Bulletin No. 268 Series C, Systematic Geology and Paleontclogy, 75

DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

MIOCENE FORAMINIFERA FROM THE MONTEREY SHALE OF CALIFORNIA

WITH A

FEW SPECIES FROM THE TEJON FORMATION

BY

RUFUS M. BAGG, Jr.

WASHINGTON
GOVERNMENT PRINTING OFFICE
1905

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LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
Washington, D. C., May 12, 1905.

SIR: I transmit herewith the manuscript of a report on "Miocene Foraminifera from the Monterey Shale of California, with a Few Species from the Tejon Formation," by Dr. Rufus M. Bagg, jr., with an introduction by Prof. J. C. Branner, and recommend that it be published as a bulletin of the Survey.

Very respectfully,

C. W. HAYES,
Geologist in Charge of Geology.

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.

MIOCENE FORAMINIFERA FROM THE MONTEREY SHALE, CALIFORNIA, WITH A FEW SPECIES FROM THE TEJON FORMATION.

By Rufus M. Bagg, Jr.

GEOLOGY.

By J. C. Branner.

The Miocene Foraminifera described in this bulletin were collected by me from the Monterey shale, on the Rancho del Encinal, near Asuncion station, in San Luis Obispo County, Cal. The exposure from which the material was taken is in the bed of Graves Creek, about 500 feet south of J. H. Henry's ranch house, and 7,000 feet nearly due south of Asuncion station, on the coast division of the Southern Pacific Railway. The same, or similar, fossiliferous beds are exposed at many places in the hills and gulches northwest of Mr. Henry's house.

The accompanying map and section on the line A–B (figs. 1 and 2) show the general geology of the neighborhood well enough for present purposes.

The Monterey shale is between 2,000 and 2,500 feet thick here, and forms one broad fold, though there are many small faults that are not indicated on the section, and considerable variations in the direction and amount of the dips. In places the beds are much wrinkled. The shale series is not uniform throughout, but contains layers that are more or less sandy. On Graves Creek, between its mouth and the ranch house, there are several exposures of a bed of coarse sandstone interbedded with the shale that is at least 10 feet thick. The shale proper also varies; at some places it is flinty, at others it is somewhat sandy, and at still others it is soft and chocolate-colored, and contains an abundance of well-preserved Foraminifera. At one place, about 1,500 feet below the ranch house, I found in the creek bed an undetermined vertebrate fossil about 4 feet long. This is the only fossil observed in these rocks beside the Foraminifera and diatoms. The bulk of this shale is made of diatom skeletons. In some places the rocks are soft and powdery enough to be used for polishing powder. In color the shale varies from white through cream colored and gray

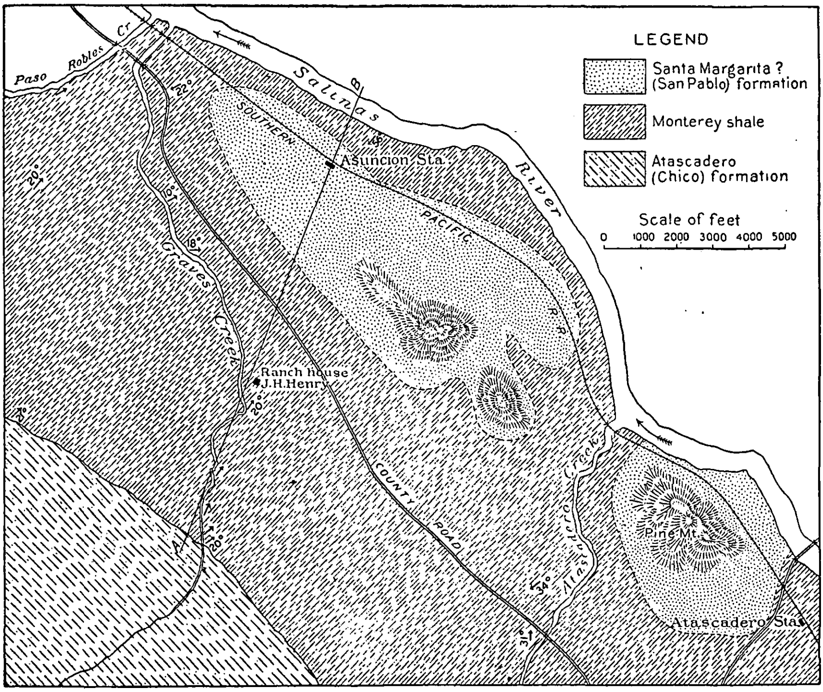

FIG. 1.—Geologic sketch map of a portion of San Luis Obispo County, Cal.

to amber colored and black. Even when the rocks are flinty they often contain good impressions of Foraminifera.

The Monterey shale is exposed at many places along Atascadero Creek, and nearly everywhere in this vicinity it contains Foraminif-

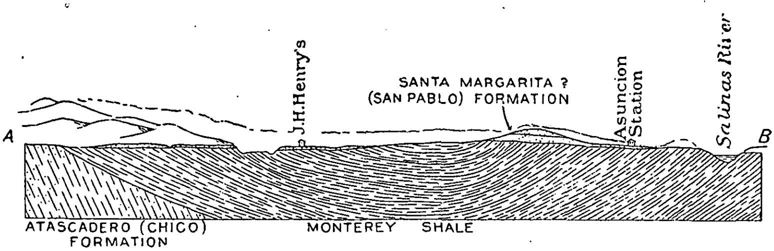

FIG. 2.—Section along line A–B in fig. 1, showing general structure.

era, though most of the rocks are too hard to allow them to be taken out.

It is of interest to note that nearly all of the Monterey shale in this neighborhood contains a notable amount of hydrocarbon—enough, at least, to cause it to burn with a flame when placed in a hot fire. I have had the hydrocarbons determined in two typical samples of the shale.

SANDSTONE INTRUSION IN MONTEREY SHALE ON GRAVES CREEK, 1,000 FEET SOUTH OF J. H. HENRY'S RANCH HOUSE.

One kind—the hard, amber-colored chert from Atascadero Creek and from just south of Havel station on the railway—yielded 12.8 ounces of oil to the ton of rock. The chocolate-colored, soft shale that contains so many Foraminifera was found to contain 102.4 ounces, or about 0.86 gallon of oil, to the ton of rock. The specimens examined in both cases came from the surface, and it is quite possible that under cover the rocks contain a little more oil.

A matter of considerable interest in connection with this shale is that it is traversed at several places along Graves Creek above the ranch house by sandstone intrusions or dikes that appear to have come from below. (See Pl. I.) They vary in thickness from less than an inch to several feet. These dikes are described by Prof. J. F. Newsom in the Bulletin of the Geological Society of America, vol. 14, page 227.

The Monterey shale in this region rests upon a series of snuff-colored sandstones which a little farther south, in the San Luis Obispo quadrangle, are referred by Fairbanks to the Atascadero (Chico). It is overlain by a series of coarse sands and gravels that form the low hills lying between Mr. Henry's ranch house and Asuncion station, and forming also Pine Ridge, the hill just west of Atascadero station. These overlying beds are regarded by Doctor Fairbanks as Santa Margarita (San Pablo), or upper Miocene. I am inclined to believe that they are Pliocene. Their age is of no especial importance in the present discussion, however, further than that they are clearly not a part of the Monterey shale.

GENERAL RELATIONS.

The writer's study of the fossils of the Miocene clay marl of Graves Creek, San Luis Obispo County, Cal., collected by Prof. J. C. Branner, has yielded an interesting fauna of sixty-six species, including a few varieties, and seventeen genera. These genera are *Bulimina*, *Bolivina*, *Lagena*, *Nodosaria*, *Cristellaria*, *Uvigerina*, *Sagrina*, *Globigerina*, *Orbulina*, *Pullenia*, *Discorbina*, *Truncatulina*, *Anomalina*, *Pulvinulina*, *Rotalia*, *Nonionina*, and *Polystomella*.

A glance at the list (pp. 13–15) reveals the absence of arenaceous genera and species, of warm-water Miliolidæ, the presence of but one member of the Nummulitic group, and the large number of rotaline types. The absence of the arenaceous genera undoubtedly shows the purity of the waters in oceanic circulation during the Miocene, and this evidence is still further substantiated by the fine argillaceous and silt character of the deposit in which the Foraminifera are deposited. The Foraminifera, in fact, constitute a large portion of the entire mass of the marl itself, while sand and coarse pebbles are practically absent. Only in one instance was a pebble detected in the material washed. This pebble is upward of half an inch in diameter and is composed of dark flinty quartz. The majority of the mass in which the fossils are embedded is rich in aluminum and occasionally there are calcareous nodules and irregular-shaped fragments which when dissolved in hydrochloric acid leave a small deposit highly aluminous. No phosphates were detected in these calcareous masses.

The majority of forms identified are present in abundance to-day in the North Atlantic Ocean (see list, pp. 13–15), and the writer is confident that the conditions there to-day represent pretty well the oceanic temperatures and depths at which the California beds were laid down. These fossils were presumably deposited in waters the depth of which was less than 500 fathoms. Forms like *Globigerina bulloides* and *Orbulina universa* are, of course, surface types and are untrustworthy guides when the fauna as a whole is considered. The relative abundance of forms of any one species is an important indication of the conditions under which a given formation was laid down. The occurrence in relative abundance of forms found only in shallow waters, such as *Bolivina ænariensis*, *Bolivina textilarioides*, *Bulimina elegantissima*, *Discorbina allomorphinioides*, *Nodosaria filiformis*, *Pulvinulina auricula*, and *Uvigerina tenuistriata*, afford ample evidence that the entire fauna was deposited in shoal waters.

The fauna as a whole is remarkably similar to that of the older Pliocene beds of Monte Bartolomeo described by Egger in 1895.[a] This fact has already been pointed out by Chapman in his report on the California Foraminifera.[b] The foraminiferal contents of the Miocene beds examined by the writer and described in the Bulletin of American Paleontology[c] have only a general resemblance to the fossils under discussion and are not as closely related as those of the middle Tertiary beds in Europe.

The foraminiferal shells in this gray-brown marl are peculiar in that their chambers are rarely filled with the exogenous matter composing the matrix in which they are deposited. They will therefore float readily on water, which is of assistance in separating them from the matrix. This fact is also of importance as indicating the rapidity with which the Miocene beds were deposited, since in nearly all cases of fossil Foraminifera with which the writer is familiar the shells are filled more or less completely with the material in which they are embedded.

The only report on the California Miocene of which the author has any knowledge is one by Mr. Frederick Chapman, entitled "Foraminifera from the Tertiary of California," published in the Proceedings of the California Academy of Sciences, 3d series, vol. 1, No. 8, 1900 (San Francisco). Of the species identified and described in this report

[a] Fossile Foraminiferen von Monte Bartolomeo am Gardasee: Jahrsber. Naturhist. Ver. Passau, vol. 16, 1895.

[b] Foraminifera from the Tertiary of California: Proc. California Acad. Sci., ser. 3, vol. 1, No. 8, 1900.

[c] Tertiary and Pleistocene Foraminifera of the middle Atlantic slope: Bull. American Paleont., vol. 2, No. 10.

by Mr. Chapman, many were found also in the material investigated by myself, and in addition many new forms were recognized. The new Cristellarian described by Chapman under the name of *Cristellaria miocenica* was not recognized although Mr. Chapman found the fossil in abundance in his material. Mr. Chapman's material is described as a close-textured, gray-brown marl from the Tertiary marl of California marked "Miocene?" and a second specimen was from a well boring in Santa Clara County similar to the first, somewhat paler, and rather shaly. The matrix when seen in thin section Chapman describes as consisting of basaltic or palagonitic material crowded with hollow-chambered Foraminifera. From this description it appears probable that Mr. Chapman's specimens were from the same formation as the material examined by the author of this report.

Before describing the species it is perhaps best to state that the references and synonyms given under each species are not complete, only the more important and accessible references being included and in every case the original description being placed first.

Again, in one or two reports the author has been obliged to use the paging given in reprints, especially in the report of Johann Egger, previously referred to, and he does not feel positive that the pages given will correspond with what may be later found in the bound volumes, of which these abstracts are a part. The plate numbers and figures and other reference matter should be found without error.

Table showing limits of depth of existing representatives of the fossil Foraminifera found in the Miocene of California.

Name.	Depth.	Chief locality.
Anomalina ammonoides	To 1,350 fathoms	South Pacific.
Anomalina ariminensis	150 to 2,200 fathoms	North Atlantic.
Anomalina grosserugosa	345 to 2,160 fathoms	North and South Atlantic.
Anomalina rotula	Not known outside Tertiary.	
Bolivina ænariensis	Shallow waters	North Atlantic.
Bolivina dilatata	To 1,180 fathoms	Do.
Bolivina dilatata var. angusta.	do	Do.
Bolivina punctata	All depths	All oceans.
Bolivina punctata var. substriata.	do	Do.
Bolivina textilarioides	Shoal waters	Wide area.
Bulimina affinis	Deep, one Cuba	North Pacific.
Bulimina buchiana	Fairly deep water	North Atlantic.
Bulimina elegans	Depths not known	Wide range.
Bulimina elegantissima	Very shoal water	Do.
Bulimina elongata	630 North Atlantic, 1,425 South Atlantic.	North and South Atlantic.

Table showing limits of depth of existing representatives of the fossil Foraminifera found in the Miocene of California—Continued.

Name.	Depth.	Chief locality.
Bulimina ovata	South Atlantic, 2,200; South Pacific, 15 to 580; North Atlantic, shallow to 1,400.	
Bulimina pupoides	Shoal to 100 fathoms	Wide area.
Cristellaria articulata	Less than 400	
Cristellaria cassis	Shallow water	Adriatic and Mediterranean.
Cristellaria crepidula	Shoal water, one example, 2,350 fathoms.	Wide.
Cristellaria crepidula var. gladius.	Found in Tejon formation.	
Cristellaria gerlandi	Miocene only	
Cristellaria gibba	Less than 500 fathoms	Rare to-day.
Cristellaria rotulata	To 2,000 fathoms	All oceans.
Discorbina allomorphinoides	10 to 155 fathoms	Three localities only.
Globigerina bilobata	Bottom ooze, various depths	Wide range.
Globigerina bulloides	All depths	Universal area.
Globigerina cretacea	Fossil	
Globigerina dubia	Bottom ooze	Very limited distribution to-day.
Lagena apiculata	All depths to 3,000 fathoms	Every latitude.
Lagena globosa	All depths	All oceans.
Lagena gracilis	Usually shallow water, rarely to 2,775.	Wide area.
Lagena marginata	All depths to 3,125 fathoms	All latitudes.
Lagena sulcata	To 2,750 fathoms typically shoal water.	Wide range.
Nodosaria adolphina	Doubtfully recent	
Nodosaria communis	All depths	Every latitude.
Nodosaria consobrina	129 to 1,375, mostly moderate.	South Atlantic and South Pacific.
Nodosaria consobrina var. emaciata.	do	Do.
Nodosaria farcimen	All depths	Every ocean.
Nodosaria filiformis	To 500 fathoms	Not widely distributed.
Nodosaria obliqua	To 200 fathoms	Every ocean.
Nodosaria pauperata	All depths	Do.
Nodosaria radicula	Shore waters to 2,350 fathoms.	Not in North Pacific.
Nodosaria roemeri	Less than 400 fathoms	Mostly in North Atlantic.
Nodosaria soluta	125 to 1,360 fathoms	North and South Atlantic and South Pacific.
Nonionina boueana	Few to 200 fathoms	Only few places now, North Atlantic.

Table showing limits of depth of existing representatives of the fossil Foraminifera found in the Miocene of California—Continued.

Name.	Depth.	Chief locality.
Nonionina communis	Presumably fossil only	
Nonionina pompilioides	Deep water only, 1,000 to 3,000 fathoms.	Southern and northern oceans.
Nonionina umbilicatula	30 to 3,125 fathoms	Widely distributed.
Orbulina universa	All depths	Every ocean.
Polystomella crispa	To 355 fathoms	Arctic and tropical waters.
Pullenia sphæroides	To 3,000 fathoms	All oceans.
Pulvinulina auricula	Shoal waters in North Atlantic known to 500 fathoms.	
Pulvinulina brongniartii		Adriatic only so far as known.
Rotalia beccarii		Inhabits margins of all great oceans.
Rotalia soldanii	Deep waters never less than 300 fathoms.	Wide area.
Sagrina branneri	Miocene only	
Sagrina californiensis	do	
Sagrina elongata	do	
Truncatulina lobatula	Every ocean	All depths.
Truncatulina pygmæa	Deep water	Considered rare.
Truncatulina variabilis	Shallow water (only one example, 2,000 fathoms).	Wide area.
Truncatulina wuellerstorfi	200 to 2,000 fathoms	Do.
Uvigerina canariensis	Shore sands to 1,900 fathoms.	South Pacific and South Atlantic, etc.
Uvigerina pygmæa	2 to 2,500 fathoms	North Atlantic, common; universal also.
Uvigerina tenuistriata	Shallow waters	Many localities.

LIST OF SPECIES DESCRIBED (SYSTEMATICALLY ARRANGED).

Family TEXTULARIDÆ.

Subfamily BULIMINÆ.

Bulimina affinis d'Orbigny.
  buchiana d'Orbigny.
  elegans d'Orbigny.
  elegantissima d'Orbigny.
  elongata d'Orbigny.
  ovata d'Orbigny.
  pupoides d'Orbigny.

DIMORPHOUS FORM.

Bolivina ænariensis (Costa).
dilatata Reuss.
dilatata var. angusta Egger.
punctata d'Orbigny.
punctata var. substriata Egger.
textilarioides Reuss.

Family LAGENIDÆ.

Subfamily LAGENINÆ.

Lagena apiculata Reuss.
globosa (Montagu).
gracilis Williamson.
marginata (Walker and Boys).
sulcata (Walker and Jacob).

Subfamily NODOSARINÆ.

Nodosaria adolphina d'Orbigny.
communis (d'Orbigny).
consobrina d'Orbigny.
consobrina var. emaciata Reuss.
farcimen (Soldani).
filiformis (d'Orbigny).
obliqua (Linné).
pauperata (d'Orbigny).
radicula (Linné).
roemeri (Neugeboren).
soluta (Reuss).
Cristellaria articulata (Reuss).
cassis (Fichtel and Moll).
crepidula (Fichtel and Moll).
crepidula var. gladius Philippi.
(Robulina) gerlandi Andreae.
gibba d'Orbigny.
rotulata (Lamarck).

Subfamily POLYMORPHINÆ.

DIMORPHOUS FORM.

Uvigerina canariensis d'Orbigny.
pygmæa d'Orbigny.
tenuistriata Reuss.
Sagrina branneri Bagg.
californiensis Bagg.
elongata Bagg.

Family GLOBIGERINIDÆ.

