UNITED STATES DEPARTMENT OF THE INTERIOR
J. A. Krug, Secretary
GEOLOGICAL SURVEY
W. E. Wrather, Director

Professional Paper 210

SHORTER CONTRIBUTIONS TO GENERAL GEOLOGY

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ILLUSTRATIONS

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Professional Paper 210–A

TERTIARY FORAMINIFERA FROM ST. CROIX VIRGIN ISLANDS

BY

J. A. CUSHMAN

WITH

A NOTE ON THE GEOLOGY

BY

D. J. CEDERSTROM

Shorter contributions to general geology, 1946
(Pages 1–17)

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CONTENTS

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Tertiary Foraminifera from St. Croix, Virgin Islands

By J. A. Cushman

ABSTRACT

This paper records the Foraminifera found in three wells drilled on the island of St. Croix, V. I. The species and varieties found total 103 forms, of which 5 were originally described from this material. Two of the wells and the upper part of the third appear to cut Miocene rocks. The lower part of the third well appears to have reached Oligocene rocks.

INTRODUCTION

This paper is based on the Foraminifera found in the cuttings from three test wells drilled in the winter of 1938–39 on the island of St. Croix, V. I. These wells were drilled as part of a program of test drilling for ground water financed by the Public Works Administration and were located on lands owned by the United States Government that have been put to economic use by the Virgin Islands Co., a quasi-government corporation. The wells were drilled by the rotary, clay-seal method, and much mixing of material from lesser depths with that of greater depths has taken place. It is believed, however, that valuable data have been obtained from the cuttings and that the results are well worth recording.

The geographic and geologic setting of the wells is described by D. J. Cederstrom, of the Geological Survey, who made a study of the geology and ground-water conditions of the island, supervised the test drilling, and collected the cuttings on which this paper is based.

NOTE ON THE GEOLOGY OF ST. CROIX, VIRGIN ISLANDS

By D. J. Cederstrom

The island of St. Croix lies about 95 miles south-southeast of San Juan, P. R., and is one of the Virgin Islands group, of which St. Thomas, St. John, and St. Croix belong to the United States. The island is about 21 miles long. The western part is about 6 miles wide, but the eastern part tapers to a width of less than 1 mile at the eastern end.

The western part of the island is made up of a mountainous area on the north and a rolling plain on the south. The eastern part of the island is mountainous. (See fig. 1.) The mountainous areas are composed of limestones, breccia, tuff, and volcanic flows of Cretaceous age, strongly folded, metamorphosed, and intruded by dioritic rocks of early Tertiary(?) age. The rolling plain flanking the northern range of mountains is underlain by Tertiary sediments chiefly soft white or creamy marls with intercalated somewhat more consolidated thin-bedded white limestone strata. These beds are gently folded along axes that trend west-southwest. The test drilling revealed that these limy strata are underlain by a gray clay and included limestone conglomerate whose maximum thickness is unknown.[1] In test well No. 1, the location of which is shown in figure 1, a thickness of 1,400 feet of this formation was penetrated. In test well No. 2 the gray clay is underlain by a basal limestone conglomerate, as shown in the accompanying log of the well and in the diagram, figure 2.

The older Upper Cretaceous rocks making up the mountainous areas, referred to by Kemp[2] as the Mount Eagle series, are referred to now as the Mount Eagle volcanics. The marly Tertiary rocks exposed at the surface of the rolling plain were named the Kingshill series by Kemp.[3] They are now referred to as the Kingshill marl. The dark clays and included conglomeratic material found below the light colored Kingshill marl have been named by the writer[4] the Jealousy formation.

Much has been written on the geology of St. Croix by Danish, German, Swedish, and American geologists. Most of the reports written before 1927 are reviewed by Kemp in the publication referred to above. The report by Vaughan[5] on the stratigraphy of St. Croix is of especial interest to students of paleontology. Foraminifera and other fossils are listed in his report that were found in samples taken from outcrops at Evening Hill and Montpelier, 1 mile and 3 miles, respectively, northwest of Christiansted; at Annas Hope, 2 miles southwest of Christiansted; and near Wheel of Fortune Estate, 1 mile south of Frederiksted. Vaughan found that the strata at Evening Hill and Montpelier are probably late Oligocene in age, although they may possibly be assigned to early Miocene. At Annas Hope the horizon was determined to be very low in the Miocene, and near Wheel of Fortune the strata were assigned to the middle Oligocene.

The main geologic features of the island of St. Croix are outlined in two papers.[6]

[1] Cederstrom, D. J., Notes on the physiography of St. Croix, V. I.: Am. Jour. Sci., vol. 239, pt. 2, No. 8, pp. 553–576, 1941.

[2] Kemp, J. F., Introduction and review of the literature on the geology of the Virgin Islands: New York Acad. Sci., Scientific Survey of Porto Rico and the Virgin Islands, vol. 4, pt. 1, p. 49, 1926.

[3] Idem, p. 28.

[4] Cederstrom, D. J., op. cit., p. 557.

[5] Vaughan, T. W., Stratigraphy of the Virgin Islands of the United States and of Culebra and Vieques Islands, and notes on eastern Porto Rico: Washington Acad. Sci. Jour., vol. 13, pp. 303–317, 1923.

[6] Cederstrom, D. J., Notes on the physiography of St. Croix, V. I.: Am. Jour. Sci., vol. 239, pt. 2, No. 8, pp. 553–576, 1941; Geology and ground-water resources of St. Croix, V. I.: U. S. Geol. Survey Water-Supply Paper——(in preparation).

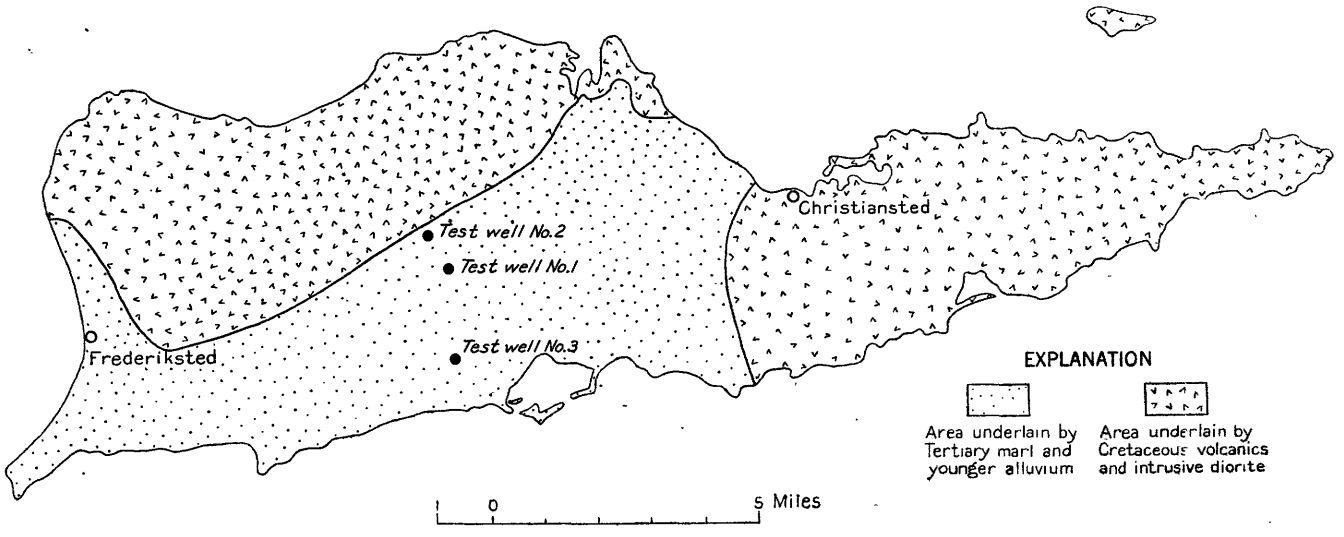

FIGURE 1.—Generalized geologic map of St. Croix, V. I.

The logs of the three wells, from which the material used in this paper were derived, are as follows:

Test well No. 1, 500 yards east-northeast of Bethlehem

	Thickness (feet)	Depth (feet)
Yellow marl	18	0–18
Coarse sand	4	18–22
Coarse gravel	3	22–25
Yellow marl	83	25–108
Greenish gray clay (thin, hard layers of limy rock at 728, 732, 762, 770, 778, and 802 ft.)	987	108–1, 095
Conglomerate-boulders of older, hard rock cemented by lime; clayey streaks present	16	1, 095–1, 111
Gray clay	85	1, 111–1, 196
Conglomerate	5	1, 196–1, 201
Gray clay, with hard streaks at 1,291, 1,305–1,307, and 1,448 ft	305	1, 201–1, 506

Test well No. 2, 300 yards west of great-house at Jealousy

Yellow marl (contains hard, limy layers, each a few inches in thickness, at 81, 83, 84, 85, and 88 ft.)	91	0–91
Gray clay	133	91–224
Clay and boulders	4	224–228
Gray clay	17	228–245
Gray and black clay containing a considerable amount of rounded pebbles and small boulders	10	245–255
Gray clay containing a variable but small amount of sand and pebbles	143	255–398
Hard limestone conglomerate	61	398–459
Hard basement rock	11	459–470

Test well No. 3, at Fair Plain, five-eighths of a mile west of Anguilla

Fine sand, gradually becoming a coarse gravel with depth	33	0–33
Clay, somewhat sandy or gravelly	24	33–57
Coarse sand and gravel (water bearing)	5	57–62
Clay	8	62–70
Sand and gravel (water bearing)	3	70–73
Yellowish marl	89	73–162
Limestone	5	162–167
Yellowish to white marl	8	167–185
Limestone and marl	10	185–195
Yellowish marl	13	195–208
Blue clay	17	208–225

FORAMINIFERA

By J. A. CUSHMAN

DISTRIBUTION AND AGE

Foraminifera are numerous in the well cuttings, 103 forms having been recognized. As noted above, the manner of drilling of the three wells was such that much mixing of materials was possible. Only the level of first appearance of a species is therefore significant, that is, the highest level in the wells, for lower appearances may be merely the effect of mixing.

The distribution of the species in each well is shown on the accompanying chart. On the following pages notes are given on the distribution of the species in the samples, and their known occurrences elsewhere for comparison.

The age of the samples from test well No. 2 and test well No. 3 and from the upper part of test well No. 1 seems to be definitely Miocene. The lower part of test well No. 1 contains species that are known to occur particularly in the Oligocene, and from these species it is inferred that the well penetrated the Oligocene.

NOTES ON THE SPECIES

Family TEXTULARIIDAE

Genus TEXTULARIA Defrance, 1824

Textularia leuzingeri Cushman and Renz

Textularia leuzingeri Cushman and Renz, Cushman Lab. Foram. Research Contr., vol. 17, p. 3, pl. 1, figs. 2a–c, 1941.
Cushman and Stainforth, Cushman Lab. Foram. Research Special Pub. 14, p. 15, pl. 1, figs. 19, 20, 1945.
Cushman and Todd, Cushman Lab. Foram. Research Special Pub. 15, p. 3, pl. 1, figs. 6a, b, 1945.

Test of medium size, broadly rounded at the initial end, sides in the adult nearly parallel, strongly compressed toward the periphery, which is subacute; chambers numerous, low and broad, the early ones indistinct, later ones with the anterior portions strongly raised, concave posteriorly; sutures indistinct, nearly straight, oblique; wall rather coarsely arenaceous, surface somewhat roughened; aperture a narrow, slightly rounded opening in the median line at the base of the apertural face. Length, 0.60–0.90 mm.; breadth 0.45–0.50 mm.; thickness 0.25 mm.

Distribution of species of Foraminifera in wells on St. Croix, Virgin Islands

Test well No. 1, 500 yards east-northeast of Bethlehem

Approximate depth below surface (feet)

Sample number

Textularia lenzingeri Cushman and Renz

Vulvulina spinosa Cushman var. mexicana Cushman

Karrerella bradyi (Cushman)

Schenckiella cf. S. petrosa (Cushman and Bermúdez)

Quinqueloculina venusta Karrer

Quinqueloculina seminula (Linné)

Spiroloculina obscura Cushman and Todd

Sigmoilina schlumbergeri A. Silvestri

Triloculina gracilis D'Orbigny

Pyrgo depressa (D'Orbigny)

Pyrgo murrhina (Schwager)

Planularia cf. P. venezuelana Hedberg

Marginulina glabra D'Orbigny

Marginulina cf. M. dubia Neugeboren

Dentalina communis D'Orbigny

Dentalina consobrina D'Orbigny var. emaciata Reuss

Dentalina cf. D. mucronata Neugeboren

Dentalina cf. D. soluta Reuss and Renz

Nodosaria verneuiliana (Bateh)

Psyllogdimalina laevigata (D'Orbigny) var. occidentalis Cushman

Pseudoglandulina galloway Cushman

Saracenaria acutauricularis (Fichtel and Moll)

Lingulina seminuda Hantken

Guttulina irregularis (D'Orbigny)

Guttulina lactea (Walker and Jacob)

Guttulina caudata D'Orbigny

Pyrulina albatrossi Cushman and Ozawa

Pseudopolymorphina dumblei (Cushman and Applin)

Nonion pompilioides (Fichtel and Moll)

Nonion affine (Reuss)

Nonion grateloupi (D'Orbigny)

Nonion medio-costatum (Cushman)

Elphidium sagrai (D'Orbigny)

Pleurostomellaria jarvisi Cushman and Todd

Pleurostomellaria bedbergi Cushman

Pleurostomellaria sp.

Bulliminella subfusiformis Cushman

Bulliminella brevior Cushman

Bulliminella elegantissima (D'Orbigny)

Bulimina ovula D'Orbigny

Bulimina striata D'Orbigny var. mexicana Cushman

Bulimina alazanensis Cushman

Entosolenia squamosa (Montagu)

Entosolenia orbignyana (Seguenza) var. trinitatensis (Nuttall)

Entosolenia orbignyana (Seguenza) var. williamsoni (Howchin)

Virgulina impleata Cushman

Bolivina tortuosa H. B. Brady

Bolivina pisciformis Galloway and Morrey

Bolivina pisciformis Galloway and Morrey var. optima Cushman

Bolivina pseudoplicata Galloway and Morrey var.

Bolivina marginata Cushman

Bolivina alata (Seguenza)

Bolivina pilicatella Cushman var. mera Cushman and Ponton

Bolivina acerosa Cushman

Bolivina mantaensis Cushman

Bolivina tongi Cushman

Reussella miocenica Cushman

Uvigerina rustica Cushman and Edwards

Uvigerina auberiana D'Orbigny

Uvigerina cf. U. hispido-costata Cushman and Todd

Uvigerina carapitana Hedberg

Uvigerina gallowayi Cushman

Siphogenerina lamellata Cushman

Siphogenerina cf. S. semi Cushman and Renz

Siphogenerina raphistoma Cushman and Jarvis

Siphogenerina multicostata Cushman and Jarvis var. optima Cushman

Angulogerina occidentalis (Cushman)

Trifarina bradyi Cushman

Pleurostomella alternans Schwager

Pleurostomella brevis Schwager

Nodosarella subcylindrica Cushman

Nodosarella robusta Cushman

Nodosarella subspinosa Cushman

Ellipsonodosaria cf. E. gradilis Palmer and Bermúdez

Ellipsonodosaria vernauili (D'Orbigny)

Gyroidina soldanii D'Orbigny

Gyroidina soldanii D'Orbigny var. planata Cushman, Todd, and Stewart

Eponides umbonatus (Reuss)

Siphonina pulchra Cushman

Siphonina tenuicarinata Cushman

Pulvinulinella culter (Parker and Jones)

Cassidulina crassa D'Orbigny

Cassidulina laevigata D'Orbigny

Cassidulina laevigata D'Orbigny var. carinata Cushman

Cassidulina subglobosa H. B. Brady

Cassidulina carapitana Hedberg

Cassidulinoides bradyi (Norman)

Ehrenbergina bradyi Cushman

Chilostomella ovoidea Schwager

Fullenia balloides D'Orbigny

Fullenia quinqueloba (Reuss)

Sphaeroidina bulloides D'Orbigny

Globorotalia menardii (D'Orbigny)

Anomalina flintii Cushman

Planulina cf. P. ariminensis D'Orbigny

Latieinitina bullbrooki Cushman and Todd

Cibicides mississippiensis (Cushman)

Cibicides americanus (Cushman)

Cibicides pseudungerianus (Cushman) var. lobatulus Cushman

Cibicides lobatulus (Walker and Jacob)

Sample number

Approximate depth below surface (feet)

F3525, F3526, F3527 — 50

F3528 — 100

F3529 — 150

F3530 — 200

F3531 — 250

F3532 — 300

F3533 — 350

F3534 — 400

F3535 — 450

F3536 — 500

F3537 — 550

F3538 — 600

F3539 — 650

F3540 — 700

F3541 — 750

F3542 — 800

F3543 — 850

F3544 — 900

F3545 — 950

F3546 — 1,000

F3547 — 1,050

F3548 — 1,100

F3549, F3550 — 1,150

F3551 — 1,200

F3552, F3553, F3554 — 1,250

F3555 — 1,300

F3556 — 1,350

F3557 — 1,400

F3558 — 1,450

F3559 — 1,500

F3560

Test well No. 2, 300 yards west of great house at Jealousy

F 3561 — 50

F 3562 — 100

F 3563, F 3564 — 150

F 3565 — 200

F 3566 — 250

F 3567 — 300

F 3568 — 350

F 3569 — 400

Test well No. 3, at Fair Plain, ⅝ mile west of Anguilla

F 3570 — 50

F 3571 — 100

F 3572, F 3573 — 150

F 3574 — 200

F 3575

F 3576

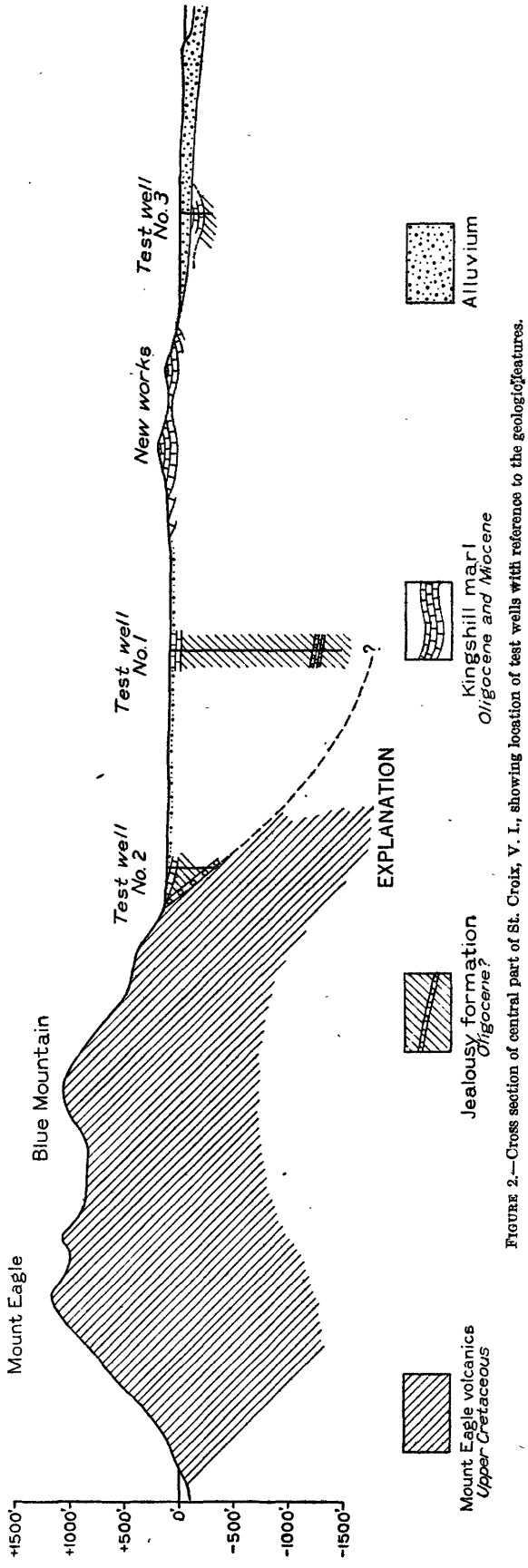

FIGURE 2.—Cross section of central part of St. Croix, V. I., showing location of test wells with reference to the geologic features.

Specimens referable to this species, described from Venezuela, are rare in test well No. 1 at 960, 1,020, 1,390, and 1,430 feet and in test well No. 3 at 100 feet. The species occurs in Venezuela in beds ranging from the upper Oligocene to the middle Miocene, in the Oligocene Cipero formation of Trinidad, and in the Miocene of Buff Bay, Jamaica.

Genus VULVULINA D'Orbigny, 1826

Vulvulina spinosa Cushman var. miocenica Cushman

Vulvulina spinosa Cushman var. *miocenica* Cushman, Cushman Lab. Foram. Research Contr., vol. 8, p. 80, pl. 10, fig. 10, 1932.
Coryell and Rivero, Jour. Paleontology, vol. 14, p. 325, pl. 41, fig. 1, 1940.
Cushman and Todd, Cushman Lab. Foram. Research Special Pub. 15, p. 4, pl. 1, fig. 10, 1945.
Vulvulina capreolus Cushman [not D'Orbigny], Cushman Lab. Foram. Research Contr., vol. 5, p. 80, pl. 12, fig. 6, 1929.
Vulvulina capreolus D'Orbigny var. *spinosa* Nuttall, Jour. Paleontology, vol. 6, p. 6, 1932.

This variety occurs in the Miocene of Jamaica, Haiti, Trinidad, Venezuela, and Ecuador. It is present in test well No. 1 at 1,090 and 1,430 feet. A single immature specimen from test well No. 2 at 30 feet may belong to this variety.

Family VALVULINIDAE

Genus KARRERIELLA Cushman, 1933

Karreriella bradyi (Cushman)

Karreriella bradyi Cushman, Cushman Lab. Foram. Research Special Pub. 8, p. 135, pl. 16, figs. 6–11, 1937.
Coryell and Rivero, Jour. Paleontology, vol. 14, p. 326, pl. 43, fig. 5, 1940.
Franklin, Jour. Paleontology, vol. 18, p. 307, pl. 44, figs. 16a, b, 1944.
Cushman and Todd, Cushman Lab. Foram. Research Special Pub. 15, p. 8, pl. 1, fig. 20, 1945.
Gaudryina pupoides H. B. Brady [not D'Orbigny], *Challenger* Rept., Zoology, vol. 9, p. 378, pl. 46, figs. 1–4, 1884.
Gaudryina bradyi Cushman, U. S. Nat. Mus. Bull. 71, pt. 2, p. 67, text figs. 107a–c, 1911.
Gaudryina globulifera Galloway and Morrey [not Reuss], Bull. Am. Paleontology, vol. 15, No. 55, p. 33, pl. 5, figs. 3, 4, 1929.

This species is widely distributed and ranges from the Oligocene to the Recent. The records in the Miocene are from Ecuador, Haiti, Jamaica, and Egypt. In the material from St. Croix it is present in all three wells. Only a few of the references are given above.

Genus SCHENCKIELLA Thalmann, 1942

Schenckiella cf. S. petrosa (Cushman and Bermúdez)

A single specimen from test well No. 1, at a depth of 1,360 feet, is very similar to this species, described from the Eocene of Cuba and recorded from the Oligocene of Cuba and Trinidad.

Family MILIOLIDAE

Genus QUINQUELOCULINA D'Orbigny, 1826

Quinqueloculina venusta Karrer

Quinqueloculina venusta Karrer, Akad. Wiss. Wien Sitzungsber., vol. 58, pt. 1, p. 147, pl. 2, fig. 6, 1868.
Cushman, U. S. Geol. Survey Bull. 676, pp. 23, 70, pl. 28, fig. 3; pl. 29, fig. 2, 1918.
Miliolina venusta (Karrer) H. B. Brady, *Challenger* Rept., Zoology, vol. 9, p. 162, pl. 5, figs. 5, 7, 1884.
Flint, U. S. Nat. Mus. Rept. for 1897, p. 289, pl. 44, fig. 2, 1899.

This species has already been recorded from the Miocene of the eastern Coastal Plain region of the United States. It is present in test well No. 1 at depths ranging from 100 to 1,430 feet.

Quinqueloculina seminula (Linné)

This species has been widely recorded. Single specimens from test well No. 1, at 1,120 and 1,450 feet, may be referred to it.

Quinqueloculina lamarckiana D'Orbigny

A single slightly broken specimen with angular periphery is similar to this species.

Genus SPIROLOCULINA D'Orbigny, 1826

Spiroloculina obscura Cushman and Todd

Spiroloculina grateloupi D'Orbigny [not Terquem, 1878], Annales sci. nat., vol. 7, p. 298, 1826.
Terquem, Soc. géol. France Mém., 3d ser., vol. 2, p. 155, pl. 16 (24), figs. 6 a, b, 1882.
Fornasini, Accad. sci. Ist. Bologna Mem., ser. 6, vol. 1, p. 4, pl. 1, figs. 3a, b, 1904.
Spiroloculina obscura Cushman and Todd, Cushman Lab. Foram. Research Special Pub. 11, p. 20, pl. 1, figs. 8a, b; pl. 3, figs. 22–25, 1944.

This species was named from the Miocene of France and also recorded from the Eocene of France. A single specimen from test well No. 1 at 520 feet is of the general form of this species.

Genus SIGMOILINA Schlumberger, 1887

Sigmoilina schlumbergeri A. Silvestri

A single specimen from test well No. 3 at 130 feet is typical. The species has been recorded from the Miocene of Haiti by Coryell and Rivero (Jour. Paleontology, vol. 14, p. 324, 1940) and the Miocene of Jamaica by Palmer (Bull. Am. Paleontology, vol. 29, No. 115, p. 31, 1945) and by Cushman and Todd (Cushman Lab. Foram. Research Special Pub. 15, p. 11, pl. 2, fig. 3, 1945).

Genus TRILOCULINA D'Orbigny, 1826

Triloculina gracilis D'Orbigny

Triloculina gracilis D'Orbigny, in De la Sagra, Historia física, política y natural de la isla de Cuba, Foraminifères, p. 181, pl. 11, figs. 10–12, 1839.
Cushman, Carnegie Inst. Washington Pub. 311, p. 74, 1922; U. S. Nat. Mus. Bull. 104, pt. 6, p. 59, pl. 14, figs. 4a–c, 1929.
Cushman and Wickenden, U. S. Nat. Mus. Proc., vol. 75, art. 9, p. 3, pl. 1, figs. 3a–c, 1929.
Cushman and Ponton, Florida Geol. Survey Bull. 9, p. 53, pl. 6, figs. 8, 9, 1932.

Slender specimens referred to this species are present in test well No. 1 from 1,200 to 1,430 feet and in test well No. 2 at 160 and 360 feet. The species was originally described from the West Indian region, and it has been recorded from the Miocene Chipola formation of Florida.

Genus PYRGO Defrance, 1824

Pyrgo depressa (D'Orbigny)

This is a species of rather deep, cool waters. Single typical specimens are present in material from test well No. 1 at 100 and 480 feet. It occurred also in late Tertiary material from the Georges Bank in the western Atlantic Ocean (Cushman, Geol. Soc. America Bull., vol. 47, p. 430, pl. 4, fig. 10, 1936).

Pyrgo murrhina (Schwager)

Biloculina murrhina Schwager, *Novara*-Exped., Geol. Theil, vol. 2, p. 203, pl. 4, figs. 15a–c, 1866.
Pyrgo murrhina Cushman, U. S. Nat. Mus. Bull. 104, pt. 6, p. 71, pl. 19, figs. 6, 7, 1929.
Cushman and Jarvis, Jour. Paleontology, vol. 4, p. 357, pl. 32, figs. 7a, b, 1930.
Coryell and Rivero, Jour. Paleontology, vol. 14, p. 324, pl. 43, fig. 9, 1940.
Cushman and Stainforth, Cushman Lab. Foram, Research Special Pub. 14, p. 21, pl. 2, fig. 22, 1945.
Cushman and Todd, Cushman Lab. Foram. Research Special Pub. 15, p. 12, pl. 2, fig. 5, 1945.

