whence delicate striae radiate to the processes and the border. The center and the ridge bear many irregularly disposed, coarse apiculi. On the ridge between each pair of processes are four long, stout spines. The flat portion of the border is clear but the margin itself is fringed with densely crowded apiculi. Diameter, .09 mm.

There is an obvious resemblance between this form and *Cerataulus subangulatus* Grove and Sturt, of Oamaru, and if, as seems necessary, a new genus is created for that form this should accompany it.

Holotype, No. 3385.

BIDDULPHIA TUOMEYII Bailey

Biddulphia tuomeyii, Schmidt, 1888, Atlas, Diat., pl. 119, figs. 1, 8, 15, 17.

This widely spread diatom is not frequent in the Moreno shale. The forms are generally small and correspond most closely, perhaps, to those figured by Schmidt.

BIDDULPHIA UNDULATA Long, Fuge and Smith, n. sp.
Plate 15, figure 9

Valve narrowly elliptical; surface divided into three unequal parts by narrow channels. The central portion, which is elevated and almost square, has a small hyaline center whence proceed radial lines of small pearls, set fairly close. The terminal portions have similar pearls in long lines directed towards the center. Across the middle of each terminal portion is a depressed zone where the lines of pearls are somewhat interrupted. At each end is a raised process whose upper part is subtriangular and marked by about six rows of dots arranged longitudinally. Length, .120, width, .04 mm.

Holotype, No. 3386.

CENTROPORUS CALIFORNICUS Long, Fuge and Smith, n. sp.
Plate 16, figure 8

Valve circular, with a striking border one-sixth of the diameter in breadth. The inner portion is yellowish and granular, the color and markings suggesting those of *Hyalodiscus*. The central area, about one-third of the diameter, consists of a thirteen pointed star. The rest of the area within the border is divided by narrow lines into thirteen tongue-shaped segments. On the border, between each of the thirteen lines is a hyaline oblong compartment of about half the breadth of the border. The radial lines of these and also the lines forming the compartments are continued across the border. Except on the star-shaped portion and on the hyaline parts of the border the whole diatom is covered by very fine, punctate striae. Diameter, .070 mm.

We have not seen Pantocsek's type specimen of *Centroporus crassus* (1889, pl. 4, fig. 57), but judging from the figure there is good reason for placing this in the same genus.

Because it presents different aspects at different foci, this valve is not easy to describe or to photograph.

Holotype, No. 3387.

CLADOGRAMMA MORENOENSIS Long, Fuge and Smith, n. sp.
Text figure 2

Valve circular, the surface rising conically from a wide, upright, hyaline girdle. The surface is hyaline with striations consisting of broken lines of various sizes and shapes which run subradially to the center. Diameter, .050 mm.

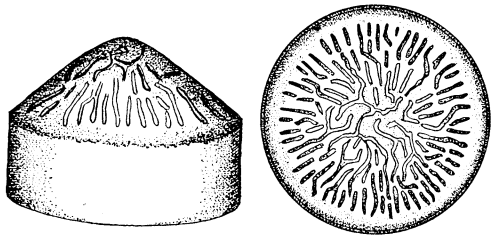


FIG. 2.—*Cladogramma morenoensis* Long, Fuge and Smith, n. sp. Holotype. Diam., 050 mm.

In general appearance this diatom resembles *C. conicum* figured by Greville, (1865b, pl. 8, figs. 1, 2) but in that species the markings are distinctly continuous and radiate and the girdle is as distinctly marked as the surface.

Holotype, No. 3444.

COSCINODISCUS CIRCUMSPECTUS Long, Fuge and Smith, n. sp.
Plate 15, figure 12

Valve flat, a small irregular rosette standing at the center. The markings are hexagonal, subequal to the border, six in .01 mm., disposed in radial rows. The border is limited on the inner side by a row of slightly larger markings which are almost oblong and which seem to be continued as apiculi overlying the narrow clear border. Diameter, about .090 mm.

Holotype, No. 3388.

COSCINODISCUS CLARESCENS Long, Fuge and Smith, n. sp.
Plate 16, figure 6

Valve flat, the central space small and clear, sometimes surrounded by an indistinct rosette. The markings, arranged in a radiate manner, are irregularly compressed into various shapes; some are almost square, subequal, five in .01 mm.; near the border two or three rows become much smaller showing as rounded pearls with clear interspaces. The border possesses well-defined striae. Diameter, about .07 mm.

Holotype, No. 3389.

COSCINODISCUS CONVEXUS Schmidt

Coscinodiscus conuexus Schmidt, 1877, Atlas, Diat., pl. 60, fig. 15.—Hanna, 1932, Calif. Acad. Sci., Proc., ser. 4, vol. 20, p. 179, pl. 6, fig. 2, 3, pl. 7, fig. 1.

This interesting diatom with its well marked secondaries is by no means rare. The figure given in Schmidt's Atlas is not very satisfactory.

COSCINODISCUS DEFINITUS Long, Fuge and Smith, n. sp.
Plate 16, figure 1

Valve circular; surface flat for about two thirds of the diameter then it falls gently to the narrow, finely marked margin. The markings consist of coarse pearls varying little in size, but becoming slightly smaller near the margin. At the margin these are arranged in a sub-concentric manner, but as the center is approached the arrangement is lost and hyaline interspaces appear, largest towards the center. Towards the outer half the beads can be observed in curved, decussating lines. Diameter, .060 mm.

Holotype, No. 3390.

COSCINODISCUS DENARIUS Schmidt

Coscinodiscus denarius Schmidt, Atlas, Diat., pl. 57, 1877, fig. 20.

A few forms which seem to correspond to the figure cited have been found in the Moreno samples.

COSCINODISCUS DISTINCTUS Long, Fuge and Smith, n. sp.
Plate 15, figure 15

Valve circular and slightly convex. Markings consist of large polygonal alveoli arranged in transverse lines somewhat after the manner of *Coscinodiscus excentricus* and largest toward the center; each alveolus presents a secondary structure consisting of an eye-spot surrounded by a ring of fine dots. The bold margin is finely striated on the outer side, while on the inner, it is provided with two or three rows of puncta. Diameter, .170 mm.

The one valve examined possessed a minute and easily overlooked central space which may possibly not be found in other specimens.

Holotype, No. 3391.

COSCINODISCUS DUPLEX Long, Fuge and Smith, n. sp.
Plate 16, figure 7

Valve circular, the narrow margin divided into small squares; surface slightly curved; radial rows of pearls gradually diminishing in size run half way to the center. The central area is raised and almost flat, with radial rows of cellules, which are a continuation of the outer rows. These run to a small circular hyaline center in which is a prominent nodule. Diameter, .05 mm.

This is a very distinctive species.

Holotype, No. 3392.

COSCINODISCUS INORDINATUS Long, Fuge and Smith, n. sp.
Plate 18, figure 6

Margin, narrow, bearing one or two puncta which are carried over from the edge of the valve and form radial rows of minute puncta; valve surface almost flat with clear puncta scattered over the whole except for a small circular hyaline center. Diameter, .06 mm.

Holotype, No. 3393.

COSCINODISCUS LINEATUS Ehrenberg
Plate 16, figure 5

Coscinodiscus lineatus, Schmidt, 1877, Atlas, Diat., pl. 59, figs. 27, 29.—Hanna, 1932, Calif. Acad. Sci. Proc., ser. 4, vol. 20, p. 180, pl. 8, figs. 1–3.

The forms we have noticed correspond to the diatom referred to by Hanna. They have hexagonal markings, considerably larger in proportion, when compared with the forms more usually met with and illustrated in the Atlas.

Hypotype, No. 3394.

COSCINODISCUS MACULOSUS Long, Fuge and Smith, n. sp.
Plate 15, figure 16

Valve flat for three-fourths of radius whence it slopes gently to the border. A central space, irregularly rounded, contains a few scattered pearls. The markings consist of radial rows of rounded pearls about 9 in .01 mm., extending from the central space to the narrow border. The valve face displays a number of irregular clear spaces chiefly on the inner half. Diameter, .08 mm.

Holotype, No. 3395.

COSCINODISCUS MARGINATUS Ehrenberg
Plate 16, figure 13

Coscinodiscus marginatus, Rattray, 1889, Roy. Soc. Edinburgh Proc., vol. 16, p. 509.—Schmidt, 1877, Atlas, Diat., pl. 62, figs. 1, 2, 3, 4, 5, 9, 11 & 12, (teste Rattray).—Mann, 1907, U. S. Nat. Herb. Cont., vol. 10, pt. 5, p. 253, pl. 49, fig. 2.

Great confusion exists in the group of *Coscinodiscus* to which this form belongs. *C. marginatus* Ehrenberg is not only extremely variable but shades gradually into species bearing other distinctive names. Between *C. robustus* Greville and *C. marginatus* Ehrenberg the confusion is intolerable and possibly will only be dispelled by merging the two species.

The form under consideration here is very close to that illustrated by Mann which he named "*marginatus*," and equally close to the form in Schmidt's Atlas, pl. 62, fig. 5 which is termed by Schmidt "*robustus*," but which Rattray corrected to *marginatus*. This diatom is not common in the Moreno shale, but abounds in other, later, Californian deposits.

Hypotype, No. 3396.

COSCINODISCUS MORENOENSIS Hanna
Plate 17, figure 3

Coscinodiscus morenoesis Hanna, 1927, Calif. Acad. Sci. Oc. Pprs. 13, p. 18, pl. 2, figs. 3, 4.