Globigerina bilobata d'Orbigny.
bulloides d'Orbigny.
cretacea d'Orbigny.
dubia Egger.
Orbulina universa d'Orbigny.
Pullenia sphæroides (d'Orbigny).

Family ROTALIDÆ.

Subfamily Rotalinæ.

Discorbina allomorphinoides (Reuss).
Truncatulina lobatula (Walker and Jacob).
  pygmæa Hantken.
  variabilis d'Orbigny.
  wuellerstorfi (Schwager).
Anomalina ammonoides (Reuss).
  ariminensis (d'Orbigny).
  grosserugosa (Gümbel).
  rotula d'Orbigny.
Pulvinulina auricula (Fichtel and Moll).
  brongniartii (d'Orbigny).
Rotalia beccarii (Linné).
  soldanii (d'Orbigny.)

Family NUMMULINIDÆ.

Subfamily Polystomellinæ.

Nonionina boueana d'Orbigny.
  communis d'Orbigny.
  pompilioides (Fichtel and Moll).
  umbilicatula (Montagu).
Polystomella crispa (Linné).

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CHAPMAN, FREDERICK. Foraminifera from the Tertiary of California. Proc. California Acad. Sci., ser. 3, vol. 1, No. 8, pp. 241-260, pls. xix, xxx. 1900. San Francisco.

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PARKER, W. K., and JONES, T. R. On some Foraminifera from the North Atlantic and Arctic oceans, etc. Philos. Trans., vol. 155, pp. 325-441, pls. xii-xix. 1865. London.

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N. B.—Only the more important reports are given in this bibliographic list. A fuller account of American papers in which reference to Foraminifera is made is found in the author's preceding papers referred to in the above list.

DESCRIPTIONS OF THE SPECIES.

Family TEXTULARIDÆ.

Subfamily BULIMINÆ.

Genus BULIMINA d'Orbigny (1826).

BULIMINA AFFINIS d'Orbigny.

Pl. II, fig. 1

Bulimina affinis d'Orbigny, 1839, De la Sagra, Hist. Physiq., etc., de Cuba, Foraminifères, p. 105, pl. ii, figs. 25, 26.
Bulimina ovulum Reuss, 1850, Haidinger's Naturw. Abhandl., vol. 4, p. 38, pl. iv, fig. 9.
Bulimina affinis Brady, 1884, Challenger Report, vol. 9, pp. 400, 401, pl. l, figs. 14a, b.
Bulimina affinis Sherborn and Chapman, 1886, Jour. Roy. Microsc. Soc., ser. 2, vol. 6, p. 743, pl. xvi, fig. 1.
Bulimina affinis Egger, 1895, Jahrsber. Naturhist. Ver. Passau, vol. 16, pp. 14, 15, pl. iv, figs. 4, 5.
Bulimina affinis Chapman, 1900, Proc. California Acad. Sci., ser. 3, vol. 1, No. 8, p. 244, pl. xxix, fig. 4.

Bulimina affinis in its ovate character and few chambers resembles *B. ovata* d'Orbigny and *B. pupoides* d'Orbigny. The arrangement of chambers in *B. affinis* is, however, more tapering at the distal end, while *B. pupoides* has shorter segments. The species occurs frequently in the California Miocene. Its geological range is very extensive, as it is found in the lower Greensand of the English Cretaceous. At the present time it is found in the North Pacific and west of Patagonia. D'Orbigny's single specimen came from the shore sands of Cuba.

BULIMINA BUCHIANA d'Orbigny.

Pl. II, fig. 2.

Bulimina buchiana d'Orbigny, 1846, Foram. Foss. Vienne, p. 186, pl. xi, figs. 15–18.
Bulimina buchiana Carpenter, Parker, and Jones, 1862, Introd. Study Foram., pl. xii, fig. 19.
Bulimina buchiana Brady, 1884, Challenger Report, vol. 9, pp. 407, 408, pl. li, figs. 18, 19.
Bulimina buchiana Bagg, 1898, Bull. American Paleont., vol. 11, No. 10, pp. 315, 316, pl. xxii (2), fig. 4.
Bulimina buchiana Chapman, 1900, Proc. California Acad. Sci., ser. 3, vol. 1, No. 8, pp. 244, 245, pl. xxix, fig. 5.

Test short and stout, triserial, tapering; posterior end acutely rounded, anterior, obtuse; segments distinct, slightly inflated; surface of shell marked by definite longitudinal costæ, which extend with varying lengths two-thirds or less upward from initial chamber. In typical forms these reach to within one-third the end of the final segment.

The length and size of this species are variable, but the stoutly built form and surface decoration serve to identify it. Sometimes, as in the California specimens, the striæ are so delicate as only to be visible in reflected light, while again, as in the specimens the author found in well borings at Norfolk, Va., they are large, deep, and remarkably sharp.

The geological range of the species is from Eocene to Recent.

Prof. H. B. Brady remarks that this species inhabits fairly deep water, and further adds that while it is abundant in the North Atlantic it has not been found in the North Pacific. He considers that *Bulimina inflata* and *Bulimina rostrata* are closely related to the present species. Compared with the present form, *Bulimina inflata* is of similar size, but the costæ are short and are extended beyond the margin of the chambers in the form of spines; *Bulimina rostrata* is smaller, has indistinct segmentation, and the costæ cover the entire shell.

BULIMINA ELEGANS d'Orbigny.

Pl. II, fig. 3.

Bulimina elegans d'Orbigny, 1826, Annales Sciences Naturelles, vol. 7, p. 270, No. 10, Modèle No. 9.

Bulimina elegans Parker, Jones, and Brady, 1865, Ann. Mag. Nat. Hist., ser. 3, vol. 16, p. 20, pl. ii, fig. 64.

Bulimina elegans Brady, 1884, Challenger Report, vol. 9, p. 398, pl. 1, figs. 1-4.

Bulimina elegans Jones, 1895, Mon. Foram. Crag, pt. 2 (Pal. Soc.), pp. 162, 163, woodcut, fig. 17.

Bulimina elegans Woodward, 1898, Jour. New York Microsc. Soc., pp. 1, 3.

Bulimina elegans Chapman, 1900, Proc. California Acad. Sci., ser. 3, vol. 1, No. 8, p. 244, pl. xxix, fig. 3.

Test small, with rapidly expanding triserial chambers, which are globose, with deep depressions between each. Professor Brady considered this form as a central type of a somewhat numerous group of recent Buliminæ.

The geological range of the species is from Upper Cretaceous to Recent.

Mr. Chapman describes it from the upper Chalk, Egger from the older Pliocene, T. Rupert Jones from the Pliocene of England, and Woodward from the Miocene of New Jersey and Alabama. The species is common in the California Miocene material.

Bulimina elegantissima d'Orbigny.

Pl. II, fig. 4.

Bulimina elegantissima d'Orbigny, 1839, Foram. Amérique Mérid., p. 51, pl. vii, figs. 13, 14.
Bulimina elegantissima Williamson, 1858, Recent Foram. Great Britain, p. 64, pl. v, figs. 134, 135.
Bulimina pulchra Terquem, 1882, Mém. Soc. Géol. France, sér. 3, vol. 2, mém. 3, p. 114, pl. xii, figs. 8–12.
Bulimina elegantissima Brady, 1884, Challenger Report, vol. 9, pp. 402, 403, pl. l, figs. 20–22.
Bulimina elegantissima Woodward, 1898, Jour. New York Microsc. Soc., p. 3.
Bulimina elegantissima Chapman, 1900, Proc. California Acad. Sci., ser. 3, vol. 1, No. 8, p. 243, pl. xxix, fig. 2.

"The test of *Bulimina elegantissima*, as portrayed by d'Orbigny, is distinctly and regularly spiral. It consists of from two to three convolutions, the last of which occupies more than three-fourths of the visible shell. The chambers number from seven to ten in the final whorl; they are long in the direction of the axis of the test, narrow and obliquely set, and the sutures are only slightly excavated."[a]

The California forms which belong under this species are smaller than some of the other Buliminæ associated with it, and their chambers are not so definitely arranged in triserial oblique spire as in the more typical forms. The species is not uncommon, and Chapman states that it is frequent in the Miocene of Santa Clara County, Cal.

As a fossil it is first recorded from the Eocene of the Isle of Wight (Brady), in the Eocene of Paris (Terquem), and in the post-Tertiary clays of Norway. It is found at very shallow depths in existing oceans.

Bulimina elongata d'Orbigny.

Pl. II, fig. 5.

Bulimina elongata d'Orbigny, 1826, Annales Sciences Naturelles, vol. 7, p. 269, No. 9.
Bulimina elongata d'Orbigny, 1846, Foram. Foss. Vienne, p. 187, pl. xi, figs. 19, 20.
Bulimina eocena Hantken, 1872, Jahr. K. ungar. geol. Anstalt, vol. 1, p. 136, pl. ii, fig. 16.
Bulimina elongata Hantken, 1875 (1876), A magy. kir. foldt. int. evkonyve, vol. 4, p. 52, pl. x, fig. 7.
Bulimina elongata Brady, 1884, Challenger Report, vol. 9, pp. 401, 402, pl. li, figs. 1 (and 2?).
Bulimina elongata Woodward, 1898, Jour. New York Microsc. Soc., p. 1.
Bulimina elongata Bagg, 1898, Bull. American Paleont., vol. 2, No. 10, p. 316.
Bulimina elongata Chapman, 1900, Proc. California Acad. Sci., ser. 3, vol. 1, No. 8, p. 243, pl. xxix, fig. 1.

The test of *Bulimina elongata* is, as its name implies, much attenuated, though it tapers but slightly from end to end. The segments are

[a] Brady, Challenger Report, vol. 9, 1884, p. 402.

short, oval, and somewhat irregularly arranged with lobulated margins, not smooth as in *B. imbricata* Reuss, which it somewhat resembles. The primordial end is sharply, the anterior obtusely, rounded, with numerous chambers of irregular size separated by depressed septa. The ultimate chamber is provided on its lower surface with a comma-shaped aperture.

This is a very common form in the California Miocene. As a fossil its earliest appearance is in the lower Tertiary. Brady mentions the species at depths of 630 fathoms in the North Atlantic and of 1,425 fathoms in the South Atlantic.

Bulimina ovata d'Orbigny.

Pl. III, fig. 1.

Bulimina ovata d'Orbigny, 1846, Foram. Foss. Vienne, p. 185, pl. xi, figs. 13, 14.
Bulimina pedunculata Costa, 1856, Atti Accad. Pontaniana, vol. 7, p. 334, pl. xviii, fig. 13.
Bulimina ovata Parker and Jones, 1865, Philos. Trans., vol. 155, p. 374, pl. xvii, fig. 67a, 67b.
Bulimina ovata Brady, 1884, Challenger Report, vol. 9, p. 400, pl. 1, fig. 13a, b.
Bulimina ovata Egger, 1895, Jahrsber. Naturhist. Ver. Passau, vol. 16, p. 15, pl. iii, fig. 11a, b.

The test is characterized by its oval outline. From the cylindrical center the shell tapers rapidly at each end and these are rounded, not pointed as in *Bulimina affinis*. This species is less frequent than *B. affinis*, which it closely resembles. Its geological distribution begins with the Eocene and it is common in shore sands of the British Isles. In the North Atlantic it occurs at various depths down to 1,400 fathoms. In the South Atlantic, Brady records its occurrence as deep as 2,200 fathoms and in the South Pacific at from 15 to 580 fathoms.

Bulimina pupoides d'Orbigny.

Pl. III, fig. 2.

Bulimina pupoides d'Orbigny, 1846, Foram. Foss. Vienne, p. 185, pl. xi, figs. 11, 12.
Bulimina pupoides Williamson, 1858, Recent Foram. Great Britain, p. 62, pl. v, figs. 124, 125.
Bulimina pupoides Terrigi, 1880, Atti Accad. Pontificia Nuovi Lincei, vol. 33, p. 193, pl. ii, figs. 30-34.
Bulimina pupoides Brady, 1884, Challenger Report, vol. 9, pp. 400, 401, pl. 1, fig. 15a, b.
Bulimina pupoides Egger, 1895, Jahrsber. Naturhist. Ver. Passau, vol. 16, p. 14, pl. iv, figs. 6a, 6b, 7, 8.

Test composed of rapidly enlarging oval segments arranged spirally and with depressed septal lines between each. The initial chamber is not as sharp and the termination is less acute than in *Bulimina affinis*, which it closely resembles. It is not so regularly built as *Bulimina ovata* and the segments are more distinct and separate. The three forms are so nearly related that it is difficult to decide with certainty into which division the specimens should be placed. It would have been wise to have made these forms varieties of one species, but they have been held as distinct so long and by so many authors that it seems best to keep them as species still. This form is rare as compared with other types in the California Miocene. The species has a length of 0.25 mm. Geologically the species has the same range as its relatives, but Woodward and Thomas report it in the Cretaceous of Minnesota. The shallow-water deposits of many oceans yield specimens of *Bulimina pupoides*, and it ranges from shoal depths down to 1,000 fathoms.

Genus BOLIVINA d'Orbigny (1839).

BOLIVINA ÆNARIENSIS (Costa).

Pl. III, fig. 3.

Brizalina ænariensis Costa, 1856, Atti Accad. Pontaniana, vol. 7, p. 297, pl. xv, fig. 1, A, B.

Bolivina ænariensis Brady, 1884, Challenger Report, vol. 9, p. 423, pl. liii, figs. 10, 11.

Bolivina ænariensis Jones, 1895, Mon. Foram. Crag (Pal. Soc.), pt. 2, pp. 169, 170, pl. vi, fig. 21.

Bolivina ænariensis Chapman, 1900, Proc. California Acad. Sci., ser. 3, vol. 1, No. 8, p. 246, pl. xxix, fig. 8.

The genus *Bolivina* is one of the most common types found in the California Miocene and it is represented by many species. The form described by Costa under the term *Brizalina* has a fairly regular outline, elongated, tapering, and having the surface marked by lines which resemble delicate costæ, but which are said to be due to two tubular internal siphons. The striæ in the California specimens run about two-thirds up and are very delicate and not easily discernible. The presence of striations, the sharp peripheral margin, and the elongated flattened outline afford means of identifying this shallow-water species.

At the present time the best specimens, according to Prof. H. B. Brady, come from the North Atlantic, but the species is found northwest of Ireland, in the Faroe Channel, near the Philippine Islands, on the south coast of Japan, and at the mouth of the Rio de la Plata. Mr. Chapman's specimens were from a well in Santa Clara County, Cal. Costa's specimens were from the Tertiary beds of Casamicciola, Ischia.

The geological range is from the Miocene to Recent, but the form is more abundant in the middle and late Tertiary.

BOLIVINA DILATATA Reuss.

Pl. III, fig. 4.

Bolivina dilatata Reuss, 1849, Denkschr. K. Akad. Wiss. Wien, vol. 1, p. 381, pl. xlviii, fig. 15.

Bolivina dilatata Terrigi, 1880, Atti Accad. Pontificia Nuovi Lincei, vol. 33, p. 197, pl. ii, fig. 42.

Bolivina dilatata Brady, 1884, Challenger Report, vol. 9, p. 418, pl. lii, figs. 20, 21.
Bolivina dilatata Egger, 1895, Jahrsber. Naturhist. Ver. Passau, vol. 16, pp. 10, 11, pl. i, figs. 6a–c.
Bolivina dilatata Chapman, 1900, Proc. California Acad. Sci., ser. 3, vol. 1, No. 8, p. 245, pl. xxix, fig. 6.

The test of *Bolivina dilatata* is broadly expanded at its final segment, and the long rather narrow intermediate chambers taper rapidly to the initial chamber. The lateral margins terminate acutely, and the form varies considerably in size, length, and amount of expansion, but the fossil specimens so abundant in the California Miocene are typical.

As a fossil *Bolivina dilatata* first appears in the Miocene, and is living to-day at various stations in the North Atlantic Ocean. It occurs in dredgings from a few to 1,180 fathoms.

Bolivina dilatata var. angusta Egger.

Pl. III, fig. 5.

Bolivina dilatata var. *angusta* Egger, 1895, Jahrsber. Naturhist. Ver. Passau, vol. 16, p. 11, pl. i, figs. 7, 12a, b.
Bolivina dilatata var. *angusta* Chapman, 1900, Proc. California Acad. Sci., ser. 3, vol. 1, No. 8, p. 245, pl. xxix, fig. 7.

The variety of *Bolivina dilatata* figured by Egger under the name *angusta* differs from the type only in the unimportant features of a longer, more tapering test, an increased number of lateral chambers, and more acute ending of the distal chamber. Egger's forms were from the Pliocene of Monte Bartolomeo. The variety is a little less frequent than the type in the California Miocene.

Bolivina punctata d'Orbigny.

Pl. III, fig. 6.

Bolivina punctata d'Orbigny, 1839, Foram. Amérique Mérid., p. 63, pl. viii, figs. 10–12.
Bolivina antiqua d'Orbigny, 1846, Foram. Foss. Vienne, p. 240, pl. xiv, figs. 11–13.
Bolivina punctata Macdonald, 1857, Ann. Mag. Nat. Hist., ser. 2, vol. 20, p. 193, pl. vi, figs. 26, 27.
Bolivina punctata Brady, 1884, Challenger Report, vol. 9, p. 417, pl. lii, figs. 18, 19.
Bolivina punctata Woodward and Thomas, 1884 (1885), Thirteenth Ann. Rept. Geol. Nat. Hist. Survey Minnesota, p. 169, pl. iii, fig. 12.
Bolivina punctata Bagg, 1898, Bull. U. S. Geol. Survey No. 88, p. 33, pl. ii, fig. 3.

The test of *Bolivina punctata* is typically represented by an elongated textulariform arrangement of short chambers and the segments are more numerous than in most of the *Bolivina* forms. The term *Bolivina antiqua* has been used by d'Orbigny, Bronn, Costa, Egger, Terrigi, and perhaps others for this same species, but it seems best to the writer to regard *B. antiqua* as a synonym of the earlier name given by d'Orbigny. The specimen d'Orbigny described as *B. antiqua* is undoubtedly only a modification of *B. punctata*, and there is no good ground for separating the two even under varieties.

This species is from the Tertiary to the Recent. It occurs to-day in all oceans and at all possible depths.

BOLIVINA PUNCTATA var. SUBSTRIATA Egger.

Pl. III, fig. 7.

Bolivina punctata var. *substriata* Egger, 1893, Abhandl. K. bayer. Akad. Wiss., p. 298, pl. viii, figs. 4–6.

Bolivina punctata var. *substriata* Egger, 1895, Jahrsber. Naturhist. Ver. Passau, vol. 16, p. 11, pl. i, fig. 14, a, b.

The form figured by Egger as a variety of *B. punctata* differs from the type by the presence of a number of striations which run from the primordial chamber for about one-half the distance of the entire shell. The forms from California are more slender than *B. punctata* and are less abundant. The geological range is similar to that of *B. punctata*.