This is another species of fairly deep water. It has already been recorded from the Miocene of Jamaica and Haiti and the Oligocene of Trinidad.

Family LAGENIDAE

Genus ROBULUS Montfort, 1808

A few specimens of *Robulus*, nearly all of them young stages and therefore difficult to identify with any degree of certainty, are perhaps referable to *R. americanus* (Cushman), and one or two others to *R. catenulatus* (Cushman).

Genus PLANULARIA Defrance, 1824

Planularia cf. P. venezuelana Hedberg

This species was described from the upper Oligocene of Venezuela. A single specimen was found in the sample from test well No. 1 at a depth of 1,390 feet.

Genus MARGINULINA D'Orbigny, 1826

Marginulina glabra D'Orbigny

A number of specimens may be referred to this species, and as usual the specimens show a wide range of variation. In test well No. 1 the specimens were found at depths of 230, 520, 1,270, and 1,430 feet; in test well No. 2 at 90 feet; and in test well No. 3 at 90 feet.

Marginulina cf. M. dubia Neugeboren

A specimen from test well No. 1 at 580 feet seems fairly typical; another from test well No. 2 at 330 feet is less typical. The species has been recorded from the Miocene of Florida and elsewhere.

Genus DENTALINA D'Orbigny, 1826

Dentalina communis D'Orbigny

In the Florida Miocene this species seems confined to the Choctawhatchee formation. It occurs also in the Miocene Gatun formation of the Panama Canal Zone and in the Miocene of Buff Bay, Jamaica. In test well No. 1 the occurrences are at 70, 280, 480, 1,120, and 1,430 feet, and in test well No. 3, at 130 feet.

Dentalina consobrina D'Orbigny var. emaciata Reuss

Records include the Miocene Shoal River formation of Florida and Yorktown formation of Virginia. Specimens are present in test well No. 1 at 100, 580, and 690 feet.

Dentalina cf. D. mucronata Neugeboren

Specimens resembling this species are from test well No. 1 at 100 and 920 feet and test well No. 3 at 100 feet.

Dentalina cf. D. isidroensis Cushman and Renz

A single incomplete specimen from test well No. 1, at 960 feet, closely resembles this species, described from the Miocene of Venezuela.

Genus NODOSARIA Lamarck, 1812

Nodosaria vertebralis (Batsch)

A single typical megalospheric specimen from test well No. 1 at 640 feet is the only record from these wells.

Genus PSEUDOGLANDULINA Cushman, 1929

Pseudoglandulina laevigata (D'Orbigny) var. occidentalis Cushman

A single specimen from test well No. 2 at 100 feet is the only representative of this variety. It has been recorded from the late Tertiary of Georges Bank, in the western Atlantic Ocean.

Pseudoglandulina gallowayi Cushman

Records for this species include the Miocene of Ecuador, Trinidad, and California and the Oligocene of Trinidad. A single specimen was found in test well No. 1 at 1,110 feet.

Genus SARACENARIA Defrance, 1824

Saracenaria acutauricularis (Fichtel and Moll)

This species is known from the Miocene of Trinidad, Venezuela, and Haiti, and from the Miocene Choctawhatchee and Shoal River formations of Florida. The only specimen in the present material is from test well No. 1 at 24 to 30 feet.

Genus LINGULINA D'Orbigny, 1826

Lingulina seminuda Hantken

This species has been recorded from the Miocene of Buff Bay, Jamaica. A single specimen was found in test well No. 1 at a depth of 1,390 feet.

Genus LAGENA Walker and Jacob, 1798

A number of species of this genus, mainly represented by single specimens, were found in the material from St. Croix. Larger series of most of them are needed to show possible variation, and they are not here specifically identified.

Family POLYMORPHINIDAE

Genus GUTTULINA D'Orbigny, 1839

Guttulina irregularis (D'Orbigny)

Globulina irregularis D'Orbigny, Foraminifères fossiles du bassin tertiaire de Vienne, p. 226, pl. 13, figs. 9, 10, 1846.
Guttulina irregularis Cushman and Ozawa, U. S. Nat. Mus. Proc., vol. 77, art. 6, p. 25, pl. 3, figs. 4, 5: pl. 7, figs. 1, 2, 1930.
Cushman, Florida Geol. Survey Bull. 4, p. 33, 1930.
Cushman and Ponton, Florida Geol. Survey Bull. 9, p. 64, pl. 9, figs. 10–12, 1932.
Cushman, U. S. Geol. Survey Prof. Paper 181, p. 24, pl. 9, figs. 13–16, 1935.

This species has been recorded from the Miocene of Florida as well as from most of the Tertiary of the Gulf Coastal Plain area. It is present in test well No. 2 at depths of 30 and 100 feet and in test well No. 3 at a depth of 90 feet.

Guttulina lactea (Walker and Jacob)

(For references to this species see Cushman and Ozawa, U. S. Nat. Mus. Proc., vol. 77, art. 6, p. 43, 1930.)

This widely distributed species has been recorded from the Miocene of Florida (Cushman and Ponton, Florida Geol. Survey Bull. 9, p. 65, pl. 9, figs. 15a, b, 1932), where it occurs in the Shoal River and Chipola formations. The only occurrence in the St. Croix material is in test well No. 2 at a depth of 30 feet.

Guttulina caudata D'Orbigny

This species, like the preceding, has been recorded from the Miocene of Florida, from both the Shoal River and Chipola formations (Cushman and Ponton, Florida Geol. Survey Bull. 9, p. 65, pl. 9, figs. 16, 17, 1932). It is present in test well No. 1 at a depth of 580 feet.

Genus PYRULINA D'Orbigny, 1839

Pyrulina albatrossi Cushman and Ozawa

Pyrulina albatrossi Cushman and Ozawa, U. S. Nat. Mus. Proc., vol. 77, art. 6, p. 58, pl. 15, figs. 1–3, 1930.
Cushman, Florida Geol. Survey Bull. 4, p. 34, pl. 5, figs. 17, 18, 1930.
Cushman and Ponton, Florida Geol. Survey Bull. 9, p. 66, 1932.
Cushman and Cahill, U. S. Geol. Survey Prof. Paper 175–A, p. 18, pl. 6, figs. 5a, b, 1933.

This species is known from the Miocene of the Coastal Plain region of the United States. The types are Recent from a station off Cuba.

Genus PSEUDOPOLYMORPHINA Cushman and Ozawa, 1928

Pseudopolymorphina dumblei (Cushman and Applin)

Polymorphina compressa D'Orbigny var. *dumblei* Cushman and Applin, Am. Assoc. Petroleum Geologists Bull., vol. 10, p. 173, pl. 9, figs. 4, 5, 1926.
Pseudopolymorphina dumblei Cushman and Ozawa, U. S. Nat. Mus. Proc., vol. 77, art. 6, p. 97, pl. 25, figs. 1a, b, 1930.
Cushman, Florida Geol. Survey Bull. 4, p. 35, pl. 6, fig. 5, 1930.
Cushman and Ponton, Florida Geol. Survey Bull. 9, p. 67, 1932.
Ellisor, Am. Assoc. Petroleum Geologists Bull., vol. 17, no. 11, pl. 7, fig. 2, 1933.
Cushman and Cahill, U. S. Geol. Survey Prof. Paper 175–A, p. 19, pl. 6, figs. 10a, b, 1933.
Cushman, U. S. Geol. Survey Prof. Paper 181, p. 29, pl. 10, figs. 14, 15, 1935.

Although first described from Eocene deposits, in which it is found at various localities, the form also occurs in the Miocene Shoal River and Chipola formations of Florida, and in the Miocene St. Marys and Calvert formations of Maryland. It was found in material from test well No. 2 at depths of 90 and 330 feet.

Family NONIONIDAE

Genus NONION Montfort, 1808

Nonion pompilioides (Fichtel and Moll)

(For references see Cushman, U. S. Geol. Survey Prof. Paper 191, p. 19, 1939.)

This species is recorded from the Miocene of Ecuador, Venezuela, Trinidad, and Haiti, from the late Tertiary

of Georges Bank in the western Atlantic Ocean, and from the American Pliocene and Oligocene. Specimens are present in samples from test well No. 1 at depths of 230 to 1,390 feet and from test well No. 3 at 330 feet.

Nonion affine (Reuss)

(For references see Cushman, U. S. Geol. Survey Prof. Paper 191, p. 9, 1939.)

This species is common in the Oligocene of Europe and has been recorded from the Miocene of Venezuela and Ecuador. It is also recorded from California in formations of similar age. It occurs in test well No. 1 at depths ranging from 24 to 1,360 feet and in test well No. 3 from 90 to 130 feet.

Nonion grateloupi (D'Orbigny)

(For references see Cushman, U. S. Geol. Survey Prof. Paper 191, p. 21, 1939.)

This species was described from the West Indian region. In the American Miocene it occurs in the Choctawhatchee, Shoal River, Oak Grove, and Chipola formations of Florida; the Choptank and Calvert formations of Maryland; and the Yorktown formation of Virginia. The specimens from St. Croix are in some features similar to *Nonion extensum* (Cushman). The few specimens are from test well No. 1 at depths of 780 and 1,120 feet and from test well No. 2 at 100 feet.

Nonion medio-costatum (Cushman)

(For references see Cushman, U. S. Geol. Survey Prof. Paper 191, p. 15, 1939.)

This species, known from the Miocene Monterey shale of California, is represented by a single typical specimen from test well No. 1 at a depth of 580 feet.

Genus ELPHIDIUM Montfort, 1808

Elphidium sagrai (D'Orbigny)

(For references see Cushman, U. S. Geol. Survey Prof. Paper 191, p. 55, 1939.)

This species was originally described from the shore sands of Cuba and is widely distributed in the general West Indian region. It occurs in the Miocene in Cuba, Puerto Rico, and Jamaica; in the Choctawhatchee, Chipola, and Oak Grove formations of Florida; and in the Duplin marl of North Carolina. It is found in test well No. 1 at depths of 580 and 1,090 feet and in test well No. 2 at 90 feet.

Family HETEROHELICIDAE

Genus PLECTOFRONDICULARIA Liebus, 1903

Plectofrondicularia jarvisi Cushman and Todd

Plectofrondicularia vaughani Cushman and Jarvis [not Cushman], Jour. Paleontology, vol. 4, p. 361, pl. 33, fig. 4, 1930.
Cushman, Cushman Lab. Foram. Research Special Pub. 5, pl. 26, fig. 27, 1933.
Coryell and Rivero, Jour. Paleontology, vol. 14, p. 341, pl. 42, fig. 28, 1940.
Cushman, Foraminifera, 3rd Ed., Key, pl. 26, fig. 27, 1940.
Plectofrondicularia jarvisi Cushman and Todd, Cushman Lab. Foram. Research Special Pub. 15, p. 38, pl. 6, fig. 4, 1945.

This species was described from the Miocene of Buff Bay, Jamaica, and it occurs in the Miocene of Haiti. A typical specimen was found in test well No. 1 at a depth of 1,330 feet.

Plectofrondicularia hedbergi Cushman

Plectofrondicularia californica Hedberg [not Cushman and Stewart], Jour. Paleontology, vol. 11, p. 675, pl. 91, fig. 7, 1937.
Plectofrondicularia hedbergi Cushman, Cushman Lab. Foram. Research Contr., vol. 19, p. 90, pl. 16, fig. 1, 1943.

Test compressed, elongate, sides nearly parallel for most of their length, broad faces flattened or slightly concave, periphery keeled with an additional lateral keel at either side near the margin; chambers numerous, biserial in early stages, uniserial in the adult and increasing rapidly in height, in the adult higher than broad; sutures limbate, slightly depressed; wall smooth, except for a central costa for most of the length of the test and occasionally other less developed ones at each side. Length 0.50–0.60 mm.; breadth 0.20 mm.

This species, described from the upper Oligocene Carapita formation of Venezuela, has been confused with *Plectofrondicularia californica* Cushman and Stewart. It differs from that species in the smaller size, nearly parallel sides throughout, more elongate median costa, and much higher chambers.

Specimens comparable to those from Venezuela were found in test well No. 1 at 580 and 1,210 feet and test well No. 2 at 30 feet.

Plectofrondicularia sp.

A few specimens of a species somewhat similar to the preceding but with a tapering test, lower chambers, more costae, and the broad faces distinctly concave, were found in test well No. 1 at 1,430 feet. Not enough specimens are available to warrant description, although the species appears to be undescribed.

Family BULIMINIDAE

Genus BULIMINELLA Cushman, 1911

Buliminella subfusiformis Cushman

This species was described from the Miocene of California, but also occurs in the Miocene Choctawhatchee, Shoal River, and Oak Grove formations of Florida, and in the Duplin marl of North Carolina. It is found in test well No. 1 at 870 feet.

Buliminella brevior Cushman

This species has been known previously only from the Miocene of California. It occurs in typical form in test well No. 1 at a depth of 70 feet.

Buliminella elegantissima (D'Orbigny)

This species is known from a wide range in the American Tertiary. It occurs in the Miocene of both the east and west coasts of America. The only record in the present material is from test well No. 2 at 360 feet.

Genus BULIMINA D'Orbigny, 1826

Bulimina ovula D'Orbigny

Bulimina ovula D'Orbigny, Voyage dans l'Amérique méridionale, vol. 5, Foraminifères, p. 51, pl. 1, figs. 10, 11, 1839.
Cushman and Parker (part), Cushman Lab. Foram. Research Contr., vol. 16, p. 10, pl. 2, figs. 13 14 (not fig. 15), 1940.

This species was described from Recent material off Chile and Peru. It has been recorded from the Mio-

cene of California and seems to be common in the well samples from St. Croix. Specimens were found in test well No. 1 from 100 feet to the bottom of the well; in test well No. 2 from 30 to 330 feet; and in test well No. 3 from 90 and 130 feet.

Bulimina striata D'Orbigny var. mexicana Cushman

Bulimina inflata Seguenza var. *mexicana* Cushman, U. S. Nat. Mus. Bull. 104, pt. 3, p. 95, pl. 21, fig. 2, 1922.
Bulimina inflata Flint [not Seguenza] (part), U. S. Nat. Mus. Rept. for 1897, p. 291, pl. 37, fig. 5, 1899.
Cushman and Jarvis, Jour. Paleontology, vol. 4, p. 362, pl. 33, fig. 5, 1930.
Bulimina striata D'Orbigny var. *mexicana* Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 16, p. 16, pl. 3, fig. 9, 1940.
Cushman and Todd, Cushman Lab. Foram. Research Special Pub. 15, p. 40, pl. 6, fig. 10, 1945.

The types are from an *Albatross* station in 210 fathoms in the Gulf of Mexico. The variety has been recorded from the Miocene of Buff Bay, Jamaica. In test well No. 1 it is present from 100 to 1,450 feet, in test well No. 2 at 360 feet, and in test well No. 3 at 62 to 70 feet.

Bulimina alazanensis Cushman

Bulimina alazanensis Cushman, Jour. Paleontology, vol. 1, p. 161, pl. 25, fig. 4, 1927.
Palmer and Bermúdez, Soc. cubana historia nat. Mem., vol. 10, p. 286, 1936.
Bermúdez, Soc. cubana historia nat. Mem., vol. 11, p. 341, 1937.
Parker and Bermúdez, Jour. Paleontology, vol. 11, p. 514, pl. 58, figs. 5a–c, 1937.
Cushman and Stainforth, Cushman Lab. Foram. Research Special Pub. 14, p. 40, pl. 6, fig. 2, 1945.

This species was originally described from the Oligocene Alazan shale of Mexico. It is common in the samples from St. Croix. In test well No. 1 it ranges from 24 to 1,390 feet; in test well No. 2, from 30 to 390 feet; and in test well No. 3, from 90 to 100 feet.

Genus ENTOSOLENIA Ehrenberg, 1848

Entosolenia marginata (Walker and Boys)

A number of specimens referable to this species are present in the well samples, from test well No. 1 at 1,210 feet and test well No. 2 at 30, 100, 330, and 390 feet. As usual in any series referred to this species, there is a wide range of variation in the width of the keel.

Entosolenia squamosa (Montagu)

A single specimen from test well No. 2 at 100 feet is typical.

Entosolenia orbignyana (Seguenza) var. trinitatensis (Nuttall)

Rather typical specimens of this variety, described by Nuttall from Trinidad, are present in test well No. 3 at 90 and 100 feet.

Entosolenia orbignyana (Seguenza) var. elliptica Cushman

Well characterized specimens of this variety are present in test well No. 1 at 230, 480, and 1,360 feet and in test well No. 3 at 130 feet.

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Entosolenia sp.

Numerous other species, mostly represented by single specimens in the St. Croix material, are difficult to identify positively, and are merely noted here.

Genus VIRGULINA D'Orbigny, 1826

Virgulina implicata Cushman

Virgulina implicata Cushman, Cushman Lab. Foram. Research Contr., vol. 19, p. 90, pl. 16, figs. 3a, b, 1943.

Test elongate, slender, strongly twisted; early portion triserial, remainder of the test biserial, slightly fusiform; chambers distinct, slightly inflated, increasing gradually in height as added; sutures distinct, slightly depressed; wall smooth, coarsely perforate; aperture broadly rounded, at the base of the last-formed chamber. Length up to 0.40 mm.; diameter 0.12 mm.

This species was described from material from a depth of 230 feet in the Bethlehem Test well No. 1, at a locality 500 yards east-northeast of Bethlehem, Island of St. Croix, V. I. It differs from *Virgulina delmonteensis* Cushman and Galliher in its more slender, more strongly twisted test, and larger, more rounded aperture. It is common in the well samples, in test well No. 1 from 90 feet at intervals to 1,270 feet, and in test well No. 2 at 100, 280, 360, and 390 feet.

Genus BOLIVINA D'Orbigny, 1839

Bolivina tortuosa H. B. Brady

Bolivina tortuosa H. B. Brady, Quart. Jour. Micr. Sci., vol. 21, p. 27, 1881; (part), *Challenger* Rept., Zoology, vol. 9, p. 420, pl. 52, figs. 31, 32 (not figs. 33, 34), 1884.
Egger, K. bayer, Akad. Wiss., Math.-naturh. Abt., Abh., Kl. 2, vol. 18, pt. 2, p. 298, pl. 8, figs. 43, 44 (part), 1893.
Millett, Royal Micr. Soc. Jour., p. 543, 1900.
Chapman, Linnean Soc. Jour., Zoology, vol. 28, p. 187, 1900; p. 382 (list), 1902.
Sidebottom, Royal Micr. Soc. Jour., 1918, p. 127.
Cushman, Carnegie Inst. Washington Pub. 342, p. 18, pl. 5, figs, 4, 5, 1924.
Heron-Allen and Earland, Royal Micr. Soc. Jour., 1924, p. 145; Linnean Soc. Jour., Zoology, vol. 35, p. 621, 1924.
Yabe and Hanzawa, Japanese Jour. Geology and Geography, vol. 4, p. 50 (list), 1925 (1926).
Hanzawa, Japanese Jour. Geology and Geography, vol. 4, p. 40 (table), 1925 (1926).
Macfadyen, Egypt Geol. Survey, 1930, p. 57, 1931.
Cushman and Parker, U. S. Nat. Mus. Proc., vol. 80, art. 3, p. 16, pl. 3, figs. 22a, b, 1931.
Bermúdez, Soc. cubana historia nat. Mem., vol. 9, p. 195, 1935.
Cushman, Cushman Lab. Foram. Research Special Pub. 9, p. 133, pl. 17, figs. 11–19, 1937.
Cushman and McGlamery, U. S. Geol. Survey Prof. Paper 189–D, p. 107, pl. 25, figs. 13, 21, 1938.
Palmer, Soc. cubana historia nat. Mem., vol. 14, p. 301, 1940.
Cushman, Smithsonian Misc. Coll., vol. 99, no. 9, p. 10, 1941; U. S. Nat. Mus. Bull. 161, pt. 3, p. 20, pl. 7, figs. 1a, b, 1942.
Cushman and McGlamery, U. S. Geol. Survey Prof. Paper 197–B, p. 70, 1942.
Cushman and McCulloch, Allan Hancock Pacific Exped., vol. 6, No. 4, p. 220, pl. 27, figs. 12a, b, 1942.
Macfadyen, Geol. Mag., vol. 79, p. 136 (list), 1942.
Palmer, Bull. Am. Paleontology, vol. 29, no. 115, p. 48, 1945.
Cushman and Todd, Cushman Lab. Foram. Research Special Pub. 15, p. 44, pl. 7, fig. 6, 1945.

The American records for this species as a fossil are from the Oligocene of Alabama and Cuba and the

Miocene of Jamaica. It occurs in the Miocene of Egypt, where numerous other species occur that are identical with those of the Miocene of tropical America.

Specimens are rare but occur in test well No. 1 at depths of 24 to 30, 100, and 370 feet, and in test well No. 2 at a depth of 10 feet.

Bolivina pisciformis Galloway and Morrey

Bolivina pisciformis Galloway and Morrey, Bull. Am. Paleontology, vol. 15, no. 55, p. 36, pl. 5, figs. 10a, b, 1929.
Cushman, Cushman Lab. Foram. Research Contr., vol. 5, p. 93, pl. 13, fig. 26, 1929.
Palmer and Bermúdez, Soc. cubana historia nat. Mem., vol. 10, p. 289, 1936.
Cushman, Cushman Lab. Foram. Research Special Pub. 9, p. 92, pl. 11, figs. 20, 21, 1937.
Kleinpell, Miocene stratigraphy of California, p. 279, pl. 4, fig. 10, Tulsa, 1938.
Renz, 8th Am. Sci. Congress Proc., pp. 546, 553 (lists), 1942.

This species is known from the Miocene of Ecuador, Venezuela, Trinidad, and California and the Oligocene of Cuba and Trinidad. It is present in test well No. 1 from 370 to 1,450 feet and in test well No. 2 from 30 to 280 feet.

Bolivina pisciformis Galloway and Morrey var. optima Cushman

Bolivina pisciformis Galloway and Morrey var. *optima* Cushman, Cushman Lab. Foram. Research Contr., vol. 19, p. 91, pl. 16, figs. 2a, b, 1943.

The variety differs from the typical form in having the early one-third or one-half of the test with numerous longitudinal costae, the later portion of the test smooth. It was described from material at a depth of 520 feet in the Bethlehem test well No. 1, at a locality 500 yards east-northeast of Bethlehem, St. Croix, V. I. The main characters of sutures and chambers are like those of typical *B. pisciformis*, but the ornamentation of the early portion is distinctive. Specimens are common in the samples from St. Croix.

Bolivina pisciformis Galloway and Morrey var.

Two specimens with spinose periphery seem in other essential characters very much like this species. In the peripheral spines they resemble *B. difformis* (Williamson) and *B. pygmaea* H. B. Brady, but not in their main characters. Full description must await more specimens. These single specimens are from test well No. 1 at 100 and 1,390 feet.

Bolivina marginata Cushman

Bolivina marginata Cushman, U. S. Geol. Survey Bull. 676, p. 48, pl. 10, fig. 1, 1918; Cushman Lab. Foram. Research Contr., vol. 1, pt. 2, p. 30, pl. 5, figs. 5a, b, 1925; vol. 2, pt. 3, p. 54, 1926; Florida Geol. Survey Bull. 4, p. 45 pl. 8, figs. 9a, b, 1930.
Cushman and Laiming, Jour. Paleontology, vol. 5, p. 110, pl. 12, figs. 6–8, 1931.
Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 7, p. 9, pl. 2, fig. 1, 1931.
Cushman and Ponton, Florida Geol. Survey Bull. 9, p. 81, 1932.
Barbat and von Estorff, Jour. Paleontology, vol. 7, p. 171, pl. 23, figs. 14a, b, 1933.
Cushman and Cahill, U. S. Geol. Survey Prof. Paper 175–A, p. 25, pl. 8, figs. 9a, b, 1933.
Woodring, Bramlette, and Kleinpell, Am. Assoc. Petroleum Geologists Bull., vol. 20, p. 141 (list), 1936.
Cushman, Cushman Lab. Foram. Research Special Pub. 9, p. 86, pl. 10, figs. 4–6, 1937.
Kleinpell, Miocene stratigraphy of California, p. 275, pl. 9, fig. 2; pl. 12, fig. 7, Tulsa, 1938.
Ellisor, Am. Assoc. Petroleum Geologists Bull., vol. 24, no. 3, pl. 5, figs. 22a, b, 1940.
Cushman and Todd, Cushman Lab. Foram. Research Contr., vol. 17, p. 30, pls. 7, 8, 1941.
Renz, 8th Am. Sci. Congress Proc., pp. 553, 556 (lists), 1942.
LeRoy, Colorado School of Mines Quart., vol. 39, no. 3, p. 29, pl. 1, figs. 34–37, 1944.
Weaver, Washington Univ. [Seattle] Pub. in Geology, vol. 6, no. 1, p. 23. (list), 1944.

This is a common species in the Miocene of Florida and is confined largely to the middle part, the *Ecphora*, *Arca*, and *Yoldia* zones of the Choctawhatchee formation and all three zones of the Shoal River formation. It also occurs in the Duplin marl of North Carolina and in the Miocene of Louisiana, California, Venezuela, Trinidad, and central Sumatra.

Bolivina alata (Seguenza)

(For references see Cushman Lab. Foram. Research Special Pub. 9, p. 106, 1937, and Special Pub. 15, p. 42, 1945.)

Specimens referable to this species have been recorded from the late Tertiary of Georges Bank, in the western Atlantic Ocean, in a fauna closely related to that of the Miocene of the West Indian region. The species is present in test well No. 1 from 1,200 to 1,330 feet, in test well No. 2 from 30 to 160 feet, and in test well No. 3 at 90 feet.

Bolivina plicatella Cushman var. mera Cushman and Ponton

Bolivina plicatella Cushman var. *mera* Cushman and Ponton, Florida Geol. Survey Bull. 9, p. 82, pl. 12, figs. 4a, b, 1932.
Bermudez, Soc. cubana historia nat. Mem., vol. 9, p. 195, 1935.
Cushman, Cushman Lab. Foram. Research Special Pub. 9, p. 90, pl. 11, figs. 5–8, 1937.
Cushman and McGlamery, U. S. Geol. Survey Prof. Paper 189–D, p. 108, 1938.

This species was described from the Miocene of Florida, occurring only in the lower part, the Oak Grove sand and Chipola formation. It was also found in the Oligocene of Alabama. In the St. Croix well samples it is present at various depths as follows: test well No. 1, 180 to 1,020 feet; test well No. 2, 10 and 360 feet; and test well No. 3, at 90 feet.

Bolivina acerosa Cushman

Bolivina acerosa Cushman, Cushman Lab. Foram. Research Special Pub. 6, p. 54, pl. 8, figs. 1a, b, 1936; Special Pub. 9, p. 94, pl. 12, figs. 11–13, 1937.
Palmer, Soc. cubana historia nat. Mem., vol. 14, p. 297, pl. 52, fig. 1, 1940.

This species was described from the Miocene Gurabo formation of Santo Dominica and has been recorded from the Oligocene of Cuba. It was found in test well No. 1 from 100 to 1,020 feet; test well No. 2 at 90 and 360 feet; and test well No. 3 at 90 and 100 feet.

Bolivina mantaensis Cushman

Bolivina mantaensis Cushman, Cushman Lab. Foram. Research Contr., vol. 5, p. 92, pl. 13, figs. 27a, b, 1929; Special Pub. 9, p. 91, pl. 11, figs. 25, 26, 1937.
Bolivina applinae Galloway and Morrey [not Plummer], Bull. Am. Paleontology, vol. 15, No. 55, p. 35, pl. 5, figs. 9a, b. 1929.

This species occurs in the Miocene of Ecuador and Venezuela. It is present in numerous samples from test well No. 1, from 24 to 1,330 feet; in test well No. 2, at 90, 160, and 390 feet.