This form is dominant in the Moreno shale and is worthy of close study. The center with a slightly eccentric clear space and what appears to be a nodule is characteristic. The diagrammatic section of the valve suggests that what appears to be a nodule may bea siliceous rod or tube uniting the frustules as in *Thalassiosira*. Most of the valves are in fragments, and the fact that the centers are generally damaged somewhat confirms this theory.

We illustrate (plate 17, figure 3) a most interesting variant of this diatom. It possesses the typical nodule and clear space at the center, but at about a third of the radius from the center there is a distinct ridge as in *Craspedodiscus*. The striation within the ridge is discontinuous with that without, and the inner portion of the diatom is distinctly sunken. We do not presume to suggest what is the relationship of this form to *Craspedodiscus*. Diameter, .125 mm.

Hypotype, No. 3397.

COSCINODISCUS NITIDULUS Grunow
Plate 16, figure 12

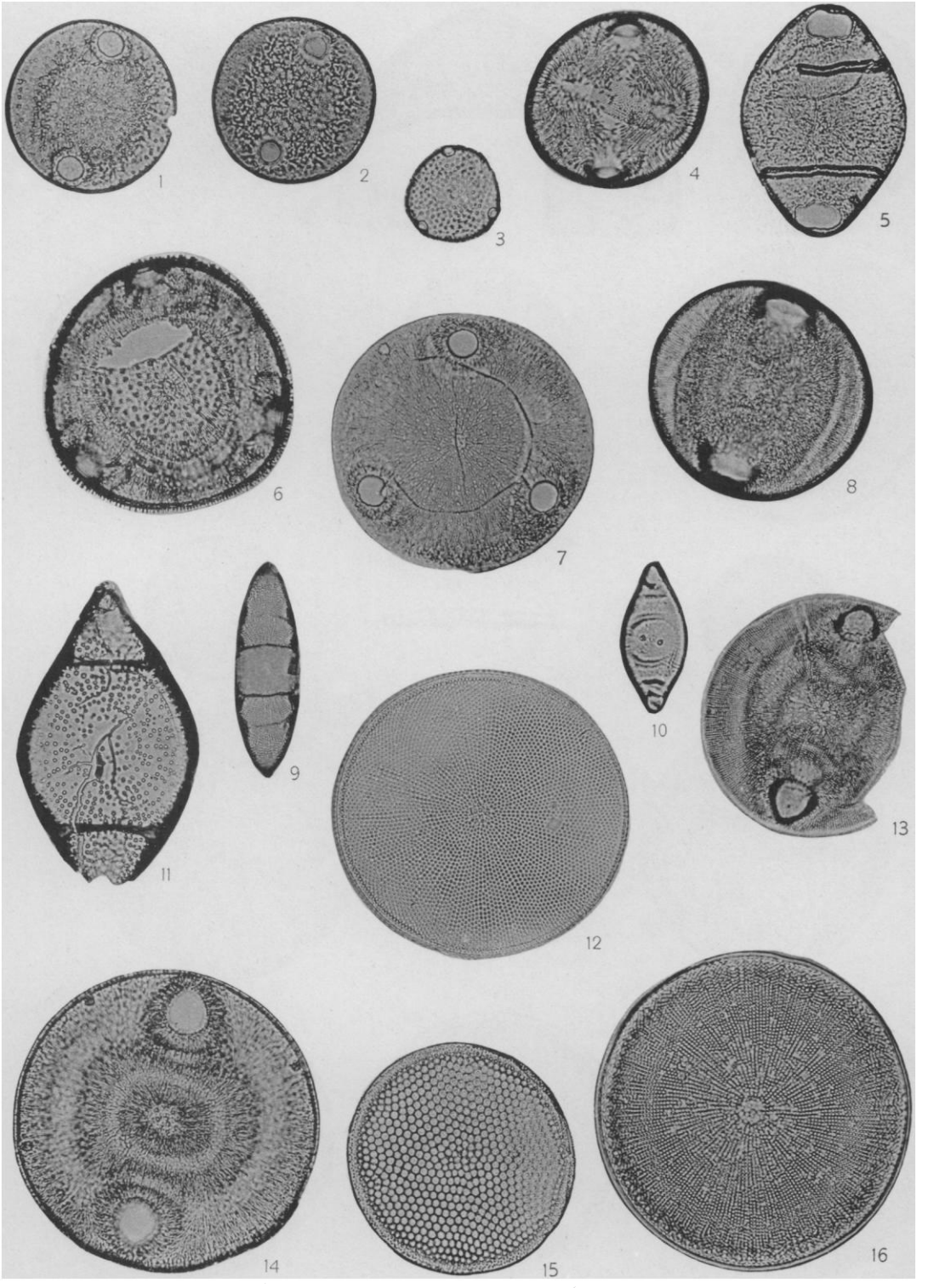
Coscinodiscus nitidulus, Schmidt, 1877, Atlas, Diat., pl. 58, fig. 20.—Hanna and Grant, 1926, Calif. Acad. Sci. Proc., ser. 4, vol. 15, p. 141, pl. 15, fig. 10.

This diatom, which betrays little evidence of fasciculation, is closer to the figure given by Hanna and Grant than that of the Atlas. Diameter, .040 mm.

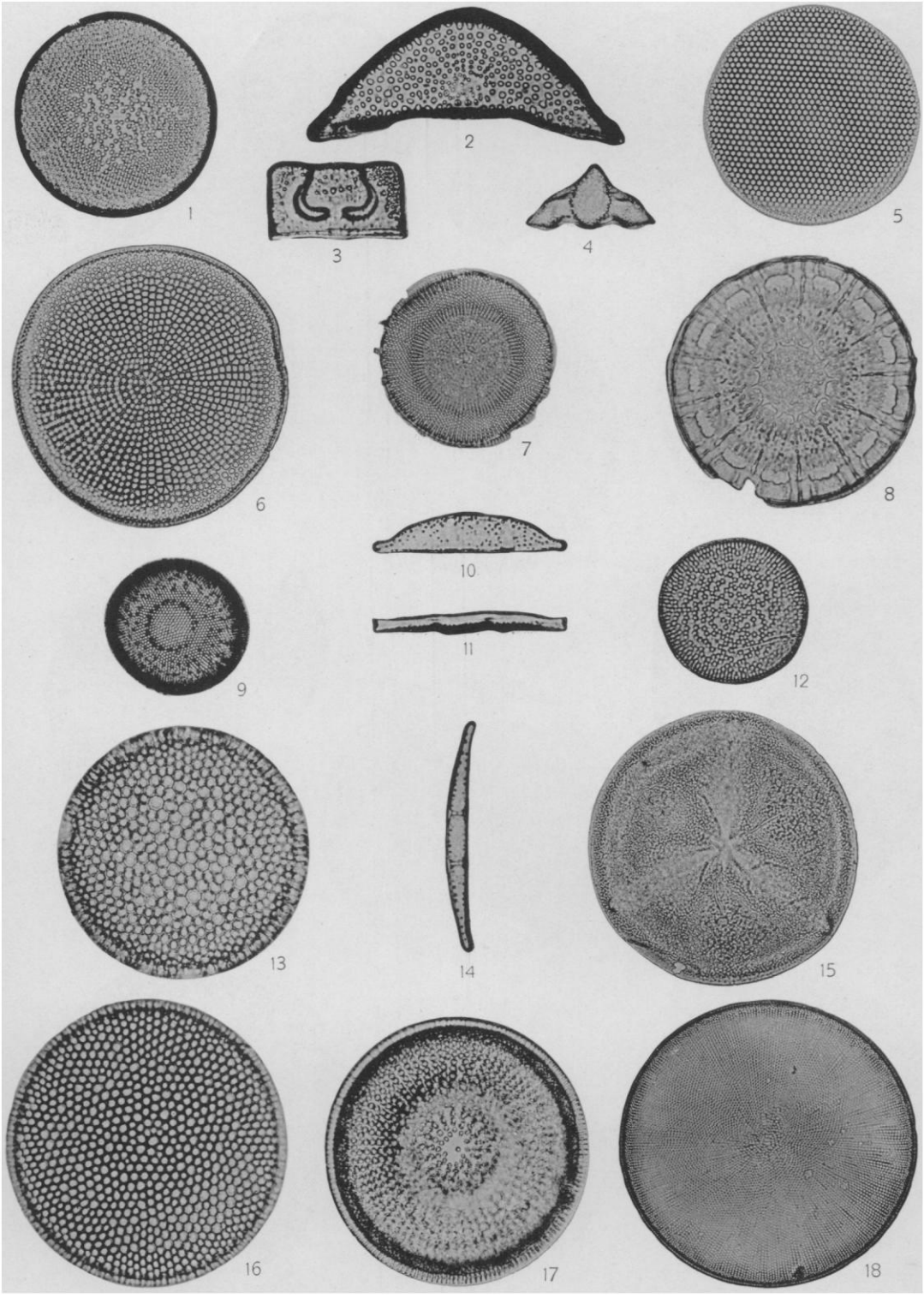
Hypotype, No. 3398.