BOLIVINA TEXTILARIOIDES Reuss.

Pl. IV, fig. 1.

Bolivina textilarioides Reuss, 1862, Sitzungsber. K. Akad. Wiss. Wien, vol. 46, p. 81, pl. x, fig. 1.

Bolivina textilarioides (*textularioides*) Berthelin, 1880, Mém. Soc. Géol. France, sér. 3, vol. 1, p. 28, pl. i (xxiv), fig. 5.

Bolivina textilarioides Terrigi, 1883, Atti Accad. Pontificia Nuovi Lincei, vol. 35, p. 191, pl. iii, fig. 32.

Bolivina textilarioides Brady, 1884, Challenger Report, vol. 9, p. 419, pl. lii, figs. 23–25.

Bolivina textilarioides Brady, Parker, and Jones, 1888, Trans. Zool. Soc., vol. 12, pt. 7, p. 221, pl. xliii, fig. 1.

Bolivina textilarioides (*textularioides*) Egger, 1895, Jahrsber. Naturhist. Ver. Passau, vol. 16, p. 12, pl. i, fig. 8.

Bolivina textilarioides is shorter and considerably broader than *Bolivina punctata* or *B. antiqua*, which it closely resembles. Is has chambers less high or arched and the margin is more nearly round. Chambers vary from six to eight on each side and the shell in general appearance resembles *Textularia*, but the test is calcareous with fine but very distinct pores. The original spelling of the species is *textilarioides*, not *textularioides* as is adopted by many authors. The original name should stand, although Reuss used the old spelling for the species, evidently after *Textularia*, the well-known genus which the species resembles. The fossil is rather rare in the California Miocene. Its geological range extends from the Cretaceous through the Tertiary, and at the present day it is found in many localities in comparatively shoal waters and occasionally at considerable depths.

Family LAGENIDÆ.

Subfamily LAGENINÆ.

Genus LAGENA Walker and Boys (1784).

LAGENA APICULATA Reuss.

Pl. IV, fig. 2.

Oolina apiculata Reuss, 1850, Haidinger's Naturw. Abhandl., vol. 4, p. 22, pl. i, fig. 1.
Lagena apiculata Reuss, 1862, Sitzungsber. K. Akad. Wiss. Wien, vol. 46, p. 319, pl. i, fig. 1.
Lagena apiculata Jones, Parker, and Brady, 1866, Foram. Crag, Pal. Soc., vol. 19, p. 44, pl. i, fig. 27.
Lagena apiculata Brady, 1884, Challenger Report, vol. 9, p. 453, pl. lvi, figs. 4, 15–18.
Lagena apiculata Sherborn and Chapman, 1886, Jour. Roy. Microsc. Soc., ser. 2, vol. 6, p. 744, pl. xiv, fig. 14.

This form is found more frequently in fossil beds than any other species of *Lagena*, occurring as far back as the Lias and extending to the present. It is present in all oceans and at every depth down to nearly 3,000 fathoms. The form is similar to *Lagena globosa*, but is separated from it by the spinous prolongation on the posterior portion of the shell. The short diameter of the only specimen of this species in the present collection measures 0.15 mm.

LAGENA GLOBOSA (Montagu).

Pl. IV, fig. 3.

Vermiculum globosum Montagu, 1803, Test. Brit., p. 523.
Entosolenia globosa Parker and Jones, 1857, Ann. Mag. Nat. Hist., ser. 2, vol. 19, p. 278, pl. xi, figs. 25–29.
Entosolenia globosa Williamson, 1858, Recent Foram. Great Britain, p. 8, pl. i, figs. 15, 16.
Lagena globosa Reuss, 1863, Sitzungsber. K. Akad. Wiss. Wien, vol. 46, p. 318, pl. i, figs. 1–3.
Lagena globosa Terquem, 1876, Anim. Plage Dunkerque (2), p. 67, pl. vii, figs. 3, 4.
Lagena globosa Brady, 1884, Challenger Report, vol. 9, pp. 452, 453, pl. lvi, figs. 1, 2, 3.
Lagena globosa Bagg, 1898, Bull. American Paleont., vol. 2, No. 10, pp. 317, 318.

Test subglobular, elliptical or pyriform, smooth, anterior margin somewhat projecting; cell walls thin, hyaline, aperture typically an entosolenian neck. It was discovered by the writer in the Pleistocene marl of Cornfield Harbor, Md., and the California Miocene has furnished one specimen. Its geological range is from the Jura to the present; it is possible that it existed in Carboniferous time. It is known in every ocean and at all depths.

Lagena gracilis Williamson.

Pl. IV, fig. 4.

Lagena gracilis Williamson, 1848, Ann. Mag. Nat. Hist., ser. 2, vol. 1, p. 13, pl. i, figs. 3, 4.
Lagena gracilis Reuss, 1862, Sitzungsber. K. Akad. Wiss. Wien., vol. 46, p. 331, pl. iv, figs. 58–61; pl. v, fig. 62.
Lagena gracilis Brady, 1884, Challenger Report, vol. 9, p. 464, pl. lviii, figs. 2, 3, 7–10, 19, 22–24.

This finely costate or striated *Lagena* is much longer than *Lagena sulcata*, and is further distinguished by the presence of a small spine at the distal end. The neck is long, tubular, and in our specimen there are only a few striations along the shell surface. Brady considers the typical forms a modification of *Lagena clavata*. The only specimen in the present collection is 0.2 mm. in length.

It is of world-wide distribution at the present day, and is usually found in shallow waters, but it is known in many instances to occur as deep as 2,775 fathoms in the South Atlantic Ocean. Its geological range is from Cretaceous to Recent.

Lagena marginata (Walker and Boys).

Pl. IV, fig. 5.

Serpula marginata Walker and Boys, 1784, Test. Min., p. 2, pl. i, fig. 7.
Vermiculum marginatum Montagu, 1803, Test. Brit., p. 524.
Oolina compressa d'Orbigny, 1839, Foram. Amérique Mérid., p. 18, pl. v, figs. 1, 2.
Lagena sulcata var. *marginata* Parker and Jones, 1865, Philos. Trans., vol. 155, p. 355, pl. xiii, figs. 42–44; pl. xvi, fig. 12a, b.
Lagena marginata Brady, 1884, Challenger Report, vol. 9, pp. 476, 477, pl. lix, figs. 21–23.

The interesting species *Lagena marginata* was observed in the California Miocene, but unfortunately the single specimen was lost in transferring and no duplicate was discovered.

The form observed was similar to fig. 22, pl. lix, Challenger Report. The test of *Lagena marginata* is oval or rounded in outline, with more or less lateral compression, and with the periphery ending in a carina, or double ridge or groove, or in exceptional cases extended into a flange-like lamella, with a width of one-third the diameter of the shell. Aperture is an external fissurine opening, extending from an entosolenian neck. The species is widely distributed at the present time, being found from the most northern arctic waters southward to the Antarctic Circle, and at every depth down to 3,125 fathoms.

As a fossil it first appears in the Cretaceous, and is described from every subsequent formation.

LAGENA SULCATA (Walker and Jacob).

Pl. IV, fig. 6.

Serpula sulcata Walker and Jacob, 1798, Adam's Essays, Kanmacher's ed., p. 634, pl. xiv, fig. 5.

Ovulina sulcata Seguenza, 1862, Foram. Monotal. Messina, p. 41, pl. i, fig. 8.

Lagena sulcata Parker and Jones, 1865, Philos. Trans., vol. 155, p. 351, pl. xiii, figs. 24m, 28–32; pl. xvi, figs. 6, 7.

Lagena sulcata Brady, 1884, Challenger Report, vol. 9, pp. 462, 463, pl. lvii, figs. 23, 26, 33, 34; apiculate forms, pl. lviii, figs. 4, 17, 18.

Lagena sulcata Chapman, 1900, Proc. California Acad. Sci., ser. 3, vol. 1, No. 8, p. 246, pl. xxix, fig. 9.

The species includes noncompressed forms which have their surface ornamented by longitudinal costæ. Only one specimen was found, the California Miocene, and it has about ten or twelve delicate superficial striations distinctly visible under low power. The form is elongated oval with a slightly extended aperture of the fissurine type.

Geologically the form is one of the oldest types of *Lagena* known, and has been discovered in upper Silurian shales at Woolhope by John Smith. It is known in every latitude at depths of from a few down to 2,750 fathoms, though the species is normally present in shallow waters.

Subfamily NODOSARINÆ.

Genus NODOSARIA Lamarck (1816).

NODOSARIA ADOLPHINA d'Orbigny.

Pl. V, fig. 1.

Dentalina adolphina d'Orbigny, 1846, Foram. Foss. Vienne, p. 51, pl. ii, figs. 18–20.

Dentalina adolphina Bornemann, 1855, Zeitschr. Deutsch. geol. Gesell., vol. 7, p. 324, pl. xiii, fig. 5.

Dentalina adolphina Sherborn and Chapman, 1886, Jour. Roy. Microsc. Soc., ser. 2, vol. 6, p. 750, pl. xv, figs. 11a, b, 12.

Nodosaria adolphina Bagg, 1898, Bull. U. S. Geol. Survey No. 88, p. 37 (spelled erroneously adolphinula).

Nodosaria adolphina Chapman, 1900, Proc. Acad. California Acad. Sci., ser. 3, vol. 1, No. 8, p. 249, pl. xxix, fig. 16.

In large typical specimens of *N. adolphina* the segments are ornamented upon the posterior margin by spines, but in the California forms these appear to be wanting and the shells are apparently young and very minute. The peculiar shape of the constrictions and segmentation serves to furnish a basis for the placing of these California specimens under the above-named species. The species occurs from the Cretaceous to Recent, but is chiefly found in the Tertiary.

NODOSARIA COMMUNIS (d'Orbigny).

Pl. V, fig. 2.

Dentalina communis ?d'Orbigny, 1826, Annales Sciences Naturelles, vol. 7, p. 254, No. 35.
Dentalina communis d'Orbigny, 1840, Mém. Soc. Géol. France, vol. 4, p. 13, pl. i, fig. 4.
Nodosaria communis Reuss, 1845, Verstein. böhm. Kreid., pt. 1, p. 28, pl. xii, fig. 21.
Dentalina communis Reuss, 1860, Sitzungsber. K. Akad. Wiss. Wien, vol. 40, p. 186.
Dentalina legumen Reuss, 1860, Sitzungsber. K. Akad. Wiss. Wien, vol. 40, p. 186.
Nodosaria communis Brady, 1884, Challenger Report, vol. 9, pp. 504, 505, pl. lxii, figs. 19–22.
Nodosaria communis Egger, 1895, Jahrsber. Naturhist. Ver. Passau, vol. 16, p. 20, pl. ii, figs. 1, 2.

Only one specimen of *Nodosaria communis* was found in the material under investigation. This has but three segments, and is probably a young form. It is 0.4 mm. long. The segments are obliquely set, marked by depressed septa, not flush as in *N. roemeri*, and the shell is slightly arcuate as in typical specimens of greater length. The geological distribution of the species is, from the Permian to Recent, like *N. farcimen*. It is found to-day at every depth and in every latitude.

NODOSARIA CONSOBRINA d'Orbigny.

Pl. V, fig. 3.

Dentalina consobrina d'Orbigny, 1846, Foram. Foss. Vienne, p. 46, pl. ii, figs. 1–3.
Dentalina consobrina Neugeboren, 1856, Denkschr. K. Akad. Wiss. Wien, vol. 12, p. 86, pl. iii, fig. 15.
Nodosaria consobrina Brady, 1884, Challenger Report, vol. 9, p. 501, pl. lxii, figs. 23, 24.

The typical forms of *Nodosaria consobrina* are marked by smooth, attenuate, elongated shells with frequently irregular chambers, which are not as compactly built as in the variety of this species, and with a more enlarged ultimate and initial chambers, the latter often provided with a spine, as in d'Orbigny's original figure. There are only a few specimens of this species in the California Miocene. They are more regular than typical forms, and there is no terminal spine upon the primordial segment. The shells are similar to *N. consobrina* var. *emaciata*, but the smaller number of chambers and their larger size may be used to distinguish the two forms.

The geological and geographical range is similar to the variety *emaciata*, described on page 30. The broken segments of the specimens with eight chambers are 0.8 mm. in length.

NODOSARIA CONSOBRINA var. EMACIATA Reuss.

Pl. V, fig. 4.

Dentalina emaciata Reuss, 1851, Zeitschr. Deutsch. geol. Gesell., vol. 3, p. 63, pl. iii, fig. 9.
Nodosaria (D.) consobrina var. *emaciata* Reuss, 1865, Denkschr. K. Akad. Wiss. Wien, vol. 25, p. 132, pl. ii, figs. 12, 13.
Nodosaria consobrina var. *emaciata* Brady, 1884, Challenger Report, vol. 9, p. 502, pl. lxii, figs. 25, 26.
Nodosaria consobrina var. *emaciata* Bagg, 1898, Bull. U. S. Geol. Survey No. 88, p. 38.
Nodosaria consobrina var. *emaciata* Bagg, 1898, Bull. American Paleont., vol. 2, No. 10, p. 319.

Test very long, smooth, tapering gracefully, with numerous compact, closely set segments, only slightly expanding, separated by septa but little depressed, set straight across the chambers. Similar to *Nodosaria consobrina*, but more slender and elongated and with more chambers in proportion to its length. Initial segment neatly rounded, but little marked off from the second and third chambers, which can not be easily distinguished. Only a few specimens are present in the California Miocene. The species is found in all rocks from Cretaceous to Recent.

Brady, in the Challenger Report, states that the species is living in the North Atlantic at depths of from 290 to 725 fathoms; in the South Atlantic at 350 fathoms; off the Cape of Good Hope at 150 fathoms, and in the South Pacific from 129 to 1,375 fathoms. No specimens were obtained by the Challenger from the North Pacific. Length of broken specimen of ten chambers is 1.1 mm.

NODOSARIA FARCIMEN (Soldani).

Pl. V, fig. 5.

Orthoceras farcimen Soldani, 1791, Testaceographia, vol. 1, pt. 2, p. 98, pl. cv, fig. 0.
Dentalina farcimen Reuss, 1861 (1863), Bull. Acad. Roy. Belgique, sér. 2, vol. 15, p. 146, pl. i, fig. 18.
Nodosaria farcimen Brady, 1884, Challenger Report, vol. 9, pp. 498, 499, pl. lxii, figs. 17, 18, and woodcuts, p. 499.
Nodosaria farcimen Bagg, 1898, Bull. U. S. Geol. Survey No. 88, pp. 38, 39.
Nodosaria farcimen Bagg, 1898, Bull. American Paleont., vol. 2, No. 10, pp. 25, 26, pl. i, fig, 2.
Nodosaria farcimen Chapman, 1900, Proc. California Acad. Sci., ser. 3, vol. 1, No. 8, p. 248, pl. xxix, fig. 13.

The test of *Nodosaria farcimen* consists of a small number of smooth segments (generally less than ten) separated by straight instead of oblique septa, as in *N. communis*, which the species resembles. The chambers are longer than in *N. soluta*, and in the typical forms constricted rather deeply, each succeeding chamber enlarging rapidly. The shell is curved and the nipple-shaped aperture is located on the inner margin of the curve in a prolongation of the ultimate segment.

The length is extremely variable, being 2.82 mm. in the Cretaceous specimens and only 1.10 mm. in the Maryland Eocene. The California forms are smaller yet, and are so fragile that entire specimens are extremely difficult to obtain. The best form in the present collection has eight segments. The geological age of the species goes back to the Permian, and in existing seas it is known at almost every depth and in every ocean.

NODOSARIA FILIFORMIS (d'Orbigny).

Pl. V, fig. 6.

Nodosaria filiformis d'Orbigny, 1826, Annales Sciences Naturelles, vol. 7, No. 14, p. 253.

Nodosaria filiformis Brady, 1884, Challenger Report, vol. 9, p. 500, pl. lxiii, figs. 3–5.

The type represented by *Nodosaria filiformis* has been described under a variety of names which are given in the list of references in the Challenger Report. This synonymy is probably incomplete.

The shell is very long, slender, delicately built, slightly curved, and with many short, oval, smooth segments which taper gracefully to the primordial end. The septa are straight, depressed, not obliquely set as in *N. communis* and the ultimate chamber is prolonged into a nipple-shaped aperture.

This species is not uncommon in the California Miocene, but only fragments can be obtained. It is found in the Lias and every succeeding formation. It occurs in dredgings from a depth of a few feet to about 500 fathoms, but is not widely distributed.

NODOSARIA OBLIQUA (Linné).

Pl. V, fig. 7

Nautilus obliquus Linné, 1767, Syst. Nat., 12th ed., pp. 281, 1163; 1788, ibid., 13th (Gmelin's) ed., p. 3372, No. 14.

Orthocera obliqua Lamarck, 1822, Anim. sans Vert., vol. 7, No. 4, p. 594.

Dentalina obliqua Jones, Parker, and Brady, 1866, Foram. Crag, Pal. Soc., vol. 19, p. 54, pl. i, fig. 9.

Nodosaria obliqua Brady, 1884, Challenger Report, vol. 9, pp. 513, 514, pl. lxiv, figs. 20–22.

Nodosaria obliqua Bagg, 1898, Bull. U. S. Geol. Survey No. 88, p. 41.

Nodosaria obliqua Bagg, 1898, Bull. American Paleont., vol. 2, No. 10, p. 320.

Nodosaria obliqua Chapman, 1900, Proc. California Acad. Sci., ser. 3, vol. 1, No. 8, p. 249, pl. xxix, fig. 17.

This species is exceedingly variable in size, length, and arcuate character, but the obliquely set striations, which run in more or less conflicting ends, together with the distinct ventricose segments with depressed septa, serve as sufficient aids in the determination of even fragments of this interesting species. If, as Brady and other authors have done, we include all forms with very numerous oblique striations, such as *Dentalina confluens*, *Nodosaria sulcata* Nilsson, *Dentalina steenstrupi* Reuss, etc., the synonymy becomes enormous. The species first appears in the lower Lias and is present in increasing numbers in all subsequent formations. In existing oceans it is found in every sea and at all possible depths down to 2,000 fathoms.

The California specimens of *Nodosariæ* are nearly always broken and compared with the forms found in the New Jersey Cretaceous are exceedingly small. *Nodosaria obliqua* is one of the rarest species found by the writer in the material submitted from California. This species was also found in material from the calcareous Tejon beds near New Idria, in De los Reyes Canyon, given to the author by Mr. T. W. Stanton, of the United States Geological Survey.

Nodosaria pauperata (d'Orbigny).

Pl. V, fig. 8.