Bolivina tongi Cushman

Bolivina tongi Cushman, Cushman Lab. Foram. Research Contr., vol. 5, p. 93, pl. 13, figs. 29a, b, 1929.
Nuttall, Jour. Paleontology, vol. 6, p. 21, pl. 5, fig. 4, 1932.
Palmer and Bermúdez, Soc. cubana historia nat. Mem., vol. 10, p. 290, 1936.
Cushman, Cushman Lab. Foram. Research Special Pub. 9, p. 92, pl. 12, figs. 7, 8, 1937.
Palmer, Soc. cubana historia nat. Mem., vol. 14, p. 300, 1940.

This species was originally described from the lower Miocene of Venezuela. It has been recorded from the Oligocene of Mexico by Nuttall and from the Oligocene of Cuba by Palmer and Bermúdez. It is present in test well No. 1 at 180, 1,200, 1,270, and 1,430 feet.

Genus REUSSELLA Galloway, 1933

Reussella miocenica Cushman

Reussia spinulosa Cushman [not Reuss], Florida Geol. Survey Bull. 4, p. 48, pl. 8, fig. 17, 1930.
Cushman and Ponton (part), Florida Geol. Survey Bull. 9, p. 84, pl. 12, figs. 14, 16 (?) (not fig. 15), 1932.
Cushman and Cahill, U. S. Geol. Survey Prof. Paper 175–A, p. 27, pl. 9, figs. 1a, b, 1933.
Reussella miocenica Cushman, Cushman Lab. Foram. Research Contr., vol. 21, p. 36, pl. 6, figs. 19, 20, 1945.
Cushman and Todd, Cushman Lab. Foram. Research Special Pub. 15, p. 49, pl. 7, fig. 22, 1945.

This species has been recorded from various parts of the Miocene of Florida and South Carolina and from the Miocene of Buff Bay, Jamaica. The specimens from St. Croix are few and spinose. They are present in test well No. 1 at 24 to 30 feet and 520 feet; test well No. 2 at 90 feet; and test well No. 3 at 100 feet.

Genus UVIGERINA D'Orbigny, 1826

Uvigerina rustica Cushman and Edwards

Uvigerina hispida Galloway and Morrey [not Schwager], Bull. Am. Paleontology, vol. 15, no. 55, p. 39, pl. 6, fig. 3, 1929.
Cushman, Cushman Lab. Foram. Research Contr., vol. 5, p. 95, pl. 13, fig. 35, 1929.
Uvigerina auberiana Nuttall [not D'Orbigny], Quart. Jour. Geol. Soc., vol. 84, p. 94, pl. 6, fig. 16, 1928.
Uvigerina rustica Cushman and Edwards, Cushman Lab. Foram. Research Contr., vol. 14, p. 83, pl. 14, fig. 6, 1938.
Palmer, Soc. cubana historia nat. Mem., vol. 15, p. 184, pl. 15, fig. 19, 1941.
Renz, 8th Am. Sci. Congress Proc., pp. 546, 548, 560 (lists), 1942.
Cushman and Stainforth, Cushman Lab. Foram. Research Special Pub. 14, p. 47, pl. 7, fig. 13, 1945.
Cushman and Todd, Cushman Lab. Foram. Research Special Pub. 15, p. 50, pl. 7, fig. 26, 1945.

This species was described from material from Venezuela that is probably of early Miocene age. The species has been recorded from Trinidad, Ecuador, Cuba, and Jamaica. It is common in test well No. 1, from 230 to 1,450 feet; in test well No. 2, from 30 to 390 feet; and in test well No. 3 at 90 feet.

Uvigerina auberiana D'Orbigny

Uvigerina auberiana D'Orbigny, in De la Sagra, Historia física, política y natural de la isla de Cuba, Foraminifères, p. 106, pl. 2, figs. 23, 24, 1839.
Cushman, U. S. Nat. Mus. Bull. 104, pt. 4, p. 163, pl. 42, figs. 3, 4, 1923; Cushman Lab. Foram. Research Contr., vol. 5, p. 95, pl. 13, fig. 36, 1929; Florida Geol. Survey Bull. 4, p. 49, pl. 9, fig. 7, 1930.
Cushman and Ponton, Florida Geol. Survey Bull. 9, p. 86, 1932.
Cushman and Cahill, U. S. Geol. Survey Prof. Paper 175–A, p. 27, pl. 9, fig. 3, 1933.
Cushman, Geol. Soc. America Bull., vol. 47, p. 423, pl. 2, figs. 18a, b, 1936.
Cushman and Todd, Cushman Lab. Foram. Research Contr., vol. 17, p. 44, pl. 13, figs. 4, 5, 1941.

D'Orbigny described this species from the region of Cuba. It is rare in the Miocene Choctawhatchee and Shoal River formations of Florida. Specimens from the lower Miocene of Venezuela and from the late Tertiary of Georges Bank, in the western Atlantic Ocean, are probably also to be referred here. This species is common in the well samples from St. Croix, occurring in test well No. 1 from 24 to 1,430 feet, test well No. 2 from 100 to 390 feet, and test well No. 3 from 90 to 130 feet.

Uvigerina cf. U. hispido-costata Cushman and Todd

A number of specimens are similar to, although smaller than, this species described from the Miocene of Buff Bay, Jamaica, and known from the West Indian region. In the well samples it is present in test well No. 1 at 100 feet and is then common from 520 feet to the bottom of the well at 1,450 feet, in test well No. 2 at 90 feet and 360 feet, and in test well No. 3 from 62 to 70 feet.

Uvigerina carapitana Hedberg

Uvigerina carapitana Hedberg, Jour. Paleontology, vol. 11, p. 677, pl. 91, fig. 20, 1937.
Cushman and Edwards, Cushman Lab. Foram. Research Contr., vol. 14, p. 82, pl. 14, fig. 2, 1938.
Palmer, Soc. cubana historia nat. Mem., vol. 15, p. 182, 1941.
Renz, 8th Am. Sci. Congress Proc., pp. 546, 557 (lists), 1942.

This species was described originally from the Oligocene Carapita formation of Venezuela, and similar specimens occur in the upper Oligocene of Cuba and the Oligocene and Miocene of Trinidad. It is present in test well No. 1 at 24 to 30, 580, and 920 feet, and from there more frequently to the bottom of the well at 1,450 feet; and in test well No. 2 at 90 and 390 feet

Uvigerina gallowayi Cushman

Uvigerina gallowayi Cushman, Cushman Lab. Foram. Research Contr., vol. 5, p. 94, pl. 13, figs. 33, 34, 1929.
Cushman and Edwards, Cushman Lab. Foram. Research Contr., vol. 14, p. 75, pl. 13, figs. 8, 9, 1938.
Kleinpell, Miocene stratigraphy of California, p. 294, pl. 5, figs. 1, 2, 5, Tulsa, 1938.
Cushman and Todd, Cushman Lab. Foram. Research Contr., vol. 17, p. 45, pl. 13, fig. 11, 1941.
Galloway and Heminway, New York Acad. Sci., Sci. Survey Porto Rico and Virgin Ids., vol. 3, pt. 4, p. 429, pl. 33, fig. 8, 1941.
Cushman and Simonson, Jour. Paleontology, vol. 18, p. 200, pl. 32, figs. 18, 19, 1944.
Weaver, Washington Univ. [Seattle] Pub. in Geology, vol. 6, no. 1, p. 25 (list), 1944.
Cushman and Stainforth, Cushman Lab. Foram. Research Special Pub. 14, p. 48, pl. 7, fig. 14, 1945.
Cushman and Todd, Cushman Lab. Foram. Research Special Pub. 15, p. 49, pl. 7, fig. 24, 1945.

This species is known from the lower Miocene or possibly upper Oligocene of Ecuador and Venezuela, the Oligocene and Miocene of California, the Oligocene of Puerto Rico and Trinidad, and the Miocene of Buff Bay, Jamacia. Rather typical material occurs in test well No. 1 at 740, 820, and 1,190 feet.

Genus SIPHOGENERINA Schlumberger, 1883

Siphogenerina lamellata Cushman

Siphogenerina lamellata Cushman, U. S. Geol. Survey Bull. 676, p. 55, pl. 12, fig. 3, 1918; U. S. Nat. Mus. Proc., vol. 67, art. 25, p. 10, pl. 1, fig. 13, 1926; Florida Geol. Survey Bull. 4, p. 49, pl. 9, fig. 10, 1930.
Cushman and Ponton, Florida Geol. Survey Bull. 9, p. 86, 1932.
Cushman and Cahill, U. S. Geol. Survey Prof. Paper 175–A, p. 28, pl. 9, fig. 4, 1933.
Cole, Florida Geol. Survey Bull. 16, p. 18 (list), pl. 1, fig. 1, 1938.
Ellisor, Am. Assoc. Petroleum Geologists Bull., vol. 24, No. 3, pl. 4, fig. 6, 1940.
Renz, 8th Am. Sci. Congress Proc., pp. 554, 557 (lists), 1942.

This species was found in test well No. 1 from 230 to 1,450 feet, and in test well No. 2 at 30, 100, and 360 feet.

Siphogenerina cf. S. senni Cushman and Renz

Single specimens from test well No. 1 at 280 and 1,430 feet are close to this species described from the Miocene of Venezuela.

Siphogenerina basispinata Cushman and Jarvis

Siphogenerina basispinata Cushman and Jarvis, Cushman Lab. Foram. Research Contr., vol. 5, p. 13, pl. 3, figs. 4, 5, 1929.
Cushman and Stainforth, Cushman Lab. Foram. Research Special Pub. 14, p. 49, pl. 8, fig. 3, 1945.

A single specimen from 1,360 feet in test well No. 1 is very similar to this species, described from Trinidad, probably from the early Tertiary.

Siphogenerina multicostata Cushman and Jarvis

Siphogenerina multicostata Cushman and Jarvis, Cushman Lab. Foram. Research Contr., vol. 5, p. 14, pl. 3, fig. 6, 1929.
Cushman, Cushman Lab. Foram. Research Contr., vol. 5, p. 95, pl. 13, fig. 38, 1929.
Hadley, Bull. Am. Paleontology, vol. 20, no. 70A, p. 17, pl. 2, fig. 8, 1934.
Kleinpell, Miocene stratigraphy of California, p. 302, pl. 5, fig. 7, Tulsa, 1938.
Galloway and Heminway, New York Acad. Sci., Sci. Survey Porto Rico and Virgin Ids., vol. 3, pt. 4, p. 435, pl. 34, figs. 3, 4, 1941.
Renz, 8th Am. Sci. Congress Proc., pp. 545, 546, 548, 560 (lists), 1942.
Weaver, Washington Univ. [Seattle] Pub. in Geology, vol. 6, no. 1, p. 25 (list), 1944.
Cushman and Stainforth, Cushman Lab. Foram. Research Special Pub. 14, p. 49, pl. 8, fig. 1, 1945.

This species was described from Trinidad and has been recorded from the Miocene of Venezuela and California and from the Oligocene of Cuba, Puerto Rico, and Trinidad. Typical specimens of this species are present in test well No. 1 at 580 feet.

Siphogenerina multicostata Cushman and Jarvis var. optima Cushman

Siphogenerina multicostata Cushman and Jarvis var. *optima* Cushman, Cushman Lab. Foram. Research Contr., vol. 19, p. 91, pl. 16, figs. 9, 10, 1943.

This variety differs from the typical form in the finer costae and the uniserial chambers, which tend to be in an irregular line. It was described from material at a depth of 90 feet in the Fair Plain test well No. 3, five-eighths of a mile west of Anguilla, St. Croix, V. I.

The variety was found in test well No. 1 from 100 to 1,430 feet; in test well No. 2 at 30, 160, and 390 feet; and in test well No. 3 at 90 feet.

Genus ANGULOGERINA Cushman, 1927

Angulogerina occidentalis (Cushman)

Uvigerina angulosa Cushman [not Williamson], Carnegie Inst. Washington Pub. 311, p. 34, pl. 5, figs. 3, 4, 1922.
Uvigerina occidentalis Cushman, U. S. Nat. Mus. Bull. 104, pt. 4, p. 169, 1923.
Angulogerina occidentalis Cushman, Florida Geol. Survey Bull. 4, p. 50, pl. 9, figs. 8, 9, 1930.
Cole, Florida Geol. Survey Bull. 6, p. 44, pl. 2, fig. 5, 1931.
Cushman and Laiming, Jour. Paleontology, vol. 5, p. 112, pl. 12, figs. 15, 16, 1931.
Cushman and Ponton, Florida Geol. Survey Bull. 9, p. 86, 1932.
Palmer and Bermúdez, Soc. cubana historia nat. Mem., vol. 9, p. 249, 1935.

This species, described from Recent material of the West Indian region, where it is common, has been found in the Miocene. The records include the Calvert formation of Maryland, the Yorktown formation of North Carolina and Virginia, the Duplin marl of North Carolina, and the Choctawhatchee formation of Florida. It has been recorded also from the Tertiary of Cuba and the Miocene of California. In the well-samples from St. Croix it is present in test well No. 1 almost throughout the series of sediments penetrated from 24 to 1,450 feet, in test well No. 2 from 10 to 330 feet, and in test well No. 3 at 90 feet.

Genus TRIFARINA Cushman, 1933

Trifarina bradyi Cushman

Scattered specimens in the well samples seem identical with this species, as figured from the Miocene of Venezuela (Cushman, Cushman Lab. Foram. Research Contr., vol. 5, p. 96, pl. 13, fig. 39, 1929) and the Oligocene of Trinidad (Cushman and Stainforth, Cushman Lab. Foram. Research Special Pub. 14, p. 50, pl. 8, fig. 4, 1945). These are present in test well No. 1 at the following depths: 24 to 30, 370, 580, 690, 1,110, and 1,210 feet; in test well No. 2 at 30 feet; and in test well No. 3 at 90 and 100 feet.

Family ELLIPSOIDINIDAE

Genus PLEUROSTOMELLA Reuss, 1860

Pleurostomella alternans Schwager

In the American Miocene this species has been recorded from Ecuador, Venezuela, Trinidad, and Haiti. Specimens are fairly common in the well samples from St. Croix, being present almost throughout all three wells.

Pleurostomella brevis Schwager

This species is not so common as the preceding species but occurs at scattered levels in all three wells. It has been recorded from the Miocene of Trinidad and Jamaica and the Oligocene of Cuba.

Genus NODOSARELLA Rzehak, 1895

Nodosarella subcylindrica Cushman

Nodosarella subcylindrica Cushman, Cushman Lab. Foram. Research Contr., vol. 19, p. 91, pl. 16, figs. 4, 5, 1943.
Cushman and Stainforth, Cushman Lab. Foram. Research Special Pub. 14, p. 53, pl. 9, fig. 4, 1945.

Test small, elongate, subcylindrical, slightly tapering; early stages biserial, adult uniserial; chambers distinct, slightly inflated, those in the adult uniserial portion higher than broad; sutures distinct, slightly depressed; wall smooth, finely perforate; aperture terminal, narrow, with a slightly overhanging lip. Length 0.55–0.65 mm.; diameter 0.10–0.12 mm.

This species was described from material at a depth of 90 feet in the Jealousy test well No. 2, 300 yards west of great-house at Jealousy, St. Croix, V. I. It differs from *Nodosarella pacifica* Cushman in the much smaller size and higher chambers. It also occurs in test well No. 1 at 230, 740, 1,330, 1,360, and 1,450 feet and in test well No. 3 at 90 and 130 feet, and has been recorded from the Oligocene Cipero formation of Trinidad.

Nodosarella robusta Cushman

Nodosarella robusta Cushman, Cushman Lab. Foram. Research Contr., vol. 19, p. 92, pl. 16, fig. 8, 1943.
Cushman and Stainforth, Cushman Lab. Foram. Research Special Pub. 14, p. 53, pl. 9, figs. 1, 2, 1945.

Test of medium size, elongate, subcylindrical; biserial stage very short; chambers distinct, very slightly inflated, overlapping, broader than high except the final chamber; sutures fairly distinct, slightly if at all depressed; wall smooth and polished; aperture terminal, a narrow opening with a distinctly overhanging lip. Length 1.10–1.25 mm.; diameter 0.28–0.35 mm.

This species was described from material at a depth of 100 feet in the Bethlehem test well No. 1, at a locality 500 yards east-northeast of Bethlehem, St. Croix, V. I.

This species differs from *Nodosarella pacifica* Cushman in the typically shorter, stouter test, and more strongly overhanging lip. It occurs in test well No. 1 at intervals from 100 to 1,360 feet and in test well No. 2 at 90 feet.

Genus ELLIPSONODOSARIA A. Silvestri, 1900

Ellipsonodosaria subspinosa Cushman

Ellipsonodosaria sp. Cushman and Jarvis, Cushman Lab. Foram. Research Contr., vol. 10, pl. 10, figs. 4, 5, 1934.
Ellipsonodosaria subspinosa Cushman, Cushman Lab. Foram. Research Contr., vol. 19, p. 92, pl. 16, figs. 6, 7, 1943.
Cushman and Stainforth, Cushman Lab. Foram. Research Special Pub. 14, p. 56, pl. 9, figs. 9, 10, 1945.

Test elongate, subcylindrical, slightly tapering, greatest breadth near the apertural end; chambers distinct, strongly inflated, increasing gradually in size as added; sutures distinct, strongly depressed; wall with short stout spines, either entirely covering the chamber or in the early stages confined to the lower portion of the chamber wall; aperture with a subcylindrical neck and distinct lip with an inwardly projecting tooth. Length 2.50–3.25 mm.; diameter 0.35–0.90 mm.

This species was described from the Oligocene Cipero formation of Trinidad, originally designated as "lower middle Miocene, Green clay, Cipero section" (see Cushman and Stainforth, Cushman Lab. Foram. Research Special Pub. 14, p. 7, 1945). It differs from *Ellipsonodosaria mappa* Cushman and Jarvis in the more elongate, tapering test, and the surface ornamentation of short spines. It occurs in test well No. 1 at 640, 870, and 1,430 feet.

Ellipsonodosaria cf. E. gracilis Palmer and Bermúdez

A number of specimens are curved and typically have a row of spines near the base of the chamber, two characters which apparently distinguish this species, described by Palmer and Bermúdez from the Oligocene of Cuba (Soc. cubana historia nat. Mem., vol. 10, p. 296, pl. 18, figs. 8, 9, 1936). In the later stages of the specimens from St. Croix, however, additional spines are found on the upper part of the chambers and in some specimens these nearly cover the chamber. Specimens are found in all three wells.

Ellipsonodosaria verneuili (D'Orbigny)

A number of specimens, variable in size and amount of inflation of the chambers, seem to belong to this species. The species has already been recorded from the Miocene of Ecuador, Venezuela, Trinidad, and Jamaica. It is present in test well No. 1 from 690 to 1,450 feet, and in test well No. 3 at 90 and 130 feet.

Family ROTALIIDAE

Genus GYROIDINA D'Orbigny, 1826

Gyroidina soldanii D'Orbigny

Material referred to this species needs much more study, as a glance at the figures of the specimens referred to it will show. The species has been recorded from the Miocene of Ecuador, Colombia, Venezuela, Trinidad, Puerto Rico, Costa Rica, and California, as well as from the late Tertiary of the Georges Bank in the western Atlantic Ocean. What seem to be typical specimens are present with a wide range in all three of the wells on St. Croix.

Gyroidina soldanii D'Orbigny var. altiformis R. E. and K. C. Stewart

This variety has been recorded from the Miocene of Haiti (Coryell and Rivero, Jour. Paleontology, vol. 14, p. 337, pl. 43, figs. 19a–c, 1940) and the Miocene of Buff Bay, Jamaica (Cushman and Todd, Cushman Lab. Foram. Research Special Pub. 15, p. 57, pl. 9, figs. 3a, b, 1945). Although not as common as the typical form, specimens referable to the variety are present in test well No. 1 at 230 to 1,330 feet, test well No. 2 at 280 and 390 feet, and in test well No. 3 at 90 and 100 feet.

Genus EPONIDES Montfort, 1808

Eponides umbonata (Reuss)

Very typical specimens similar to those recorded from the Miocene of Ecuador and Venezuela (Cushman Lab. Foram. Research Contr., vol. 5, p. 98, pl. 14, figs. 8a-c, 1929) were found in material from all three wells.

Genus SIPHONINA Reuss, 1850

Siphonina pulchra Cushman

This species was described from the Miocene of Cuba and has been recorded from the Miocene of Haiti and Jamaica and from the late Tertiary of Georges Bank in the western Atlantic Ocean. Specimens occur only in test well No. 1 at 1,090, 1,190, and 1,430 feet.

Siphonina tenuicarinata Cushman

This species, originally described from the Oligocene Alazan formation of Mexico, has been recorded from Eocene to Miocene. It occurs in the lower Miocene of Venezuela, Trinidad, Haiti, Puerto Rico, and Mexico. A few specimens are found in all three wells in St. Croix.

Family CASSIDULINIDAE

Genus PULVINULINELLA Cushman, 1926

Pulvinulinella culter (Parker and Jones)

This species has been recorded from the Miocene of Ecuador, Venezuela, and Trinidad. A few specimens occur at scattered depths in test well No. 1 and test well No. 2. All the specimens have a very strong keel.

Genus CASSIDULINA D'Orbigny, 1826

Cassidulina crassa D'Orbigny

A few specimens may belong to this species. The aperture, however, is more elongate than in the typical form and considerable variation is shown in the series of specimens. The species has already been recorded from the Miocene of Venezuela, Florida, North Carolina, Virginia, and Maryland, and from the late Tertiary of Georges Bank in the western Atlantic Ocean. There are also records from the Oligocene. Specimens are present only in test well No. 1 at 230, 640, and 1,450 feet.

Cassidulina laevigata D'Orbigny

A very few specimens may be referred to this species. They most closely resemble the specimens with very elongated aperture figured by Macfadyen from the Miocene of Egypt (Egypt Geol. Survey, 1930, p. 63, pl. 2, figs. 6a, b, 1931). Specimens occur in test well No. 1 at 100 and 1,430 feet and test well No. 3 at 100 feet.

Cassidulina laevigata D'Orbigny var. carinata Cushman

This variety has been recorded widely in the American Miocene but is very rare in the present material, occurring only in test well No. 1 at 1,330 and 1,390 feet.

Cassidulina subglobosa H. B. Brady

This species is the most common member of the genus in the well-samples, occurring in all three wells in a large number of the samples with a wide range. In the American Miocene it has been recorded from Cuba, Jamaica, Puerto Rico, Costa Rica, Ecuador, Venezuela, Trinidad, and California.

Cassidulina carapitana Hedberg

This species, described from the upper Oligocene of Venezuela (Jour. Paleontology, vol. 11, p. 680, pl. 92, figs. 6a, b, 1937), is represented in the present material by a single specimen from test well No. 1 at 24 to 30 feet. It has also been recorded from the Oligocene of Cuba and Trinidad.

Genus CASSIDULINOIDES Cushman, 1927

Cassidulinoides bradyi (Norman)

This species has been recorded from the Miocene of Florida and Jamaica and the Oligocene of Trinidad. Adult specimens are present in test well No. 1 at 580 feet and in test well No. 2 at 360 feet. A few specimens, perhaps representing young stages, are present also in some of the other samples.

Genus EHRENBERGINA Reuss, 1850

Ehrenbergina bradyi Cushman

Coryell and Rivero have recorded this species from the Miocene of Haiti (Jour. Paleontology, vol. 14, p. 342, pl. 44, figs. 22a–c, 1940). It may be the same as the form I have identified as *E. trigona* (Goës) from the late Tertiary of Georges Bank in the western Atlantic Ocean (Geol. Soc. America Bull., vol. 47, p. 425, pl. 3, figs. 9a, b, 1936). Scattered specimens are present in test well No. 1 at 24 to 30, 100, 1,360, and 1,390 feet.

Family CHILOSTOMELLIDAE

Genus CHILOSTOMELLA Reuss, 1850

Chilostomella oolina Schwager

The only previous American Miocene record for this species rests on a single broken specimen from the Choctawhatchee formation of Florida. It has been recorded also from the Oligocene of Venezuela by Hedberg.

Single typical specimens are present in test well No. 1 at 230, 1,190, and 1,430 feet; test well No. 2 at 30 feet; and test well No. 3 at 100 feet.

Genus PULLENIA Parker and Jones, 1862

Pullenia bulloides D'Orbigny

(For references see Cushman and Todd, Cushman Lab. Foram. Research Contr., vol. 19, p. 13, 1943.)

Under this name have been grouped those specimens that are nearly spherical and show little if any sign of compression. The species occurs in the late Tertiary of the Georges Bank in the western Atlantic Ocean, in the Miocene near Manta, Ecuador, and in the Miocene of Egypt. It is present in test well No. 1 from 24 to 1,360 feet and in test well No. 3 at 100 and 130 feet.

Pullenia quinqueloba (Reuss)

(For references see Cushman and Todd, Cushman Lab. Foram. Research Contr., vol. 19, p. 10, 1943.)

This species is usually recorded with the preceding and represents a more compressed test. In the well samples such forms are present in test well No. 1 at 440, 1,170, 1,210, 1,360, and 1,390 feet; test well No. 2 at 100 and 160 feet; and test well No. 3 at 90 and 130 feet.

Genus SPHAEROIDINA D'Orbigny, 1826

Sphaeroidina bulloides D'Orbigny

It is probable that there is little difference between this species and *S. variabilis* Reuss. Specimens from the well samples seem to be identical with those, figured as *S. variabilis*, from the Miocene of Ecuador, Venezuela, and Trinidad, and with those, figured as *S. bulloides*, from the Miocene of Puerto Rico and Jamaica and from the late Tertiary of Georges Bank in the western Atlantic Ocean. Specimens are present in test well No. 1 at numerous depths from 230 to 1,430 feet, and in test well No. 2 at 330 feet.

Family GLOBIGERINIDAE

This family is now being intensively studied in a monographic way and the species from St. Croix, which are represented by abundant specimens, will be included in those studies. No attempt has been made to deal with them in this report.

Family GLOBOROTALIIDAE

Genus GLOBOROTALIA Cushman, 1927

Globorotalia menardii (D'Orbigny)

This species is abundant in nearly all the well-samples from St. Croix. It occurs also in the Miocene of Florida and elsewhere. Studies now under way on this and related species may show that these Miocene forms are separable from the Recent ones. With *G. menardii* in the St. Croix material, are other species of this genus, but all need special study and comparison with those of other areas before satisfactory determinations can be made.

Family ANOMALINIDAE

Genus ANOMALINA D'Orbigny, 1826

Anomalina flintii Cushman

Anomalina ammonoides Flint [not Reuss], U. S. Nat. Mus. Rept. for 1897, p. 335, pl. 78, fig. 4, 1899.
Anomalina flintii Cushman, U. S. Nat. Mus. Bull. 104, pt. 8, p. 108, pl. 18, figs. 5a-c, 1931.
Coryell and Rivero, Jour. Paleontology, vol. 14, p. 334, pl. 44, figs. 8a-c, 1940.

The types of this species are from stations off Cuba. The species occurs in the Miocene of Haiti and is present in typical form in the well material from St. Croix. Specimens occur in test well No. 1 at intervals from 180 to 1,330 feet, in test well No. 2 at 360 feet, and in test well No. 3 at 100 feet.

Genus PLANULINA D'Orbigny, 1826

Planulina cf. P. ariminensis D'Orbigny

A single specimen from test well No. 1 at 24 to 30 feet is close to this species and similar to that figured from the Miocene of Haiti (Coryell and Rivero, Jour. Paleontology, vol. 14, p. 337; pl. 44, figs. 7a-c, 1940).

Genus LATICARININA Galloway and Wissler, 1927

Laticarinina bullbrooki Cushman and Todd

Laticarinina bullbrooki Cushman and Todd, Cushman Lab. Foram. Research Contr., vol. 18, p. 19, pl. 4, figs. 8, 9, 1942.
Cushman and Stainforth, Cushman Lab. Foram. Research Special Pub. 14, p. 73, pl. 15, figs. 2a, b, 1945.
Cushman and Todd, Cushman Lab. Foram. Research Special Pub. 15, p. 70, pl. 12, fig. 5, 1945.

Single immature specimens of this species are present in test well No. 3 at 100 and 130 feet. The species occurs in the Miocene and Oligocene of Trindad and the Miocene of Buff Bay, Jamaica.