EXPLANATION OF PLATE 15

FIGS. *1—Auliscus spissus* Long, Fuge and Smith, n. sp. Holotype, Diam., .046 mm. (p. 100)
2—Auliscus paleaceus Long, Fuge and Smith, n. sp. Holotype, Diam., .0425 mm. (p. 99)
3—Biddulphia apiculata Long, Fuge and Smith, n. sp. Holotype, Diam., .025 mm. (p. 100)
4—Auliscus hardmanianus maculosus Long, Fuge and Smith, n. var. Holotype, Diam., .059 mm. (p. 99)
5—Biddulphia (?) perplexa Long, Fuge and Smith, n. sp. Holotype, Length, .060, width, .0425 mm. (p. 101)
6—Biddulphia suborbiculata Long, Fuge and Smith, n. sp. Holotype, Diam., .09 mm. (p. 101)
7—Auliscus trioculatus Long, Fuge and Smith, n. sp. Holotype, Diam., .0675 mm. (p. 100)
8—Biddulphia impressa Long, Fuge and Smith, n. sp. Holotype, Diam., .070 mm. (p. 100)
9—Biddulphia undulata Long, Fuge and Smith, n. sp. Holotype, Length, .12, width, .04 mm. (p. 102)
10—Biddulphia lacunosa Long, Fuge and Smith, n. sp. Length, .04, width, .0175 mm. (p. 101)
11—Biddulphia longaeva Long, Fuge and Smith, n. sp. Holotype, Length, .1125, width, .0675 mm. (p. 101)
12—Coscinodiscus circumspectus Long, Fuge and Smith, n. sp. Holotype, Diam., .09 mm. (p. 102)
13—Auliscus whartoni Long, Fuge and Smith, n. sp. Holotype, Diam., .085 mm. (p. 100)
14—Auliscus dilectus Long, Fuge and Smith, n. sp. Holotype, Diam., .095 mm. (p. 99)
15—Coscinodiscus distinctus Long, Fuge and Smith, n. sp. Holotype, Diam., .17 mm. (p. 103)
16—Coscinodiscus maculosus Long, Fuge and Smith. n. sp. Holotype, Diam., .08 mm. (p. 103)
All specimens from Sec. 24, T. 14 S., R. 11 E., M.D.M., Fresno County, California.



Long, Fuge and Smith—Cretaceous Diatoms



Long, Fuge and Smith—Cretaceous Diatoms

COSCINODISCUS OBSCURUS Schmidt
Plate 16, figure 16

Coscinodiscus obscurus Schmidt, 1877, Atlas, Diat., pl. 61, fig. 16.—Rattray, 1889, Roy. Soc. Edinburgh Proc., vol. 16, p. 513.

Forms agreeing closely with the above are found from time to time, in the Moreno samples though they are by no means frequent. Diameter, .088 mm.

Hypotype, No. 3399.

COSCINODISCUS STEINYI Hanna

Coscinodiscus steinyi Hanna, 1927, Calif. Acad. Sci. Oc. Pprs. 13, p. 19, pl. 2, figs. 5, 6.

This diatom occurs in great abundance, second only to *C. morenoensis*.

COSCINODISCUS SUBTILIS Ehrenberg, var.
Plate 16, figure 18

Coscinodiscus subtilis Schmidt, 1877, Atlas, Diat., pl. 57, figs. 11, 13, 28, 29; 1877, pl. 58, fig. 37.—Van Heurck, Syn. Diat. Belgique, pl. 131, 1883, fig. 1.—Van Heurck, Treat. Diat., 1896, pl. 34, fig. 901.—Rattray, Proc. Roy. Soc. Edinburgh, Vol. 16, 1889, p. 494.

The representative of this varying and widely distributed form differs from the generally accepted type in its somewhat larger size, less obvious "fasciculi" and somewhat strongly striated border. Diameter, .145 mm.

Hypotype, No. 3400.

COSCINODISCUS SUPERBUS CALIFORNICUS
Long, Fuge and Smith, n. var.
Plate 16, figure 17

Cestodiscus pulchellus Greville, 1866, Micr. Soc. London Trans., vol. 14, p. 123, pl. 11, fig. 5.—Rattray, 1889, Roy. Soc. Edinburgh Proc., vol. 16, p. 458.

The forms observed differ from the type in that the brilliant markings are more crowded and the prominent apiculi mentioned by Rattray are not to be seen. Diameter, .085 mm. We regard the difference sufficient to constitute a new variety.

Holotype, No. 3401.

CRASPEDODISCUS MORENOENSIS Long, Fuge and Smith, n. sp.
Plate 17, figure 1

This diatom is a replica of the smaller types of *Coscinodiscus morenoensis* Hanna which is so common in the shale, but possesses a slightly eccentric, sub-oval or pear-shaped depression, distinctly delimited and depressed in the typical Craspedodiscoid manner. It can hardly be regarded as a freak as a number of similar forms have been detected. It raises many problems, chiefly the soundness of *Craspedodiscus* as a genus, and its relation to *Coscinodiscus* which cannot be dealt with here. After considerable

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EXPLANATION OF PLATE 16

FIGS. *1*—*Coscinodiscus definitus* Long, Fuge and Smith, n. sp. Holotype, Diam., .06 mm. (p. 103)
2—*Triceratium lunatum* Long, Fuge and Smith, n. sp. Holotype, Length, .080 mm. (p. 114)
3—*Terpsinoe anguinea* Long, Fuge and Smith, n. sp. Holotype, Length, .046; width, .035 mm. (p. 112)
4—*Eunotogramma sp.* Length, .065 mm. (p. 106)
5—*Coscinodiscus lineatus* Ehrenberg. Diam., .068 mm. (p. 103)
6—*Coscinodiscus clarescens* Long, Fuge and Smith, n. sp. Holotype, Diam., .07 mm. (p. 102)
7—*Coscinodiscus duplex* Long, Fuge and Smith, n. sp. Holotype, Diam., .05 mm. (p. 103)
8—*Centroporus californicus* Long, Fuge and Smith, n. sp. Holotype, Diam., .07 mm. (p. 102)
9—*Stephenopyxis rudis* Greville. Diam., .090 mm. (p. 111)
10, 11—*Eunotogramma productum* Grunow, var. *rectum* Long, Fuge and Smith, n. var.; *10*, Holotype, Length, .050, width, .009 mm.; *11*, Paratype (p. 106)
12—*Coscinodiscus nitidulus* Grunow. Diam., .040 mm. (p. 104)
13—*Coscinodiscus marginatus* Ehrenberg. Diam., .125 mm. (p. 104)
14—*Eunotogramma margino punctatum* Long, Fuge and Smith, n. sp. Holotype, Length, .06, width, .0056 mm. (p. 106)
15—*Debya californica* Long, Fuge and Smith, n. sp. Holotype, Diam., .133 mm. (p. 106)
16—*Coscinodiscus obscurus* Schmidt. Diam., .088 mm. (p. 105)
17—*Coscinodiscus superbus* Hardman, var. *californicus* Long, Fuge and Smith, n. var. Holotype, Diam., .085 mm. (p. 105)
18—*Coscinodiscus subtilis* Ehrenberg var. Diam., .145 mm. (p. 105)
All specimens from Sec. 24, T. 14 S., R. 11 E., M.D.M., Fresno County, California.

consideration we have decided to create the new species, and would call attention to the form as worthy of careful study. Diameter, .072 mm.

Holotype, No. 3402.

DEBYA CALIFORNICA Long, Fuge and Smith, n. sp.
Plate 16, figure 15

The presence of this diatom is of considerable interest for it sheds light on a controverted genus. Pantocsek created the genus for a form found by him in a Hungarian deposit and which he named *D. insignis* (1886, p. 65; Van Heurck, 1896, p. 495; Karsten, 1928, p. 219; Schmidt, 1875, pl. 29, fig. 11; Coupin, 1930, pl. 293, fig. D). Ralfs, Van Heurck and Hustedt have regarded it as a "plate" or "internal valve" of *Actinoptychus*. Karsten on the other hand is inclined to admit its validity.

In the Moreno shale several of these valves have been found, mostly imperfect, but one, the specimen from which the figure has been prepared, is complete. This is an attractive form and gives every suggestion of a complete diatom valve. Comparison with figures of Pantocsek's form, reveals a close relationship therewith, but at the same time a number of differences compel us to create a new species which we define as follows:

Valve circular, .050 to .133 mm. in diameter. At the highest focus there are three narrow ridges proceeding from the center to just within the border and terminating in small processes which are somewhat aulacodiscoid in character. Between the ridges are depressions, deepest on the inner side which rise gradually towards the border until they reach almost to the plane of the processes. There is no distinction of marking at the border. The markings consist of fine puncta irregularly arranged which extend all over the valve. Over the puncta is spread a fine but well-marked reticulum. At the center there is a single punctum from which the ridges proceed, while alternating with the ridges, but proceeding only a short way into the compartments are three hyaline lines. The valve thus possesses features which suggest relationship both with *Aulacodiscus* and *Actinoptychus*. Diameter, .133 mm.

Holotype, No. 3403.

ENDYCTIA OCEANICA Ehrenberg

Endyctia oceanica, Schmidt, 1881, Atlas, Diat., pl. 65, fig. 10.—Rattray, 1889, Proc. Roy. Soc. Edinburgh, p. 469, vol. 16.

This diatom is familiarly known under the above name and as *Coscinodiscus concavus* Gregory. We prefer the earlier, as the distinctively marked border seems to mark *Endyctia* off from *Coszindiscus* and any scheme that will reduce the vast horde of species in this great genus is welcome.

EUNOTOGRAMMA sp.
Plate 16, figure 4

This resembles *E. weissii* in shape but is divided into three segments by deep depressions of the valve. The central segment is pear-shaped; the terminal segments end in an acute angle. The markings consist of irregularly scattered, coarse puncta save on the terminal segments where the puncta are finer and arranged in lines. Length, .065 mm. Unfortunately, the only specimen found was accidently lost after the description and photograph were made. It is apparently an undescribed form but a name has not been assigned to it, pending the finding of additional material.