Dentalina pauperata d'Orbigny, 1846, Foram. Foss. Vienne, p. 46, pl. i, figs. 57, 58.
Dentalina pauperata Bornemann, 1855, Zeitschr. Deutsch. geol. Gesell., vol. 7, p. 324, pl. xiii, fig. 7.
Dentalina pauperata Jones and Parker, 1860, Quart. Journ. Geol. Soc. London, vol. 16, p. 453, pl. xix, fig. 22.
Nodosaria pauperata Brady, Challenger Report, vol. 9, p. 500, woodcuts a, b, c.
Dentalina pauperata Sherborn and Chapman, 1886, Jour. Roy. Microsc. Soc., ser. 2, vol. 6, p. 750, pl. xv, fig. 9.
Nodosaria pauperata Jones, 1896, Mon. Foram. Crag, pt. 3, 1895, pp. 224–226, pl. i, figs. 13–18, 20.
Nodosaria pauperata Bagg, 1898, Bull. U. S. Geol. Survey No. 88, p. 42.
Nodosaria pauperata Chapman, 1900, Proc. California Acad. Sci., ser. 3, vol. 1, No. 8, p. 247, pl. xxix, fig. 12.

Test smooth, somewhat arcuate, tapering very slightly and with chambers of nearly uniform size, with little or no constrictions in lower portion. The sutures become more pronounced at the ultimate end. In the California specimens the initial segment is enlarged and the posterior rounded, not aciculate as in some of the specimens placed under this species. The geological range begins with the Lias and extends to the present. Found at all depths and in all oceans.

Nodosaria radicula (Linné).

Pl. V, fig. 9.

Nautilus radicula Linné, 1767, Syst. Nat., 12th ed., pp. 285, 1164; 1788; Gmelin's ed., vol. 1, pt. 6, p. 3373, No. 18.
Nautilus radicula Montagu, 1803, Test. Brit., p. 197, pl. vi, fig. 4.
Nodosaria radicula d'Orbigny, 1826, Annales Sciences Naturelles, vol. 7, p. 252, No. 3, Modèle No. 1.
Nodosaria radicula Brady, 1884, Challenger Report, vol. 9, p. 495, pl. lxi, figs. 28–31.
Nodosaria radicula Agassiz, 1888, Three Cruises "Blake," vol. 2, p. 166, fig. 504.
Nodosaria radicula Bagg, 1898, Bull. U. S. Geol. Survey No. 88, p. 42.
Nodosaria radicula Chapman, 1900, Proc. California Acad. Sci., ser. 3, vol. 1, No. 8, p. 247, pl. xxix, fig. 11.

The test of *Nodosaria radicula* is characterized by a straight, closely built shell of but few chambers, having a smooth surface and straight septa. The chambers are globular, constricted, and relatively large in proportion to the length of the shell as compared with some of the more tapering *Nodosariæ*. The California forms have the primordial chamber slightly enlarged, and in some specimens there are six or seven chambers preserved, although every one of them examined is broken. The constrictions become more pronounced toward the ultimate segment. The specimens obtained by the writer from the New Jersey Cretaceous measured 2 mm. in length. The California forms are much smaller. Brady, in the Challenger Report, speaks of the distribution of the species as follows: "*Nodosaria radicula* has a wide area of distribution. It is found in the Arctic seas, and on the shores of Norway and of the British islands; in the North Atlantic, from shallow water to a depth of 1,360 fathoms; in the South Atlantic as deep as 2,350 fathoms, and in the South Pacific from 37 to 1,100 fathoms, and it also occurs in the Adriatic. It has not been observed in the North Pacific."

Its fossil range dates from the Permian, and it is known throughout the Cretaceous and Tertiary formations in many regions.

NODOSARIA ROEMERI (Neugeboren).

Pl. V, fig. 10.

Dentalina roemeri Neugeboren, 1856, Denksch. K. Akad. Wiss. Wien, vol. 12, p. 82, pl. ii, figs. 13-17.
Nodosaria roemeri Reuss, 1870, Sitzungsber. K. Akad. Wiss. Wien, vol. 62, p. 475.
Nodosaria roemeri Schlicht, 1870, Foram. Pietzpuhl., pl. x, figs. 21, 22, 24.
Nodosaria roemeri Brady, 1884, Challenger Rèport, vol. 9, pp. 505, 506, pl. lxiii, fig. 1.

The shell of *Nodosaria roemeri* resembles *Nodosaria communis* in its obliquely set septal partitions, but in the latter the sutures are depressed, while in *N. roemeri* they remain flush with the surface of the test. The form is stoutly built in proportion to its length, and the later chambers are much longer and larger than the earlier segments. The form is approximately straight, but in some specimens figured there is a limited amount of curvature, as in the earlier *Dentalina* types. The distal end is neatly rounded, in which respect it differs from *N. mucronata*. It is very rare in the California Miocene, and only one specimen was found, with four chambers preserved, the length of which is 2.3 mm.

The species is not common in existing oceans, but Prof. H. B. Brady reports its occurrence in the North Atlantic, where it chiefly occurs at depths of less than 400 fathoms. Its geological range is from Cretaceous to Recent.

NODOSARIA SOLUTA (Reuss).

Pl. V, fig. 11.

Dentalina soluta Reuss, 1851, Zeitschr. Deutsch. geol. Gesell., vol. 3, p. 60, pl. iii, fig. 4, a, b.
Nodosaria soluta Reuss, 1865, Denkschr. K. Akad. Wiss. Wien, vol. 25, p. 131, pl. ii, figs. 4–8.
Nodosaria soluta Brady, 1884, Challenger Report, vol. 9, p. 503, pl. lxii, figs. 13–16, var. pl. lxiv, fig. 28.
Nodosaria soluta 1886, Sherborn and Chapman, Jour. Roy. Microsc. Soc., ser. 2, vol. 6, p. 746, pl. xiv, figs. 25, 26.
Nodosaria soluta Chapman, 1900, Proc. California Acad. Sci., ser. 3, vol. 1, No. 8, p. 248, pl. xxix, fig. 14.

The above species is represented only by fragments, the smaller of which pass into *N. adolphina* with their deep constricted segments. The large almost globular segments with smooth surface of only a small number of chambers serve to distinguish the species. The forms in the collection studied are not mucronate. The shell is either bent or straight, and varies greatly in size and length. Common to-day in the North Atlantic at depths from 300 to as low as 1,360 fathoms (Brady); South Atlantic, 350 to 675 fathoms; South Pacific, only from 125 to 410 fathoms (one instance 1,350) (Brady). The geological range is from Cretaceous to Recent. It is one of the most common *Nodosariæ* in the California material.

Genus CRISTELLARIA Lamarck (1816).

CRISTELLARIA ARTICULATA (Reuss).

Pl. VI, fig. 1.

Robulina articulata Reuss, 1863, Sitzungsber. K. Akad. Wiss. Wien, vol. 48, p. 53, pl. v, fig. 62.
Cristellaria articulata Reuss, 1870, Sitzungsber. K. Akad. Wiss. Wien, vol. 62, p. 483.
Cristellaria articulata Brady, 1884, Challenger Report, vol. 9, p. 547, pl. lxix, figs. 10–12.
Cristellaria articulata Bagg, 1898, Bull. U. S. Geol. Survey No. 88, p. 54.

The test of *Cristellaria articulata* is to be regarded as a thickened form of *Cristellaria rotulata*, and it must not be confounded with *Cristellaria articulata* Seguenza. The shell is nearly circular, smooth, thickened, flattened at the sides, and with an obtusely angular periphery. There are six or seven broadly triangular chambers, separated by depressed septa, which are somewhat curved backward and sickle-shaped. The aperture is an oval fissured opening close to the outer margin of the ultimate segment. The diameter of the specimens which the author found in the New Jersey Cretaceous measured 1.3 mm.

The writer has but one specimen, nearly perfect, from California, a trifle smaller than the above. The geological distribution is from the

Cretaceous to Recent. The species in existing oceans is mentioned by Brady as occurring at several stations at depths of less than 400 fathoms.

CRISTELLARIA CASSIS (Fichtel and Moll).

Pl. VI, fig. 2.

Nautilus cassis Fichtel and Moll, 1798, Test. Microsc., p. 95, pl. xvii, figs. a, 1.
Cristellaria cassis Lamarck, 1816, Tabl. Encycl. et Méthod., pl. cccclxvii, figs. 3 a–d.
Cristellaria cassis Brady, 1884, Challenger Report, vol. 9, pp. 552, 553, pl. lxviii, fig. 10.
Cristellaria cassis Bagg, 1898, Bull. U. S. Geol. Survey No. 88, p. 54.
Cristellaria cassis Silvestri, 1899, Mem. Accad. Lincei, vol. 15, pp. 206–212, pl. vii, figs. 13–17.
Cristellaria cassis Chapman, 1900, Proc. California Acad. Sci., ser. 3, vol. 1, p. 250, pl. xxix, fig. 18.

There are several types of *Cristellaria cassis* given in descriptions of earlier authors. The test is complanate or nearly so in all, but frequently the exogenous tubercles or surface beading is entirely absent, and the presence of a well-defined keel, with complanate segmenta, serves to mark the species. The number of chambers in the final volution is fifteen in the New Jersey forms, but there are only six in the single California form. The sutures are depressed, arcuate, surface smooth, not beaded as in typical specimens. Mr. Chapman figures a variety from California with a serrated keel, but the margin is smooth, sharp, transparent, and of small width in the specimen we have identified. Breadth of shell is 0.25 mm. The geological range is from the Cretaceous to Recent. The bathymetric range at present is in shallow coral sands, and in the Adriatic, Mediterranean, etc., of shoal depths. The list of synonyms for the species is large, and there are many records of the species in the Tertiary deposits.

CRISTELLARIA CREPIDULA (Fichtel and Moll).

Pl. VI, fig. 3.

Nautilus crepidula Fichtel and Moll, 1803, Test. Microsc., p. 107, pl. xix, figs. g–i.
Cristellaria crepidula d'Orbigny, 1839, Foram. Cuba, p. 64, pl. viii, figs 17, 18.
Cristellaria crepidula Parker and Jones, 1865, Philos. Trans., vol. 155, p. 344, pl. xiii, figs. 15, 16, pl. xvi, fig. 4.
Cristellaria crepidula Brady, 1884, Challenger Report, vol. 9, pp. 542, 543, pl. lxvii, figs. 17, 19, 20; pl. lxviii, figs. 1, 2.
Cristellaria crepidula Bagg, 1898, Bull. U. S. Geol. Survey No. 88, p. 55.

The above list contains only a few of the many references for this interesting *Cristellaria*. The only specimen we have is broken, but exhibits the typical compressed elongate-oval outline, with oblique segments separated by depressed septa. The margin is sharp but not keeled, and the surface is smooth and white and glistening. The short diameter of this form is 0.25 mm.

The geographical range is very wide and it belongs to the shoal-water fauna, and only in one instance in the *Challenger* dredgings was the species detected in deep water (2,350 fathoms). Geologically it is known from the Lias and is present in greater abundance in succeeding formations.

CRISTELLARIA CREPIDULA (F. & M.) var. GLADIUS Philippi.

Pl. VI, fig. 4.

Marginulina gladius Philippi, 1843, Tertiär. nordwest. Deutsch., p. 40, pl. i, fig. 37.
Cristellaria crepidula var. *gladius* Burrows and Holland, 1897, Proc. Geologists' Assoc., vol. 15, pts. 1, 2, pp. 39, 40, pl. i, figs. 6, 9, 16.

Of all possible modifications, with an indefinite number of synonyms, variously described under both *Marginulina* and *Cristellaria*, this variety marks but one of perhaps the most variable of specific forms known among the Foraminifera. It is impossible, when the material from one locality shows such gradations as Burrows and Holland give in their paper on the Foraminifera of the Thanet Beds of Pegwell Bay, to consider more than mere varieties the large list of fossil-figured forms included under such names as *Cristellaria intermedia*, *C. simplex*, *C. cymboides*, *C. varians*, *C. protracta*, *C. harpa*, etc., of Reuss, d'Orbigny, d'Orbigny, Bornemann, Bornemann, and Reuss, respectively.

In De los Reyes Canyon and in the Tejon formation, near New Idria, Cal., there is one large (diameter long axis 1.1 mm.) ensiform *Cristellaria* belonging to the *crepidula* type and consisting of twelve chambers. The shell is compressed into an oval, slightly involute on the posterior end, and with extended evolute chambers on the anterior portion. There is a suggestion of angularity at the outer periphery without keel and the shell is arcuate. The form studied is most similar to the form figured by Burrows and Holland on pl. 1, fig. 6, in the above reference. The species must be considered a shallow-water form, and only in one instance were specimens dredged by the *Challenger* at a depth of over 2,000 fathoms (2,350).

The geological distribution of this species in some of its varieties is very extensive and is known in deposits as early as the Lias. It is also reported in the English chalk, the London clay, and in the later Tertiaries.

CRISTELLARIA (ROBULINA) GERLANDI Andreae.

Pl. VI, fig. 5.

Cristellaria (*Robulina*) *gerlandi* Andreae, 1884, Abhandl. Geol. Specialkarte Elsass-Lothringen, vol. 2, pt. 3, p. 208, pl. ix, fig. 25.

The form figured by Andreae under the name *Robulina gerlandi* is characterized by an exceedingly complanate suboval test with periphery definitely-keeled as in *C. cultrata*. The septal markings are wide and slightly depressed, and the septa are curved backward in the California specimen somewhat more than in the figure shown by Andreae. There are fourteen chambers in the California specimen, fifteen in Andreae's type. This complanate *Cristellaria* resembles *Cristellaria alberti* of Andreae, but the chambers are more numerous and the inner volution is distinct. Mr. Chapman in his report on the California fossils figures a new species of *Cristellaria* under the name *C. miocenica*, which is also closely related to the form under consideration, but his specimens did not exhibit the carinate feature seen in *C. gerlandi*. Andreae's form came from the Septaria clay of Unter-Elsass. There appears to be no other description of his peculiar species. The important feature of Andreae's type is the unsymmetrical development of the initial chamber which is slightly raised upon one side. This is less clearly seen in the California form, but the distinction is apparent upon close examination.

CRISTELLARIA GIBBA d'Orbigny.

Pl. V, fig. 6.

Cristellaria gibba d'Orbigny, 1839, Foram. Cuba, p. 63, pl. vii, figs. 20, 21.
Cristellaria gibba Brady, 1884, Challenger Report, vol. 9, pp. 546, 547, pl. lxix, figs. 8, 9.
Cristellaria gibba Chapman, 1900, Proc. California Acad. Sci., ser. 3, vol. 1, No. 8, pl. xxx, fig. 3.

Test oblong, biconvex, smooth; subcarinate, narrow; chambers few, seven or eight, slightly arcuate, separated by distinct septa; aperture marginate. The specimens found by the author in the New Jersey Cretaceous measured 1.3 mm. in length; 0.87 mm. in breadth.[a] This species resembles *C. acutauricularis*, but the septal face is more narrow. The above is exceedingly rare in the material under examination, and the writer has observed only one specimen. There are only five chambers in the elongated oblong-oval shell. The geological range is from the Cretaceous, possibly earlier, to the present time. The species does not seem to be abundant in existing oceans, and occurs sporadically at depths of less than 500 fathoms.

CRISTELLARIA ROTULATA (Lamarck).

Pl. V, fig. 7.

Lenticulites rotulata Lamarck, 1804, Ann. du Mus., vol. 5, p. 188, No. 3.
Cristellaria rotulata Brady, 1884, Challenger Report, vol. 9, p. 547, pl. lxix, fig. 13.
Cristellaria rotulata Dervieux, 1892, Boll. Soc. Geol. Italiana, vol. 10, p. 626.
Cristellaria rotulata Bagg, 1898, Bull. U. S. Geol. Survey No. 88, pp. 57, 58.

Test involute, biconvex, smooth; peripheral margin sharp, noncarinate; chambers numerous, but only eight or nine in final volution; septa moderately curved, visible externally as fine lines; aperture elliptical, radiate. The size of the shell is extremely variable. In

[a] Bull. U. S. Geol. Survey No. 88, p. 56.

the lime sand of New Jersey the author found specimens which measured over 2 mm. in diameter. The species is exceedingly rare in the California Miocene, and the genus is poorly represented in other types of *Cristellaria*. The geological range is from the Triassic to Recent. In nearly all existing oceans *Cristellaria rotulata* is abundant, and occurs at every depth from shore sands down to below 2,000 fathoms. The synonymy is altogether too cumbersome to be given here in full.

Subfamily POLYMORPHINÆ.

Genus UVIGERINA d'Orbigny (1826).

Uvigerina canariensis d'Orbigny.

Pl. VI, fig. 1.

Uvigerina canariensis d'Orbigny, 1839, Foram. Canaries, p. 138, pl. i, figs. 25–27.
Uvigerina canariensis Brady, 1884, Challenger Report, vol. 9, pp. 573, 574, pl. lxxiv, figs. 1–3.
Uvigerina canariensis Woodward and Thomas, 1884 (1885), Thirteenth Ann. Rept. Geol. Nat. Hist. Survey Minnesota, p. 171, pl. iv, fig. 37.
Uvigerina canariensis Bagg, 1898, Bull. American Paleont., vol. 2, No. 10, pp. (31, 32), 325, 326.

The test of *Uvigerina canariensis* may well serve as a type of the rather uncommon, smooth-shelled forms of *Uvigerinæ*, nearly all being more or less ornamented with some form of surface striations. The form is irregularly triserial, elongate, built of projecting globose segments with well-defined septal constrictions between. It is quite likely that the form described as *Uvigerina urnula* by d'Orbigny in his Memoir on the Miocene Foraminifera of Vienna belongs under this species and the writer has so included it in a former publication.

The species is rather common in the California Miocene, but not nearly so frequent as its congenitor *Uvigerina tenuistriata*. It appears in the middle Tertiaries of many localities, and is rather widely distributed at the present time in existing oceans. Professor Brady mentions its occurrence in shore sands of Teneriffe, at a depth of 435 fathoms off Bermuda, of 150 fathoms near Cape of Good Hope, of 1,900 fathoms in the South Atlantic, and of 40 and 1,375 fathoms in the South Pacific. It has been found by several scientists on the coasts of the British Isles. The writer obtained this form from a well boring at Crisfield, Md. (Miocene), and also at Norfolk, Va.

Uvigerina pygmæa d'Orbigny.

Pl. VII, fig. 2.

Uvigerina pygmæa d'Orbigny, 1826, Annales Sciences Naturelles, vol. 7, p. 269, pl. xii, figs. 8, 9, Modèles No. 67.
Uvigerina pygmæa d'Orbigny, 1846, Foram. Foss. Vienne, p. 190, pl. xi, figs. 25, 26.
Uvigerina pygmæa Brady, 1884, Challenger Report, vol. 9, p. 575, pl. lxxiv, typical figs. 11, 12 elongate forms figs. 13, 14.