Genus CIBICIDES Montfort, 1808

Cibicides mississippiensis (Cushman)

A number of specimens seem much more like this species than like *C. americanus*. They are all from test well No. 1 and largely from the lower part of that well. The species was described from the Oligocene of Mississippi and seems to be more characteristic of that part of the section than of the Miocene.

Cibicides americanus (Cushman)

A few specimens from St. Croix apparently belong to this species but they are rare and are scattered throughout the well sections.

Cibicides pseudoungerianus (Cushman) var. io Cushman

Cibicides pseudoungerianus (Cushman) var. *io* Cushman, U. S. Nat. Mus. Bull. 104, pt. 8, p. 125, pl. 23, figs. 1, 2, 1931.
Palmer and Bermúdez, Soc. cubana historia nat. Mem., vol. 9, p. 257, 1935.
Cibicides io Coryell and Rivero, Jour. Paleontology, vol. 14, p. 334, pl. 44, figs. 11a-c, 1940.
Galloway and Heminway, New York Acad. Sci., Sci. Survey Porto Rico and Virgin Islands., vol. 3, pt. 4, p. 392, pl. 22, figs. 4a-c, 1941.

Rather typical specimens of this form, described from Recent material dredged off Florida, occur in the well samples. They are from test well No. 1 at 24 to 30, 180, 1,090, and 1,430 feet; test well No. 2 at 30 feet; and test well No. 3 at 100 feet. It has been recorded from the Miocene of Cuba, Haiti, and Puerto Rico.

Cibicides illingi (Nuttall)

Truncatulina illingi Nuttall, Geol. Soc. London Quart. Jour., vol. 84, p. 99, pl. 7, figs. 11, 17; text fig. 5, 1928.

This species was described from the lower Miocene or upper Oligocene of Trinidad. Typical specimens are present in the well samples; in test well No. 1 at 960, 1,360, and 1,450 feet; and in test well No. 2 at 100 feet.

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Professional Paper 210–B

A PENNSYLVANIAN FLORULE FROM THE FORKSTON COAL IN THE DUTCH MOUNTAIN OUTLIER NORTHEASTERN PENNSYLVANIA

BY

CHARLES B. READ

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By CHARLES B. READ

ABSTRACT

Dutch Mountain is an outlier of Pennsylvanian strata situated some 15 miles north of the west end of the Northern Anthracite coal field. The Forkston coal, semianthracite in rank and in the midst of a great conglomeratic sandstone, has been mined on Dutch Mountain for many years. From the roof of this coal at several points collections of fossil plants have been obtained. There are *Lacoea seriata* Read, n. gen. and n. sp., *Neriopteris lanccolata* Newberry, *Archaeopteridium bellasylviana* Read, n. sp., *Mariopteris* sp., *Neuropteris* sp., *Cordaites* sp., *Cardiocarpon phillipsi* Read n. sp. The age of this flora is lower Pennsylvanian, and it is believed to indicate approximate contemporaneity of the Forkston coal with coal-bearing strata near the position of the lower portion of the Connoquenessing sandstone member of the Pottsville formation of the Allegheny Plateau, the Nuttall sandstone member of the Sewell formation of West Virginia, and perhaps the Makanda sandstone and the sandstone immediately below the Tarter coal in Illinois. It is believed that this flora will aid in the difficult problem of establishing correlations between the anthracite region of eastern Pennsylvania and the great areas of Pennsylvanian strata of the Allegheny Plateau.

INTRODUCTION

Dutch Mountain is one of several small outliers of Pennsylvanian strata that lie north of the western part of the Northern Anthracite coal fields, in Northeastern Pennsylvania. It is in Forkston and North Branch townships, Wyoming County, about 15 miles northwest of Wilkes-Barre, 15 miles due north of the western end of the Northern Anthracite field, and 3 miles southwest of the village of Forkston. From their position in the drainage basin of Mehoopany Creek these outliers are sometimes spoken of as the "Mehoopany coal basins."

The Mehoopany basins are the easternmost of the remnants of Pennsylvanian strata that are scattered from western Wyoming County across Sullivan, Bradford, Lycoming, and Tioga Counties to the northern Allegheny Plateau region of Clinton and Potter Counties, in which there are more continuous areas of the "Coal Measures." Because of its position, linking the anthracite basins of the eastern part of the State with the great area of the Allegheny Plateau in the west, this chain of outliers has been of interest to stratigraphers from the time of the early Pennsylvania surveys. Unfortunately, exposures in most of the basins are poor, and they have not furnished the data that an inspection of the State maps would lead one to expect.

In Dutch Mountain, as well as in several of the other areas, small coal mines have been operated intermittently for many years. During the time of his activity as a collector, in the latter half of the past century, R. D. Lacoe obtained a very interesting lot of fossil plants from mines in the Forkston coal in Dutch Mountain. While engaged in field work in Pennsylvania in 1938, H. A. Swenson, of the Geological Survey, and the writer paid a brief visit to the Mehoopany coal basins to investigate the occurrence of the fossils. It is the purpose of this paper to record the observations made and to describe the available collection of plants.

POSITION OF THE FOSSIL PLANTS

As is stated above, Dutch Mountain is a small area of Pennsylvanian rocks preserved in a syncline and situated 15 miles north of the west end of the Northern Anthracite coal field. Outcrops are poor, owing to the heavy cover of timber and to the mantle of glacial debris. Coal has been mined at a number of points near the top of Dutch Mountain, where a few hundred acres of coal is preserved. At the time of the writer's visit only one mine was in operation.

A section of the Pennsylvanian rocks could not be measured in the region, owing to the poor exposures. It was, however, possible to obtain a few facts regarding their occurrence. The Forkston coal, a semianthracite, is a rather variable bed, ordinarily maintaining a thickness of 3 feet or a few inches less, but in a few places increasing to about 4 feet, and at others becoming too thin to mine. It is underlain by a few inches to 4 feet of dark-gray carbonaceous, root-traversed, massive to irregularly bedded siltstone and underclay that contain occasional fernlike pinnules and large *Cordaites* leaves. The roof, at points where it was seen in the one mine entered, was sandstone or conglomerate. Miners report, however, that in some of the old workings a few inches to a foot of silty gray shale lies between the coal and the sandstone.

Under the Forkston coal and its associated root bed is a conglomeratic sandstone, exposures of which are very poor but sufficient to indicate a thickness of about 200 feet. Above the coal some 50 feet of conglomerate is present and in at least two air shafts that have been driven through the upper conglomerate a thin coal has been encountered about 20 feet above the Forkston bed. Details of this upper coal bed are not available.

The florule here described comes from the roof of the Forkston coal at points in several drift mines not now in operation.

COMPOSITION OF THE FLORULE AND AGE OF THE ASSOCIATED STRATA

The composition of the Forkston florule is as follows:

Lacoea seriata Read, n. gen., n. sp.
Neriopteris lanceolata Newberry.
Archaeopteridium bellasylviana Read, n. sp.
Mariopteris sp.
Neuropteris sp.
Cordaites sp.
Cardiocarpon phillipsi Read, n. sp.

As shown by the list, the number of species is small. Only seven forms are known and but four of these are specifically identifiable. The significance of these four is great, however, from the viewpoint of the stratigraphic paleontologist. Thus *Neriopteris lanceolata* Newberry and a form closely related to *Archaeopteridium bellasylviana*, *A. stricta* (Andrews) (n. comb.), are known from strata associated with the lower part of the Connoquenessing sandstone member of the Pottsville formation in southern Ohio and with the Nuttall sandstone member of the Sewell formation in the Kanawha-New River Valley of West Virginia. In addition, a close relative of *A. bellasylviana*, *A. plumosum* White, is known from rocks in the zone just above the Makanda sandstone in southern Illinois.

Lacoea seriata is known in sandstone above the Sharon coal in the Youngstown region of northeastern Ohio and in shale just under the Connoquenessing sandstone member of the Pottsville formation in Jackson County, Ohio. *Cardiocarpon phillipsi* is a type of seed common in the strata under the Quakertown coal and associated with the lower part of the Connoquenessing sandstone.

It thus appears that the data in hand indicate the equivalence of the Forkston coal to coal-bearing strata at the approximate position of the lower part of the Connoquenessing sandstone of the northern Allegheny Plateau and the Nuttall sandstones of the West Virginia region. Approximate correlation with the Makanda sandstone of southern Illinois or beds just above it is also suggested.

As regards the position of the Forkston floral zone in the general section of the anthracite region, it appears possible to establish it, but pending a more detailed study of the sequence a report on this must be deferred. It may be said, however, that the zone appears to be present near the base of the Pennsylvanian section in the Northern Anthracite field and completely absent in the Southern Anthracite field.

DESCRIPTION OF FOSSILS

Genus LACOEA Read, n. gen.

Characters at present those of the single species, *Lacoea seriata*. The generic name is in honor of the collector of the type specimens, R. D. Lacoe.

Lacoea seriata Read, n. sp.

Plate 1, figures 1–14

The most abundant recognizable fossils in the Forkston collection are the flattened impressions and incrustations of a rather remarkable type of fructification. As usually seen on the bedding planes of the dark-gray sandy shale, these are roughly oval to ovate and show a considerable range in size. However, it is relatively rare to find one larger than 2 centimeters in diameter. The general appearance of typical individuals is seen in plate 1, figures 1–10, 13. It is evident that some specimens are globular and others somewhat cup-shaped. In all a notable feature is the more or less asymetrical base. The form of the base differs considerably in the several specimens and, as will be shown farther on in this paper, is dependent upon the position of the body with reference to other similar organs. The main part of the fossil just above the base in many specimens is somewhat lenticular in transverse section, a feature indicating that its cross section was circular prior to fossilization. A very obvious character is the surface patterns, which in the better-preserved individuals is made up of abundant small rhomboidal or diamond-shaped areas (pl. 1, figs. 3 and 5, particularly) ranging from 1 to 2 millimeters in length and usually half as broad as long. These are closely spaced and are arranged in what appear to be close spirals. Normally they stand in relief, with shallow depressions or furrows between. The general effect of the pattern is, in fact, superficially similar to that of a fragment of some small *Lepidodendron* stem that has lost its foliage.

Fringing distal parts of the structure is a lacinate border of variable width (pl. 1, figs. 2, 3, 5, 6, 10, 13), usually a centimeter or more across. The tissues that made up this fringe were evidently rather thin and delicate, if the present vague limits and the lack of relief may be taken as criteria.

The cupular organs just briefly described are borne in pinnate aggregates of 10 or more pairs and are seated on short pedicels attached to slender rachises. Some of these aggregates are seen in plate 1, figures 11, 12, and 14. It is apparent that the cupules are crowded on the axis, so that a strobilus is simulated. A notable feature is the small size of the individual structures in those specimens in which they are attached as compared to those detached. That the large and small individuals are identical in structure is seen by their form as well

as by their superficial rhomboidal markings. The difference in size will be more fully treated in connection with the interpretation of the fossils.

The specific name refers to the seriate or serrate fringe at the apex of the specimen.

Interpretation.—The interpretation of *Lacoea seriata* and the reconstruction of its aspect before crushing and fossilization demand some thought. If it is recalled that the specimens were derived from a region of rather considerable crustal deformation, one in which the strata have been subjected to a great deal of pressure, as evidenced by the very high rank of the coal,[1] it will be clear that the lenticular cross section of the ovate body (pl. 1, fig. 9) of the *Lacoea* specimens is evidence of an original rounded form. Thus it would appear that the structures were originally sphaeroidal or cupular, with a constricted brim, although without any definite radial symmetry (pl. 1, figs. 1, 7, 9, particularly). This striking lack of radial symmetry was noted in an earlier paragraph and is undoubtedly related to the grouping of the structures into dense strobiluslike aggregates. However, the individual bodies are two-ranked on the axis rather than in whorls or in spirals. In consequence it is rather clear that the axis upon which these bodies are borne is a rachis rather than a stem.

A point that has been made in connection with the grouping of the specimens is that those that are assembled in the pinnate aggregates are much smaller than those that are detached. (See pl. 1, fig. 14, in which a group as well as an isolated structure may be seen.) Likewise, although this was not brought out earlier, the detached bodies differ considerably in size. The writer is of the opinion that the strobiluslike groups of these bodies represent the young or decidedly immature state and that, with enlargment of the individual structures and elongation of the rachis upon which they were borne, the strobiluslike masses became less rigid and the individual bodies were easily detached. Hence it is only in the very young specimens that large aggregates are found. As to the difference in size of the individual specimens, it is certainly related in part to their maturity and probably in part to their position on the rachis; that is to say, it is quite probable that the basally placed structures tended to be larger than these situated apically.

As regards the individual bodies, they seem almost certainly to represent the spore-bearing or pollen-bearing organs of some early gymnosperm, probably a seed fern, or pteridosperm. The rhomboidal surface markings are apparently the basal ends of sporangia or pollen sacs seen slightly obliquely. From their size and position it is believed tha they were situated on a convex or subspherical receptacle, from which they radiated upward and possibly slightly outward.

The relationship of the membranaceous fringe or border to the sporangia is not clear. The fringe may be an extension of the ends of the sporangia, for similar fringes have been observed in *Potoniea adiantiformis* Zeiller. Or, as seems more likely, it may represent the extension beyond the receptacle proper of a sterile sheath enclosing the sporangia. The distal part of this sheath is either normally laciniate or else frays readily.

Because of its bearing on the morphology of the Forkston specimens it is necessary to bring into the discussion a specimen from the horizon of the lower part of the Connoquenessing sandstone near Youngstown, Ohio. The aspect of this specimen is seen in plate 1, figure 4. As compared with the individuals just reviewed, the Ohio fragment is relatively uncrushed. In form it is obconical or funnel-shaped. The sides, in the region of marked downward tapering, are slightly concave. The dimensions of the specimen are approximately 2 by 2 centimeters. The upper 0.5 to 1.0 centimeter forms a sort of rim that is deeply torn at irregular intervals, the tearing being due beyond doubt to abrasion, or some other cause related to its preservation. This part is otherwise structureless and presents no characteristic markings. It evidently represents a rather thin sheathing tissue for the structures next to be described.

Below the rim are seen here and there, almost to the base of the organ, rhomboidal markings similar to those noted in the specimens of *Lacoea seriata* from the Forkston coal. At the very base these markings are absent, and the surface is covered with a thin unmarked carbonaceous layer. It is apparent that the point of attachment has been broken off, and the base is seen to be somewhat frayed.

The interpretation of this uncrushed specimen is rather simple. The obconical structure is a cupule of rather delicate tissue that is readily disorganized and that leaves at most only a film of carbon if preserved. Traces of this sheath are seen at the apex of the cupule and also at the base. In the markedly tapering part of the structure (the obconical part) are closely spaced rhomboidal or possibly saclike areas. It is evident that these are the bases of elongate, cylindrical sporangia attached regularly around the concave inner surface of the cupule. The rhomboidal rather than circular form of the bases of the sporangia is due in part to the oblique course of the rows of sporangia across the walls of the cupule, and in part to the crowding of the bases and at the same time their alinement in regular spirals. To bring out these relationships as well as the general morphology of the structure, a sketch incorporating the writer's ideas is presented in figure 3. On the left

[1] The Forkston coal is classified as semianthracite.

are shown the surface features reconstructed from the fossil, and on the right a part of the outer receptacle has been cut away to show the attachment of the individual sporangia.

Comparisons.—In the Carboniferous strata of this country, particularly the Pennsylvanian, a great variety of polleniferous organs pertaining to pteridosperms occur, and these are known in collections. Many of them have been acquired by the Geological Survey during field work done in connection with stratigraphic

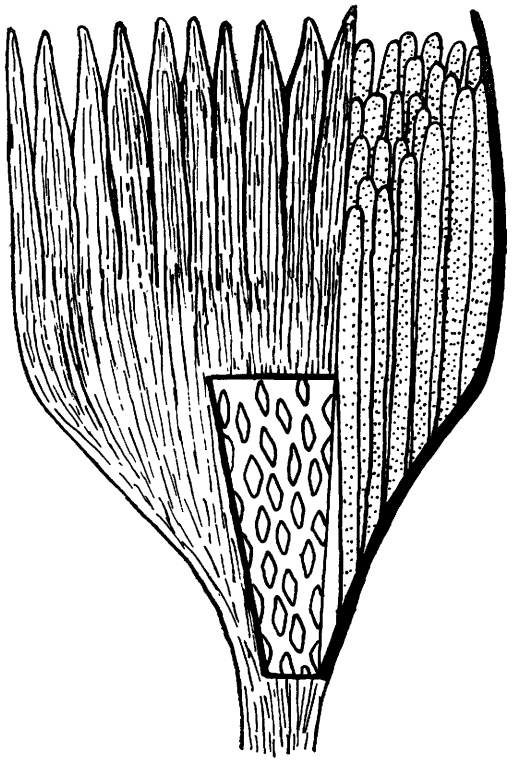

FIGURE 3.—Reconstruction of *Lacoea seriata* Read, n. sp., to show gross morphology.

studies of the upper Paleozoic rocks, and others have been acquired by the United States National Museum. Unfortunately most of these remain undescribed.

One of the best known of these fossil polleniferous organs is *Whittleseya elegans* Newberry, elucidated by the recent efforts of T. G. Halle.[2] A typical specimen of this species is shown in plate 2, figure 10. As ordinarily seen these appear as flattened, fan-shaped, leaflike organs somewhat suggestive of Ginkgo leaves. In fact, *W. elegans* was originally assigned to the Ginkgoales. It appears, however, that this flat structure is a crushed cup, the walls of which are formed by closely spaced tubular sporangia extending the length of the cup. Thus *Lacoea seriata* differs markedly from *W. elegans* in the solid nature of the aggregate of sporangia and likewise in the presence of a receptacle.

Lacoea seriata, in its features of gross morphology, is perhaps closer to *Dolerotheca* or to *Potoniea*. These are spore-bearing organs without a hollow central area, the sporangia extending to the center of the body. In *Dolerotheca* there is a ground mass of tissue between the sporangia, whereas in *Potoniea* the sporangia are free save for a leaflike sheath on the exterior of the whole synangium. In neither form does there seem to be a structure entirely comparable to *Lacoea*, with the rhomboidal sporangia bases spirally arranged on a concave receptable and a long raylike sterile sheath.

No pollen grains have been observed in the material of *Lacoea seriata*, nor could any be expected in fossils found in strata that have undergone such intense pressure as is evidenced by the high rank of the coal.

Genus NERIOPTERIS Newberry

Neriopteris lanceolata Newberry

1873. *Neriopteris lanceolata* Newberry, Ohio Geol. Survey Rept., vol. 1, pt. 2, p. 381, pl. 45, figs. 1–3.

The Forkston collection contains occasional fragments of a large, long-pinnuled fern that is beyond doubt referable to *Neriopteris lanceolata* Newberry. The plant is of the alethopteroid type, with long, strap-shaped leaflets or pinnules, the apices of which are acute and set at somewhat less than a right angle to the axis of the pinna. These pinnules are attached across approximately their own breadth to the rachis of the pinna, the base of the pinnule being decurrent and the upper margin tending to curve slightly downward, following the proximal one. As the pinnules are very closely set, the lamina is thus continuous from one pinnule to the next. The venation is of the alethopteroid type, a heavy midrib extending the complete length of the pinnule and giving off, at an acute angle, secondaries that immediately curve sharply to pass to the margin at approximately a right angle, forking once or twice. At the base of the pinnules the midrib or primary vein is slightly decurrent on the rachis. The material is too poor to illustrate, but there can be no doubt regarding its identity.

The writer has recently examined the type specimen of *Neriopteris lanceolata* Newberry, which is in the collection of the New York Botanical Garden. It will be recalled that in Newberry's original description the pinnules were said to be basally constricted. In the figures accompanying his description they were shown to be attached across a narrow zone immediately adjacent to the midrib, and their bases were rounded. Actually the type specimen does not show these features but agrees very closely with the Forkston plant, in which the pin-

[2] Halle, T. G., The structure of certain fossil spore-bearing organs believed to belong to pteridosperms: K. svenska vetensk. akad. Handl., ser. 3, Band 12, No. 6, pp. 17–24, 1933.

nules are attached across the whole breadth of the base and are slightly decurrent.

According to present data, this species, though extremely rare, is of considerable importance stratigraphically. It is known at several localities in eastern Ohio, where it occurs either in the extreme upper part of the Sharon shale or in the lower part of the Connoquenessing sandstone, most commonly in the latter. It is generally, but not invariably, associated with species of the genus *Cannophyllites*.

Neriopteris lanceolata Newberry is perhaps similar in some respects to the plant that was called *Taeniopteris? missouriensis* by White.[3] The systematic position of White's species is still in doubt, but there is no question regarding the similarity of the plants from Pennsylvania and those from Missouri. The Missouri plant is distinguished, however, by its somewhat more widely spaced pinnules, set more commonly at a right angle to the rachis, and by the more open venation.

Another form to which there is a certain degree of similarity, although probably superficial, is *Protoblechnum wongii* Halle,[4] from the Shihotse series in central China. *P. wongii* shows, however, a somewhat different type of venation, oblique rather than at right angles, and it has somewhat more flabellate pinnules. The similarity in form probably is best regarded as a sort of homeomorphy whereby widely separated groups may show a similar external form.

According to Jongmans,[5] the American species that White referred to *Taeniopteris? missouriensis* should more properly be placed in *Macralethopteris*, the genotype of which is *M. hallii* Jongmans and Gothan, from deposits of Stephanian age in Java. From the figures given by Jongmans and Gothan one cannot be at all sure regarding this determination. At all events, in considering a name for these large, long-pinnuled *Alethopteris*-like plants the genus *Neriopteris* must be noted and its relationships to similar plants must be determined.

Genus ARCHAEOPTERIDIUM Kidston

Archaeopteridium bellasylviana Read, n. sp.

Plate 2, figures 6–9

Main divisions of the frond unknown, the secondary pinnae short, linear-lanceolate and acute, with a narrow lineate rachis. Pinnules alternate, small, short, close, tending to overlap, obliquely set, rhomboidal to ovate, 6 to 15 millimeters long, 3 to 6 millimeters wide, the widest point being situated below the middle; pinnules usually obtusely rounded at the apex, broadly attached (the attachment about one-half the width of the pinnule), slightly decurrent, the border nearly straight for about two-thirds of the length on the lower side, but arched strongly on the upper side. Proximal basal pinnules heteromorphous. Nervation distinct, coarse, apparently derived from the rachis, and radiating, the nerves forking once or twice in passing nearly straight to the margins of the pinnule.

The specific name is derived from the settlement of Bellasylvia, southwest of Dutch Mountain.

The fragmentary condition of the fossils here described and the gritty nature of the matrix prevent the illustration of large parts of the pinnae. Likewise it has been impossible to determine all the features of the apical parts of the pinnules. It is possible that they may be denticulate, as are the numerous species of *Archaeopteris* from the Devonian, with which this material was originally identified.

The general aspect of the pinnae of this species is seen in plate 2, figure 6, which illustrates a specimen with rather crowded pinnules. A phase with slightly narrower and somewhat less crowded pinnules is seen in plate 2, figures 8; in this latter specimen there is a tendency toward a more erose or denticulate margin on the pinnules. An inferior, basal, heteromorphous pinnule is shown in figure 9.

Archaeopteridium bellasylviana is perhaps comparable to *A. tschermaki* Stur from Bohemia.[6] The latter has more cuneate, crowded pinnules attached across the entire base, and the general habit of the frond is closer to that generally found in the genus *Rachopteris*.

Genus MARIOPTERIS Zeiller

Mariopteris sp.

Several specimens in the collection are referable to a species of *Mariopteris*. However, these fragments are scarcely sufficient to warrant specific reference. The best preserved specimen is a pinna approximately 6 centimeters long and narrowly lanceolate. The pinnules are rather variable in shape but in general are triangular, and from their attitude with reference to the rachis of the pinna it is evident that they were rather lax. The venation is partly obliterated by the coarse grains of the matrix, but where seen it is typical of the group *M. muricata*, to which the form evidently belongs.

Mariopteris sp. recalls, in some measure, a form from the Eastern Interior coal field of Illinois, recently studied and described under the name *M. speciosa* (Lesquereux) White.[7] This latter species has a pin-

[3] White, David, Fossil flora of the Lower Coal Measures of Missouri: U. S. Geol. Survey Mon. 37, pp. 140–144, pl. 40, figs. 1–7, 1899.

[4] Halle, T. G., Palaeozoic plants from central Shansi: Palaeontologica Sinica, ser. A, vol. 11, fasc. 1, pp. 135–138, pls. 35–36; pl. 64, fig. 12, 1927.

[5] Jongmans, W. J., and Gothan, Walther, Die Paläobotanischen Ergebnisse der Djambi-Expedition 1925: Jaarb. mijnwezen Ned.-Indië 1930, Verh., pt. 2, pp. 130–132, 1935.

[6] Stur, D. R. J., Beiträge zur Kenntniss der Flora der Vorwelt. Band 1, Die Culm-Flora; K.k. geol. Reichsanstalt Abh., Band 8, Heft 1, pp. 57–60, pl. 12, fig. 1; pl. 16, fig. 1, 1875.

[7] Lesquereux, Leo, Description of the coal flora of the Carboniferous formation in Pennsylvania and throughout the United States: Pennsylvania 2d Geol. Survey Rept. Progress P, vol. 1, pp. 216–217, 1880 (under *Pseudopecopteris speciosa* Lesquereux).

nule rather similar in form and of the same size. However, the Forkston species does not bear the sparingly serrate margins observed in the Illinois plant. *M. speciosa* is known from the Battery Rock coal horizon and in consequence is about the age of the Sharon coal and its correlatives in the Appalachian region.

Genus NEUROPTERIS Brongniart

Neuropteris sp.

A few fragments of a *Neuropteris* in the Dutch Mountain collection may be identical with *N. tenuifolia*, but the material is not sufficient to determine the relationships. The fossils are isolated pinnules and very fragmentary pinnae, highly macerated and with venation obliterated by the relatively coarse grains of the matrix.

Genus CORDAITES Unger

Cordaites sp.

Throughout the collection there are abundant fragments of *Cordaites* leaves, all greatly macerated, and all with the details of the venation obliterated by the coarse matrix. It is impossible to form any very close idea regarding the size or relative proportions of the leaves.

Genus CARDIOCARPON Brongniart

Cardiocarpon phillipsi Read, n. sp.

Plate 2, figures 1-3

Seeds very large, some of them as much as 4 centimeters in length and 3.5 centimeters in width including wing, of which the wing makes up about 0.5 centimeter on either side of the seed proper, about 1 centimeter at the chalazal end, and 0.5 centimeter at the micropylar end. Form of the seed with wing somewhat orbicular to oval, and of seed alone distinctly orbicular, with the base slightly modified to a truncate or even cordate shape and the apex tending to be slightly pointed. Details of seed coats or divisions of the testa not distinct. Wing deeply incised apically in the vicinity of the micropyle, the slit running to the apex of the seed in a distinct V directed to the upper end of the micropyle.

The specific name was chosen in honor of Mr. Ben Phillips, who was associated with Lacoe in making the collection from the Forkston coal.

The general aspect of *Cardiocarpon phillipsi* is seen in plate 2, figures 1–3. A very large number of specimens of this seed are known, and those figured have been selected to illustrate the diagnostic features as seen in the whole range. It is apparent at the outset that one of the most characteristic features of this species is its large size. In fact, in this country such large forms of *Cardiocarpon* as *C. phillipsi* are rarely encountered. It is notable, as has been pointed out by White [8] in a paper read before the Geological Society of America but published only in abstract, that these large species occur at a rather definite horizon and are commonly associated with the remains of *Cannophyllites* spp. (originally known as *Megalopteris*) in the Appalachian region and also in the Eastern Interior coal field. The narrow range of these seeds is about the position of the lower portion of the Connoquenessing sandstone in the northern Appalachians, the Nuttall sandstones of New River, and the sandstone underlying the Tarter coal in the Illinois region. Elsewhere the flora is not well known owing to its inability to compete in other than a very narrow range of environments.