EUNOTOGRAMMA MARGINOPUNCTATUM Long, Fuge and Smith, n. sp.
Plate 16, figure 14

Long and narrow like a shallow crescent. A septum on each side of the middle crosses the diatom. Along each margin there is a row of fine beads irregularly distributed. Length, .060, width .0056 mm.

Holotype, No. 3404.

EUNOTOGRAMMA PRODUCTUM RECTUM Long, Fuge and Smith, n. var.
Plate 16, figures 10, 11

This little diatom seems to correspond closely to Grunow's form (Van Heurck, 1883, pl. 126, fig. 5; Schmidt, 1889, pl. 144, figs. 12, 14) from Russia save that the variety has a straight ventral line and is not constricted at the segments. Length, .050, width, .009 mm.

Holotype, No. 3406.

EUPODISCUS RADIATUS Bailey
Plate 17, figure 2

Eupodiscus radiatus Greville, 1860, Micr. Soc. Quart. Journ., vol. 8, pl. 5, fig. 10.—Van Heurck, 1883, Syn. Diat. Belgique, pl. 118, figs. 1, 2.—Rattray, 1888, Roy. Micr. Soc. Journ., vol. 8, p. 913.

The form we illustrate seems identical with that referred to above save that the well marked margin of the type is absent and the cellules do not diminish in size noticeably at the border. Diameter, .112 mm.

Hypotype, No. 3407.

GLORIOPTYCHUS CALLIDUS Hanna

Glorioptychus callidus Hanna, 1927, Calif. Acad. Sci., Oc. Pprs. 13, pl. 2, figs. 7, 8.

This most interesting diatom occurs frequently in the Moreno shale.

HENDEYA Long, Fuge and Smith, n. gen.

Valve elliptical with irregularly radial, close-set striae with an ocellus and a blunt spine toward each end.

The genus is named in honor of Mr. N. Ingram Hendey of the British Museum (Natural History) in recognition of his great work on "The Plankton Diatoms of the southern Seas; Discovery Reports, vol. 16, 1937, pp. 151–364, pls. 6–13.

Genotype, *Hendeya dehiscens* L. F. and S., n. sp.

HENDEYA DEHISCENS Long, Fuge and Smith, n. sp.
Plate 18, figure 16

Valve elliptical; surface sloping in a gentle curve from center to circumference; markings consist of close, finely marked striae running irregularly from an undifferentiated center. Near each extremity of the valve and at the border is a small circular hyaline space with a tiny central nodule apparently analogous to the ocelli of such forms as *Eupodiscus* or *Auliscus* and opposite each of these there is a short blunt spine. Length, .10; width, .065 mm.

The paratype is somewhat less elongate than the holotype and the margin is nearly perfect. It measures, length, .050; width, .042 mm.

Holotype, No. 3446; paratype, No. 3447.

HUTTONIA CRETACEA Long, Fuge and Smith, n. sp.
Plate 17, figure 9

Valve narrowly elongate, with a series of fine closely spaced transverse wavy lines and two heavy internal bars across the midsection; ocelli large and apparently nearly circular, placed near each end and 180 degrees apart. Length, .080, width, .0234 mm.

This strange species is not so twisted on an axis perpendicular to the plane of the valve as *H. alternans* Grove and Sturt (1887, p. 142) and does not possess the fine, rather widely spaced puncta of that form. It bears even less resemblance to the coarsely punctate *H. reichardtii* Grunow (1863, pl. 4, fig. 22; Leuduger-Fortmorel, 1898, pl. 8, fig. 23; Rampi, 1938, pp. 88–90) living along the Mediterranean and African coasts and originally referred to *Cerataulus*.

Holotype, No. 3408.

KENTRODISCUS BLANDUS Long, Fuge and Smith, n. sp.
Plate 19, figures 3, 4, 5
(Pl. 18, fig. 14?)

This *Kentrodiscus* differs from the other species of the genus chiefly by the presence of the thorny processes which are generally associated with it. Moreover, even with a high power we are not able to distinguish any markings.

While we hold the view that *Kentrodiscus* consists, probably, of the spores of another genus, we deem it wise to report the presence of this form which occurs along with the more usual species, *K. andersoni* Hanna. Diameter, .035, length, .070 mm.

Holotype, No. 3409, paratypes, Nos. 3410, 3411.

On plate 18, figure 14 we have given a photograph of a diatom from the same series of slides as the above; it seems doubtful if this may be a lower valve of *K. blandus* but we have not been able to place it satisfactorily elsewhere. The spines are not grouped centrally but until more information is available it seems best to leave it with this species.

KITTONIA HANNAI Lefébure and Chenevière
Plate 19, figures 6, 7

Kittonia hannai Lefébure and Chenevière, 1939, Soc. française Micro. Bull., vol. 8, no. 1, p. 23, pl. 1, fig. 3.

Valve triangular with slightly convex sides, about .02 mm., from angle to angle. The sides rise somewhat sharply for a short distance, bearing rows of alveoli arranged at right angles to the margin. The central area is almost flat, and the rows of alveoli are continued towards a circular, hyaline center, marked by a few scattered pearls or short lines irregularly placed. Near each angle is a small circular, hyaline space from the center of which rises gently a long, slender, tubular process, boldly curved, and terminating in a trumpet-shaped mouthpiece; the terminal surface having a number of small scattered dots.

The first specimens of this diatom were found by Mons. E. Chenevière, the French diatomist, in Moreno shale material sent to him by Dr. Hanna.

The illustrations are drawings by Mr. N. Ingram Hendey, F.R.M.S., from a specimen in the possession of Mr. H. Potter of Birmingham. The above description is from the same specimen. The holotype is supposed to be in the collection assembled by M. Chenevière. The length of one side of it was given as 60 microns.

LEPIDODISCUS sp.
Plate 17, figure 13

We publish a view of what is apparently a fragment of a new species of *Lepidodiscus*. Unfortunately the specimen is incomplete, consisting only of a portion of a "plate" or layer of one of these rare and complex valves.

This, the first noted presence of such a form in an American deposit, is of great interest and affords another reason for relating the Moreno formation with those ancient deposits in Russia with which this genus is usually associated (Schmidt, 1886, pl. 103, fig. 5; Van Heurck, 1896, p. 499; Karsten, 1928, p. 220).

Since the fragment is incomplete we give the reproduction of the photograph, but do not feel justified in attempting to describe it or to create a new species therefor, but wait in hope for the discovery of a perfect valve. Diameter, .095 mm.

Hypotype, No. 3412.

LITHODESMIUM CALIFORNICUM Grunow

Lithodesmium californicum Grunow in Van Heurck, 1883, Syn. Diat. Belgique, pl. 115, fig. 9.—Schmidt, 1890, Atlas, Diat., p. 159, fig. 11.

This form, of which we have observed a number of specimens is by no means rare in certain samples. It seems to carry somewhat larger markings than does the type.

LITHODESMIUM MARGARITACEUM Long, Fuge and Smith, n. sp.
Plate 17, figure 16

Valve triangular; surface flat save for the large triangular bosses which are well raised. The markings consist of pearls which are closely set and which flow in distinct radiating lines from a small clear center to the uppermost part of the bosses. Close to the center is the well-marked scar marking the site of the typical rod of *Lithodesmium*.

This form bears a distinct resemblance to the *T. undulatum* of Ehrenberg, illustrated by Van Heurck (1883, pl. 116, fig. 7) and which comes from Maryland. This also may be the *L. undulatum* of the same plate (figs. 8, 12). The Moreno form has, however, larger and differently shaped bosses, and more clearly marked pearls. Length, angle to angle .090 mm.

Holotype, No. 3413.

MAMMIDION Long, Fuge and Smith, n. gen.

Valves disciform; outer portion flat, divided into radial segments; inner portion rising to a mammiform protuberance.

Genotype: *Mammidion elegans*, n. sp.

MAMMIDION ELEGANS Long, Fuge and Smith, n. sp.
Plate 17, figure 4

Valve circular, flat for almost two-thirds of the diameter, when a notable mammiform protuberance rises to a flat center. The hyaline center bears a few scattered puncta and is surrounded by three or four irregular rows of large beads. The flat portion of the valve is divided into about twenty rectangular sections by narrow, hyaline, radial

channels; each section has subradial and subconcentric rows of large pearls; outside the sections a ring of close-set pearls somewhat oval in shape and a definite border line separate the compartments from a finely striated hyaline margin. Diameter, .060 mm.

Whilst this valve is somewhat coscinodiscoid in type, the fact of its unusual contour and also the possession of markings of four different types or sizes seems to justify the creation of a new genus for its reception.

Holotype, No. 3414.

MELOSIRA (?) DENS-SERRAE Long, Fuge and Smith, n. sp.
Plate 17, figure 12

Valve circular, surface almost flat. There is a prominent, hyaline border, which apparently curves to the outer edge. This border is about one-tenth of the diameter of the valve in breadth. The central portion of the valve overlaps the border in an irregular manner giving the suggestion of a toothed wheel; this portion consists of two layers; the upper shows about twelve short narrow bars or costae about .005 mm. long placed at regular intervals on the outer edge and pointing towards the center; these bear evident puncta and a number of large clear spots arranged more or less subconcentrically. The lower layer shows numerous, crowded, fine, dotted striae arranged radially and reaching the center.

This diatom has evident affinity with *Melosira*, in which genus we leave it at present. Diameter, .050 mm.

Holotype, No. 3415.