The species was described and figured by the author[a] from the well-boring material of the Miocene from Crisfield, Md., and Norfolk, Va. The test is more or less broadly ovate and stoutly built with thick shell walls. The chambers are numerous, large, and globose, and are separated by depressed septa. The species is easy to recognize, for in addition to the above features the surface is marked by a number of longitudinal costæ, which are more abundant and more definite than in its congenitor *Uvigerina tenuistriata* Reuss. Both forms are frequently found in the same deposits. Its range is from the middle Tertiary to Recent, and the shell is universally distributed over nearly all waters at the present day. Its bathymetric range is from 200 to more than 2,500 fathoms. The fossil forms in California appear to belong mostly to *Uvigerina tenuistriata*, and only a few forms of the species under discussion were obtained.

UVIGERINA TENUISTRIATA Reuss.

Pl. VII, fig. 3.

Uvigerina tenuistriata Reuss, 1870, Sitsungsber. K. Akad. Wiss. Wien, vol. 62, p. 485.
Uvigerina tenuistriata Schlicht, 1870, Foram. Pietzpuhl., pl. xxii, figs. 34–37.
Uvigerina tenuistriata Brady, 1884, Challenger Report, vol. 9, p. 574, pl. lxxiv, figs. 4–7.
Uvigerina tenuistriata Bagg, 1898, Bull. American Paleont., vol. 2, No. 10, pp. (32, 33) 326, 327.
Uvigerina tenuistriata Chapman, 1900, Proc. California Acad. Sci., ser. 3, vol. 1, No. 10, p. 252, pl. xxx, fig. 5.

The test of the above species is much more finely costate than *Uvigerina pygmæa* and it is more slender. It tapers to a neat well-rounded primordial segment, and enlarges by irregular sized chambers to the ultimate chamber. The septa are not as depressed as in *U. pygmæa* and the segments are less globose. The species terminates its ultimate chamber in the flaring tubular neck. Not uncommon in the California Miocene; rarer than *U. pygmæa* in the Maryland and Virginia Miocene. The shell is known from a number of localities in shallow waters. Its geological range is from Miocene to Recent.

Genus SAGRINA (d'Orbigny 1839) Parker and Jones.

The name *Sagrina* as given by d'Orbigny was applied to a biserial or Textulariform shell related to *Uvigerina* and provided with longitudinal striations. In his report of the Foraminifera of Cuba, d'Orbigny again applies the term to a rough dimorphous Textularian which differs from *Gaudryina* simply in the terminal aperture. The name appears therefore to have been used in different descriptions, but it has been revived and restricted by Parker and Jones to apply to a

[a]Tertiary and Pleistocene Foraminifera of the middle Atlantic slope: Bull. American Paleont., vol. 2, No. 10, p. 326, pl. xxii (2), fig. 3.

group of dimorphous *Uvigerinæ* whose biserial initial segments become Nodosarian in their ultimate growth. There seems to be but one step farther from a form which has but one or two biserial chambers to one in which the entire shell becomes a true Nodosarian in its type of development. The remarkable peculiarity of the aperture, however, is something altogether different from the typical *Nodosariæ*, and the arrangement of the chambers serves at once to separate the two genera as at present understood. While, therefore, at first the biserial growth, followed in its later stages by moniliform segmentation, must be regarded as representative of the type of the genus, we are forced to admit under the same a number of genera whose growth is altogether Nodosarian. The walls of the shell are invariably hyaline and perforate, and the surface decoration is extremely varied and beautiful. The genus first makes its appearance in the middle Tertiary, being known in Miocene, Pliocene, and Recent deposits.

In shallow waters of tropical oceans it exists to-day, and according to Brady it is generally limited to depths less than 200 fathoms. It is not a common form, though fairly widely distributed at the present time.

Synonymous terms for this genus are given by Prof. H. B. Brady in the Challenger Report, vol. 9, page 580. These are *Sagrina* (d'Orbigny, 1839); Parker and Jones (1865); Carpenter, Brady, Bütschli; *Sagraina*, Reuss (1861), Zittel, Schwager, Marsson; *Dimorphina*, Schwager (1866), Hantken; *Siphogenerina*, Schlumberger (1883).

SAGRINA BRANNERI n. sp.

Pl. VII, fig. 4.

In the material from California occur a large number of Nodosarian types with expanded elongated apertures of the *Sagrina* type. The surface is decorated with a large number of longitudinal costæ, as many as twenty occurring on some specimens. There are three distinct types of these, possibly more. These types are closely allied with the forms described and figured by Professor Brady in the Challenger Report under the name *Sagrina raphanus* Parker and Jones. They all differ from these figured types in the larger number of striations, and in the method of septal formation. In the California specimen the septa are arched between chambers and the arches extend from one surface costal ridge to another, and furthermore the striations are continuous, not broken, and extend to the very aperture, though the last chamber has them as fine lines running to the phialine aperture. The form selected to represent the species *Sagrina branneri* is acuminate and has about ten successive chambers closely set and with the surface marked by about sixteen longitudinal striations. Aperture raised, tubular, with flaring opening. Shell walls white, perforate. The form is large, nearly one-sixteenth inch in length.

Sagrina californiensis n. sp.

Pl. VII, fig. 5.

The *Sagrina* selected as a type for this species consists of a number of obtusely rounded shells with a more or less barrel-shaped outline due to an enlargement of the median chambers and a very slight tapering at both ends. There are ten chambers in most forms, which are compactly joined along a zigzag suture line, and the surface is deeply inset between large longitudinal costæ which run the entire length in unbroken ridges upon the shell. The aperture is tubular, flaring, short. This is the most common of the three types observed.

Sagrina elongata n. sp.

Pl. VII, fig. 6.

The form of *Sagrina elongata* is but little longer than its associate species, but it is considerably smaller and more slender, so that the test appears to possess considerable length. There is no swelling in the median portion and the margins are neatly rounded. Segments are ornamented similarly with the other types, though less prominently so. Common in the California Miocene.

Family GLOBIGERINIDÆ.

Genus GLOBIGERINA d'Orbigny (1826).

Globigerina bulloides d'Orbigny.

Pl. VII, fig. 7.

Globigerina bulloides d'Orbigny, 1826, Annales Sciences Naturelles, vol. 7, p. 277, No. 1, Modèle No. 17 (young) and No. 76.
Globigerina hirsuta d'Orbigny, 1839, Foram. Canaries, p. 132, pl. ii, figs. 4–6.
Globigerina bulloides Brady, 1884, Challenger Report, vol. 9, pp. 593, 594, 595, pls. lxxvii, lxxix, figs. 3–7.
Globigerina bulloides Bagg, 1898, Bull. U. S. Geol. Survey No. 88, p. 63.
Globigerina bulloides Bagg, 1898, Bull. American Paleont., vol. 2, No. 10, p. 33.

Globigerina bulloides is one of the most widely distributed Foraminifera, occurring at the present time in every latitude and at all possible depths and being also found in numberless fossil localities in Cretaceous and later rocks. It is characterized by a spiral, subtrochoid test with globular chambers with deeply sunken umbilicus around which on the reverse side the spiral segments are wound and the number of chambers is varied in size, shape, and arrangement. In recent specimens about seven globose segments compose the final convolution. The forms found in the California Miocene are typical, for the species are frequent.

Globigerina bilobata d'Orbigny.

Pl. VII, fig. 8.

Globigerina bilobata d'Orbigny, 1846, Foram. Foss. Vienne, pp. 164, 165, pl. ix, figs. 11–14.
Globigerina bilobata Costa, 1856, Atti Accàd. Pontaniana (2), vol. 7, p. 241, pl. xxi, fig. 6A, B.
Globigerina bilobata Brady, 1884, Challenger Report, vol. 9, p. 608, pl. lxxxi, figs. 20, 21; pl. lxxxii, figs. 2 and (3 ?) (here described under *Orbulina universa*).
Orbulina bilobata Egger, 1895, Jahrsber. Naturhist. Ver. Passau, vol. 16, p. 39, pl. iv, fig. 20, a, b.

This bilobate form resembles *Orbulina universa*, from which it is distinguished by being formed of two chambers which are not wholly distinct, but are united along a straight septal division and perhaps without aperture, although some figures show this feature. The perforations of the test are similar to those of *Orbulina universa*. One chamber is invariably somewhat larger than the other, although in some specimens this character is not pronounced. The species is not common and but few specimens have been detected in the material investigated. The longer diameter is 0.85 mm. and the diameter of the larger segment 0.6 mm. Fornasini has described this species in the Tertiary of Messina in 1893 and it is known in the Miocene of Monte Bartolomeo (Egger), the Miocene of the Vienna basin (d'Orbigny), and it is possibly coextensive with *Orbulina universa*, although this is not certain (Lias to Recent). It is present in existing oceans in bottom oozes from many localities and at various depths.

Globigerina cretacea d'Orbigny.

Pl. VIII, fig. 1.

Globigerina cretacea d'Orbigny, 1840, Mém. Soc. Géol. France, vol. 4, p. 34, pl. iii, figs. 12–14.
Globigerina cretacea Brady, 1879, Quart. Jour. Microsc. Sci., new series, vol. 19, p. 285.
Globigerina cretacea Brady, 1884, Challenger Report, vol. 9, pp. 596, 597, pl. lxxxii, fig. 10a–c. (Fossil form fig. 11.)
Globigerina cretacea Bagg, 1898, Bull. U. S. Geol. Survey No. 88, p. 64.

Test rotaliform, but strongly depressed; superior surface flattened or but slightly convex, inferior side depressed toward the center and excavated at the umbilicus; periphery obtuse and lobulated; shell consisting of from five to seven segments, the latter relatively small, subglobular aperture opening into the umbilical vestibule. Diameter less than 1 mm. Geological range is from Cretaceous to Recent.

In the California Miocene *Globigerina bulloides* is extremely common. *Globigerina dubia* is also numerous, but typical specimens of *Globigerina cretacea* are hard to find. There are undoubtedly present better specimens than the writer could obtain by boiling the marl, but a number of perfect forms were obtained of *Globigerinæ* by collecting the forms which float and drying them on a cloth by straining the water.

GLOBIGERINA DUBIA Egger.

Pl. VIII, fig. 2.

Globigerina dubia Egger, 1857, Neues Jahrb. für Min., Geol., Pal., p. 281, pl. ix, figs. 7–9.
Globigerina dubia Brady, 1879, Quart. Jour. Microsc. Sci., new series, vol. 19, p. 71.
Globigerina dubia Brady, 1884, Challenger Report, vol. 9, pp. 595, 596, pl. lxxix, fig. 17.
Globigerina dubia Egger, 1895, Jahrsber. Naturhist. Ver. Passau, vol. 16, p. 37, pl. iv, fig. 17.

"Test rotaliform, subglobular, somewhat compressed; margin rounded and lobulated; inferior umbilicus large and deeply sunk; composed of about three convolutions, the outermost of which consists of five or six relatively small, inflated segments; the apertures of the chambers opening directly into the umbilical vestibule. Diameter often nearly one thirty-fifth of an inch (0.73 mm.)."[a]

This species is rather common in the California material though less frequent than *Globigerina bulloides*. The specimens are much larger than the latter species, are more stoutly built, and the pores of the cell walls are larger and coarser. Its geological range is apparently confined to the later Tertiary and Recent period and the writer has no record of its occurring in the Eocene. The present range of the species is also limited, and while it occupies bottom oozes it is by no means widely diffused or as abundant as many of its congenitors.

Genus ORBULINA d'Orbigny (1839).

ORBULINA UNIVERSA d'Orbigny.

Pl. VIII, fig. 3.

Orbulina universa d'Orbigny, 1839, Foram. Cuba, p. 3, pl. i, fig. 1.
Orbulina universa d'Orbigny, 1839, Foram. Canaries, p. 122, pl. i, fig. 1.
Orbulina universa Brady, 1884, Challenger Report, vol. 9, pp. 608, 609, pl. lxxviii; pl. lxxxi, figs. 8–26; pl. lxxxii, figs. 1–3.
Orbulina universa Egger, 1895, Jahrsber. Naturhist. Ver. Passau, vol. 16, p. 38, pl. iv, figs. 18, 19.

Test globular or nearly so, composed of only one chamber, or perhaps in variable types two indistinct chambers, or of one chamber inclosing a polythalamous, globigerina-like shell, which in recent specimens can be seen occasionally through the transparent hyaline walls of the outer enveloping chamber. This outer chamber is frequently spinous, though these spines are absent apparently in fossil forms and perhaps are broken off, although it is not certain that they are always

[a] Brady, Challenger Report, vol. 9, 1884, p. 595.

present. There is a roughness about the outer surface which may represent these spinous markings in recent forms, but they are so minute that it is doubtful if this character is of value in determination of the species and if it is constantly a characteristic. There seems to be a marked difference in the size of the shell, but on an average good specimens measure about 0.15 mm. in diameter. The test is often broken and it is possible that some of the single-shell chambers seen in the washed marl are fragments of *Globigerina*, but in some almost perfectly globular forms there can be no question but that this species is present in rather considerable abundance. The species first occurs in the Lias (Terquem), and it is found in the Jurassic limestones of Switzerland (Haeusler), in the chalk of the island of Rugen, and at Volsk, Russia (Reuss), in Septaria clays and upper Oligocene of Germany (Reuss), in the Miocene of Vienna (d'Orbigny), in the later Tertiaries of Italy (Costa, Terrigi, etc.), and elsewhere. It is the commonest of all pelagic Foraminifera to-day and is known in bottom specimens and surface dredgings at every depth and in all latitudes.

Genus PULLENIA Parker and Jones (1862).

PULLENIA SPHÆROIDES (d'Orbigny).

Pl. VIII, fig. 4.

Nonionina sphæroides d'Orbigny, 1826, Annales Sciences Naturelles, vol. 7, p. 293, No. 1, Modèle, No. 43.

Pullenia sphæroides Carpenter, 1862, Introd. Study Foram., p. 184, pl. xii, fig. 12.

Pullenia sphæroides Brady, 1884, Challenger Report, vol. 9, pp. 615, 616, pl. lxxxiv, figs. 12, 13, and cut in text, p. 616, fig. 18.

Pullenia sphæroides Chapman, 1900, Proc. California Acad. Sci., ser. 3, vol. 1, No. 8, p. 252, pl. xxx, fig. 6.

Chapman reports this species as frequent in the California Miocene of Santa Clara County. It appears to be very rare in the material the writer investigated. The species in its outer appearance resembles the thick forms of the genus *Nonionina*. It is, as its name implies, nearly spheroidal in outline, but is slightly compressed at the umbilici. The few large outer segments, five or six in number, completely envelope the earlier chambers. Surface of shell smooth, glistening. The test is finely perforate, much more so than in *Globigerinæ*. Professor Brady stated in the Challenger Report that these pores do not exceed 0.001 mm. in diameter. The septal lines are only faintly indicated on the exterior surface and are not depressed in the slightest, but they can be seen in reflected light and appear as nearly straight lines running to the shell margin. The septal face is very narrow, very broadly oval, and the aperture occurs as a long cavity extending nearly the entire width of the shell upon the inner margin of the final segment. Cross sections show three or four convolutions.

Geologically the species is found from Cretaceous to Recent. In existing oceans *Pullenia sphæroides* is widely distributed both areally and bathymetrically, since it is found from a few fathoms down to nearly 3,000 fathoms. It has been described from many Tertiary deposits where the species seems to have its greatest development.

Family ROTALIDÆ.

Subfamily ROTALINÆ.

Genus DISCORBINA Parker and Jones (1862).

DISCORBINA ALLOMORPHINOIDES (Reuss).

Pl. VIII, fig. 5.

Valvulina allomorphinoides Reuss, 1860, Sitzungsber. K. Akad. Wiss. Wien, vol. 40, p. 223, pl. xi, fig. 6.
Discorbina allomorphinoides Brady, 1884, Challenger Report, vol. 9, p. 654, pl. xci, figs. 5, 8.
Discorbina allomorphinoides Chapman, 1900, Proc. California Acad. Sci., ser. 3, vol. 1, No. 8, p. 253, pl. xxx. fig. 8.

The *Challenger* expedition (Brady) reports the finding of this species at three stations—at a depth of 10 fathoms off Port Jackson, at 155 fathoms off Raine Island, and at 95 fathoms off the Philippines. Reuss's specimens were from the Cretaceous of Westphalia.

Test discoidal, thick, built of a few massive chambers, six or seven in the final convolution, separated by nearly straight depressed septa. Ultimate chamber much the largest, with the opening under the margin upon the inferior side. Chapman reports the species as very abundant. The author finds numerous examples also in the material studied.

Genus TRUNCATULINA d'Orbigny (1826).

TRUNCATULINA PYGMÆA Hantken.

Pl. VIII, fig. 6.

Truncatulina pygmæa Hantken, 1875, Mitth. K. ung. geol. Anstalt, vol. 4, p. 78, pl. x, fig. 8.
Truncatulina pygmæa Brady, 1884, Challenger Report, vol. 9, pp. 666, 667, pl. xcv, figs. 9, 10.
Truncatulina pygmæa Chapman, 1900, Proc. California Acad. Sci., ser. 3, vol. 1, No. 8, p. 254, pl. xxx, fig. 11.

The test of *Truncatulina pygmæa* is circular, vaulted on both sides, with nine or ten chambers in the final volution separated by slightly arched septa on the inferior surface. On the superior side there are a few more chambers in the final volution separated by curving septa and with from two and a half to three convolutions, all of which are seen on the superior aspect. The shell is rather common in the California Miocene. As a fossil it was recorded by Hantken from the Oligocene of Hungary. In existing seas it is rare and is essentially a deep-water foraminifer.

TRUNCATULINA LOBATULA (Walker and Jacob).

Pl. IX, fig. 1.

Nautilus lobatulus Walker and Jacob, 1798, Adam's Essays, Kanmacher's ed., p. 642, pl. xiv, fig. 36.
Truncatulina lobatula Brady, 1884, Challenger Report, vol. 9, pp. 660, 661, pl. xcii, fig. 10; pl. xciii, figs. 1, 4, 5; pl. cxv, figs. 4, 5.
Truncatulina lobatula Egger, 1895, Jahrsber. Naturhist. Ver. Passau, vol. 16, p. 31, pl. v, fig. 5, a, b, c.
Truncatulina lobatula Bagg, 1898, Bull. U. S. Geol. Survey No. 88, p. 65.

The species designated *Truncatulina lobatula* is probably as widely diffused as *Globigerina bulloides* which is known in every ocean, in every sea, and at all depths. The earliest record of the form as a fossil is in carboniferous strata and it is well known in every subsequent deposit.

The characteristic features of this very variable species are its plano-convex habit; only moderately vaulted on the inferior surface; last volution with from six to eight chambers, separated by very slightly depressed septa which are more arcuate upon the superior surface and more nearly straight upon the lower or vaulted side. The aperture is typically located in an extended cavernous slit at and along the inner margin of the ultimate segment upon the superior surface.