Although the apices of these seeds are slightly pointed, they do not show the acute and prominent tips that characterize so many species of this genus. The seeds tend to be orbicular rather than to assume the cordate or heart-shaped outline commonly seen.

It is clear that this seed must have been markedly flattened even in its original form. The residue is slight, and in none of the specimens examined has there been any evidence that the impression showed marked relief when originally made, prior to compaction of the enveloping sediments.

As has been previously stated, the number of species of these very large Cardiocarpons is relatively small. They include *Cardiocarpon baileyi* Dawson [9] and *C. newberryi* Andrews,[10] both of which differ markedly from *C. phillipsi* in seed form and in the proportions of the wings; *C. samaraeforme* Newberry,[11] whose seed is similar in size and form but has a rather different type of wing; and *C. ingens* Lesquereux (pl. 2, fig. 4),[12] which approaches very closely the form and size of *C. phillipsi*, but differs in the wings, which are narrower, basally not so broad, and very deeply cut at the micropylar end.

Remarkable for its size, which is perhaps the largest known in the genus, is *Cardiocarpon akroni* Read, n. sp. (pl. 2, fig. 5), from the uppermost part of the Sharon shale near Akron, Ohio. This species has fully twice the breadth of *C. phillipsi* or *C. ingens*. The illustration is introduced to indicate the wide range of size of the genus and, with the figure of *C. ingens*, for comparison with *C. phillipsi*.

[8] White, David, *Megalopteris* and the giant-winged cardiocarps (abstract): Geol. Soc. America Bull., vol. 44, pt. 1, p. 213, 1933.

[9] Dawson, J. W., Acadian geology, 3d ed., p. 555, text fig. 194D, 1878.

[10] Andrews, E. B., Descriptions of fossil plants from the Coal Measures of Ohio: Ohio Geol. Survey Rept., vol. 2, pt. 2, Paleontology, pp. 425–426, pl. 46, fig. 2, 1875.

[11] Newberry, J. S., Descriptions of fossil plants from the Coal Measures of Ohio: Ohio Geol. Survey Rept., vol. 1, pt. 2, Paleontology, p. 375, pl. 43, fig. 11, 1873.

[12] Lesquereux, Leo, Botanical and paleontological report on the geological State survey of Arkansas, in Owen, D. D., Second report of a geological reconnaissance of the middle and southern counties of Arkansas, p. 311, pl. 4, figs. 4–4a, 1860.

PLATES 1–2

PLATE 1

FIGURES 1–3, 5–10, 13. *Lacoea seriata* Read, n. sp., individual synangia from the Forkston coal in Dutch Mountain, Pa., showing features of gross morphology. In figure 1 a large synangium shows the rhomboidal surface markings particularly well. Figures 2, 3, 5, 6, 8, and 9 illustrate the membranaceous sheath extending as a fringe far beyond the globular to cupular synangium. Note in figures 3, 5, 8, 9, and 10 the rhomboidal scars left by the bases of sporangia attached obliquely to the plane of the surface exposed. Cotypes, U. S. Nat. Mus. 26217, 26219, 26251, 26213, 26235, 26256, 26252, 26214, 1626, 26247.

4. *Lacoea seriata* Read, n. sp., an uncrushed specimen from the lower portion of the Connoquenessing sandstone near Youngstown, Ohio, illustrating the cupular nature of the polleniferous synangia. U. S. Nat. Mus. 26261.

11, 12, 14. *Lacoea seriata* Read, n. sp., strobiluslike aggregates of the synangia from the Forkston coal in Dutch Mountain, Pa. Note the crowded, rigid, biseriate arrangement. Cotypes, U. S. Nat. Mus. 26242, 26241.

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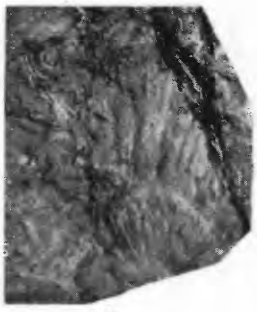

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FLORA OF THE FORKSTON COAL.

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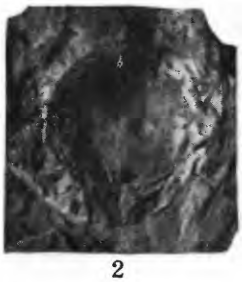

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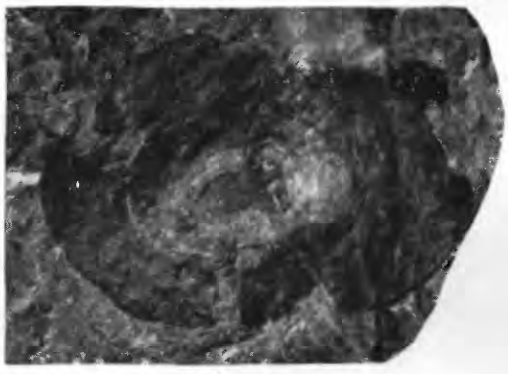

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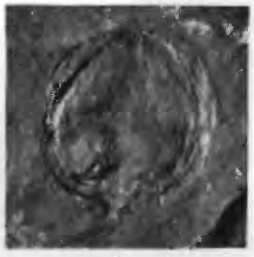

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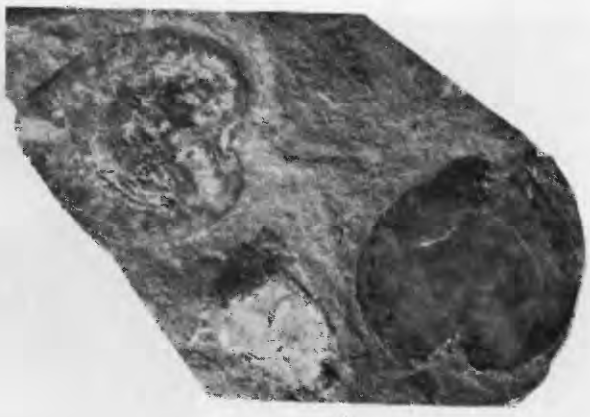

4

FLORA OF THE FORKSTON COAL.

PLATE 2

FIGURES 1–3. *Cardiocarpon phillipsi* Read, n. sp., showing the large size and the form of the seeds. Forkston coal, Dutch Mountain, Pa. Cotypes, U. S. Nat. Mus. 25391, 25390, 25396.

4. *Cardiocarpon ingens* Lesquereux, typical specimens of this species introduced for comparison with *C. phillipsi*. Coal-bearing Bloyd shale, Morrow group, at Lemons coal bank, Washington County, Ark. U. S. Nat. Mus. 25417.

5. *Cardiocarpon akroni* Read, n. sp., an extremely large species of *Cardiocarpon* introduced to show the size that some species of this group attain. Sharon shale near Akron, Ohio. Holotype, U. S. Nat. Mus. 25382.

FIGURES 6–9. *Archaeopteridium bellasylviana* Read, n. sp., two pinnae (figs. 6 and 8) and details of a typical pinnule and a heteromorphous pinnule (figs. 7 and 9, ×2). Forkston coal in Dutch Mountain, Pa. Cotypes in U. S. Nat. Mus.

10. *Whittleseya elegans* Newberry, a specimen from the upper Sharon shale near Akron, Ohio, introduced for comparison with *Lacoea seriata*. U. S. Nat. Mus. 18843.

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UNITED STATES DEPARTMENT OF THE INTERIOR
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Professional Paper 210-C

REPTILIAN FAUNA OF THE NORTH HORN FORMATION OF CENTRAL UTAH

BY

CHARLES W. GILMORE

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ILLUSTRATIONS

REPTILIAN FAUNA OF THE NORTH HORN FORMATION OF CENTRAL UTAH

By Charles W. Gilmore [1]

ABSTRACT

In Part 1 a sauropod dinosaur from the lower part of the North Horn formation in central Utah, represented by 30 procoelous caudal vertebrae, with chevrons, and the ischia, right forelimb, scapula, coracoid, and sternal plates, is referred to the species *Alamosaurus sanjuanensis* Gilmore. This specimen substantiates a previous discovery of sauropod remains in New Mexico and establishes definitely the presence of the family Titanosauridae in the Upper Cretaceous of North America. It also supplies new data on skeletal features of the late sauropods.

In Part 2, a new species, assigned tentatively to the genus *Arrhinoceratops* Parks, and other ceratopsian specimens from the North Horn formation of central Utah are described.

In Part 3, the reptilian forms of the fauna are reviewed, and correlation with other Upper Cretaceous faunas is briefly discussed.

Part 1. Osteology of *Alamosaurus*, a Sauropod Dinosaur from the Upper Cretaceous

INTRODUCTION

In a brief note [2] attention has recently been directed to the discovery of a partial skeleton of a large sauropod dinosaur in the Upper Cretaceous of central Utah. It is proposed to give here a detailed discussion of its relationships. Its geologic occurrence has been described by E. M. Spieker.[3]

The general appearance of the area on which the specimen was found is shown on plate 3 and close views of the quarry on plate 4. The broader relationships of the locality are shown on the map included by Spieker in his description of the Wasatch Plateau.[4]

The discovery of the specimen by the 1937 Smithsonian Paleontological Expedition is of more than ordinary interest: (1) It substantiates the authenticity of the original discovery that sauropod dinosaurs may be found in the Upper Cretaceous of North America; (2) it demonstrates the presence of a member of the family Titanosauridae in North America; (3) it permits for the first time an adequate diagnosis of the genus *Alamosaurus*; and (4) it strongly suggests that the North Horn formation may be the equivalent in age of the Ojo Alamo formation of New Mexico.

Family TITANOSAURIDAE Lydekker

In view of the fact that the Titanosauridae have hitherto not been positively recognized as occurring in North America, a brief review of the family seems appropriate.

The term Titanosauridae was proposed by Lydekker [5] in 1893 to include the sauropodous dinosaurs described by him from India and South America. At that time he provisionally defined the family as follows:

> Sauropodous dinosaurs in which the caudal vertebrae, with the exception of the first, are procoelus, the presacrals opisthocoelus, and the lumbars without lateral cavities; the superior extremities of the chevron bones being open.

The family Titanosauridae has since become the repository of practically all the Cretaceous sauropod dinosaurs that have been described. In many instances these assignments rest primarily on the presence of similar procoelous caudal vertebrae. If correctly referred, representatives of this family have been reported from India,[6] Indo-China, Madagascar,[7] Egypt,[8] Transylvania,[9] southern France,[10] Isle of Wight,[11] Brazil,[12] Patagonia,[13] South Africa,[14] and North America.[15] Thus it would appear that the Titanosauridae have the widest geographical range of any known family of the Dinosauria.

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[1] Late Curator of Vertebrate Paleontology, U. S. National Museum. This paper is a product of informal cooperation between the Geological Survey and the U. S. National Museum and is published by permission of the Secretary, Smithsonian Institution.

[2] Gilmore, C. W., Sauropod dinosaur remains in the Upper Cretaceous: Science, new ser., vol. 87, no. 2257, p. 299, 1938.

[3] Spieker, E. M., Late Mesozoic and early Cenozoic history of central Utah: U. S. Geol. Survey Prof. Paper 205–D, pp. 134–135, 1946.

[4] Spieker, E. M., The Wasatch Plateau coal field, Utah: U. S. Geol. Survey Bull. 819, pl. 32, 1931.

[5] Lydekker, R., Contributions to a knowledge of the fossil vertebrates of Argentina, 1, The dinosaurs of Patagonia: Paleontología Argentina, t. 2, Mus. de La Plata Anales (unnumbered) p. 3, 1893.

[6] Lydekker, R., Notices of new and other Vertebrata from Indian Tertiary and secondary rocks: India Geol. Survey Rec., vol. 10, pp. 38–41, 1877.

[7] Depéret, Charles, Note sur les dinosauriens sauropodes et théropodes du Crétacé supérieur de Madagascar: Soc. géol. France, sér. 3, t. 24, p. 192, 1896.

[8] Stromer, E , Ergebnisse der Forschungsreisen Prof. E. Stromers in den Wüsten Ägyptens, II. Wirbeltierreste der Baharîe-Stufe (unterstes Cenoman) 11. Sauropoda: Bayer. Akad. Wiss., Math.-naturwiss. Abt., Abh., neue Folge, Heft 10, 1932.

[9] Nopsca, Francis, On the geological importance of the primitive reptilian fauna of the uppermost Cretaceous of Hungary; with a description of a new tortoise (*Kallokibotion*): Geol. Soc. London Quart. Jour., vol. 79, p. 107, 1923.

[10] Depéret, Charles, op. cit., p. 176.

[11] Lydekker, R., On certain Dinosauriae vertebrae from the Cretaceous of India and the Isle of Wight: Geol. Soc. London Quart. Jour., vol. 43, pp. 156–160, 1887.

[12] Huene, Friedrich von, Los saurisquios y ornitisquios del Cretáceo Argentino: Mus. La Plata Anales, ser. 2. t. 3, p. 167, 1929.

[13] Lydekker, R., op. cit. (Paleontología Argentina, t. 2), p. 1, 1893.

[14] Broom, R., On the occurrence of an opisthocoelian dinosaur (*Alogosaurus bauri*) in the Cretaceous beds of South Africa: Geol. Mag., dec. 5, vol. 1, pp. 445–447, 1904.

[15] Gilmore, C. W., A new sauropod dinosaur from the Ojo Alamo formation of New Mexico: Smithsonian Misc. Coll., vol. 72, no. 14, 1922.

Huene [16] was the first to assign the genus *Alamosaurus* to the Titanosauridae, an assignment proved correct by the specimen here discussed.

From the information furnished by the Utah specimen, in conjunction with a review of the literature, the definition of the family Titanosauridae may now be amplified as follows:

First caudal vertebra with biconvex centrum; other caudals strongly procoelous; neural arches on most of the caudals attached to the anterior half of the centrum; caudals without lateral cavities; presacrals opisthocoelus; 5 or 6 vertebrae in sacrum; all chevron bones open at articular end; pubes not narrowing distally; ischia short and wide, without especial distal thickening.

The following genera have been included in this family: *Titanosaurus*, India, Indo-China, and South America; *Argyosaurus*, *Laplatasaurus*, *Antarctosaurus*, *Campylodon*, all from South America; *Macrurosaurus*, England; *Hypselosaurus*, *Aepyosaurus*, both from southern France; *Aegyptosaurus*, Egypt; *Algosaurus*, South Africa; and *Alamosaurus*, New Mexico.

When more complete specimens are found, it is quite probable that some of these genera will be shown to have other family affiliations.

Genus ALAMOSAURUS Gilmore

Alamosaurus Gilmore, Smithsonian Misc. Coll., vol. 72, no. 14, pp. 1–9, pls. 1–2, 1922.

Genotype: *Alamosaurus sanjuanensis* Gilmore.

The genus *Alamosaurus* was established on a meager specimen collected by John B. Reeside, Jr., from the Ojo Alamo formation, Upper Cretaceous, in New Mexico. The type material consists of two bones, a left scapula and a right ischium, somewhat incomplete and perhaps pertaining to two individuals. The rather unusual procedure of founding a genus on such scanty evidence was justified on the ground that this was the first authentic record of the occurrence of sauropodous dinosaur remains in the Upper Cretaceous of North America. Fortunately, the specimen found in Utah has a scapula and both ischia preserved, thus permitting the fullest possible comparison to be made.

The present specimen is in close agreement with the type in all important particulars, and as the slight differences observed could not be considered of specific importance, I refer this specimen to *Alamosaurus sanjuanensis*.

Contributory evidence of the correctness of this conclusion is furnished by a second specimen from the type area—No. 15658, United States National Museum. This specimen consists of approximately the twenty-first caudal centrum and a caudal neural spine collected in 1916 by John B. Reeside, Jr., from a shale bed 3 to 8 feet above the base of the Ojo Alamo formation, in Barrel Springs Arroyo, west of the road, 1 mile south of Ojo Alamo, N. Mex. These bones are in perfect agreement with the caudal vertebrae of the Utah specimen, down to the smallest details. Thus it is shown that these typically procoelous caudal vertebrae also may be found in the same formation as the type materials on which the genus *Alamosaurus* was established and to that extent verify the identification of the Utah specimen with the meager materials from New Mexico. For the first time an adequate diagnosis of the skeletal characteristics of the genus *Alamosaurus* is possible.

Diagnosis: First caudal vertebra with biconvex centrum; other caudals procoelous; spines of anteriorly caudal vertebrae relatively short; neural arches arising from the anterior half of the centra; prezygapophyses long, with articular faces looking more strongly inward than upward; transverse processes on first eight caudals, stout and raking backward; 25 chevrons, the first carried by caudal 1, none bridged across at the articular end; scapula with blade regularly widening from the narrowest diameter upward, blade wide throughout; spine at right angles to longest axis of scapula; ischia short, narrowing but little distally, joined along median line for their full length; humerus long in relation to length of radius and ulna; ulna with short, stout olecranon process; five metacarpels, stout, first and second subequal in length; sternal bones very large.

Alamosaurus sanjuanensis Gilmore

Alamosaurus sanjuanensis Gilmore, Smithsonian Misc Coll. vol. 72, no. 14, pp. 1–9, pls. 1–2, 1922.

Specimen: United States National Museum 15560. Consists of 30 articulated caudal vertebrae, beginning with the first; 25 chevrons; 2 ischia, right somewhat incomplete; left scapula and coracoid; right humerus, ulna, radius, and metacarpus articulated; 2 sternal plates and parts of 3 ribs. Although not collected, the sacrum was observed in the field, and evidence was noted that the complete sacrum consisted of 5 vertebrae. Found by George B. Pearce, June 15, 1937.

Locality: Southwest toe of North Horn Mountain, Manti National Forest, Emery County, Utah.

Horizon: Lower part of North Horn formation, Upper Cretaceous.

DETAILS OF THE SKELETAL PARTS

THE TAIL

Caudal vertebrae

The tail is represented by 30 consecutive vertebrae, beginning with the first and retaining all the chevrons. In place, the tail showed a slight displacement between the ninth and tenth vertebrae but otherwise formed an articulated series. All tail vertebrae, except caudal 1, are strongly procoelous. None of the centra have lateral

[16] Huene, Friedrich von, op. cit., p. 118, 1929.

cavities. The anterior caudals are relatively long; short centra, such as are found in *Camarasaurus*, *Apatosaurus*, and *Diplodocus*, are lacking.

The first caudal in *Alamosaurus* is characterized by its biconvex centrum, a feature found elsewhere among the Reptilia only in the Crocodilidae. Viewed from the front this centrum is subrectangular in outline, with the greatest diameter vertically. The anterior ball is more evenly rounded than the posterior and projects prominently forward from the centrum. (See pl. 5, fig. 1.)

The neural arch is low, restricted fore and aft, and arises wholly from the anterior half of the centrum. The diapophyses are thin, winglike processes that spring about equally from the sides of the centrum and arch, extending outward nearly at right angles to the bone. Both processes are slightly incomplete, but the right one gives a fairly good idea of its main features. (See pl. 8, fig. 1.) The upper border slopes steeply downward and outward from the level of the prezygapophyses as a thin plate, being thickened only along the ventral border. The extreme outer end is missing on both processes.

The prezygapophyses are lacking, except for their thin bases adjacent to the spine. These are deep dorso-ventrally and indicate that the missing articular faces looked more strongly inward than upward. Superiorly they are braced by the supraprezygapophyseal laminae. Additional support is given by the supradiapophyseal lamina that terminates near their superior borders. The postzygapophyses are somewhat beneath the base of the spine. Their articular faces are poorly defined.

The spine on caudal 1 is badly distorted by crushing, which somewhat obscures its structure. It is composed primarily of prezygapophyseal, postzygapophyseal, prespinal, and postspinal laminae. The spine viewed from the front gradually widens from the base upwards. (See pl. 8, fig. 1.) The prespinal and postspinal laminae have their surfaces rugosely roughened throughout the greater part of their lengths. The prespinal is the more prominently developed. There is only slight evidence of emargination of the top of the spine. On the lower posterior angle chevron facets are developed. Anterior to these facets the median surface is flattened, with little indication of the lateral ridges that form such a conspicuous feature in the most posterior vertebrae.

Caudals two to thirty may be discussed as a group. From the table of measurements on page 32 it will be noted that the centra gradually decrease in length posteriorly as far as the thirteenth; beyond which they gradually lengthen for a few vertebrae and then progressively shorten to the end of the series. The last two show a more rapid reduction in size than those before, suggesting a near approach to the whiplash that probably was present, as in the South American *Titanosaurus australis*.

The centra have a pronounced ball on the posterior end with a deep cup on the anterior. Viewed endwise (see pl. 8) caudal 2 is higher than wide, which proportion persists back to caudal 12. The fourteenth shows subequal diameters, and the remaining members of the series are wider than high.

The chevrons are articulated intercentrally, and the articular facets are clearly observable posteriorly as far as caudal 18.

The inferior caudal surfaces, posterior to caudal 1, are rudely rectangular in outline, but slightly expanded at either end. Commencing with caudal 2 the conspicuous feature of the ventral view is the pair of lateral ridges developed on either side of the centrum. Anteriorly these begin 60 to 70 millimeters posterior to the lip of the cup and terminate posteriorly at the beginning of the ball; at the posterior termination of each ridge the ends are obliquely truncated, thus forming facets for the articulation of the chevron. These ridges become progressively less and less conspicuous posteriorly, practically disappearing on caudal 14. Although chevrons persist as far as caudal 25, distinct facets for their articulation appear for the last time on caudal 18. The median longitudinal channel, which is such a conspicuous feature of the ventral surface on the anterior third of the tail, has all but disappeared on the posterior members; on the eighteenth centrum all that remains are shallow median depressions at either end, and these persist to the last of the vertebral series but become shallower and less well defined in the posterior caudals. On the anterior ventral end of caudals 29 and 30 a decided median notch appears in the border of the cup. (See pl. 8.)

Except on the first caudal the transverse processes are heavy, rounded, and blunt, and they project outward and backward, springing about equally from the arch and the top of the centrum. These processes gradually decrease in length posteriorly, disappearing after caudal 8. The next four vertebrae have raised, roughened rectangular areas (see pl. 6) in lieu of transverse processes, and from caudal 13 to 26 these areas are replaced by a raised longitudinal ridge. The ridges gradually decrease in size from front to back, disappearing entirely on caudal 27.

The prezygapophyses are strongly developed throughout the caudal series and were probably functional as far back as caudal 23. They regularly increase in size from the first to the thirtieth. In the anterior caudals the prezygapophyses are deep dorso-ventrally, are exceptionally long, and strongly overhang the ends of the centra. They appear to have a downward curve, an appearance due largely to the convex contour of their upper borders. The articular faces look more strongly inward than upward. On the anterior vertebrae the prezygapophyses are strengthened superiorly by supraprezygapophyseal laminae and inferiorly by the walls of the neural arch. The laminae largely disappear posterior to caudal 13. Near caudal 13 the prezygapophyses are long and fingerlike, becoming progressively shorter posteriorly until on caudal

27 their anterior ends terminate within the end of the centrum. (See pl. 7, fig. 27.) On many vertebrae one prezygapophysis is shorter than its opposite fellow.

The postzygapophyses are at the base of and slightly beneath the spine and face outward and slightly downward. From first to last these articular facets are poorly defined.

The spine on the caudals is composed primarily of the prezygapophyseal, postzygapophyseal, prespinal, and postspinal laminae. Except for the prezygapophyseal, these laminae largely disappear as distinct structures near caudal 7.

The neural arches throughout the series arise from the forward half of the centrum and are present on all 30 vertebrae.

The spines of the anterior caudals are relatively short, contrasted with the attenuated spines corresponding in *Apatosaurus* and *Diplodocus*. They rapidly decrease in height posteriorly and disappear as separate structures near caudal 15, in this respect most nearly resembling those of *Brachiosaurus*. The spines are simple, none having emarginate tops as in *Apatosaurus* and *Diplodocus*.

In comparison with *Titanosaurus australis* the caudal vertebrae of *Alamosaurus* are simple and rectangular, viewed from the side, with a squarely truncated upper extremity. The tops of the spines are transversely widened on the first nine vertebrae, but more especially on the first six. In the anterior caudal spines the anterior and posterior surfaces are strongly rugose, probably in connection with the attachment of strong interspinous ligaments. At the base of the spines both front and back are deep pits leading into the interior of the bone, and these continue posteriorly as far as the eighteenth vertebra.

Caudals 5 and 6 are coossified by their centra. (See pl. 5, figs. 5 and 6.) There is little distortion of the bones, and very little extraneous bony matter extends over the joint. It is in no way comparable to the lesion on the sauropod caudals described and illustrated by Moodie,[17] but the union may have been brought about by a slight injury.

The outstanding features of the caudal region of *Alamosaurus sanjuanensis* may be summarized as follows:

Caudal 1 with strongly convex ends.
Caudals 2 to 30 strongly procoelous.
Neural spines arising from the anterior half of centra.
Spines of anterior caudals relatively short, diminishing rapidly in height posteriorly.
Transverse processes only on caudals 1 to 8.
Functional zygapopyhses ending on caudal 25.
First caudal chevron bearing.

The type caudal vertebrae on which the genus *Titanosaurus* was established were considered by Lydekker to belong to the postmedian part of the tail, but comparison with the articulated caudals of *Alamosaurus* indicates they pertain to the anterior half. The caudal figured by Lydekker [18] belongs about at the thirteenth or fourteenth from the proximal end of the tail. It is distinguished from the *Alamosaurus* caudals by its much smaller size, more compressed centrum, and sharper definition of the chevron facets. Except for their smaller size, the caudal vertebrae of *Titanosaurus blandfordi*, illustrated on plate 7 of Lydekker's paper, cited above, bear a closer resemblance to the *Alamosaurus* caudals than do those of *T. indicus*.

Although the forward position of the neural arches distinguishes the caudals of this animal from all other North American Sauropoda, this feature is found also in the genus *Titanosaurus*.

Measurements of caudal vertebrae, in millimeters

Vertebra No.	Greatest length of centrum	Greatest horizontal diameter of centrum, distal end	Greatest vertical diameter of centrum, distal end	Greatest height over all	Greatest width tip to tip of transverse processes
1	370	----------	218	645	----------
2	314	195	200	595	----------
3	296	190	183	561	343e
4	280	189	195	465	325
5	468	----------	----------	452e	290
6		161	189	----------	253
7	270	160	175	383	248
8	263	153	162	351	213
9	262	155	160	328	150
10	249	139	150	324	150
11	266	121	154	295	----------
12	252	133	145	282	----------
13	238	148	131	275	----------
14	245	149	105	258	----------
15	257	152	109	210	----------
16	251	124	92	203	----------
17	248	153	106	203	----------
18	251	162	101	188	----------
19	245	166	92	186	----------
20	241	160	80	171	----------
21	240	156	87	172	----------
22	235	146	84	176	----------
23	225	134	82	153	----------
24	220	134	89	149	----------
25	210	123	79	140	----------
26	208	117	77	136	----------
27	200	102	68	122	----------
28	200	84	65	109	----------
29	173	73	57	103	----------
30	144	46	52	93	----------

Chevrons

Commencing with caudal 1, intervertebral chevron bones are present as far back as the twenty-fifth, which, from its small size, is probably the last of the series. For the sake of clearness in discussing the chevrons they are enumerated with the vertebrae, the most anterior numbered one. All were found articulated, and their arrangement here may be considered as positively determined.

In having a chevron on caudal 1, *Alamosaurus* is in accord with *Apatosaurus* but differs from *Diplodocus*, in which the first chevron is carried on the second caudal.

In this series (see fig. 4) there are three quite distinct types of chevron bones. Nos. 1 to 15 are typically reptilian but open above the haemal canal, the two arms uniting below to form a laterally compressed spine that widens somewhat toward the distal end. Nos. 16 to 18 have the upper portion of chevron joined below but lack

[17] Moodie, R. L., Two caudal vertebrae of a sauropodous dinosaur exhibiting a pathological lesion: Am. Jour. Sci., 4th ser., vol. 41, pp. 530–531, fig. 1, 1916.

[18] Lydekker, R., Fossil Reptilia and Batrachia: Palaeontologia Indica, ser. 4, Indian pre-Tertiary Vertebrata, vol. 1, pt. 3, pl. 4, figs. 1, 2, 1879.