MELOSIRA PATERA Long, Fuge and Smith, n. sp.
Plate 17, figure 18

Valve circular; flat at border for about one-fifth diameter, where there is a short, sharp rise to an almost flat center. At the border are a number of short lines, separated .005 mm. to .01 mm., irregular in direction, but all more or less pointing towards the center. The middle portion of the disk presents a few clear spots. The general impression of the valve is of a hyaline disk resembling an undecorated, white porcelain dinner plate. Diameter, about .010 mm.

This diatom is fairly common in some strata, but is evidently delicate for an uncracked valve has not been noted.

Holotype, No. 3416.

METROSULUS GRACILIS Hanna

Metrosulus gracilis Hanna, Calif. Acad. Sci. Oc. Pprs. 13, 1927, pl. 3, figs. 9, 10.

This form appears very sparsely in the material at our disposal.

MONOPSIA MAMMOSA Grove and Sturt
Plate 18, figure 1

Monopsia mammosa Grove and Sturt, 1887, Quekett Micr. Club Journ., ser. 2, vol. 3, p. 141, pl. 13, fig. 38.—Schmidt, Atlas, Diat. pl. 125, figs. 14, 15.

The form discovered in the shale differs from that described and illustrated by Grove and Sturt only in the marking of the circular process. Grove and Sturt describe the marks as consisting of two rings of large dots. In our specimen there is a ring of radial striae extending halfway to the center which is irregularly dotted.

But since there is variety in the markings of the Oamaru specimens, some of which certainly carry striae upon the process, we do not regard it necessary to separate this form in any way from the type.

Considerable interest is attached to the discovery of this form, which until recently was associated only with the New Zealand deposit, the more so since M. Chenevière (1934, p. 106) has recently described a closely allied form, *M. marginata*, found by him in the Russian deposit of Kamichev.

Hypotype, No. 3417.

PLANKTONELLA (?) CALIFORNICA Long, Fuge and Smith, n. sp.
Plate 17, figure 10

Valve circular, surface almost flat. The markings consist of distinct beads arranged at the margin in radial rows of two, three or four beads. Within this area the beads, even in size, are sparsely and irregularly scattered over a finely reticulated surface. From the outer ends of the rows, spines are attached which protrude radially and regularly outwards, in length about one

tenth of the diameter of the valve. Diameter, .050 mm.

It is only with hesitation that we have referred this curious valve, of which only one specimen has been observed, to *Planktonella*.

Holotype, No. 3418.

PODOSIRA MIRABILIS Long, Fuge and Smith, n. sp.
Plate 17, figure 5

The general appearance of the valve corresponds to such a form as *P. argus*, with well-marked border and broad ring surrounding a clear center. Here the center is broad and subhyaline, surrounded by a wide-arched ring which is provided with large radial spines inserted mainly on the inner margin of the ring and reaching wholly or partly across it. These spines appear to lie on the diatom until their end is reached when the apex can be seen, with a high power, to be lifted slightly above the body of the valve. At the outer edge of the ring another row of shorter spines is directed outwards over the hyaline margin. Diameter, .0425 mm.

Holotype, No. 3419.

PODOSIRA SUPERBA Long, Fuge and Smith, n. sp.
Plate 19, figure 1

This diatom is akin to *P. mirabilis* described above, but we regard the differences as sufficient to warrant the creation of a new species.

Valve circular; center large and circular, hyaline, the inner portion irregularly and sparsely dotted with coarse beads and distinct from the outer portion. Outside this is a narrow, radially striated ring with numerous coarse beads, chiefly on the outer edge; surrounding this is another wide ring covered with fine, decussate markings bearing coarse knobbed protuberances on the outer edge and falling sharply to a narrow hyaline rim. Diameter, .085 mm.

Holotype, No. 3420.

PODOSIRA SUPERBA RETICULATA Long, Fuge and Smith, n. var.
Plate 19, figure 2

In the variety *reticulata* the whole of the central hyaline portion, with the exception of the dotted middle, is broken up into irregular compartments by narrow channels which afford the most striking feature of the valve. Diameter, .088 mm.

Holotype, No. 3421.

PORPEIA sp.
Plate 17, figure 11

Quadrangular in girdle view with rounded edges. The valves are oblong with strong puncta closely arranged towards the angles but more distant in the median portion. Internal septa distinct. Girdle bearing transverse rows of parallel puncta. Length, .065, width, .0525 mm.

This is probably a new species, but in view of the importance of the valve aspect in this genus we prefer to leave it unnamed awaiting the finding of the necessary specimen.

Hypotype, No. 3422.

RHAPHIDOPHORA Long, Fuge and Smith, n. gen.

Valve circular, divided into segments alternately raised and depressed; segments punctate in parallel lines.

Genotype, *Rhaphidophora elegans*, n. sp.

RHAPHIDOPHORA ELEGANS Long, Fuge and Smith, n. sp.
Plate 17, figure 6

Valve circular; central area large and round with about twelve radial rows of four pearls each, and surrounded by a narrow hyaline ring. The outer portion of the diatom is divided into about twenty-four cuneate sectors, alternately raised and depressed, and varying alternately in width. The wider sectors have parallel and concentric lines of pearls; the narrower ones have a median line of five or six pearls running from the margin halfway to the hyaline ring. Diameter, .033 mm.

This diatom has been described from what is apparently an upper "plate," but is so striking that we think it should be noted. Affinities to *Coscinodiscus* and *Actinoptychus* are evident.

Holotype, No. 3423.

STEPHANOPYXIS APPENDICULATA
Ehrenberg

Stephanopyxis appendiculata Schmidt, 1888, Atlas, Diato., pl. 130, figs. 18–26, 29–33; also *S. turris* Grunow, pl. 130, figs. 42, 43.—Mann, 1907, Cont. U. S. Nat. Herb., vol. 10, pt. 5, p. 244.—Hanna, 1927, Calif. Acad. Sci. Oc. Ppers. 13, p. 32, pl. 4, fig. 9.

This diatom appears to be common in many of the samples. Rarely a small, stout and somewhat cylindrical form is to be noted, but the regular form greatly resembles that illustrated in the Atlas, pl. 120, fig. 35. In some samples the diatom reaches a considerable size and there may be distinguished from an accompanying form, which is only slightly larger, by the fact that *S. appendiculata* lacks any trace of border when observed in the valve aspect.

As the above references will indicate this form is very similar to *S. turris*, by which name it will be recognized by many, but we have chosen to follow Hanna and Schmidt, leaving the name *turris* for the diatom illustrated in the Atlas, pl. 130, figs. 42 and 43, which, though similar, is much more delicate. In his Index, Mills reverses the matter and refers all the forms to *turris*.

STEPHANOPYXIS BARBADENSIS Greville

Stephanopyxis barbadensis Greville, 1865, Trans. Micr. Soc. London, N. S., vol. 13, p. 3, pl. 1, fig. 11; (as *Creswellia*).—Schmidt, 1888, Atlas, Diat., pl. 130, figs. 6, 10.—Grove and Sturt, 1887, Journ. Quekett Micr. Club, ser. 2, vol. 3, p. 70.

Stephenopyxis corona, Van Heurck, 1882, Syn. Diat. Belgique, pl. 83, ter. figs. 10, 11.—Schmidt, 1888, Atlas, Diat., pl. 123, figs. 10, 17; pl. 130, 1888, figs. 16, 17, 36.

Examination of the references and figures cited above will reveal how great a confusion exists between these forms and how difficult it is to name one of these *Stephanopyxis* with confidence.

In certain of the Moreno samples there is found a *Stephanopyxis* of moderately large size, convex in contour, possessing a slight but very distinct rim or border and a circlet of spines of moderate stoutness. This agrees closely with Greville's illustration, save that the spines are somewhat longer than in the Moreno specimens.

STEPHANOPYXIS GRUNOWII
Grove and Sturt

Stephanopyxis grunowii Schmidt, 1888, Atlas, Diat., pl. 130, figs. 1, 4.

This distinctive form, though not plentiful, seems to be distributed throughout all of the samples studied.

STEPHANOPYXIS RETICULATA Long, Fuge and Smith, n. sp.
Plate 19, figure 8

Valve circular, the surface rising sharply from a fairly wide rim to a large convex central area. This area is finely dotted and overlaid with a coarse reticulum which affords a striking appearance. The outer edge of the conical area bears a ring of large conical spines. The border is very coarsely striated and bears an irregular ring of small beads on the inner edge. Diameter, .07 mm.

Holotype, No. 3443.

STEPHANOPYXIS RUDIS Greville
Plate 16, figure 9

Stephanopyxis rudis Schmidt, 1888, Atlas, Diat., pl. 164, fig. 9; pl. 123, 1891, figs. 16, 17, 20 (under the name of *S. corona* Grunow).

Reference to the forms cited above will illustrate the confusion in nomenclature referred to in the note under *S. appendiculata*.

We have preferred the name of *rudis* to *corona* as, while the form in question *may* be an under valve of *corona*, it is not the diatom we understand to be popularly recognized by that name.

Hypotype, No. 3424.

STICTODISCUS CONCINNUS Long, Fuge and Smith, n. sp.
Plate 17, figure 14

Valve circular, with slight central depression; border of prominent, regular, polygonal areolae. Within the border are short radial rows disposed in pairs, these rows each of three or four puncta, and each pair separated from the next by a single punctum close to the border. The central portion has larger puncta sparsely scattered in an irregularly concentric manner. Diameter, .040 mm.

Holotype, No. 3425.