The varieties of the species are interminable and some are sessile as in fig. 10, pl. xcii, of the Challenger Report. The more convex varieties merge into *Truncatulina refulgens* and the flattened varieties constitute *Truncatulina wuellerstorfi*. Regular built forms comprise the species *Truncatulina boueana* d'Orbigny, while irregular wide-growing specimens belong under *Truncatulina variabilis* d'Orbigny. The specimens are very coarsely porous in California, and are not very frequent considering the large amount of material examined.

TRUNCATULINA VARIABILIS d'Orbigny.

Pl. IX, fig. 2.

Truncatulina variabilis d'Orbigny, 1826, Annales Sciences Naturelles, vol. 7, No. 8, p. 279.
Truncatulina variabilis Terquem, 1878, Mém. Soc. Géol. France, sér. 3, vol. 1, mém. 3, p. 20, pl. i, figs. 18–25.
Truncatulina variabilis Brady, 1884, Challenger Report, vol. 9, pp. 661, 662, pl. xciii, figs. 6, 7.

D'Orbigny groups about twenty plates of Soldani's figures in his Testaceographia under the single species *Truncatulina variabilis*. There are probably no two of these wide-growing, flattened *Truncatu-*

lina exactly alike, but the general features of irregular chambers are similar. The California Miocene furnishes two or three forms which seem to belong here. The species is a shallow-water form and only in one instance was a specimen dredged from 2,000 fathoms. Usually it is present in shallow margins of tropical and temperate seas. It has been found in the Eocene of Paris basin, and is known throughout the later Tertiaries. The California specimens are broken at the ultimate segment. The portion remaining measures in short diameter 0.9 mm.

TRUNCATULINA WUELLERSTORFI (Schwager).

Pl. IX, fig. 3.

Anomalina wuellerstorfi Schwager, 1866, Novara-Exped., Geol., vol. 2, p. 258, pl. vii, figs. 105, 107.

Truncatulina wuellerstorfi Brady, 1884, Challenger Report, vol. 9, p. 662, pl. xciii, figs. 8, 9.

Truncatulina wuellerstorfi Uhlig, 1886, Jahrb. K.-k. geol. Reichsanstalt, vol. 36, p. 174, fig. 3.

Truncatulina wuellerstorfi (*wuellerstorfii*) Egger, 1895, Jahrsber. Naturhist. Ver. Passau, vol. 16, p. 31, pl. v, fig. 6 a, b, c.

Truncatulina wuellerstorfi Bagg, 1898, Bull. U. S. Geol. Survey No. 88, p. 66.

Test circular, coarsely porous; inferior surface convex, superior complanate; peripheral edge acute; chambers narrow; septa strongly curved, crescent-shaped with broad septal ridges, nine in the last convolution; aperture a small marginal slit. The specimens the writer obtained in the New Jersey Cretaceous measured 0.5 mm. in diameter. These specimens were much more vaulted than the typical forms, while the specimens (not common) in the California strata are very strongly depressed and are typical for the species. The pores are remarkably large and coarse. The form occupies an intermediate position between *Truncatulina lobatula* and *Anomalina arimensis*.

The species is known as early as the Cretaceous (Bagg); is reported from the Pliocene of Kar Nicobar (Schwager), but is not abundantly noted in fossil strata. In the deep-water oozes of existing seas *Truncatulina wuellerstorfi* is frequently present and it has been dredged from about 200 to over 2,000 fathoms.

Genus ANOMALINA d'Orbigny (1826).

ANOMALINA AMMONOIDES (Reuss).

Pl. IX, fig. 4.

Rosalina ammonoides Reuss, 1845, Verstein. böhm. Kreid., pt. 1, p. 36, pl. xiii, fig. 66; pl. viii, fig. 53.

Rotalia ammonoides Gümbel, 1870, Sitzungsber. K. bayer. Akad. Wiss., p. 283.

Planorbulina ammonoides Jones and Parker, 1872, Quart. Jour. Geol. Soc. London, vol. 28, p. 106; table, p. 109.

Anomalina ammonoides Brady, 1884 Challenger Report, vol. 9, pp. 672, 673, pl. xciv, fig. 2, 3.

Anomalina ammonoides Bagg, 1898, Bull. U. S. Geol. Survey No. 88, p. 67, pl. vi, fig. 5.

Test nautiloid, coarsely porous, small, compressed; lateral surfaces nearly equally convex; depressed at the umbilici. The peripheral margin is round and the aperture is a nearly median arched slit upon the inner margin of the ultimate segment. The diameter measures from 0.5 to 0.8 mm.

Geological distribution is from Cretaceous to Recent. The *Challenger* dredged only one station in the North Atlantic which yielded the above species from a depth of 435 fathoms. In the South Pacific many dredgings from a few fathoms to 1,350 furnished specimens and the species is widely distributed, being found in the Red Sea, off Bombay, Hongkong, New Zealand, Humboldt Bay, Papua, and in shore sands from Melbourne.

ANOMALINA ARIMINENSIS (d'Orbigny).

Pl. IX, fig. 5.

Planulina ariminensis d'Orbigny, 1826, Annales Sciences Naturelles, vol. 7, p. 280, pl. v, figs. 1–3, bis; Modèle No. 49.

Planorbulina ariminensis Parker, Jones and Brady, 1865, Ann. Mag. Nat. Hist., ser. 3, vol. 16, p. 26, pl. iii, fig. 78.

Anomalina ariminensis Brady, 1884, Challenger Report, vol. 9, pp. 674, 675, pl. xciii, figs. 10, 11.

Test perfectly complanate or nearly so, sides flat, periphery nearly square, sutures deeply incised, septa curved, aperture nearly median. The shell closely resembles *Anomalina ammonoides*, but is much more depressed. Its nearest isomorph is *Discorbina biconcava*, Parker and Jones. It appears first as a fossil in the chalk of England, and is present in succeeding formations down to the present time. In the North Atlantic it is widely distributed and ranges from 150 to 1,600 fathoms. Two localities in the South Atlantic yielded specimens at depths of 350 and 2,200 fathoms. At the greater depth specimens were rare, the species being more abundant at the lesser depth and of typical forms. It is common in the Mediterranean at every depth down to 500 fathoms. Parker and Jones detected it in material from the Abrolhos Bank at a depth from 47 to 940 fathoms. It is rare in the California Miocene. Diameter, short axis, 0.5 mm.

ANOMALINA GROSSERUGOSA (Gümbel).

Pl. IX, fig. 6.

Truncatulina grosserugosa Gümbel, 1868, Abhandl. m.-ph. Cl. K. bayer. Akad. Wiss., vol. 10, p. 660, pl. ii, fig. 104 a, b.

Truncatulina grosserugosa Hantken, 1875, Mittheil. K. ung. geol. Anstalt, vol. 4, p. 74, pl. ix, fig. 6, a, b

Anomalina grosserugosa Brady, 1884, Challenger Report, vol. 9, p. 673, pl. xciv, figs. 4, 5.
Anomalina grosserugosa Bagg, 1898, Bull. U. S. Geol. Survey No. 88, p. 67, pl. vi, fig. 4.
Anomalina grosserugosa Sherborn and Chapman, 1889, Jour. Roy. Microsc. Soc., p. 487, pl. xi, fig. 34.
Anomalina grosserugosa Chapman, 1900, Proc. California Acad. Sci., ser. 3, vol. 1, No. 1, pp. 253, 254, pl. xxx, fig. 9.

Test nautiloid, very coarsely porous, pores larger and more numerous upon the inferior surface; both sides convex; umbilici distinct; peripheral margin round; chambers large, inflated, only eight in final convolution; septa nearly straight; aperture median or nearly so, arched. The form is closely related to *Nonionina umbilicatula*, but its chambers are more strongly inflated and the pores are larger. It is also very closely related to *Anomalina ammonoides*, but there are a much smaller number of chambers in the former, and the form is more massive and the volutions are not so distinct as in *A. ammonoides*.

The geological distribution begins with the upper Cretaceous (Bagg), and the species is found in the Eocene of Bavaria (Gümbel), the Clavulina-szaboi formation of Hungary (Hantken), the Miocene of Vienna (d'Orbigny). It seems to be a rather abundant species in the Tertiary. In existing oceans, Professor Brady noted its occurrence at four stations in the North Atlantic at depths ranging from 450 to 1,000 fathoms; at three stations in the South Atlantic at depths ranging from 420 to 1,415 fathoms; at two in the South Pacific at depths of 610 and 2,160 fathoms, and at two in the North Pacific at depths of 345 and 2,050 fathoms.

Anomalina rotula d'Orbigny.

Pl. X, fig. 1.

Anomalina rotula d'Orbigny, 1846, Foram. Foss. Vienne, p. 172, pl. x, figs. 10–12.
Planorbulina rotula Sherborn and Chapman, 1886, Jour. Roy. Microsc. Soc., ser. 2, vol. 6, p. 757, cut in text No. 155.
Planorbulina rotula Terrigi, 1889, Mem. R. Accad. Lincei, ser. 4, vol. 6, p. 116, pl. vii, fig. 4.
Anomalina rotula Chapman, 1900, Proc. California Acad. Sci., ser. 3, vol. 1, No. 8, p. 254, pl. xxx, fig. 10.

The test of *Anomalina rotula* represents the extreme variation from the symmetrical form of the genus being closely allied with Planorbuline types. The entire convolutions are visible upon one side, and reveal about twenty-two chambers, of which nine or ten constitute the last volution. The aperture is nearly median as in normal species, and the reverse side is umbilicated, and the margin is neatly rounded. The shell is very abundant in the California Miocene. Its earliest appearance is from the Eocene, and it appears to be limited to the Tertiary.

Genus PULVINULINA Parker and Jones (1862).

PULVINULINA AURICULA (Fichtel and Moll).

Pl. X, fig. 3.

Nautilus auricula var. a. Fichtel and Moll, 1803, Test. Microsc., p. 108, pl. xx, figs. a, b, c.

Valvulina excavata d'Orbigny, 1839, Foram. Canaries, p. 137, pl. i, figs. 43–45.

Pulvinulina auricula, Brady, 1884, Challenger Report, vol. 9, pp. 688, 689, pl. cvi, fig. 5, a, b, c.

The test of *Pulvinulina auricula* is elongate-oval, with rather square-set anterior margin made by prolongation of the ultimate chamber. There is scarcely any difference between the vaulting of each side, but if anything the superior is the lower of the two. The form resembles *P. brongniartii*, already described in this report, but it is only one-half the size (0.3 mm.), is much whiter, cleaner, more delicate, and appears to possess fully as sharp a keel as the more pronounced acute-margined forms of the species. Only a few specimens of this species are present. The geological distribution of *Pulvinulina auricula* commences with the Eocene and extends to the present day. It has been described under many synonyms and has been placed under several genera, such as *Rotalina*, *Valvulina*, *Nautilus*, etc. The bathymetric range of the species in the North Atlantic, where it is most common, is from the littoral zone down to 200 fathoms, and specimens have been dredged at over 500 fathoms, but the form is typically a shallow-water species.

PULVINULINA BRONGNIARTII (d'Orbigny).

Pl. X, fig. 2.

Rotalia brongniartii d'Orbigny, 1826, Annales Sciences Naturelles, vol. 7, p. 273, No. 27.

Rotalina brongniarti Reuss, 1845–46, in Geinitz, Grundr. Verstein., p. 673, pl. xxiv, fig. 55.

Rotalina brongniartii d'Orbigny, 1846, Foram. Foss. Vienne, pp. 158, 159, pl. viii, figs. 23–24.

Pulvinulina brogniarti (*brongniartii*) Hantken, 1875 (1876), A magy. kir. foldt. int. evkonyve, vol. 4, p. 68, pl. ix, fig. 5.

Test similar to typical "*auricula*" *Pulvinulina* forms with obliquely set chambers on the superior surface and with nearly straight depressed septa on the inferior side. The margin terminates in sharp obtuse-angled periphery and both surfaces are vaulted with the ultimate chamber so much enlarged as to give an unsymmetrical appearance when the shell is viewed from the anterior aspect. D'Orbigny considered the species closely related to *Rotalina elliptica*, from which it is distinguished by its more elliptical form and its less rugose character. The form *Pulvinulina brongniartii* appears to be very closely related to *Pulvinulina oblonga*, but the latter has curved septa and more numerous chambers on its superior surface. It also resembles *Pulvinulina auricula*, but the latter has a somewhat greater quadrangular elongation.

It is barely possible that the species under discussion may be considered a variety of the more commonly described species *Pulvinulina auricula.* D'Orbigny's specimens were from the Miocene of Nussdorf and from Baden, Austria, and he states that it is living in the Adriatic Sea.

Genus ROTALIA (Lamarck), 1804.

ROTALIA BECCARII (Linné).

Pl. X, fig. 4.

Nautilus beccarii Linné, 1767, Syst. Nat., 12th ed., p. 1162; 1788, Gmelin's ed., p. 3370, No. 4.

Streblus beccarii Fischer, 1819, Adversaria Zoologica, fasc. ii, p. 75.

Turbinulina beccarii d'Orbigny, 1826, Annales Sciences Naturelles, vol. 7, p. 275, No. 42; Modèle No. 74.

Rotalia beccarii (sp. *becarii*) Brown, 1844, Illustr. Recent Conch. Great Britain, ed. 2, p. i, pl. i, fig. 12.

Rotalia beccarii Brady, 1884, Challenger Report, vol. 9, p. 704, pl. cvii, figs. 2, 3.

Rotalia beccarii Bagg, 1898, Bull. American Paleont., vol. 2, No. 10, p. 38, pl. iii, fig. 3.

Test finely porous, formed of a nearly circular low turbinate spire with an obtusely rounded, lobulated peripheral margin. The test is composed of three or four convolutions compactly built, and with a large number of chambers which are separated from one another by highly curved septa. The inferior surface is often beaded by exogenous granules at or near the umbilicus. As a fossil the form first occurs in the Miocene and it is known in the later Tertiaries in many regions. It is very abundant in the Pleistocene of Cornfield Harbor, Md., and was found by the writer in the Miocene of Darlington, S. C. It is a shallow-water foraminifer, and according to Professor Brady it inhabits the margins of all great oceans.

ROTALIA SOLDANII (d'Orbigny).

Pl. X, fig. 5.

Gyroidina soldanii d'Orbigny, 1826, Annales Sciences Naturelles, vol. 7, p. 278, No. 5, Modèle No. 36.

Rotalia soldanii (after d'Orbigny) Parker, Jones, and Brady, 1871, Ann. Mag. Nat. Hist., ser. 4, vol. 8, p. 176, pl. xii, fig. 151.

Rotalia soldanii Brady, 1884, Challenger Report, vol. 9, pp. 706, 707, pl. cvii, figs. 6, 7.

Rotalina soldanii Egger, 1895, Jahrsber. Naturhist. Ver. Passau, vol. 16, p. 34, pl. v, fig. 10.

Rotalia soldanii Bagg, 1898, Bull. American Paleont., vol. 2, No. 10, p. 333.

Test plano-convex or nearly so, circular, and with slightly lobulated periphery, superior side showing numerous curved septa, inferior side much vaulted, with approximately straight septa which are excavated at the umbilicus.

"The plano-convex habit of growth reaches its extreme development, so far as the present genus is concerned, in *Rotalia soldanii*, the test of which resembles that of *Rotalia orbicularis*, except that the convexity of the inferior side is considerably greater. The species corresponds morphologically to *Truncatulina refulgens* and *Truncatulina micheliniana*, but the shell is more neatly and compactly built, the outline is more rounded, and the walls more finely perforated than in either of the latter species. Sections of the test show that the septal walls are double, and that there is a considerable deposit of shell substance in the region of the umbilicus, but without any trace of canals."[a]

The species is known as far back as the Cretaceous, and is present in every succeeding formation. In existing oceans it is universally distributed in deep waters, and is seldom found at depths of less than 300 fathoms. The California Miocene contains only a few specimens of this species.

Family NUMMULINIDÆ.

Subfamily POLYSTOMELLINÆ.

Genus NONIONINA d'Orbigny (1826).

NONIONINA POMPILIOIDES (Fichtel and Moll).

Pl. X, fig. 6.

Nautilus pompilioides Fichtel and Moll, 1798, Test. Brit., p. 31, pl. ii, figs. a–e.

Nonionina umbilicatula d'Orbigny, 1826, Annales Sciences Naturelles, vol. 7, p. 293, pl. xv, figs. 10–12, No. 5, Modèle No. 86.

Nonionina pompilioides Parker, Jones, and Brady, 1871, Ann. Mag. Nat. Hist., ser. 4, vol. 8, p. 246, pl. xii, fig. 158.

Nonionina pompilioides Brady, Challenger Report, 1884, vol. 9, p. 727, pl. cix, figs. 10, 11.

Nonionina pompilioides Chapman, 1900, Proc. California Acad. Sci., ser. 3, vol. 1, No. 8, p. 256, pl. xxx, figs. 16, 16a.

The test of *Nonionina pompilioides* is characterized by a few large, thick, closely involuted chambers, the ultimate of which ends in a broad, flat, terminal septal face. Most of our forms have six chambers visible in the final volution. The septa are straight, or nearly so, and the aperture is a centrally placed slit upon the inner side of the ultimate chamber. The form resembles *Nonionina umbilicatula*, but the form is thicker, has fewer chambers, and is of smaller diameter. At the present time it seems to be almost exclusively a deep-water form, and in the Challenger Report it is recognized from seven stations in

[a] Challenger Report, vol. 9, pp. 706, 707.

the North Atlantic at from 1,000 to 2,750 fathoms; from one in the South Atlantic at 2,200 fathoms; from two in the Southern Ocean at 1,570 and 1,950 fathoms; from eight in the South Pacific Ocean from 1,350 to 2,421 fathoms; and from two in the North Pacific from 1,850 and 2,250 fathoms. Its geological distribution begins with the middle Tertiary.

Mr. Chapman recognizes it as a rare form in the Miocene of Santa Clara County, Cal. It is present in the present collection, and is common.

NONIONINA BOUEANA d'Orbigny.

Pl. XI, fig. 1.

Nonionina boueana d'Orbigny, 1846, Foram. Foss. Vienne, p. 108, pl. v., figs. 11, 12.
Nonionina boueana Brady, 1884, Challenger Report, vol. 9, p. 729, pl. cix, figs. 12, 13.
Nonionina boueana Chapman, 1900, Proc. California Acad. Sci., ser. 3, vol. 1, No. 8, pp. 255, 256, pl. xxx, figs. 14, 14a.

This beautiful species of *Nonionina* is rather rare in the material we are investigating, although Chapman reports that it is frequent in the California Miocene of Santa Clara County. The sutures are remarkably wide and gracefully curved with somewhat depressed umbo and with very sharp periphery, though without definite keel. The septal face is very long oval and with the slit-like aperture on the inner margin. There are about ten chambers in the final volution, the inner two are not easily distinguished and the outline of the shell is elongate-oval, due to lengthening of the ultimate chamber. This species has been recorded in several other places than those given above. The writer discovered it in the Miocene well-boring material from Norfolk, Va., and described it in the "Tertiary and Pleistocene Foraminifera of the Middle Atlantic Slope."[a] The small diameter of the shell measures 0.35 mm. The geological range is from the Oligocene to Recent. There are seven localities mentioned by Brady in the Challenger Report where this species was found, but in every case the shells were in very shoal waters, the deepest being in the Bay of Biscay, at a depth of 200 fathoms.