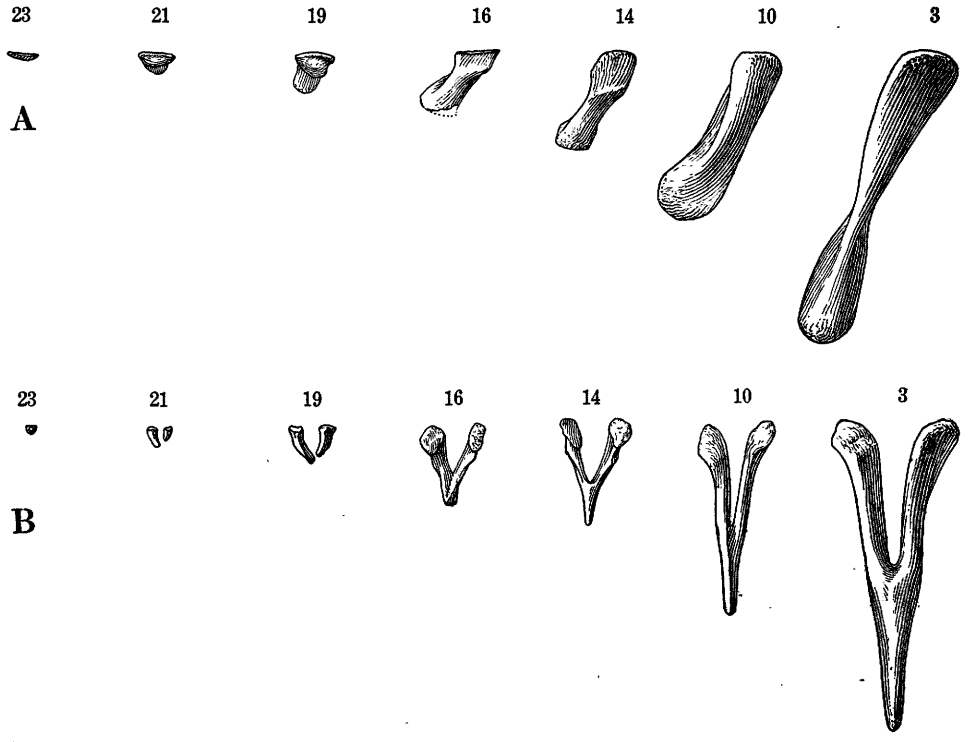


FIGURE 4.—Chevrons of *Alamosaurus sanjuanensis* Gilmore (U. S. Nat. Mus. 15560). *A*, Lateral view; *B*, posterior view. Nos. 3, 10, 14, 16, 19, 21, and 23 refer to position in the series. All one-tenth natural size.

a spine. Nos. 19 to 25 have the two halves of chevron separate. The first type gradually diminishes in length posteriorly until in the sixteenth chevron little remains except the cojoined arms. In the succeeding chevrons the articular ends are the last features to lose their identity. Even where the two halves are separate the form of the articular end is retained in the anterior pairs, but succeeding this type are elongated, subrounded, ossiclelike elements that were attached on their flattened sides to the outer lower angles of the vertebrae. These paired elements not only differ in size, but also in shape. The last, or twenty-fifth, chevron consists of a single elongated, rounded ossiclelike bone. Chevrons 7 to 17 display a lack of symmetry that is unique. On these chevrons the posterior border of the right arms, just before their junction to form the spine, is noticeably in advance of the left side. This is probably an individual peculiarity, for none of the bones gives indication of being injured or diseased.

The outstanding features of the chevrons are the great size of the haemal opening and the fact that none is bridged across with bone on the articular end. In *Diplodocus* the anterior chevrons have the haemal opening much reduced in size, whereas in *Alamosaurus* these openings are deep, constituting one-half the total length of the bone. Although retaining considerable depth, in chevrons 4 to 10, inclusive, these openings are somewhat less than one-half of the total length of the bone. From chevron 10 posteriorly, however, owing to progressive shortening of the spines, the haemal canal again becomes more than one-half the total length of the bone. The longest chevrons, 4 and 5, have a greatest length of about 403 millimeters.

PECTORAL GIRDLE

The pectoral girdle is represented in this specimen by the left scapula and coracoid and both sternal plates, all in an excellent state of preservation.

Sternal plates

The sternal plates, as shown in plate 9, were found side by side not far removed from their proper relationship to the other parts of the skeleton. These paired plates are elongate, with concave outer borders, bluntly pointed in front, and with broad squarely truncated posterior extremities.

The smooth, slightly concave side apparently is the upper or visceral surface and the slightly convex side the lower or outer surface. The lower surface near the outer anterior border is marked by a sharp ridge that extends backward from the proximal end. At the anterior end this ridge stands out prominently from the surface of the bone and leans strongly toward the outer side of the plate. Its truncated anterior end contributes to the beveled, roughened articular surface of the coracoid, and in a posterior direction it rapidly recedes in height to merge into the thickened portion of the plate. The sternal at the point of articulation with the coracoid has a greatest thickness of about 110 millimeters.

The smooth, outer concave border of the bone is thin, but it thickens rapidly inward. The broad, truncate

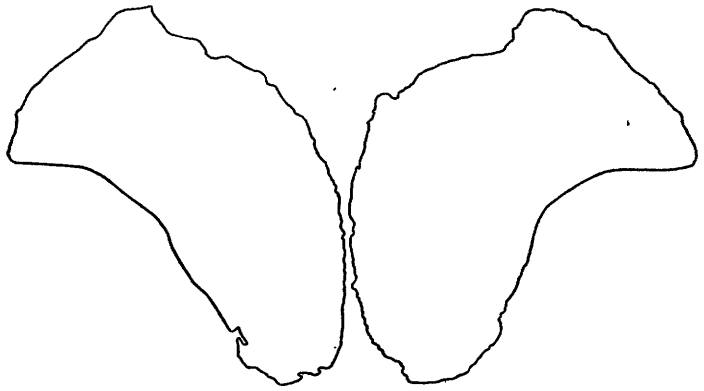


FIGURE 5.—Outlines of sternal plates of *Alamosaurus sanjuanensis* Gilmore (U. S. Nat. Mus. 15560) showing their probable relationships in the articulated sternum. One-twentieth natural size.

posterior end is thickened on the outer third, but gradually becomes thinner toward the inner edge. The thickened portion of this end gives faint indication of indentures for the attachment of the cartilaginous sternal ribs. The irregular inner border for one-half the length of the plate is thin, but the anterior half becomes increasingly thickened as it approaches the coracoidal articular facet.

These paired plates are asymmetrical to the extent that the left plate is longer and narrower than the right. This same asymmetry is also noted in a pair of sternal bones (U. S. Nat. Mus. 13786) of *Camarasaurus lentus* preserved in the National Museum collections. In general outline and in other particulars these elements are in fairly close agreement. In size the sternal plates of *Alamosaurus* (fig. 5) are the largest sternal plates that have ever come to my attention, the right sternal, which is the longest, measuring nearly 3½ feet in length (approximately 1 meter).

In outline the plates resemble those of *Brachiosaurus* more closely than those of *Apatosaurus*, *Barosaurus*, or *Camarasaurus*.

The proper articulation of these elements in the sauropod skeleton has occasioned much perplexity and much difference of opinion as to which is the anterior end. The position of the present plates in the quarry—the heavy, thickened ends facing forward—confirms the correctness of Professor Marsh's determination of the position of the sternals in a specimen of *Apatosaurus excelsus*.[19] Additional evidence that this is the correct position is furnished by a specimen of *Camarasaurus lentus* (U. S. Nat. Mus. 13786), which had the sternals preserved *in situ* between the ribs of the two sides, both of them with the heavy, more pointed end forward. In this connection it is now quite evident that Hatcher [20] and Holland [21] were in error in their interpretation of the sternals of *Diplodocus*. The heavy thickened end which they regarded as posterior is quite certainly the anterior end.

The relationship of one plate to the other along the median line also offers some perplexities, but the position of the plates as found in the ground, with the forward inner borders nearly in apposition, is probably the correct articulated position of the elements. In this position they would be as shown in figure 5, with a deep triangular-shaped cleft between their posterior ends, such as would be the relation of the sternals of *Diplodocus* if the position advocated by Hatcher and Holland were reversed. This position, furthermore, puts the thickened anterior borders nearly in apposition instead of the thinner posterior borders. By experiment it was determined that if the posterior halves of these bones were joined along the median line the articular facets for the coracoids would be approximately 4 feet apart, which would provide a chest measurement all out of proportion to the known dimensions of these large sauropod skeletons.

Measurements of sternals, in millimeters

	Right	Left
Greatest over-all length	1,015	1,071
Greatest width at posterior end	600	552
Greatest width at center	518	465

Scapula and coracoid

The left scapula coossified with the coracoid was recovered in an almost complete state of preservation, the coracoid lacking some of its anterior border, as shown in figure 6. In size these bones rival those of the largest of the sauropod dinosaurs, measuring about 76 inches, approximately 2 meters, from end to end. The blade is especially wide throughout its length. From its narrowest

[19] Marsh, O. C., Dinosaurs of North America: U. S. Geol. Survey 16th Ann. Rept., pl. 22, fig. 1, 1896.

[20] Hatcher, J. B., *Diplodocus* Marsh; its osteology, taxonomy, and probable habits, with a restoration of the skeleton: Carnegie Mus. Mem., vol. 1, no. 1, p. 39, fig. 12, 1901.

[21] Holland, W. J., The osteology of *Diplodocus* Marsh, with special reference to the restoration of the skeleton of *Diplodocus carnegiei* Hatcher: Carnegie Mus. Mem., vol. 2, no. 6, p. 256, fig. 25, 1906.

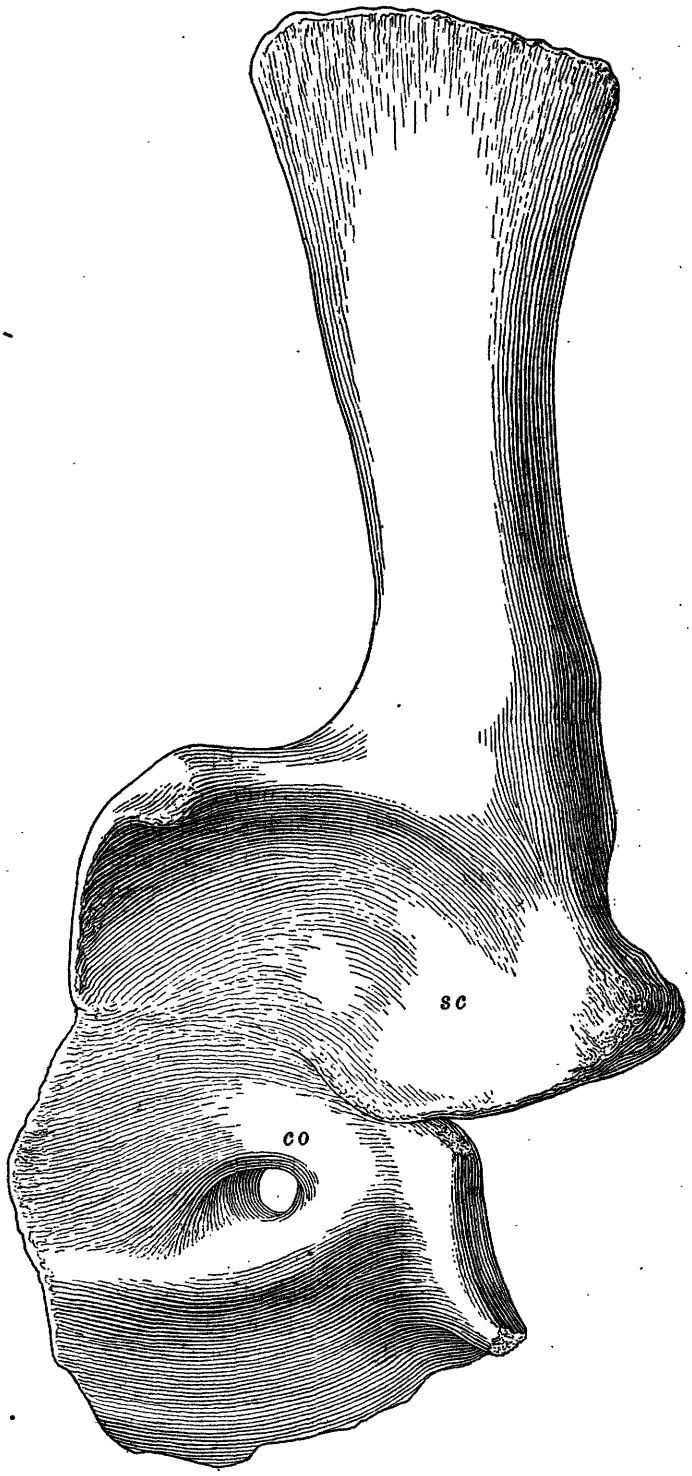


FIGURE 6.—Left scapula and coracoid of *Alamosaurus sanjuanensis* Gilmore (U. S. Nat. Mus 15560), lateral view: *co*, coracoid; *sc*, scapula. One-tenth natural size.

diameter it gradually widens from below upwards, as in the type. There is no special expansion of the anterior border of the blade, as in *Camarasaurus* and *Titanosaurus*, or of both upper borders, as in *Haplocanthosaurus* and *Diplodocus*, its closest resemblances being with the scapula of *Cetiosaurus oxoniensis*. The great width of the blade as a whole at once distinguishes it from the scapula of *Apatosaurus*. The posterior border is sinuous, with an abrupt downward turn of the thickened portion above the glenoid fossa. The upper, or suprascapular, end is thickened transversely and gently convex anteroposteriorly. Its surface is rugosely roughened, probably for the attachment of the suprascapular cartilage.

The spine is prominent and extends forward to the border, being placed at right angles to the longitudinal axis of the bone. This ridge is much thickened and along the side toward the coracoid the bone is deeply excavated, forming a muscle fossa of great extent. The opposite side of the spine slopes sharply off to the border. In this respect it differs from the type scapula of *Alamosaurus sanjuanensis*, which has a more gradual slope to this edge, as shown in plate 10, figure 1. On the internal side the scapula and coracoid are concave from end to end, thus conforming to the shape of the thorax.

In the formation of the glenoid fossa the coracoid and scapula contribute about equally. The sutural union of these two bones is so fully fused that their line of coalescence is difficult of detection. The coracoid has the usual subrectangular outline, its vertical and longitudinal diameters being about subequal. The outer side is irregularly convex, the inner concave. Approaching the glenoid fossa this border rapidly thickens. The bone is perforated by a large elliptical foramen that passes diagonally backward through the bone, emerging on the inner side close to the coraco-scapular suture.

In general the scapula closely resembles the type of *Alamosaurus sanjuanensis*, differing only in a few details, such as having a more sinuous posterior border, a more rapid slope from the thickened spine upward to the border, and slightly smaller size. None of the differences observed could be considered as more than individual variation, and for that reason, substantiated by the close resemblance of the ischia to the paratype, this specimen is referred to *Alamosaurus sanjuanensis*.

The scapula of *Alamosaurus* is quite different from the scapulae of *Titanosaurus australis* as figured and described by Huene.[22] In view of the close resemblances found in the other bones, the total dissimilarity of the scapulae and coracoids of these two species leads me to question the validity of the association of the South American scapulae with the *Titanosaurus* skeleton, especially since the corresponding bones assigned to the genus *Laplatasaurus*,[23] except for size, bear a much closer resemblance to the North American material. Because of the scattered occurrence of the South American material, the differences in the scapulae would suggest an accidental interchange of skeletal parts.

Comparative measurements of scapulae, in millimeters

	U. S. Nat. Mus.	Type U. S. Nat. Mus.
Greatest over-all length of scapula and coracoid.	1,948+	----------
Greatest length of scapula	1,475	1,700
Greatest breadth of scapula	815	820
Least diameter of blade	265	290
Greatest diameter of upper or distal end.	490	450

THE FORELIMB

The right forelimb, including the foot, was found articulated as shown in plate 4, *A*. It consists of the somewhat incomplete humerus, perfect radius and ulna, and five articulated metacarpals. As found in the quarry the forelimb measured about 9 feet (approximately 2.75 meters) from the proximal end of the humerus to the distal end of the metacarpus. Its outstanding characteristic is the great length of the humerus relative to that of the radius and ulna. In comparison, a radius and an ulna of *Apatosaurus* of lengths almost identical with those of the specimen under discussion are associated with a humerus that is 8 inches (200 millimeters) shorter than that of *Alamosaurus* (see fig. 7), and this proportional difference obtains in both *Diplodocus* and *Camarasaurus*.

Humerus

When found, the humerus was protruding from the outcrop, and much of the anterior face of the proximal end and the entire inner angle had been eroded away, though the bone otherwise was excellently preserved. The head is centrally placed, forming a rounded prominence that is especially conspicuous in its posterior aspect.

The deltoid extends well down on the outer side of the shaft, is heavy, and overhangs the center of the shaft. This feature has quite certainly been exaggerated by crushing. The outer side of the humerus is unusually straight (fig. 8), not widening out as in most other sauropod genera.

Distally the shaft terminates on the outer side in an inconspicuous radial condyle, set off by a longitudinal groove upon its anterior face. The ulnar condyle is likewise weakly defined. Viewed from the distal end the humerus is subrectangular in outline, with the median posterior border deeply and broadly hollowed out by the anconeal fossa. Viewed laterally the distal end shows a slight inclination forward. Both articular ends are rugosely roughened.

[22] Huene, Friedrich von, Los saurisquios y ornitisquios del Cretaceo Argentino: Mus. La Plata Anales, ser. 2, t. 3, pp. 36–37, pl. 9, 1929.

[23] Idem, pl. 23, figs. 1, 2.

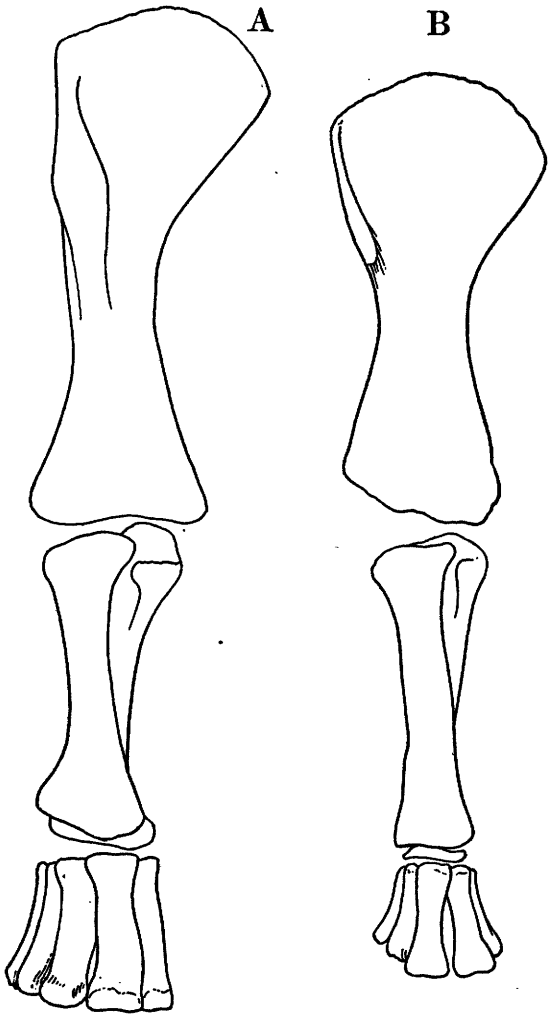


FIGURE 7.—Fore limbs of *Alamosaurus* and *Apatosaurus*, viewed from the front. *A*, *Alamosaurus sanjuanensis* (U. S. Nat. Mus. 15560); *B*, *Apatosaurus louisea* (C. M 3018). Both about one-twentieth natural size.

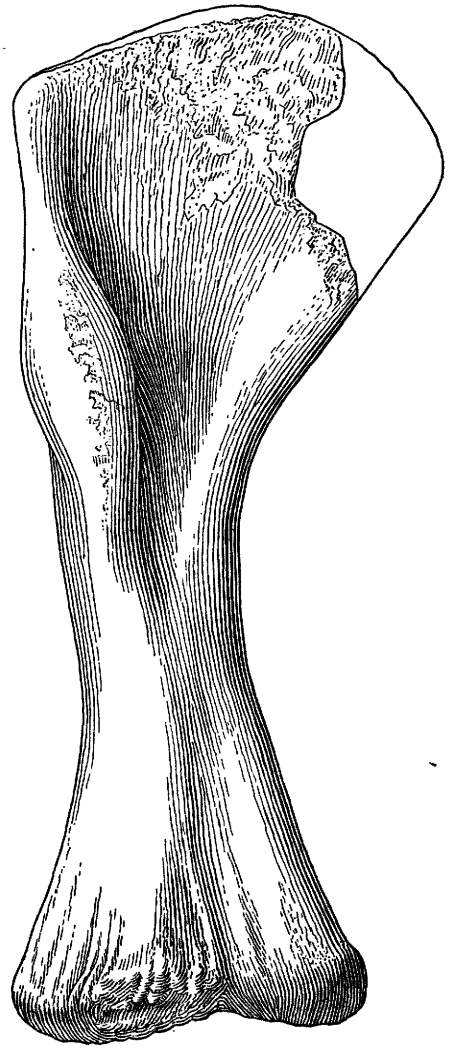


FIGURE 8.—Right humerus of *Alamosaurus sanjuanensis* Gilmore (U. S. Nat Mus. 15560), viewed from the front. One-tenth natural size.

Measurements of humerus

	Millimeters
Greatest length	1,360
Greatest transverse diameter, distal end	478
Least transverse diameter of shaft	230

Radius and ulna

The ulna is longer and heavier than the radius. It differs from most other sauropod ulnae in developing a stout, blunt olecranon process, which stands up prominently behind the articular surface for the humerus, as shown in figure 9. The ulna of *Aegyptosaurus barharijensis* Stromer,[24] a true member of the Titanosauridae, shows a somewhat similar blunt olecranon process. Posterior to the projection just described, and separated from it by a narrow notch, is a second, lesser projection. Viewed from the proximal end the ulna has the usual subtriangular outline, being hollowed out in front for the reception of the head of the radius. The distal end is reniform in outline, with the concave side looking inward and backward. This end is heavier than that of the radius and more expanded than the angularly rounded end of the ulna of *Apatosaurus*. The proximal half of the inner surface is hollowed out both longitudinally and anteroposteriorly.

The radius has a slightly constricted, bowed shaft, with ends about subequal. The upper articular end is slightly concave, the lower convex; the surfaces of both are rugosely roughened. In the articulated position in which these bones were found the shaft of the radius partly crosses that of the ulna, as shown in figure 9.

In discussing the various bones found in the "Sauropod bed" at Bara Simla, India, Huene and Matley [25] reached certain conclusions as to their association that in the light

[24] Stromer, E., Ergebnisse der Forschungsreisen Prof. E. Stromers in den Wüsten Ägyptens. II. Wirbeltierreste der Baharîe-Stufe (unterstes Cenoman). 11. Sauropoda: Bayer. Akad. Wiss., Math.-naturwiss. Abt., Abh., neue Folge, Heft 10, pl. 1, fig. 2a, 1932.

[25] Huene, Friedrich von, and Matley, C. A., The Cretaceous Saurischia and Orinthischia of the central provinces of India: Palaeontologia Indica, new ser., vol. 21, Mem. 1, pp. 31–32, 1933.

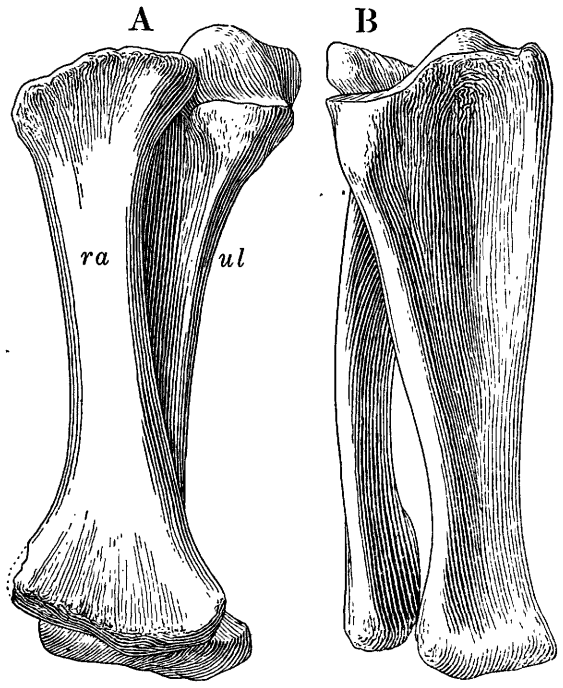


FIGURE 9.—Right radius and ulna of *Alamosaurus sanjuanensis* (U. S. Nat. Mus. 15560), shown as found articulated. *A*, Viewed from the front; *B*, lateral view. One-tenth natural size.

of the articulated forelimb of *Alamosaurus* seem to be in error. On the basis of proportionate lengths, Huene and Matley concluded that the lower-limb bones were too short for the length of the humerus. If the same ratio obtains between the two segments of the forelimb as in *Alamosaurus*, the radius and ulna assigned to the Indian form are somewhat overlong instead of being too short, as shown by the measurements given below:

Length of forelimb of Alamosaurus, *in millimeters*

	Length of humerus	Length of ulna	Length of radius
Alamosaurus	1360 (= 1)	885 (= 0.65)	800 (= 0.59)
Indian specimens	1034 (= 1)	790 (= 0.76)	780 (= 0.75)

Although the difference in measurements of the Indian specimens seems to indicate that these bones do not pertain to a single individual, they are at least close enough to warrant the suggestion that in all probability the segments of the forelimb bones of *Titanosaurus* and *Antarctosaurus* had approximately the proportions of the forelimb of *Alamosaurus*.

Measurements of ulna and radius

	Millimeters
Greatest length of ulna	885
Transverse diameter of ulna at proximal end	360
Transverse diameter of ulna at distal end	285
Transverse diameter of ulna at middle of shaft	154
Greatest length of radius	800
Greatest transverse diameter of radius at proximal end	285
Greatest transverse diameter of radius at distal end	265
Least transverse diameter, middle of shaft	118

Metacarpus

The metacarpus of *Alamosaurus*, consisting of five elements, was found articulated, and, except for the badly abraded anterior surfaces of metacarpals I and II (metacarpals I and II, fig. 10), all are in a good state of preservation. There was no indication of ossified carpal bones. In order to preserve the precise relationships of these articulated foot bones, they were prepared in deep relief, but this procedure has the disadvantage of leaving their posterior sides partly hidden in the matrix.

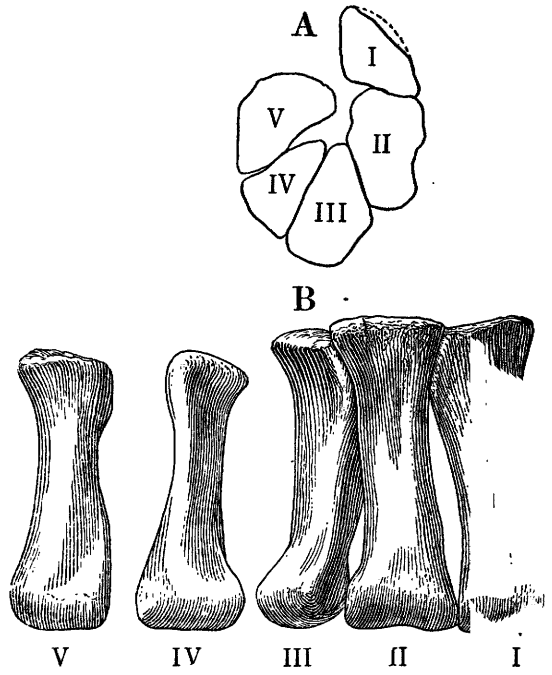


FIGURE 10.—Right metacarpus of *Alamosaurus sanjuanensis* Gilmore (U. S. Nat. Mus. 15560). *A*, Proximal ends of metacarpals as found articulated; *B*, metacarpals, with the exception of III, viewed from the front; I, II, III, IV, and V indicate metacarpals one to five, respectively. One-sixth natural size.