STICTODISCUS GROSSEPUNCTATUS Long, Fuge and Smith, n. sp.
Plate 18, figure 15

Valve triangular with gibbous sides, surface flat, sparsely and irregularly provided with pearls. These are smaller, rounded, and distant in the central area, larger, closer and generally elongated towards the margin.

This diatom presents a distinct resemblance to *Triceratium hertleini* but has neither the processes nor markings of *Triceratium* in the angles. Length from angle to angle, .0725 mm.

Holotype, No. 3426.

TERPSINOE ANGUINEA Long, Fuge and Smith, n. sp.
Plate 16, figure 3

Zonal view oblong, divided into three segments by septa which are curved and thickened at the ends in a manner suggestive of the conventional representation of an asp. Surface punctate; the puncta of the middle segment being coarser and sparse. Length, .046, width, .035 mm.

Holotype, No. 3427.

TRICERATIUM ALBUM Long, Fuge and Smith, n. sp.
Plate 18, figure 7

Valve triangular with perfectly straight sides. The center of the valve is raised presenting the figure created by the union of three narrow crescents; remainder of surface flat save that the well-marked bosses rise to the level of the central area. The markings consist of pearls; those on the raised central area being small and widely scattered; those on the flat portion being arranged subradially or in rows disposed across the angles. At the margin, larger markings suggest incipient costae. The bosses are distinctly marked in close decussating lines. Length of side, .1175 mm.

This diatom is very similar to that illustrated by Schmidt (1886, pl. 112, fig. 3) and called *T. exornatum* Greville, var. *robusta* Witt, which is much more strongly marked than the type form. Both are from Archangel, and both are quite flat. We have been disposed to make this a Californian variety of *T. exornatum*, but having regard to the considerable difference from the type form, both in marking and contour we have

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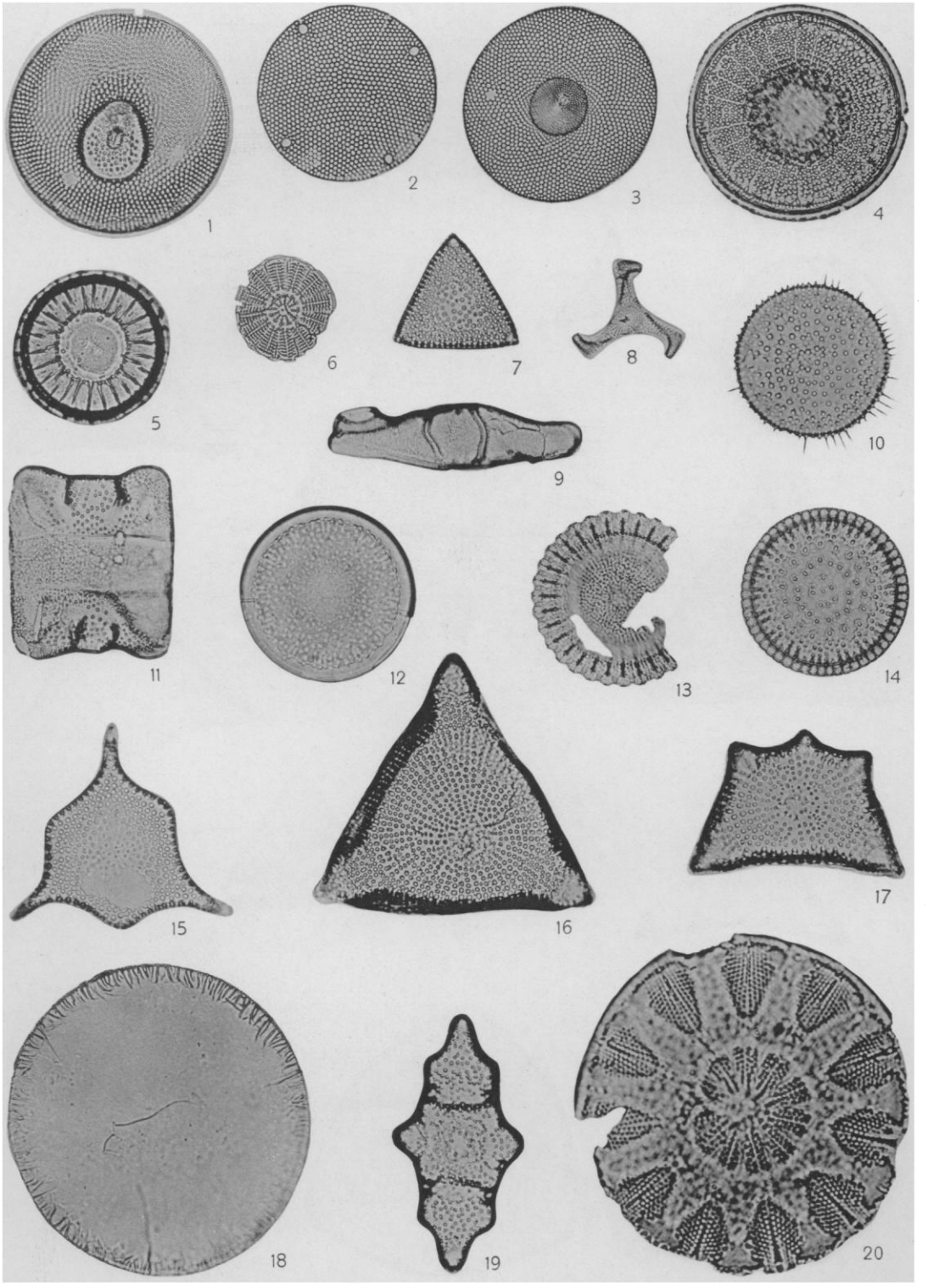
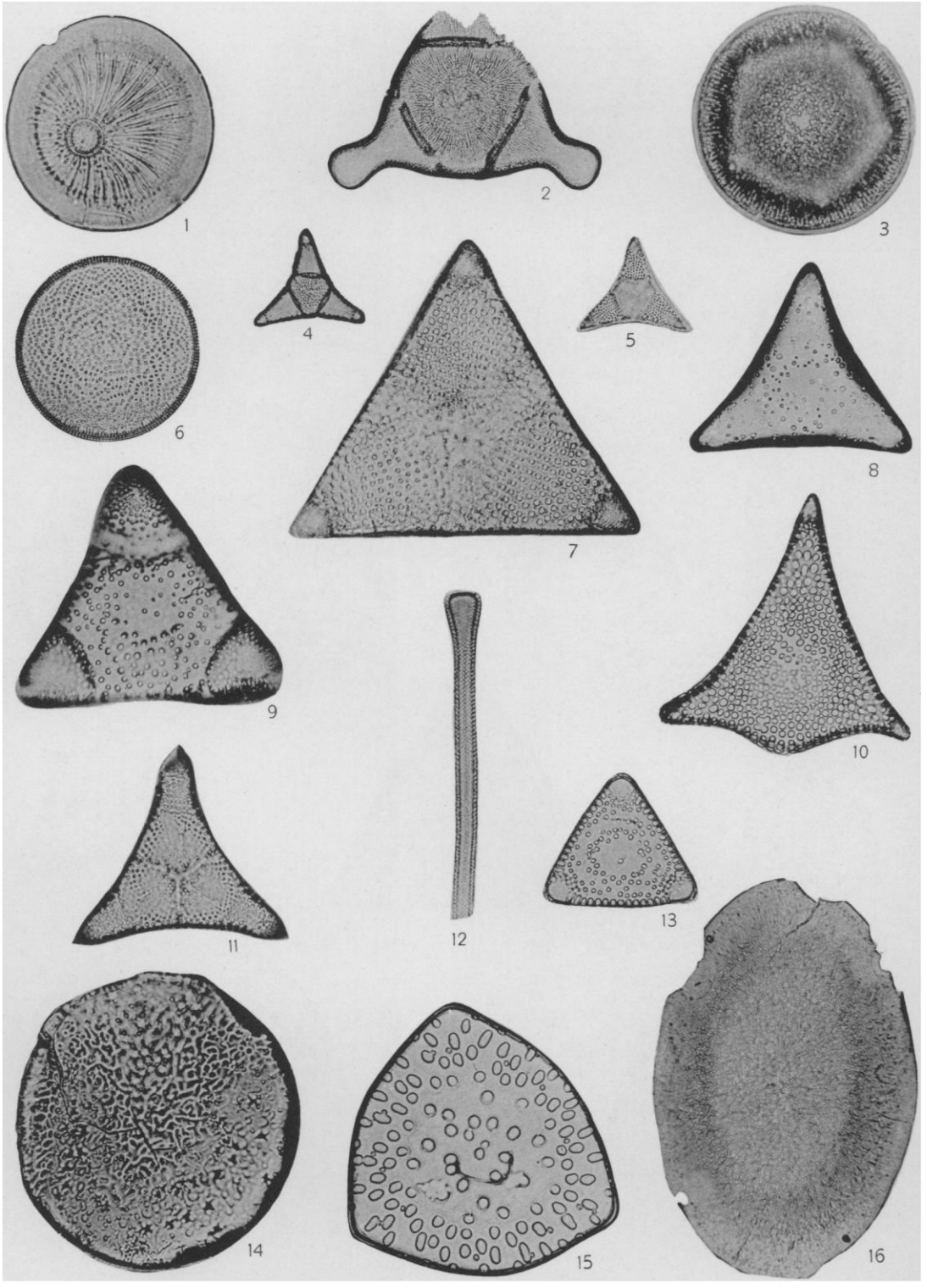
EXPLANATION OF PLATE 17