NONIONINA COMMUNIS d'Orbigny.

Pl. XI, fig. 2.

Nonionina communis d'Orbigny, 1826, Annales Sciences Naturelles, vol. 7, p. 294, No. 20.
Nonionina communis d'Orbigny, 1846, Foram. Foss. Vienne, p. 106, pl. v, figs. 7, 8.
Nonionina communis Chapman, 1900, Proc. California Acad. Sci., ser. 3, vol. 1, No. 8, p. 255, pl. xxx, fig. 13.

Mr. Chapman records this species as frequent in the Miocene of Santa Clara County, and it is not rare in the material of similar age

[a] Bull. American Paleont., vol. 2, No. 10, p. 334.

under investigation. The form occupies an intermediate position between *Nonionina scapha* and *Nonionina boueana*. The shell is composed of rapidly enlarging rather narrow chambers, of which the last is much the largest and longest, as in *N. scapha*. There are about eight or nine chambers visible in the final volution. Shell shows slightly depressed septa, but little arched, and the peripheral margin is broadly angular with a large oval septal face. The geological range is from Tertiary to Recent.

NONIONINA UMBILICATULA (Montagu).

Pl. XI, fig. 3.

Nautilus umbilicatulus Montagu, 1803, Test. Brit., p. 191; Suppl., p. 78, pl. xviii, fig. 1.
Robulina planciana d'Orbigny, 1826, Annales Sciences Naturelles, vol. 7, p. 290, No. 20.
Nonionina soldanii d'Orbigny, 1846, Foram. Foss. Vienne, p. 109, pl. v, figs. 15, 16.
Nonionina umbilicatula Terrigi, 1883, Atti Accad. Pontificia Nuovi Lincei, vol. 35, p. 203, pl. iv, fig. 48.
Nonionina umbilicatula Brady, 1884, Challenger Report, vol. 9, p. 726, pl. cix, figs. 8, 9.
Nonionina umbilicatula Chapman, 1900, Proc. California Acad. Sci., ser. 3, vol. 1, No. 8, p. 256, pl. xxx, fig. 15.

Test large and compactly built, with six or seven chambers in the outer volution, separated by nearly straight septa. The umbilicus is deeply sunken and the chambers increase rapidly in size and the ultimate segment ending in an oval almost globular septal face on the inner part of which is the elliptical aperture on the median plane. The shell is abundant in the California Miocene. It is closely related to *Nonionina depressula* and *Nonionina pompilioides*.

In existing oceans *Nonionina umbilicatula* is everywhere recognizable, and it is known in dredgings from as low as 30 to 3,125 fathoms. Its geological occurrence dates from the Eocene, and it has been recorded in every subsequent formation.

Genus POLYSTOMELLA Lamarck (1822).

POLYSTOMELLA CRISPA (Linné).

Pl. XI, fig. 4.

Nautilus crispus Linné, 1767, Syst. Nat., 12th ed., p. 1162; 275.
Polystomella crispa Lamarck, 1822, Anim. sans Vert., vol. 7, p. 625, No. 1.
Polystomella crispa d'Orbigny, 1846, Foram. Foss. Vienne, p. 125, pl. vi, figs. 9–14.
Polystomella crispa Williamson, 1858, Recent Foram. Great Britain, p. 40, pl. iii, figs. 78–80.
Polystomella crispa Brady, 1884, Challenger Report, vol. 9, p. 736, pl. cx, figs. 6, 7.

The species known as *Polystomella crispa* has been described by many authors in addition to the references given above. It is widely known in fossil beds from the Eocene, in the Septaria clays; in the Miocene of Germany, Austria, Bavaria, France, and Italy; it is also described from the salt clay of Wieliczka by Reuss; from the Pliocene of Italy and Spain; from the Crag of England, and from the Quaternary of Europe. In existing oceans the species is abundant from a depth of a few fathoms down to 355 fathoms, and is known in arctic as well as tropical regions.

The shell is characterized by a moderately vaulted nautiloid biconvex test; sharp peripheral margin, well-defined umbo; numerous narrow, slightly curved chambers, separated by prominent septa, with broad septal bridges between them, which are not as numerous as the bridges in forms like *Polystomella craticulata* (Fichtel and Moll). The test is similar to *Polystomella macella* (Fichtel and Moll), but is not depressed at the umbo as in the latter species. The aperture consists of a V-shaped row of pores along the inner margin of the final segment. There is only one specimen in the California Miocene. Diameter, short axis, 0.5 mm.

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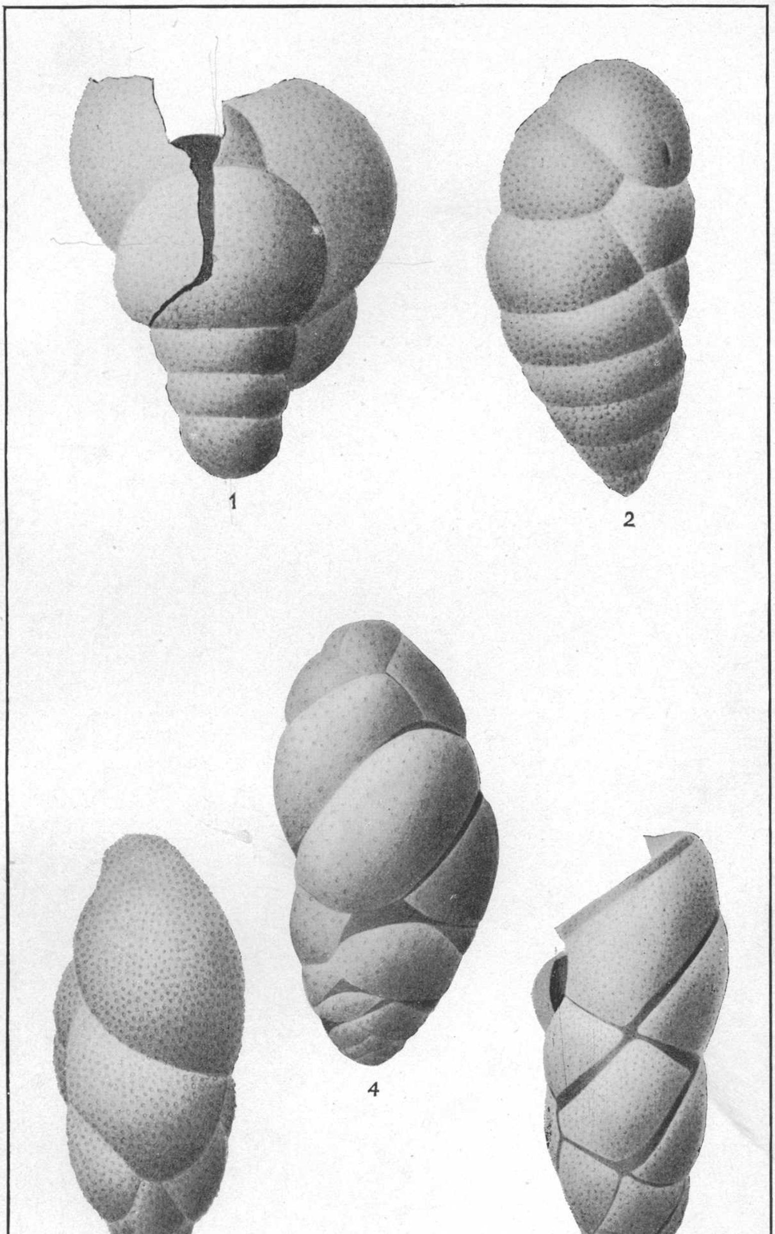

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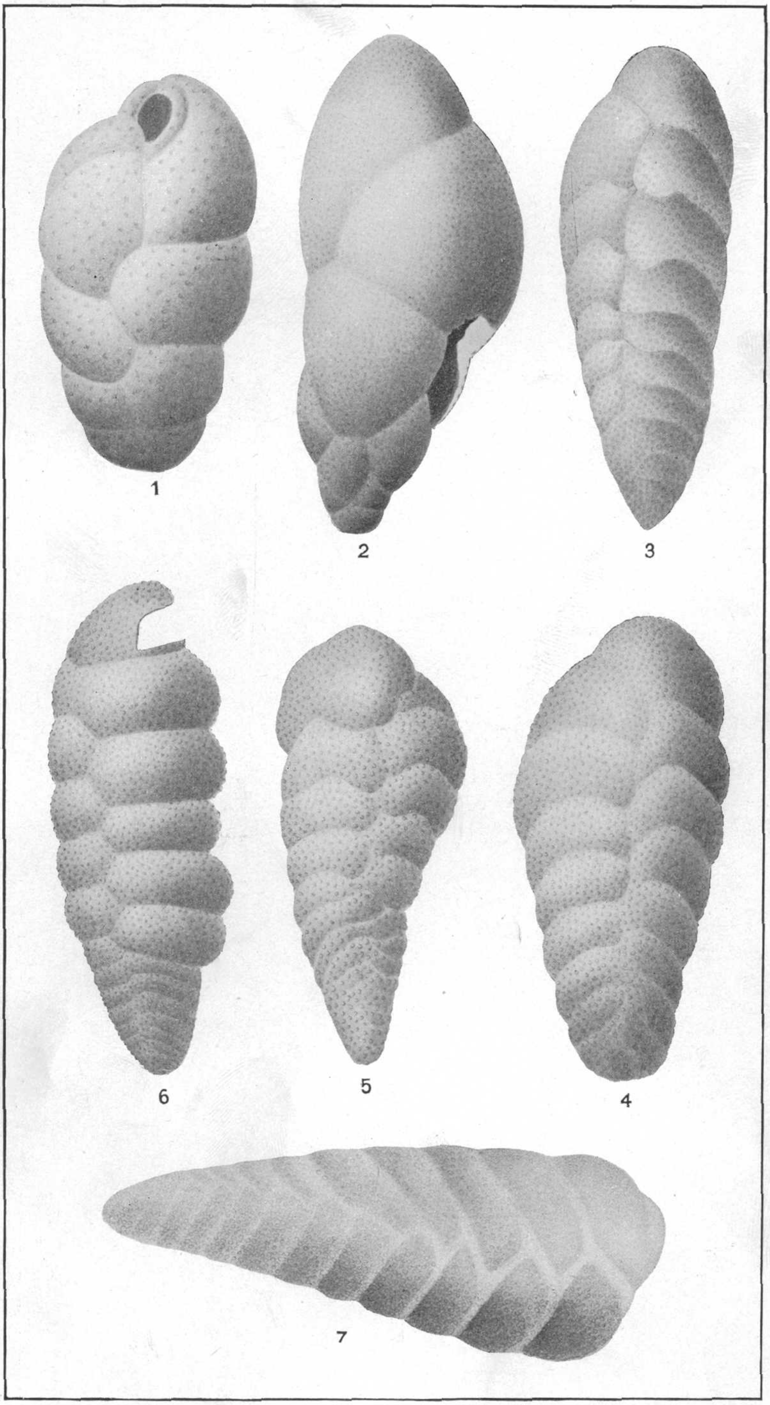

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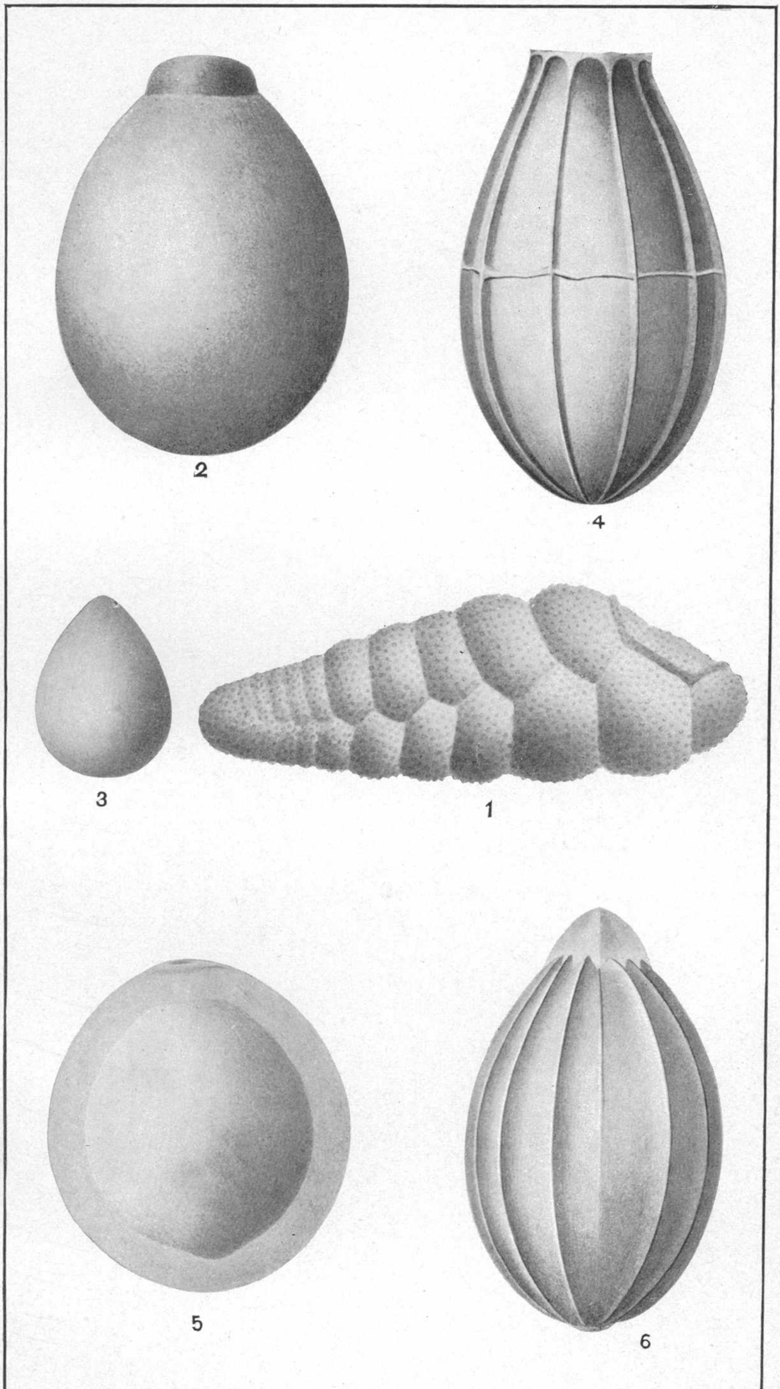

BOLIVINA AND LAGENA.

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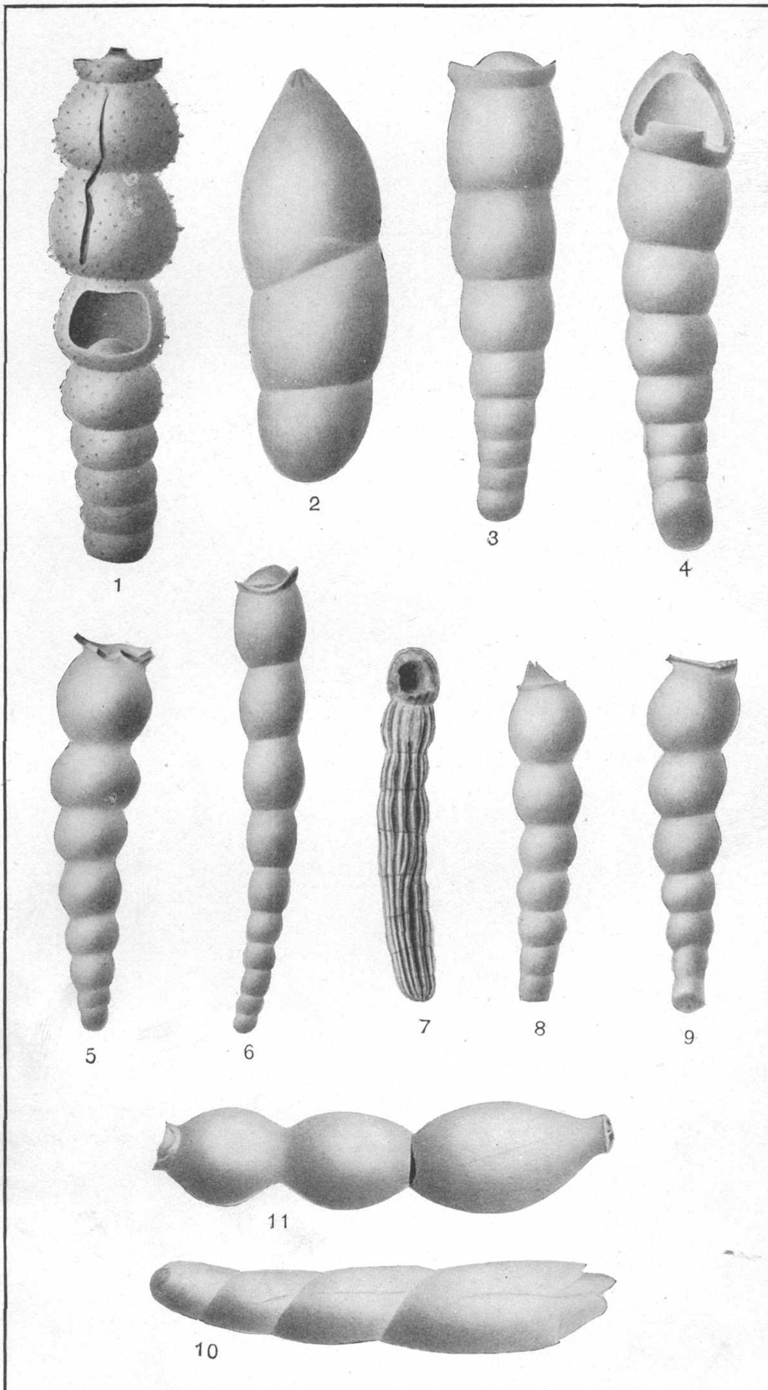