In articulated position the metacarpals interlock at their proximal ends (see fig. 10) forming a semicircle, a structure with a stability that conforms well to the great weight they are called upon to support. The metacarpus as preserved has the arc of this semi-circle flattened, so that metacarpals IV and V lie directly behind the other elements. Thus, in preparing figure 73, I, II and III were drawn as found articulated, and IV and V separately from a direct front view of each, in order to show more clearly their relative proportions.

The metacarpals of *Alamosaurus* are elongated; I and II, the longest of the series, are subequal in length, the remaining metacarpals becoming progressively shorter toward the outside of the manus.

The anterior face of metacarpal I in this specimen has been so badly planed off by erosion that its contours have been largely destroyed. The posterior side, however, is in good preservation. This surface between the expanded

ends gradually widens from above downward. On the proximal half of the external side this bone presents a flattened, beveled triangular surface that forms the chief articular contact for metacarpal II. Viewed from the end the distal extremity is rectangular in outline with the greatest diameter transverse. The articular surface of this end extends well upward on both anterior and posterior faces, being about subequal in extent. This description of the distal end of metacarpal I would apply equally well to the other metacarpals with the exception of V, which has the most robust distal end of any of the series.

Metacarpal II, which has the same length as I, may be distinguished by the subreniform outline of the proximal end. The greatest diameter of this extremity is anteroposterior. The external concave side of this end articulates with the internal side of metacarpal III. Viewed from the front, the shaft is transversely constricted above its midlength, but regularly widens from this point to the distal end, especially along the external side.

Metacarpal III is slightly shorter than II but more slender. The proximal end is triangular in outline, narrowing to an acute angle posteriorly. In a lateral view the shaft grows regularly wider from the distal third upward. In articulated position the proximal end is closely wedged in between metacarpals II and IV. (See fig. 10.)

Metacarpal IV, as shown in the table of measurements, is intermediate in length between III and V. The shaft is slightly twisted, thus bringing the planes of the two ends, viewed from the front, slightly out of alignment. Between the expanded ends the shaft is moderately constructed transversely. Viewed laterally the shaft widens regularly from the distal third upward. The proximal end is triangular in outline.

Metacarpal V is nearly as long as IV and equally stout. The proximal end is subrectangular in outline, with the longest diameter transverse. In articulated position little more than one-half of the anterior surface at the proximal end is in articulation with metacarpal IV.

Measurements of metacarpals, in millimeters

Metacarpal	Greatest length	Greatest diameter of proximal end	Greatest transverse diameter of distal end
I	410	151	142
II	409	160	131
III	390	165	104
IV	370	140	137
V	357	115	131

Among the Sauropoda the metacarpals of *Alamosaurus* are exceeded in length only by those of *Brachiosaurus brancai* Janensch.[26] In *Brachiosaurus*, metacarpal II is the longest, reaching a length of 634 millimeters, or more than 8 inches (200 millimeters) longer than metacarpal I, the longest in the *Alamosaurus* foot. The *Alamosaurus* metacarpals have relatively stouter shafts, and their proximal ends differ from those of *Brachiosaurus* in outline and relative proportion. The manner of articulation, however, of the metacarpals in these two genera is remarkably similar.

The foot clearly demonstrates the erect columnar position of the metacarpals in the articulated manus and shows them to have been arranged in a semicircular position, a relationship made possible by the triangular form of the proximal ends of metacarpals II, III, and IV, as shown in figure 10*A*. Because of the decrease toward the outside in the lengths of the metacarpals, it is quite apparent that the metacarpus had a correspondingly slanting position.

The proportionate lengths of the metacarpals are quite unlike those of such sauropods as *Apatosaurus* and *Camarasaurus*, in which the lateral elements are shortest. This would seem to indicate for *Alamosaurus* a foot in which the supported weight is more evenly distributed on the separate toes than in *Apatosaurus* and *Camarasaurus*. It might also imply a different digital formula, but unfortunately none of the phalangial bones were preserved with this specimen.

THE PELVIC REGION

Of the bones of the pelvic region, only the ischia were collected. The sacrum was noted in the field, and it appeared to consist of five vertebrae.

The coossified ischia were found in articulation with remnants of the ilia and pubes. The left ischium is fractured below the articular end, and this part is turned upward at nearly right angles to the main part of the bone. Otherwise it is nearly complete. The right element lacks the articular ends for the ilium and pubis, but in between a part of the acetabular border still remains.

The ischia are thoroughly coalesced for their full length along the median line. The exact outline of the anterior border is somewhat uncertain, either because this border has been telescoped or because the overlying bone is a narrow portion of the pubes that has slipped by the articulation and rests upon the ischia. If the latter, it indicates the pubes were closely joined across the entire anterior border of the ischia, thus entirely closing the pelvis from below.

The ischia are relatively short and broad with little expansion of their distal ends. Viewed from above, the conjoined ischia are broadly concave from side to side (see fig. 11), becoming more gutterlike distally. The outer borders are thickened, rounded, and strongly concave.

[26] Janensch, W., Das Handskelett von *Gigantosaurus robustus* und *Branchisaurus brancai* aus den Tendaguru-Schichten Deutsch-Ostafrika: Centralbl. Mineralogie, 1922, no. 15, pp. 464–480.

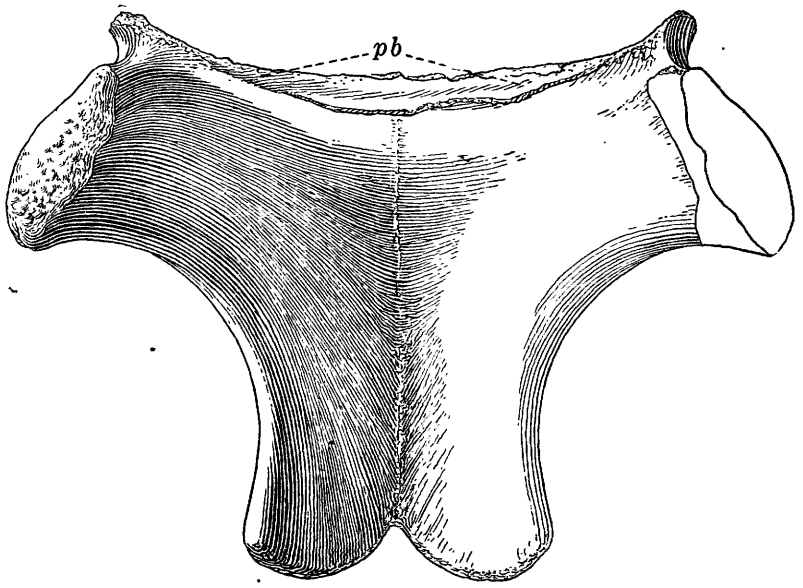


FIGURE 11.—Coossified ischia of *Alamosaurus sanjuanensis* Gilmore (U. S. Nat. Mus. 15560), viewed from above. *pb*, indicates what appears to be an overlap of the pubes. One-tenth natural size.

sweeping outward and upward to the heavy expanded end for articulation with the ischiac peduncle of the ilium. The acetabular border is relatively wide, its concave surface looking outward and forward when articulated. The upper anterior angle is thickened, with a rugosely roughened surface for articulation with the pubis. The anterior border becomes gradually thinner toward the median line. Transversely, the ventral side of the conjoined ischia is slightly convex. The distal ends are but little thickened and may have formed a broad notch on the median line, but the slightly damaged condition of this border leaves uncertainty on this point.

Among the various sauropod ischia with which these bones were compared the closest resemblance was found with the paratype of *Alamosaurus sanjuanensis* [27] from the Upper Cretaceous of New Mexico. These bones so closely resemble one another in all of their principal features that no doubt is left of their generic identity. Comparison shows at once that the original description of the *Alamosaurus* ischium erred in interpretation of the border for the pubic articulation. What appears to be a complete rugose border is now recognized as an incomplete broken edge, and the complete bone would have quite a different shape on this side. Next to *Alamosaurus* the ischium of *Titanosaurus australis*, as illustrated and described by Huene,[28] is of the same general type, differing in having a much narrower shaft.

Measurements of ischia

	Millimeters
Width across distal end of coossified ischia, about	395
Length at center	628
Greatest thickness at distal end	55

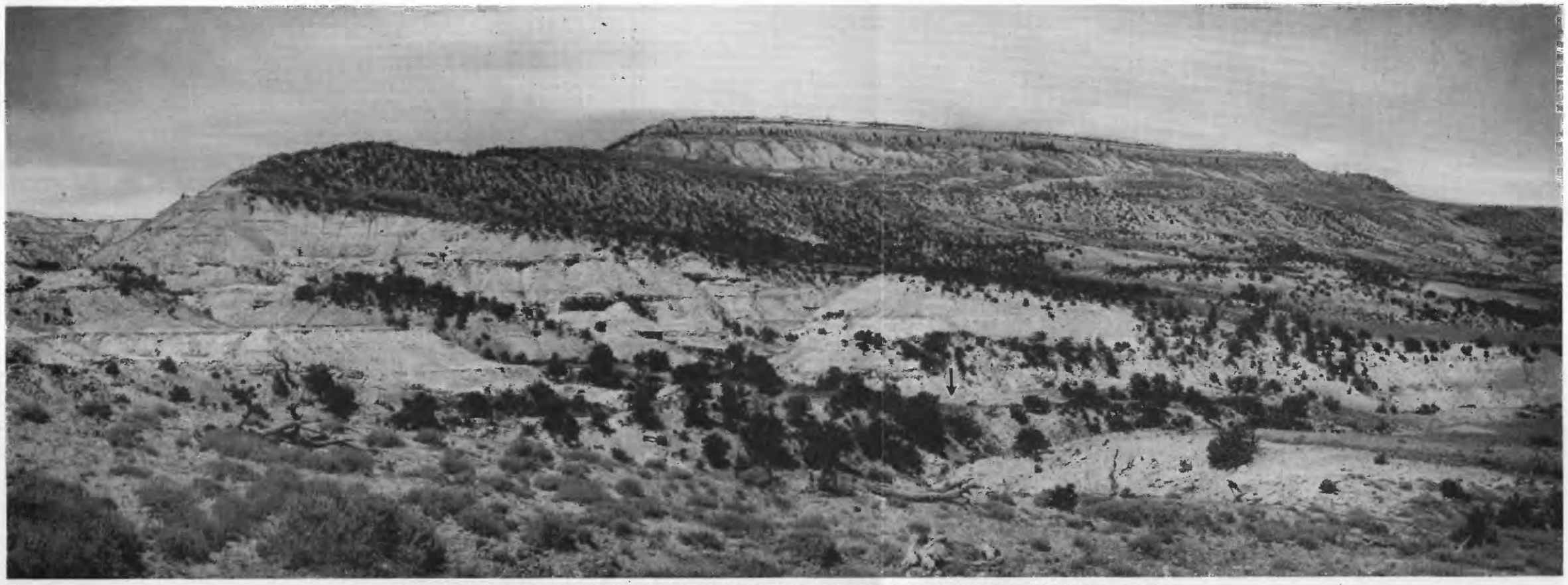
THE SKELETAL PARTS IN PLACE

The specimen of *Alamosaurus sanjuanensis* described was an isolated skeleton, that is, there were no bones of other animals found intermingled with it; thus all parts recovered are certainly those of a single individual. The skeleton was semi-articulated, the dorsal vertebrae protruding from a lens of soft, yellowish, friable sandstone. These bones lay practically on the surface and were so disintegrated that no attempt was made to collect them. They formed an articulated series in line with the sacrum, and what had been a complete pelvis was present, but bottom side up. Detached and some 2 feet distant from the last sacral was the first caudal, beginning an articulated series to the tenth vertebra. Between the ninth and tenth was a slight dislocation, but from this point to the thirtieth, the tail with all the chevrons remained in articulated sequence. Most of the ribs lay on either side and at right angles to the dorsal part of the vertebral column, those of the right side, in order and regularly spaced. The left scapula and coracoid were parallel to the column, but on the right side; whereas the complete articulated right forelimb, including the foot, was on the left side (pl. 4, *A*) and at right angles to the vertebral column. The very large sternal plates were shifted to one side (pl. 4, *B*), but their proper relationship to one another was maintained. The position of the pelvis, sternal plates, and ribs clearly indicated that the carcass when entombed was lying on its back.

Of the articulated pelvis, only the ischia were sufficiently well preserved to be worth collecting. No trace was found of the hind limbs, and the neck and skull must long since have been eroded away and destroyed.

[27] Gilmore, C. W., A new sauropod dinosaur from the Ojo Alamo formation of New Mexico: Smithsonian Misc. Coll., vol. 72, no. 14, pl. 2, 1922.

[28] Huene, Friedrich von, Los saurisquios y ornitisquoios del Cretáceo Argentino: Mus. La Plata Anales, ser. 2, t. 3, pl. 14, figs. 2a, 3b–e, 1929.



VIEW OF BADLAND AREA OF THE NORTH HORN FORMATION LOOKING TOWARD NORTH HORN MOUNTAIN FROM THE SOUTH.

Shows the location of the *Alamosaurus* quarry (indicated by the arrow in the middle foreground). Photograph by E. M. Spieker.

A. THE ARTICULATED FORELIMB OF *ALAMOSAURUS SANJUANENSIS* GILMORE IN PLACE.

B. THE STERNAL PLATES OF *ALAMOSAURUS SANJUANENSIS* GILMORE AS THEY WERE FOUND.

TWO VIEWS OF QUARRY SHOWING BONES IN PLACE.

RELATIONSHIPS OF ALAMOSAURUS

It is clearly evident that *Alamosaurus* represents one of the larger members of the Sauropoda. The markedly procoelus character of the caudal vertebrae at once distinguishes this genus from all the better known sauropodous dinosaurs of North America, and indicates that its family affiliations are with the Titanosauridae. It should be mentioned, however, that *Diplodocus* and *Brachiosaurus*, and to a lesser degree *Apatosaurus*, have a few anterior caudal vertebrae that might be called procoelus, which are soon superseded by those of amphiplatan style, not present in *Alamosaurus*.

Among all North American sauropod genera the preserved elements of *Alamosaurus* compare most favorably with *Brachiosaurus*, and although these two genera can be adequately distinguished, the several points of resemblance suggest a relationship whose implications, because of the paucity of our knowledge of the *Alamosaurus* skeleton, cannot be fully weighed at this time.

The most apparent of these common features are an elongated humerus; a stout and lengthened metacarpus; relatively short, simple spines of the anterior caudal region; a lack of pleurocoels in the caudal centra; wide ischia without distal expansion; and very large, somewhat similarly shaped sternal plates.

Of the genera assigned to the family Titanosauridae, most of which are inadequately known, *Alamosaurus* appears to have its closest affinities with the genus *Titanosaurus* of India. Insofar as one can determine from the illustrations and description of the meager type materials, the Indian *Titanosaurus* and the North American *Alamosaurus* seem to be generically identical, yet it must be kept in mind that other parts of the skeleton might display points of distinction. In fact, the South American *Titanosaurus australis*, known from more adequate specimens, appears, because of its much smaller size and differences found in the scapula and coracoid, to be readily distinguishable from *Alamosaurus*. This fact, coupled with the wide geographical separation, leads to a decision to continue the use of the term *Alamosaurus* to denote the North American representative of the Titanosauridae.

Huene has shown that *Titanosaurus australis* has a *Diplodocus*-like skull and dentition, but whether *Alamosaurus* has a similar development of the cranium, as yet we have no evidence.

Little is known of evolutionary trends in the Sauropoda, and it is therefore difficult to fix the phylogenetic value of the last of the Sauropoda. Altogether *Alamosaurus* is a type that shows no such marked specialization as do the Diplodocidae.

The neural spines of the anterior caudals are simple, not bifid, and the centra are without pleurocoels. There may have been an extension of the distal end of the tail into a long whiplash, as in *T. australis*, but as yet we have no evidence of this part of the skeleton. It would appear that in the elongation of the humerus and the metacarpus some specialization is shown, but here again the lack of knowledge concerning the proportions of the hind limbs leaves us in doubt as to whether the trend was in the direction of the Brachiosauridae or otherwise.

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PART 2. DESCRIPTION OF A NEW SPECIES OF THE CERATOPSIA

INTRODUCTION

The first recognizable ceratopsian fossils to be discovered in the North Horn formation were found in 1935 by Messrs. E. M. Spieker and J. B. Reeside, Jr., in the vicinity of North Horn Mountain, Emery County, Utah. Additional and better-preserved specimens were collected there by the 1937 and 1939 Smithsonian Paleontological Expeditions, and, in all, skeletal parts of 11 individuals are now available. The incompleteness of these specimens, especially the lack of certain critical skull parts, leaves much to be desired for a study of the material, but the discoveries have greatly extended the known geographical range of the Ceratopsia, and one of these specimens is sufficiently complete to be tentatively assigned as a new species to the genus *Arrhinoceratops* Parks.

AVAILABLE CERATOPSIAN SPECIMENS

The following specimens, all in the United States National Museum have been studied:

1. No. 15583. Partly disarticulated skull consisting of the right squamosal, jugal, lachrymal, supraorbital, postfrontal, one supraorbital horn core, right quadrate, and both quadratojugal bones. Posterior median part of frill, tentatively associated.
2. No. 15875. Right squamosal and a considerable part of the median part of the frill.
3. No. 16169. Articulated median part of a very large skull, including one complete brow horn and part of the other. Parts of both squamosals.
4. No. 16572. Posterior and median parts of the so-called parietal bone.
5. No. 16577. Palatal part of a skull, with the articulated lower parts of the jugals, epijugals, and quadrates. Small parts of both articulated squamosals are also present. All discarded except right quadrate and epijugal.
6. No. 16574. Left dentary, with a few poorly preserved teeth.
7. No. 16575. Right dentary, teeth all missing.
8. No. 15665. Right pubis.
9. No. 16576. Left pubis.
10. No. 16168. Left humerus.
11. No. 16573. Crest (median) of frill.

Family CERATOPSIDAE Marsh

Genus ARRHINOCERATOPS Parks

The genus *Arrhinoceratops* was established by Parks [29] on a well-preserved skull from the Edmonton formation, which skull he characterized as follows:

> Supraorbital horn cores large, directed outwards and forward; nasal horn core absent; facial region short; crest relatively large, subquadrate, flat; squamosal long; parietals with oval fontinelles of moderate size; anterior process of jugal unusually long.

The incompleteness of the present skull renders its generic assignment to *Arrhinoceratops* somewhat conjectural, but the presence of a thin, flattened, subquadrangular crest; a large supraorbital horn core that is directed strongly forward; and a long wide squamosal are features in accord with the type. A more complete specimen might prove the species to be distinct from *Arrhinoceratops*, but for the present a tentative assignment to that genus appears to be the more logical course.

Arrhinoceratops? utahensis Gilmore, n. sp.

Type: U. S. Nat Mus. 15583. The articulated right squamosal, quadrate, quadratojugal, postorbital, supraorbital horn core, postfrontal, lachrymal, jugal, and epijugal. Provisionally associated is a considerable portion of the posterior part of a parietal. Collected by G. B. Pearce, July 9, 1937.

Paratype: U. S. Nat Mus. 15875. A right squamosal and the posterior part of the parietal. Collected by E. M. Spieker and J. B. Reeside, Jr., 1935.

Type locality: For the type, west side of North Horn Mountain (see fig. 13, locality 6); for the paratype, southwest spur of North Horn Mountain (see fig. 13, locality 8), Manti National Forest, Emery County, Utah.

Horizon: Upper Cretaceous part of the North Horn formation.

DESCRIPTION OF THE SPECIMENS

The specimen selected as the type was found disarticulated and in association with the following skull and skeletal elements, some of which may pertain to this individual: Pair of lower jaws; fragmentary parts of a maxillary, premaxillary, and pterygoid; 13 exoccipitals; posterior parts of three parietals; coossified atlas, axis, and third cervical; 5 dorsal vertebrae; 1 cervical rib, 8 thoracic ribs, and numerous fragments. These scattered bones were found in a small area about 8 by 15 feet in extent, and at the time of collection all were thought to pertain to a single individual. Preparation, however, disclosed the presence of the posterior parts of three frill crests, indicating as many individuals and thus making it impossible to associate properly many of the scattered bones.

The question of which of the three parietals pertain to the type is to some extent solved on the evidence of the paratype. This specimen, U. S. Nat. Mus. 15875, which has a squamosal like that of the type, has much of the posterior half of the parietal associated with it. This bone

[29] Parks, W. A., *Arrhinoceratops brachyops*, a new genus and species of Ceratopsia from the Edmonton formation of Alberta: Toronto Univ. studies, geol. ser., no. 19, pp. 5–15, pls. 1–2, 1925.

resembles in all essential particulars two of the parietal parts found with the type. On the basis of the above association it would appear to be fair to assume that one of these bones pertained to the type skull. For purposes of description, all three will be used, as they are practically identical.

SQUAMOSAL

The squamosal is one of the characteristic bones of the ceratopsian cranium, and its proportionate length at once determines to what family of the Ceratopsia a specimen belongs. The squamosal of the present specimen is long and relatively wide, and is therefore referable to the long-crested line, of which *Chasmosaurus*, *Pentaceratops*, *Anchiceratops*, *Arrhinoceratops*, *Triceratops*, and *Torosaurus* are members.

The squamosal of the present specimen is broad anteriorly, narrowing posteriorly. The external surface for some distance inside the border is gently concave, then becomes convex, with another concave area paralleling the parietal border. At the posterior end this external surface is flattened, and the anterior end is gently convex from side to side. The parietal border on the posterior half is much thickened, with the usual smooth, vertical face, but more anteriorly it appears to overlap the border of the parietal. In advance of midlength, this bone presents a rounded inner edge that for a distance of 230 millimeters gives no evidence of having been in contact with another bone. Lull [30] calls attention to a *Chasmosaurus* skull in which the parietal does not have a continuous squamosal border and a similar condition might explain the rounded nonsutural section in the present skull.

The external surfaces of both squamosals of the type and paratype are covered with the usual vascular impressions. That the outer border was ornamented by a series of epoccipital bones is indicated by one on the border of the type (see *epoc* in fig. 12). Given the regular quota of articulated epoccipitals, the frill would have a scalloped border.

The right squamosal bone is preserved with the paratype (U. S. Nat. Mus. 15875) and also with a referred specimen (U. S. Nat. Mus. 16169) collected in 1939. The first mentioned has the almost complete right element present, while the other has the anterior half of the right and the posterior two-thirds of the left preserved. In shape and other proportions there is the closest agreement among all three bones. The referred specimen (U. S. Nat. Mus. 16169) is larger than the others, and the external surface of the squamosal of the paratype is more profusely ornamented with vascular impressions, but otherwise all are closely similar.

PARIETAL

The term parietal as used here comprises the median part of the crest that lies between the squamosals, thus returning to the use of the original designation of Marsh for this part of the ceratopsian skull. This procedure is adopted here to conform to present-day usage and thus avoid confusion in description, although the evidence does not yet seem conclusive that the median part of the frill is the parietal.

The parietal of *Arrhinoceratops? utahensis* is represented by the posterior parts from three individuals, of which the paratype, U. S. Nat. Mus. 15875, is most complete. The other two were found in association with the type, but which of these pertains to that specimen is uncertain. All three have a portion of the left squamosal border preserved, as shown in plate 11. The squamosal border of the paratype, as preserved, measures 523 millimeters in length. None of the specimens shows the complete transverse width between the squamosal borders, but measurements made from the midline indicate a total width between parieto-squamosal sutures of about 1,200 millimeters; thus the complete frill would have the proportions of that of a large *Triceratops*. Both specimens found with the type have portions of the sutural border for the squamosal preserved, but both have comparatively smooth upper and lower surfaces, as contrasted with the longitudinal vascular sinuses that ornament at least one surface of the paratype.

The extreme thinness of the parietal is one of the outstanding characteristics of the *Arrhinoceratops* skull. In the present specimens, exclusive of the squamosal borders, which have a greatest thickness of 24 millimeters, the maximum thickness of 18 millimeters is attained about 40 millimeters anterior to the posterior border, and from that point forward the whole bone gradually thins toward the broken anterior edge, which in places is less than 3 millimeters thick. This extreme thinness of the incomplete anterior borders strongly suggests that they participated in the formation of the boundaries of the frill fontanelles. In fact, one small anterior projection on the parietal of U. S. Nat. Mus. 15583 appears to have a finished edge. If correctly interpreted, it shows the posterior rim of the fontanelle to be 275 millimeters anterior to the posterior margin of the frill.

In the original description of *Arrhinoceratops brachyops*, Parks [31] notes that "there is some evidence of sutures running back from the fontanelles to the posterior margin. Such sutures would indicate the existence of an interparietal bone." From these remarks it is evident that Parks observed an obscure condition in the type skull that is in accord with the features found in one of the present specimens. The incomplete parietal that has been

[30] Lull, R. S., A revision of the Ceratopsia or horned dinosaurs: Peabody Mus. Nat. History Mem., vol. 3, pt. 3, p. 25, 1933.

[31] Parks, W. A., op. cit., p. 12, 1925.

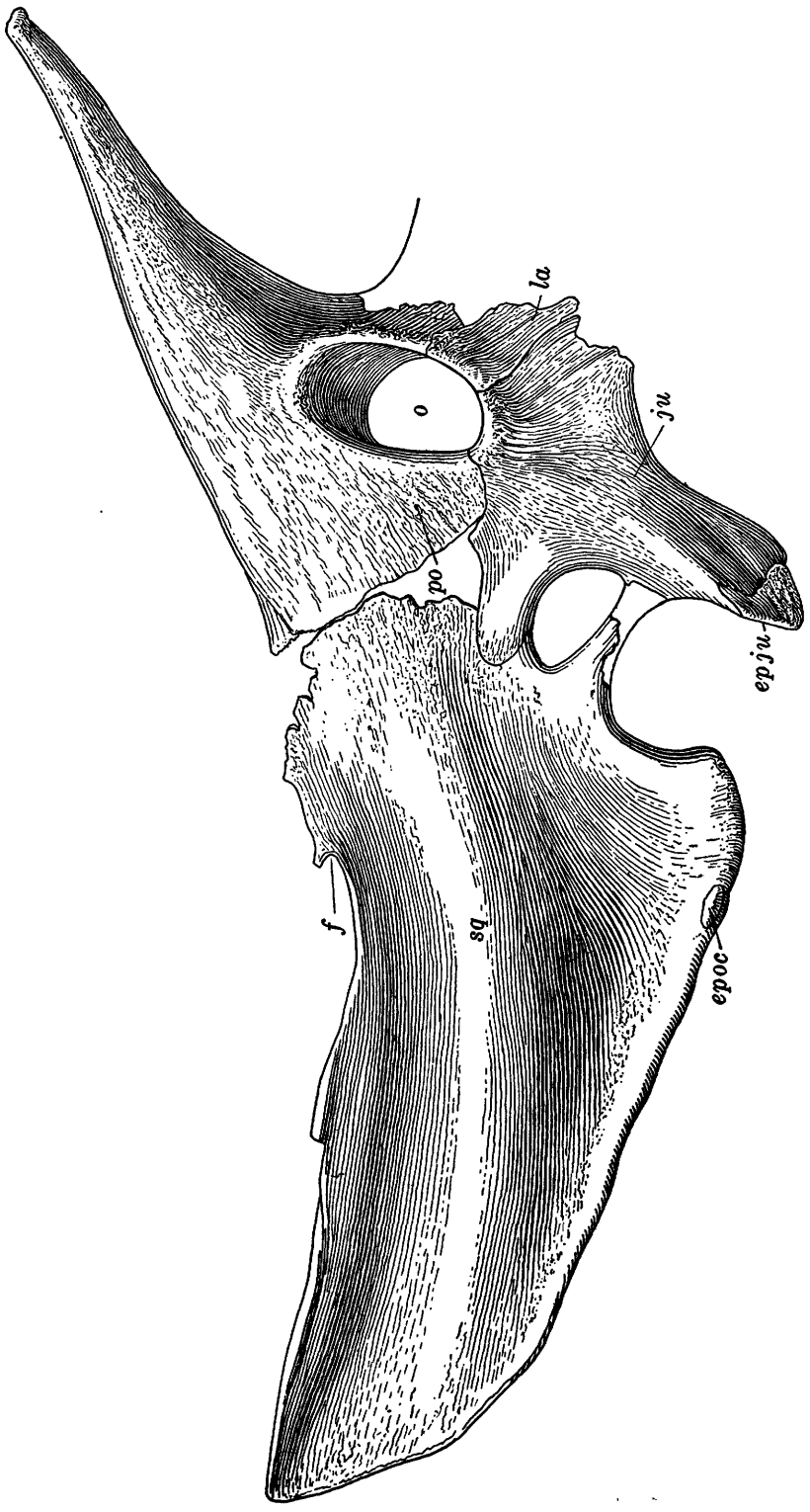


FIGURE 12.—Incomplete skull of *Arrhinoceratops? utahensis* Gilmore, n. sp. Type (U. S. Nat. Mus. 15583), viewed from the right side. *Epju*, epijugal; *epoc*, epoccipital; *f*, border suggestive of a foramen; *ju*, jugal; *la*, lachrymal; *o*, orbit; *po*, postorbital. About one-eighth natural size.

provisionally assigned to the type (see pl. 12, fig. 1) differs from the others in having two longitudinal pseudosutural divisions on either side of the midline that converge slightly in an anterior direction. It was first thought these represented true sutural separations corresponding to those noted by Parks in the type of *Arrhinoceratops brachyops*. The later discovery of similar divisional edges separating longitudinally the two halves of a ceratopsian squamosal and the presence of a similar division on the right side of the midline of the parietal of U. S. Nat. Mus. 16572 that

is divergent in an anterior direction seems to indicate these are not true sutures and thus denies the existence of a distinct element in this part of the ceratopsian frill.