FIGS. *1*—*Craspedodiscus morenoensis* Long, Fuge and Smith, n. sp. Holotype, Diam., .072 mm. (p. 105)
2—*Eupodiscus radiatus* Bailey. Diam., .112 mm. (p. 107)
3—*Coscinodiscus morenoensis* Hanna. Diam., .125 mm. (p. 104)
4—*Mammidion elegans* Long, Fuge and Smith, n. gen. and n. sp. Holotype, Diam., .060 mm. (p. 108)
5—*Podosira mirabilis* Long, Fuge and Smith, n. sp. Holotype, Diam., .0425 mm. (p. 110)
6—*Rhaphidophora elegans* Long, Fuge and Smith, n. gen. and n. sp. Holotype, Diam., .033 mm. (p. 110)
7—*Trinacria nitescens* Long, Fuge and Smith, n. sp. Holotype, Length of side, .033 mm. (p. 116)
8—*Triceratium swastika* Long, Fuge and Smith, n. sp. Holotype, Length of side, .05 mm. (p. 114)
9—*Huttonia cretacea* Long, Fuge and Smith, n. sp. Holotype, Length, .080, width, 0234 mm. (p. 107)
10—*Planktoniella ? californica* Long, Fuge and Smith, n. sp. Holotype, Diam., .050 mm. (p. 109)
11—*Porpeia* sp. Hypotype, Width, .0525, length, .065 mm. (p. 110)
12—*Melosira ? dens-serrae* Long, Fuge and Smith, n. sp. Holotype, Diam., .050 mm. (p. 109)
13—*Lepidodiscus* sp. (p. 108)
14—*Stictodiscus concinnus* Long, Fuge and Smith, n. sp. Holotype, Diam., .040 mm. (p. 111)
15—*Triceratium dignum* Long, Fuge and Smith, n. sp. Paratype, Length of base, .069 mm. (p. 113)
16—*Lithodesmium margaritaceum* Long, Fuge and Smith, n. sp. Holotype, Length of side, .090 mm. (p. 108)
17—*Triceratium perplexum* Long, Fuge and Smith, n. sp. Holotype, Length, long side, .070 mm. (p. 114)
18—*Melosira patera* Long, Fuge and Smith, n. sp. Holotype, Diam., .010 mm. (p. 109)
19—*Biddulphia primordinalis* Long, Fuge and Smith, n. sp. Holotype, Length, .1254 mm. (p. 101)
20—*Upothema californica* Long, Fuge and Smith, n. gen. and n. sp. Holotype, Diam., .0375 mm. (p. 117)

All specimens from Sec. 24, T. 14 S., R. 11 E., M.D.M., Fresno County, California.



Long, Fuge and Smith—Cretaceous Diatoms



Long, Fuge and Smith—Cretaceous Diatoms

decided to create a new species, but its relationship to the forms referred to is very close.

Holotype, No. 3428.

TRICERATIUM BELLUM Long, Fuge and Smith, n. sp.
Plate 18, figure 13

Triangular, sides almost straight, angles rounded; bosses with radial lines of fine beads; central hyaline space surrounded by an irregular ring of beads, other scattered beads outside this ring, and a row of large beads close to each side of the diatom. Length of side, .040 mm.

Holotype, No. 3429.

TRICERATIUM BICORNIGERUM Hanna

Triceratium bicornigerum Hanna, 1927, Calif. Acad. Sci. Oc. Pprs., 13, p. 34, pl. 4, figs. 13, 14.

This diatom is fairly plentiful in certain samples.

TRICERATIUM CELLULOSUM CALIFORNICUM Long, Fuge and Smith, n. var.
Plate 18, figure 9

The Moreno form is very close to that illustrated by Schmidt (1886, pl. 112, fig. 4) as var. *simbirskiana* Witt, but the sulci are not free from beads as shown in that figure. Length of side, .070 mm.

Here again there is a noteworthy relationship to the Russian fossils.

Holotype, No. 3430.

TRICERATIUM DIGNUM Long, Fuge and Smith, n. sp.
Plate 17, figure 15; plate 18, figure 10

Triangular, with very acute angles, the middle of each side strongly swollen; bosses small and finely dotted; valve covered with coarse, radial puncta becoming irregular and less definitely marked towards the center. Length of side, .070 mm.

The description pertains to the holotype. Variation is such that two sides may become definitely convex as in the paratype.

Holotype, No. 3431, paratype, No. 3432.

TRICERATIUM HERTLEINI Hanna

Triceratium hertleini Hanna, 1927, Calif. Acad. Sci. Oc. Pprs. 13, p. 35, pl. 4, fig. 15.

This diatom which has angles so marked as to place it with *Triceratium* has also many affinities with the genus *Stictodiscus*. It is by no means rare in the Moreno Shale.

EXPLANATION OF PLATE 18

FIGS. *1*—*Monopsia mammosa* Grove and Sturt. Diam., .055 mm. (p. 109)
2—*Triceratium pruinosum* Long, Fuge and Smith, n. sp. Holotype, Length of base, .088 mm. (p. 114)
3—*Aulacodiscus morenoensis* Long, Fuge and Smith, n. sp. Holotype, Diam., .080 mm. (p. 98)
4, 5—*Trinacria deciusi* Hanna, var. *summaria* Long, Fuge and Smith, n. var. *4*, Holotype, Length of base, .055 mm.; *5*, Same specimen different focus. (p. 116)
6—*Coscinodiscus inordinatus* Long, Fuge and Smith, n. sp. Holotype, Diam., .060 mm. (p. 103)
7—*Triceratium album* Long, Fuge and Smith, n. sp. Holotype, Length of base, .1175 mm. (p. 112)
8—*Triceratium lustratum* Long, Fuge and Smith, n. sp. Holotype, Length of base, .068 mm. (p. 114)
9—*Triceratium cellulosum* Grove and Sturt, var. *californicum* Long, Fuge and Smith, n. var. Holotype, Length of base, .070 mm. (p. 113)
10—*Triceratium dignum* Long, Fuge and Smith, n. sp. Holotype, Length of base, .064 mm. (p. 113)
11—*Trinacria interlineata* Long, Fuge and Smith, n. sp. Holotype, Length of base, .070 mm. (p. 116)
12—*Tubularia pistillaris* Brun, var. *grossepunctata* Long, Fuge and Smith, n. var. Holotype, Length, .11 mm. (p. 116)
13—*Triceratium bellum* Long, Fuge and Smith, n. sp. Holotype, Length of base, .04 mm. (p. 113)
14—*Kentrodiscus blandus?* Long, Fuge and Smith, n. sp. Paratype, no. 3411*a*, Diam. .086 mm. (p. 107)
15—*Stictodiscus grossepunctatus* Long, Fuge and Smith, n. sp. Holotype, Length of base, .0725 mm. (p. 112)
16—*Hendeya dehiscens* Long, Fuge and Smith, n. g., n. sp. Holotype, Length, .10, width, .065 mm. (p. 107)

All specimens illustrated from Sec. 24, T. 14 S., R. 11 E., M.D.M., Fresno County, California.

TRICERATIUM LUNATUM Long, Fuge and Smith, n. sp.
Plate 16, figure 2

Shaped like a crescent moon, five days old. From the dorsal side to a small hyaline space near the vertical border run radial or sub radial rows of beads gradually decreasing in size. The angles slightly raised with a number of fine beads irregularly arranged. Length, .080 mm.

This form is closely related to *T. semicirculare* as figured by Brightwell (1853, p. 252) and Wolle (1890, pl. 105, figs. 2, 4) but in our specimen the bosses in the angles and the channels separating them from the central portion are very obscure or missing.

Holotype, No. 3433.

TRICERATIUM LUSTRATUM Long, Fuge and Smith, n. sp.
Plate 18, figure 8

Valve triangular with sides slightly concave, angles narrowly rounded and finely dotted; surface bright, bearing irregular puncta. Length across base, .068 mm.

Holotype, No. 3434.

TRICERATIUM PERPLEXUM Long, Fuge and Smith, n. sp.
Plate 17, figure 17

Valve irregularly pentagonal, one angle occupying each end of the base line; the other three angles approaching each other in the area of what would be the apex of a normal triangle. A small clear central space is surrounded by an irregular circle of small dots whence radiating lines of larger puncta proceed to the valve edge. In the specimen examined the dots on the processes do not correspond, those on the two lower processes being smaller than those of the three upper. Length, .070, width, .040 mm.

Several specimens of this diatom have been seen; otherwise, we might feel inclined to regard it an anomalous form.

Holotype, No. 3436.

TRICERATIUM PRUNINOSUM Long, Fuge and Smith, n. sp.
Plate 18, figure 2

Valve triangular with convex sides and angles produced into large rostrate-capitate protuberances. Radial rows of fine beads run from the angles to incomplete lines or furrows which mark off a central triangle; within this, slightly coarser rows of dots run radially to the center. Length of side, 088. mm.

This diatom is possibly out of place in the genus *Triceratium;* it shows affinities with *Hydrosera.* But having only this incomplete form to work with we are leaving it in *Triceratium* which contains many forms that will probably sometime be removed to other genera.

Holotype, No. 3435.