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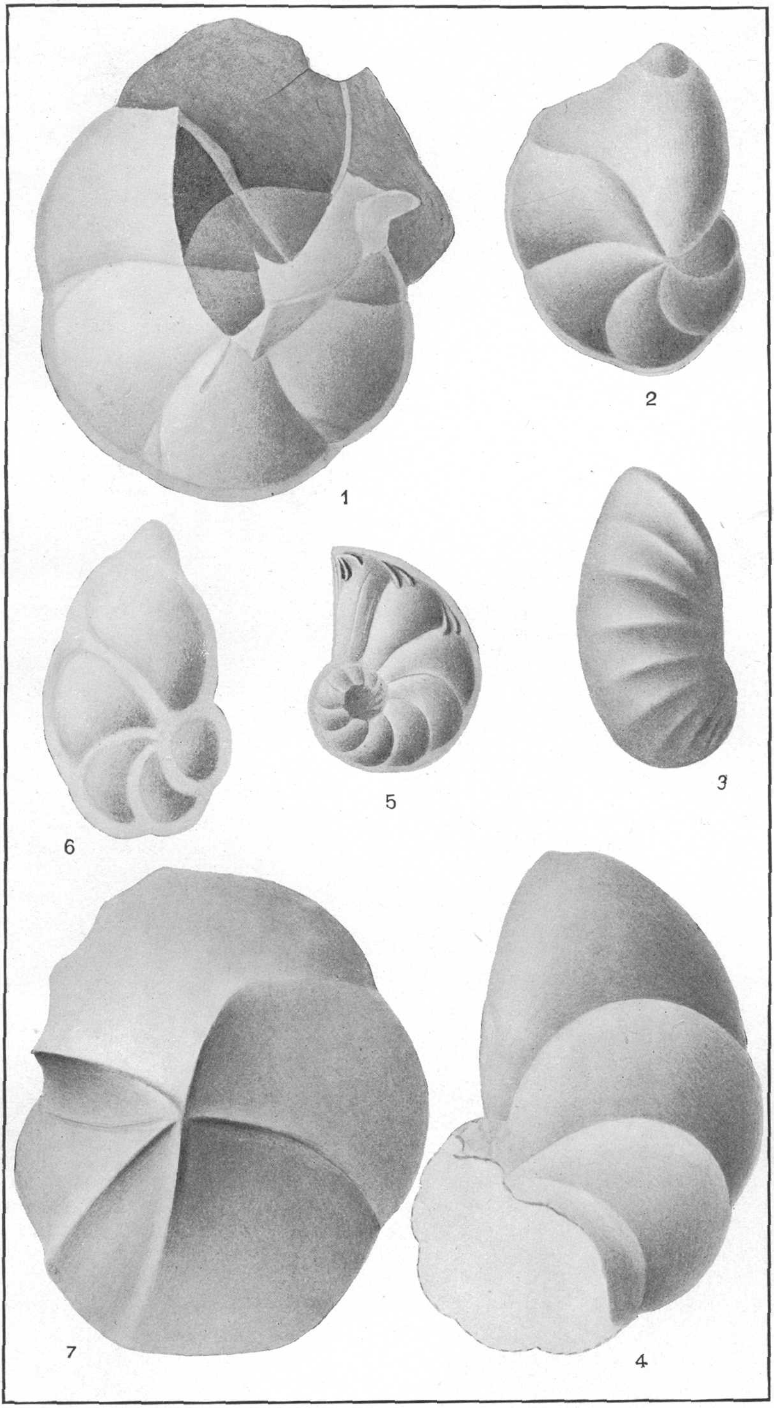

CRISTELLARIA.

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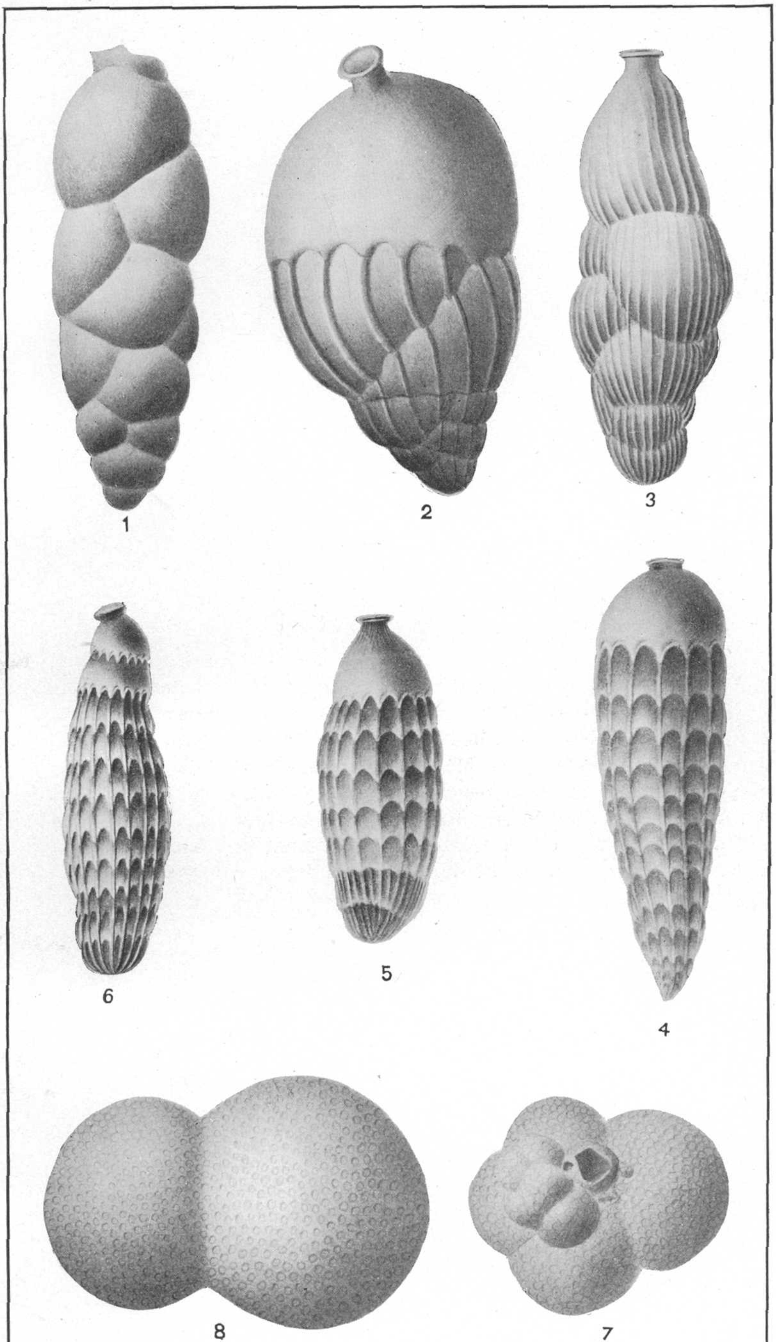

UVIGERINA, SAGRINA, AND GLOBIGERINA.

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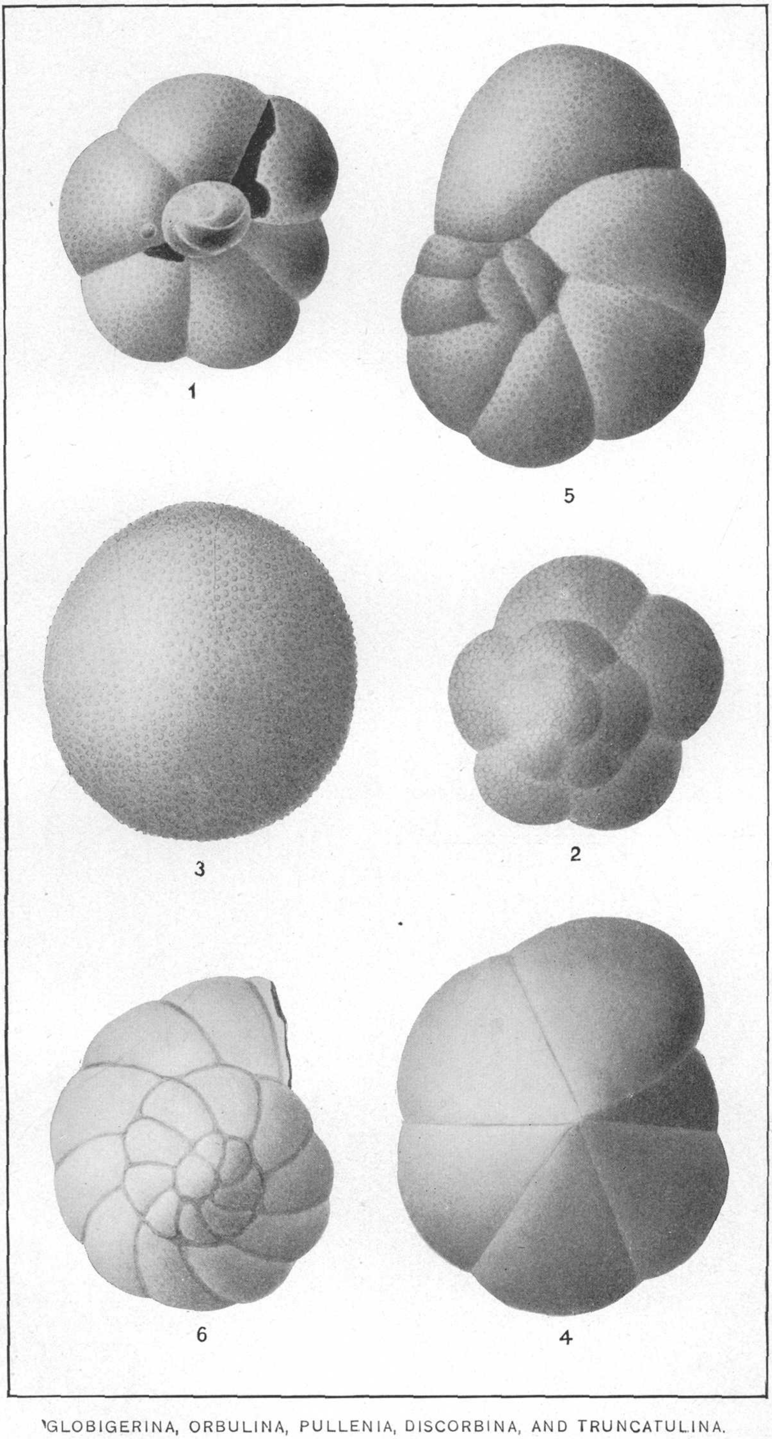

GLOBIGERINA, ORBULINA, PULLENIA, DISCORBINA, AND TRUNCATULINA.

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PLATE IX.

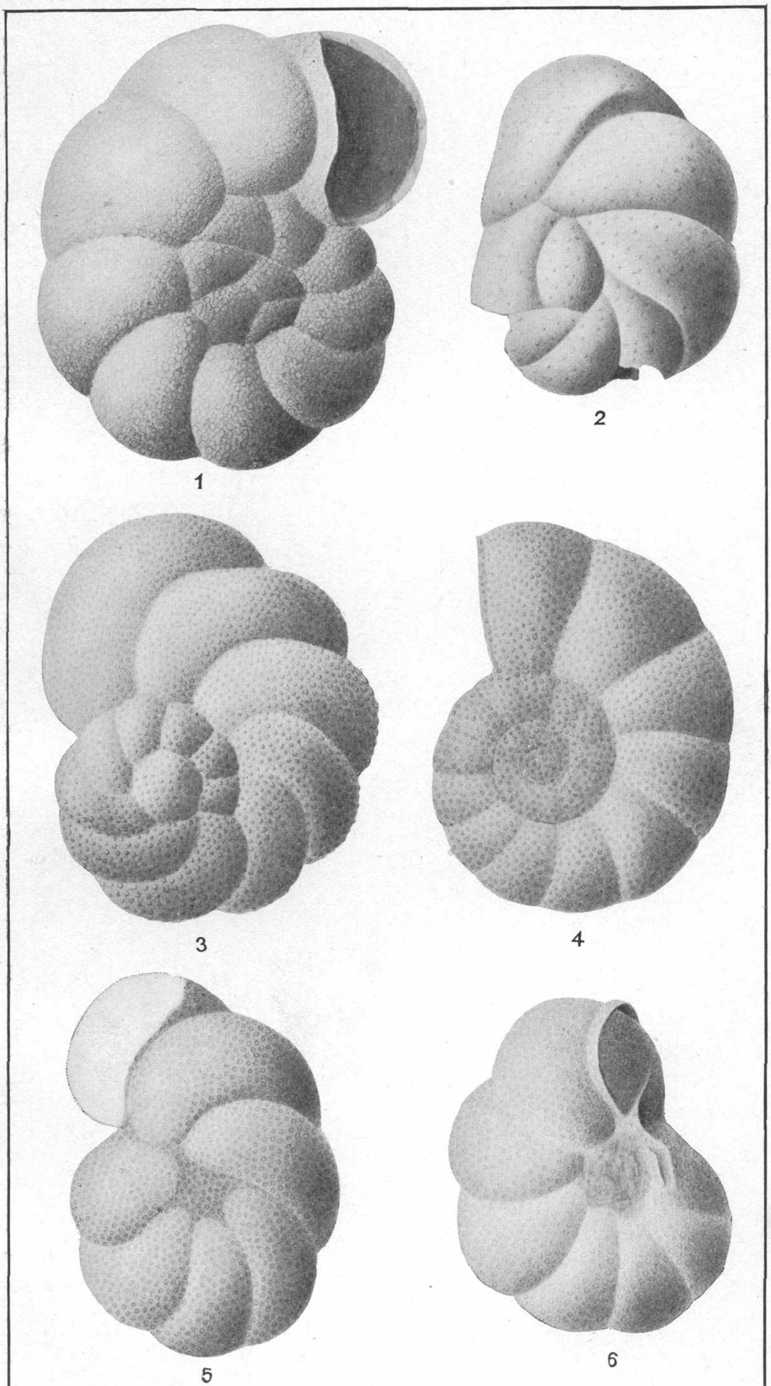

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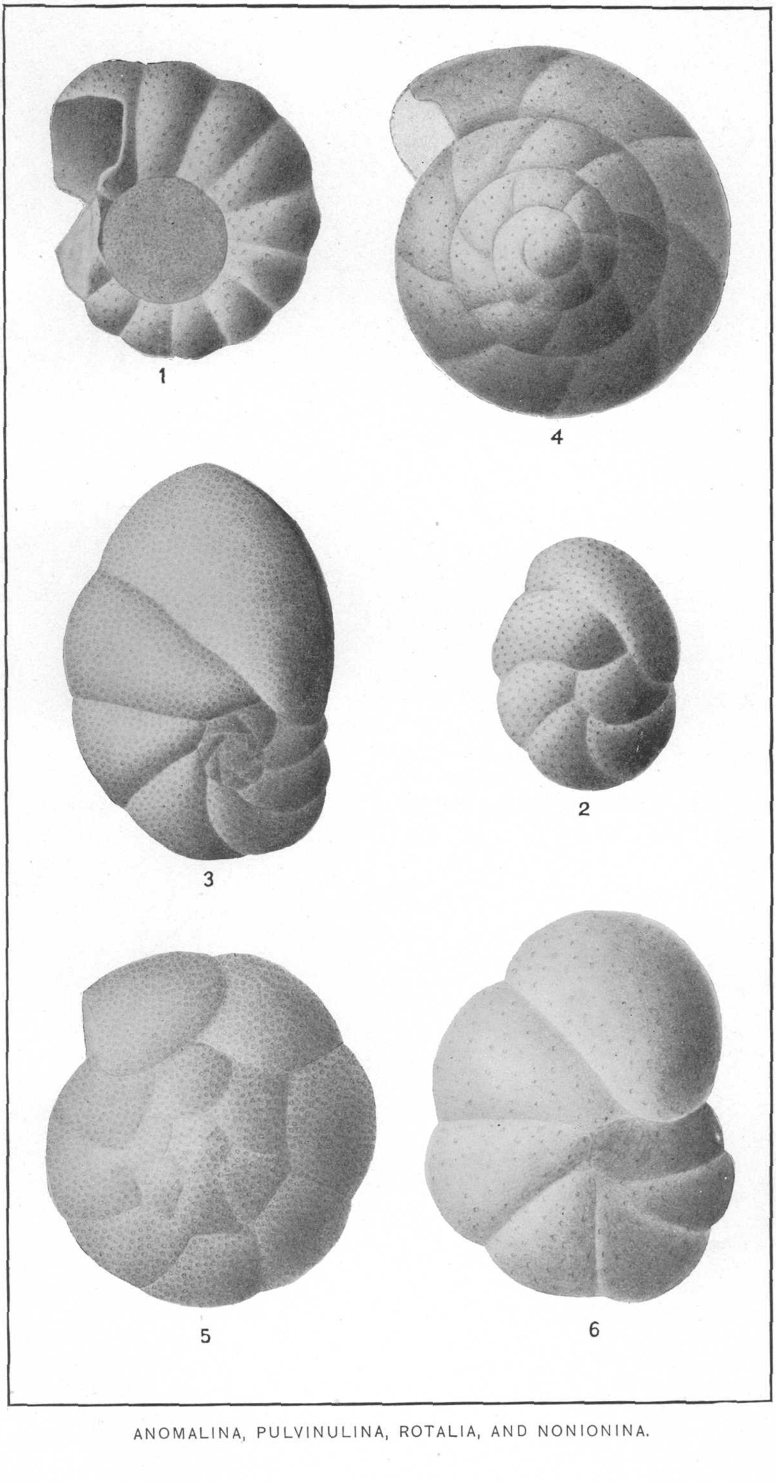
PLATE X.



ANOMALINA, PULVINULINA, ROTALIA, AND NONIONINA.

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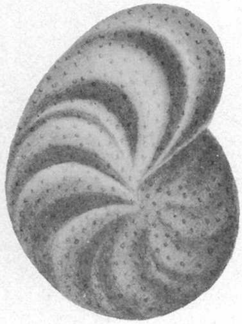
PLATE XI.



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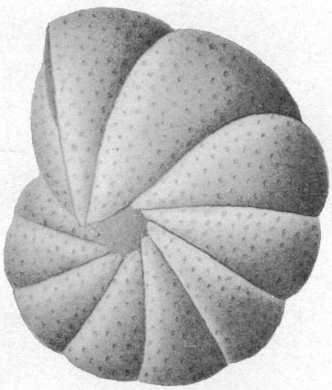

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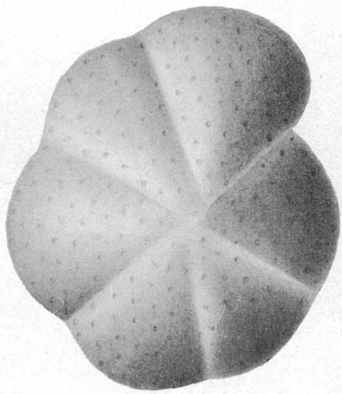

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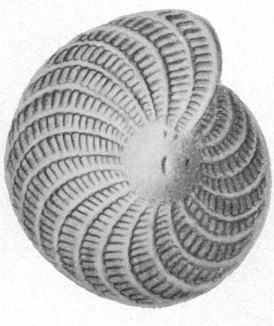

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NONIONINA AND POLYSTOMELLA.

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[Names in italic are synonyms; figures in black-face type indicate pages on which descriptions are given; figures in italic refer to plates.]