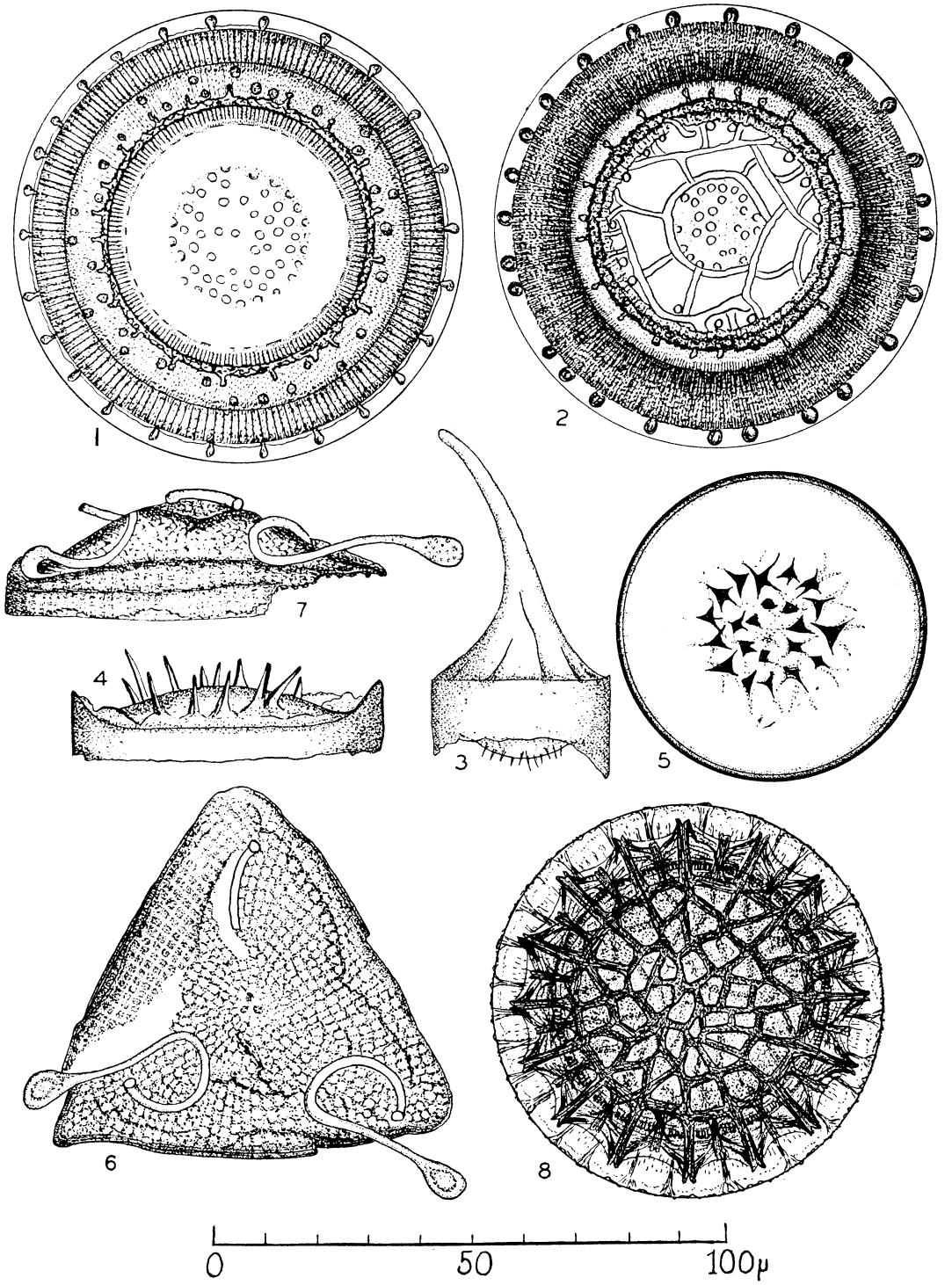
TRICERATIUM SWASTIKA Long, Fuge and Smith, n. sp.
Plate 17, figure 8

Valve triangular with deeply concave sides and arms twisted over at right angles with very protuberant bosses; center depressed, round, hyaline, and surrounded by concentric rows of pearls. Distance from angle to angle .05 mm.

Holotype, No. 3437.

PLATE 19

FIGS. *1—Podosira superba* Long, Fuge and Smith, n. sp. Holotype, Diam., .088 mm. (p. 110)
2—Podosira superba var. *reticulata*, Long, Fuge and Smith, n. var. Holotype, Diam., .088 mm. (p. 110)
3—Kentrodiscus blandus Long, Fuge and Smith, n. sp. Holotype, Diam., .035, length, .070 mm. (p. 107)
4, 5—Kentrodiscus blandus Long, Fuge and Smith, n. sp. Paratypes, Nos. 3410, 3411. Length, (fig. 4), .060 mm. Diam. (fig. 5), .060 mm. (p. 107)
6, 7—Kittonia hannai Lefébure and Chenevière. Specimen in the collection of Mr. H. Potter, Birmingham, England. (p. 108)
8—Stephanopyxis reticulata Long, Fuge and Smith, n. sp. Holotype, Diam., .0736 mm. (p. 111)
All specimens except figs. 6 and 7 from Sec. 24, T. 14 S., R. 11 E., M.D.M. Fresno County, California.



Long, Fuge and Smith—Cretaceous Diatoms

TRINACRIA ARIES Witt

Trinacria aries Schmidt, 1890, Atlas, Diat., pl. 150, figs. 14, 15.—Hanna, 1927, Calif. Acad. Sci. Oc. Pprs. 13, p. 36, pl. 5, figs. 1, 2.

This form is abundant in the Moreno formation.

TRINACRIA DECIUSI SUMMARIA Long, Fuge and Smith, n. var.
Plate 18, figures 4, 5

Valve triangular with sides concave, angles acutely rounded; central area nearly hexagonal, deeply depressed from the plane of the arms, and bounded by heavy dark lines; entire surface covered with closely set fine beads in rows which radiate out from the center; "spines" or horns at the angles apparently low and flat on top.

This form seems well characterized by the abundance and minuteness of the surface markings. The shape is almost identical to *T. deciusi* Hanna, but the two specimens of that species which have been illustrated bear very coarse beads, widely spaced. This group of diatoms is very abundant in the Moreno shale and it may well be that the present form is merely a finely sculptured variant of that which is usually seen.

Holotype, No. 3440.

TRINACRIA INSIPIENS Witt

Trinacria insipiens Witt, 1886, Verh. Russ. Kais. Min. Gesell. St. Petersburg, ser. 2, vol. 22, p. 172, pl. 10, fig. 1; pl. 11, figs. 5, 7, 11; pl. 12, fig. 2.—Schmidt, 1886, Atlas, Diat., pl. 97, fig. 16; 1886, pl. 110, figs. 11, 13; 1886, pl. 111, figs. 24, 25.—Hanna, 1927, Calif. Acad. Sci. Oc. Pprs. 13, p. 37, pl. 5, figs. 7, 8, 9.

By no means uncommon in some samples.

TRINACRIA INTERLINEATA Long, Fuge and Smith, n. sp.
Plate 18, figure 11

Valve triangular with slightly concave sides; angles pointed with triangular elongated processes. A small hyaline center is surrounded with radial lines of beads. Between this central area and the processes are elevated areas with beads irregularly placed. From the center, three prominent, narrow channels with dark borders run to the middle of the sides, and three similar, but less striking channels start near the center and run towards the angles. Length of side, .070 mm.

At first sight this form has a striking resemblance to *Lithodesmium margaritaceum* but close examination of valve and girdle views shows that the two are essentially different.

Holotype, No. 3438.

TRINACRIA MUCRONATA Schmidt

Trinacria mucronata Schmidt, 1886, Atlas, Diat., pl. 11, figs. 1, 2.—Hanna, 1927, Calif. Acad. Sci. Oc. Pprs. 13, p. 38, pl. 5, figs. 10.

Found in company with other species of the genus.

TRINACRIA NITESCENS Long, Fuge and Smith, n. sp.
Plate 17, figure 7

Valve triangular with sides slightly convex, and central portion somewhat raised; markings consist of coarse beads, closely placed near the margin, and more sparsely distributed towards the center; processes at angles, rounded and rather short. Length of side from angle to angle, .033 mm.

Holotype, No. 3439.

TUBULARIA PISTILLARIS GROSSEPUNCTATA Long, Fuge and Smith, n. var.
Plate 18, figure 12

This fragment, which is obviously a member of Brun's Genus *Tubularia* (1894, p. 88; Van Heurck, 1896, p. 337) appears only to differ from the figure in having considerably heavier puncta; we do not think a new species is called for but note the variety as above.

The occurrence of this rare form, hitherto apparently known only from Oamaru, is worthy of careful note.

A fragment only has been found, the length of which is .11 mm.

Holotype, No. 3441.

UPOTHEMA Long, Fuge and Smith, n. gen.

Valves consisting of two layers; the lower actinoptychoid in character, with alternate raised and depressed segments; the upper layer apparently superimposed, reaching neither to the center nor the border.

Genotype, *Upothema californica*, n. sp.

UPOTHEMA CALIFORNICA Long, Fuge and Smith, n. sp.
Plate 17, figure 20

This valve appears to consist of two distinct layers; the lower is actinoptychoid in character, having 22 sectors alternately raised and depressed. The raised sectors possess a distinct clear line radiating from the center to the circumference and bearing a small process at the termination. The lower sectors end in a large subtriangular clear space the base of which is on the border and almost coincident in breadth with the termination of the sector. This space also bears a nodule or process; the upper layer consists of a superimposed ring whose inner circumference is a third of the diameter from the center, and from which proceed eleven starfish-shaped arms, which terminate well within the body of the valve at the apex of the triangular spaces already referred to. The markings consist of puncta arranged on the sectors in a pinnate manner in reference to the pseudoraphe and the starfish arms. Diameter, .0375 mm.

Only one valve has been noted.

Holotype, No. 3442.

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