The unusual and misleading character of these pseudosutural divisions of the parietal deserves a detailed description. These are not fractures of the bone, but are natural separations that run in a straight line. On the right side the posterior part of the lateral border presents a flat vertical face that in the grain of the bone has a striking similarity to the sutural surfaces between the hyo-hypoplastral bones in certain trionychid turtles. More anteriorly the upper half of the edge projects outward and overlaps a corresponding projection of the lower edge of the adjacent section, thus making a lap joint. On the opposite side of the median section of the parietal, this condition is reversed, the lower half of the border forming the projecting edge and thus underlapping the contiguous portion of the upper. There is no indication of these lines of separation in either of the other two parietals (U. S. Nat. Mus. 15583 and 15875). (See pl. 11.) From this evidence it would seem that a similar condition must have existed in the skull studied by Parks, which misled him into concluding that he was dealing with a true suture.

The complete transverse extent of this median section of the parietal measured between the lateral edges at the posterior border is 333 millimeters. The surfaces of this bone are smooth, except for a few vascular depressions on the ventral side. The median frill region of specimen U. S. Nat. Mus. 15875 has one surface, presumably the ventral, sculptured by deep vascular sinuses, the deeper ones having a longitudinal direction, as in *Arrhinoceratops brachyops*.

SUPRAORBITAL HORN

The right supraorbital horn core, coalesced with the postorbital and supraorbital bones, is preserved almost in its entirety, lacking only the tip, which was lost before interment. (See fig. 12.) This horn core is moderately stout, tapers, is compressed laterally, and is elliptical in cross section throughout the great part of its length, as in *Torosaurus*. It appears quite probable that some of this transverse flattening may be attributed to postmortem deformation. The horn core rises well forward above the orbit, is strongly inclined anteriorly, and differs from the brow horns of *Arrhinoceratops brachyops* in being only slightly inclined outward. The regular forward curve of the basal half of the horn core is reversed in the upper half, thus bringing about an upward tilt at the tip. The surface of the horn core is covered with the usual vascular impressions, and there is obscure indication of sulcation, extending downward for a short distance from the tip on the anterior side. The orbit lies under the anterior margin of the horn, as in *Pentaceratops*.

Comparative measurements of supraorbital horns in millimeters

	Type of *Arrhinoceratops? utahensis* (U. S. Nat. Mus. 15583)	Type of *Arrhinoceratops brachyops*	*Specimen* U. S. Nat. Mus. 16169
Greatest length from upper median rim of orbit to tip.	510[1]	----------	710
Greatest length measured along upper convex margin.	570	555	760
Greatest length measured along lower concave margin.	485	460	655
Girth at base	495	425	612

[1] Estimated.

Specimen U. S. Nat. Mus. 16169, which is provisionally identified as pertaining to *Arrhinoceratops? utahensis*, is considerably larger than the type. It has the right supraorbital horn core preserved in almost its entirety (see pl. 12) and the detached basal half of the left. The right horn is of the same slender, tapering form as that of the type, but it stands more erect, and is nearly 8 inches longer. It differs further in having a distinct sulcus extending downward from the tip for more than half its length, the depth of which has been exaggerated by crushing. Sulcated horns in the Ceratopsia are rare, and Lull [32] is of the opinion that their presence or absence is of little significance. However, the presence of sulcation in the brow horns of all the *Arrhinoceratops* specimens known at the present time suggests a certain constancy in this genus that may have some meaning.

JUGAL

The right jugal is completely preserved, although it was found detached from the other skull elements. The precise agreement of the sutural borders with those of the lachrymal and postorbital leaves no doubt that it pertains to the same individual as the supraorbital horn core described above. In its more slender proportions, and especially the more restricted expansion of the proximal end, it differs markedly from the more robust jugal of *Arrhinoceratops brachyops*. In fact, the jugal of that species differs so much from those of other ceratopsians as to lead one to wonder if its outline has been correctly interpreted. If correctly delimited, it furnishes important features for distinguishing *Arrhinoceratops brachyops* from the species here described.

The jugal under description has a truncated anterior process that joins the maxillary, contrasting with the long and tapering process in *Arrhinoceratops brachyops*. Likewise, the posterior process that joins the squamosal is much shorter and narrower. The greatest length of the present jugal from the orbital border to the distal end is 373 millimeters, and its greatest width from the maxillary contact to the squamosal border is 355 millimeters. The thickened orbital border contributes 65 millimeters to the inferior rim of the orbit.

[32] Lull, R. S., op. cit., p. 129, 1933.

QUADRATOJUGAL

Both quadratojugal bones of U. S. Nat. Mus. 15583 are preserved, but they are not quite complete. In articulated position the quadratojugal is imposed between the lower internal side of the jugal and the lower outer side of the quadrate. A heavy, downwardly projected process articulates with the epijugal by rugose suture. The quadratojugal may have contributed to the formation of the lower border of the infratemporal fossa, as in *Triceratops*, but this feature cannot be positively determined, as, unfortunately, both quadratojugals are imperfect in this respect. In *Monoclonius* the quadratojugal does not participate.

LACHRYMAL

The lachrymal is triangular in outline, with a heavy expanded end that contributes to the anterior rim of the orbit. It is united closely with the upper border of the anterior branch of the jugal by a longitudinally grooved, sutural articulating border. The upper anterior border is deeply excavated, leaving a slender anterior process that extends between the jugal and nasal.

EPIJUGAL

The right epijugal was found detached, but its sutural contact with the jugal clearly indicates that it pertains to specimen U. S. Nat. Mus. 15583. In position it articulates on the lower outer extremity of the jugal, extending prominently outward, backward and downward. (See fig. 12.) Its outer end is bluntly pointed, upper surface shallowly concave, and ventral surface strongly convex. A triangular, cupped, articular end projects inward below the level of the jugal to meet a thickened, rounded projection from the quadratojugal. The outer surfaces are covered with the usual vascular markings. In shape and proportions the present bone has a close likeness to the epijugal of *Arrhinoceratops brachyops*.

QUADRATE

A right quadrate found in this same assemblage may quite certainly be assigned to the type, as indicated by the close articulation of the sutural surfaces with the quadratojugal and epijugal bones. The end of the quadrate that articulates with the lower jaw has a greatest transverse diameter of 115 millimeters, a greatest anteroposterior diameter of 41 millimeters, and a greatest length of about 355 millimeters.

EPOCCIPITALS

Thirteen detached epoccipital bones were found in this quarry, of which about half represent complete elements. Eight of these, although differing somewhat in size, are relatively large and closely resemble one another in shape.

Since these eight peripheral elements resemble the epoccipitals found attached to the squamosal of the type and to the parietal of the paratype, it is assumed that all pertain to *Arrhinoceratops? utahensis*. These elements are elongated and have a sharp outer edge and a raised median apex, as shown in plate 13, figures 1 to 5. Their external surfaces are ornamented with vascular impressions which suggest that in life they probably had a horny, skinlike covering. Their inner borders are hollowed out longitudinally to conform better to the rounded borders of the squamosal and parietal, along whose periphery they were arranged. With the epoccipitals in position, the border of the frill must have had a scalloped form.

The five smaller epoccipitals are slender (see pl. 13, fig. 1), triangular in cross section, and lack the median apex. Their surfaces also lack vascular markings. Their position on the frill is not known at this time.

RELATIONSHIPS OF THE SPECIMENS

The incompleteness of the type materials and especially the lack of critical parts has made it difficult to reach a satisfactory conclusion as to the true relationships of the specimen under discussion. As mentioned previously, the squamosal indicates the affinity of the species with the long-crested group of the Ceratopsia. The greater relative width of the posterior portion of the squamosal of *Arrhinoceratops? utahensis* distinguishes it from the corresponding element in *Chasmosaurus*, *Pentaceratops*, and *Torosaurus*, all of which have the posterior extremity of this bone narrow and tapering. In general outline and proportions the squamosal of *Arrhinoceratops? utahensis* has its nearest counterpart in *Triceratops*, but the presence of fenestrae in the frill satisfactorily distinguishes them. That the affinities of the present form do not lie with the genus *Anchiceratops* is indicated not alone by differences in the form of the squamosal bones, but also by the absence in the Utah specimen of the heavy epoccipital processes on the parietal that form such a prominent feature of the Edmonton genus. Meager though the evidence may be, this brief review appears to show that the specimen here discussed cannot be satisfactorily included in any of the above-mentioned genera. Of the known members of the long-crested Ceratopsia only *Arrhinoceratops* remains to be considered.

The presence in the Utah specimen of a flat quadrangular frill crest having an extremely thin parietal part perforated by fenestrae, and of well-developed, sulcated, supraorbital horns that curve strongly forward are features held in common with the skull on which Parks established the genus *Arrhinoceratops*. On the other hand, important differences appear in the jugal bones of the two specimens. In fact, the jugal of the Parks specimen differs so decidedly from those of ceratopsians in general that I am led to believe he must have erred in delimiting it. If such an assumption proves to be true, the observed differences in outline and proportions of the jugals of the two species have no special significance.

In view of the above facts it is proposed to refer the North Horn ceratopsian provisionally to the genus *Arrhinoceratops*, as the species *Arrhinoceratops? utahensis*, which may be distinguished from the genotype by differences found in the brow horn cores. In this species these horns curve strongly forward but with slight outward inclination, while in *Arrhinoceratops brachyops* they turn strongly outward.

PART 3. REVIEW OF VERTEBRATE FAUNA OF THE NORTH HORN FORMATION

INTRODUCTION

A new locality for Mesozoic reptiles was made known through the discovery by E. M. Spieker in 1934 of fragments that could be identified as dinosaurian. This locality, in the vicinity of North Horn Mountain (see fig. 13), Manti National Forest, Emery County, Utah, was again visited in 1935 by Spieker and J. B. Reeside, Jr., who were successful in obtaining specimens that could be positively identified as pertaining to ceratopsian and hadrosaurian dinosaurs. These fossils definitely indicated the Upper Cretaceous age of the lower member of the sequence that Spieker has since named the North Horn formation.

In anticipation of opening up a new field for horned and other dinosaurian specimens and also in the hope of obtaining materials that would more accurately date the beds in which the fossils are found, the Smithsonian Institution in 1937 sent an expedition under my direction to investigate the area. The success of the first expedition brought about the organization in 1938, 1939, and 1940 of field parties in the same area under the leadership of C. L. Gazin.

The localities near North Horn Mountain, where important specimens have been found by the field parties, are all clearly indicated on the geologic map. (See fig. 13.) This map is based, with modifications, on Geological Survey topographic sheets, and was drawn by Dr. Gazin, through whose kindness it is presented herein.

Locality 3 in the Dragon Valley has been referred to as the "lizard locality,"[33] because of the considerable number of lizard specimens that have been found there. Dinosaurian specimens in this same area were found both above and below the lizard horizon, and a few characteristic caudal vertebrae of *Alamosaurus* were found at the same level. All the vertebrate specimens came from a large depressed block of Upper Cretaceous sediments that had been dropped by the north-south faults traversing this area. The precise relationship of this bone-bearing level to the fossil-bearing zone around North Horn Mountain has not been determined, but the presence of *Alamosaurus* remains in both strongly suggests that they are at about the same level in the formation.

The specimens found on the west side of North Horn Mountain were considered by Spieker from examination in the field to be at about the same level in the formation as those from locality 1 on the southwest side.

With the exception of *Champsosaurus* and *Crocodylus* remains, which also may be found in the overlying Paleocene strata, all dinosaurian and other reptilian fossils found in this area have come from the lower 850 feet of the North Horn formation, which consists of variegated shales and sandstones that are conglomeratic in places. One fragmentary dinosaur specimen found in place a short distance from locality 1, but not collected, was of interest in being at the lowest level in the formation at which a vertebrate was found. This specimen was estimated to be less than 200 feet above the top of the Price River formation, which outcrops in this section.

FAUNAL LIST

A study of the fossil materials accumulated by these four expeditions has resulted in the establishment of the faunal list given below. For ready comparison a list of the fauna of the Ojo Alamo sandstone is placed beside it.

Fauna of the North Horn formation

Dinosauria:
- *Alamosaurus sanjuanensis* Gilmore.
- *Arrhinosaurus? utahensis* Gilmore.
- Ceratopsian, gen. and sp. indet.
- Hadrosaurian (large).
- Hadrosaurian (small).
- Deinodont (large).
- Deinodont (small).

Sauria:
- *Polyglyphanodon sternbergi* Gilmore.
- *Paraglyphanodon utahensis* Gilmore.

Rhynchocephalia:
- *Champsosaurus* sp.

Crocodilia:
- *Crocodylus* sp.

Chelonia:
- *Basilemys* sp.
- *Adocus* sp.
- *Compsemys* sp.
- *Aspideretes* sp.

Pisces:
- *Lepisosteus* sp.

Fauna of the Ojo Alamo sandstone

Dinosauria:
- *Alamosaurus sanjuanensis* Gilmore.
- *Monoclonius* sp.
- *Kritosaurus navajovius* Brown.
- Deinodont?
- Armored dinosaur.

Sauria:
- None known.

Rhynchocephalia:
- None known.

Crocodilia:
- *Crocodylus* sp.

Chelonia:
- *Basilemys nobilis* Hay.
- *Adocus vigoratus* Hay.
- *Compsemys* sp.
- *Aspideretes vorax* Hay.
- *Aspideretes fontanus* Hay.
- *Aspideretes austerus* Hay.
- *Thescelus rapiens* Hay.

Pisces:
- *Lepisosteus* sp.

[33] Gazin, C. L., The mammalian faunas of the Paleocene of central Utah, with notes on the geology: U. S. Nat. Mus. Proc., vol. 91, no. 3121, p. 7, fig. 1, 1941.

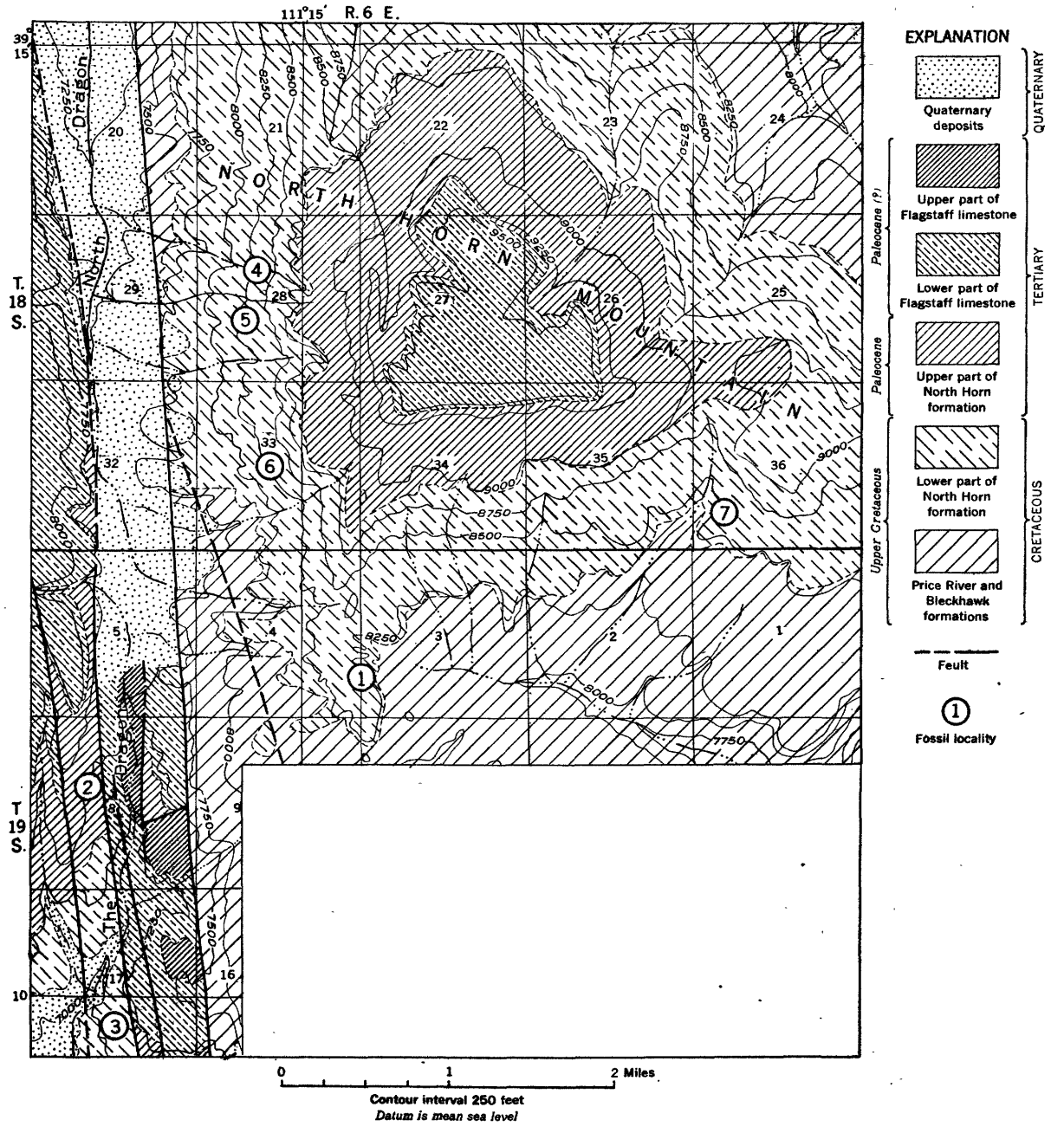


FIGURE 13.—Geologic map of the region around North Horn Mountain, Emery County, Utah, showing localities where specimens were found: (1) *Alamosaurus san juanensis*, skeleton (U. S. Nat. Mus. 15560); (2) Paleocene mammal locality; (3) lizard locality; (4) ceratopsian skull (U. S. Nat. Mus. 16169); (5) type of *Arrhinoceratops? utahensis* (U. S. Nat. Mus. 15583); (6) hadrosaurian femur locality; (7) ceratopsian (U. S. Nat. Mus. 16577). Map drawn by C. L. Gazin.

The fauna of the North Horn formation, as shown, consists almost entirely of reptiles. Five different orders are now recognized. Of these the Dinosauria are the most significant; they pertain to well-known groups whose geologic history is well understood, and they definitely indicate that the beds in which the fossils are found are of Upper Cretaceous age. Until recently the large sauropod, *Alamosaurus sanjuanensis*, had been found in association with horned dinosaurs (Ceratopsia), duck-billed dinosaurs (Hadrosauridae), and carnivorous dinosaurs (Deinodontidae) only in the Ojo Alamo sandstone of the San Juan Basin in New Mexico. This association strongly indicates the equivalence in age of the North Horn formation and the Ojo Alamo sandstone, and the conclusion is further strengthened by the presence in both formations of four genera of turtles, a fish, and a crocodile. The fragmentary condition of the fish and the crocodile renders them of little importance individually, but collectively they are of value in showing the similarity of the faunas of the two formations.

Recent discoveries [34] made in the Big Bend of the Rio Grande, Tex., show the presence in that area, also, of sauropod dinosaurs in association with Upper Cretaceous Ceratopsia and Hadrosauridae.

In order to present as complete a picture of the North Horn fauna as available materials will permit, each of the known members is briefly reviewed below, and new information resulting from the latest collecting is incorporated. In addition to the recognized genera and species there are a few fragmentary specimens identifiable only as to order or family, and these are briefly discussed.

Class REPTILIA

Order DINOSAURIA

Suborder SAUROPODA Marsh

Family TITANOSAURIDAE Lydekker

The large sauropod *Alamosaurus sanjuanensis* Gilmore was fully discussed on pages 29 to 41, and it is only necessary herein to mention the finding of new materials. Two caudal centra found by the 1939 expedition at the lizard locality, S½ sec. 17, T. 19 S., R. 6 E., in the South Dragon Valley, and from the same level as one of the specimens of *Polyglyphanodon*, somewhat extend the geographical range of *Alamosaurus*. The large size and the procoelous character of these median caudal centra at once establish their identity as pertaining to the genus *Alamosaurus*.

A second specimen consisting of two very large thoracic ribs was collected from a small patch of badland exposures on the west side of the South Dragon Valley (NE¼ sec. 12, T. 19 S., R. 5 E.). These are certainly the ribs of a sauropod dinosaur, and in all probability they record the occurrence of a third individual of *Alamosaurus* within this general area.

Suborder CERATOPSIA Marsh

In addition to the specimens of *Arrhinoceratops?* that form the subject matter of part 2 of this paper, several other fragmentary ceratopsian specimens were collected by the 1937 and 1939 expeditions.

The most important of these is the palatal part of a skull (U. S. Nat. Mus. 16577) articulated with the incomplete maxillaries and distal portions of the jugals, epijugals, quadrates, and anterior portions of both squamosals. This specimen was found by G. F. Sternberg on the west side of North Horn Mountain (SW ¼ Sec. 36, T. 18 S., R. 6 E.). Very large hornlike epijugals (see pl. 14, fig. 3), large coossified epoccipitals on the anterior border of the squamosal bones, and a more open squamosal-jugal notch appear to show its distinctness from *Arrhinoceratops*. The large size of the epijugals suggests relationship to *Pentaceratops*, a Kirtland genus that might be expected to occur here, but lack of other diagnostic parts in the present specimen does not permit verification of this. The chief interest in the specimen lies in the fact that it indicates the presence in the fauna of a second, as yet undetermined ceratopsian.

Intermingled with the bones of the type of *Arrhinoceratops? utahensis* were parts of the frill of an individual that may represent a third type of ceratopsian. These materials include a median portion of the frill crest, a considerable section of the median bar of the frill, and a portion of its anterior end showing the supratemporal fossa. No direct contacts between these three frill parts have been found, but their relative positions in the quarry were such as to suggest strongly that they belonged to one individual. Furthermore, the relative thickness of the broken ends, as well as the contours of contiguous parts, are in complete harmony with such a conclusion. These detached parts, arranged in relative sequence, are illustrated in plate 14, figures 1 and 2.

The crest portion shows a divisional partitioning of the parietal as in the type of *Arrhinoceratops? utahensis*. A pseudosutural edge on the right side of the parietal is the counterpart of those in the type of *Arrhinoceratops? utahensis*, with the exception that it runs forward and outward. Thus, if the opposite sutural edge, which is missing, should have the same course, they would be divergent, whereas in *Arrhinoceratops? utahensis* they converge in an anterior direction. This crest portion thickens on the median line, and on the dorsal side, 100 millimeters anterior to the free margin, a low, rounded boss marks the midline. (See pl. 14, fig. 2.) In front of this boss the surface slopes downward on either side. The broken anterior end has a thickness of 25 millimeters. The under side is regularly concave from side to side, the surface being marked by a few vascular impressions. The free border is slightly undulating and shallowly concave from side to side as contrasted with the convex border of the parietal of *Arrhinoceratops? utahensis*. The undulations may be the coossified epoccipital bones.

The median, or bar, portion of the frill (pl. 14, fig. 4) measures 490 millimeters in length. The bone as a whole is roof-shaped, with a heavy, rounded median ridge. Viewed laterally, the crest of this ridge is undulating, owing to a series of longitudinal swellings arranged one in front of the other. The bone thins out away from the midline. On the right side for a short space near midlength is what appears to be a finished edge. If this interpretation is correct, it would be a portion of the inner border of the right fenestra, and would indicate the median bar to have a width of approximately 226 millimeters between the fenestrae, thus resembling *Arrhinoceratops* and *Torosaurus*, rather than the very narrow bar of *Chasmosaurus* or *Anchiceratops*.

[34] Brown, Barnum, oral communication.

The anterior end of the parietal has a rounded median ridge with steep lateral sides and a relative thickness of the bone that agree with the corresponding features of the anterior end of the median part described above and that give every indication that the two parts belong together. On the left side the outline of the supratemporal fossa is distinctly indicated.

These three frill parts, with some allowance for the missing connecting pieces, have a combined length from end to end of about 984 millimeters, thus indicating an individual having about the same frill proportions as the type of *Arrhinoceratops? utahensis*. The greater thickness of the frill portions, the concave median-posterior border, the rounded median boss on the dorsal surface are all features that show the probable distinctness of this specimen from *Arrhinoceratops*. The available materials are too meager for generic designation and furthermore there is the possibility that this type of development may pertain to the ceratopsian with the large epijugals, previously mentioned, of which at the present time there is no information regarding the frill.

In the collections there are six other individuals of the Ceratopsia, each represented by a single bone. These are a left humerus (U. S. Nat. Mus. 16168), a right pubis (U. S. Nat. Mus. 15665), a left pubis (U. S. Nat. Mus. 16576), a right dentary (U. S. Nat. Mus. 16575), a left dentary (U. S. Nat. Mus. 16574), and the posterior half of an ilium. These bones are of no special significance, as genera in the Ceratopsia cannot be determined from any of them. They do permit the suggestion, however, that in this area ceratopsian dinosaurs may have been more abundant than members of the Hadrosauridae, whereas in most other Upper Cretaceous faunas the latter usually predominate in number of specimens.

Family HADROSAURIDAE Cope

A complete right femur, U. S. N. M. 16318, collected in 1939 from locality 7 (see fig. 13), is the only evidence obtained of the presence in this fauna of one of the larger representatives of the Hadrosauridae. In size it would be comparable to *Kritosaurus* or *Parasaurolophus* of the Ojo Alamo and Kirtland formations, respectively. This femur (see pl. 14, fig. 1) has a greatest length over all of 1,122 millimeters.

That a much smaller member of the Hadrosauridae exists in this fauna is indicated by an articulated ulna, radius and partial forefoot, U. S. N. M. 13808. In size it pertains to an animal smaller than *Procheniosaurus*. This specimen was collected in 1935 on the southwest spur of North Horn Mountain, only a few yards from the site of the partial skeleton of *Alamosaurus sanjuanensis* discovered in 1937. (See fig. 13, loc. 1).

Family DEINODONTIDAE Brown

The presence of carnivorous dinosaurs in the North Horn formation is shown by the finding of several characteristic teeth, a large claw pertaining to the manus, and the distal half of a lateral metatarsal. These were not found in association, and it is therefore assumed that each pertained to a separate individual. Although none of the parts is adequate for generic determination, each is sufficiently diagnostic to indicate the occurrence here of a carnivorous dinosaur of the size of the Upper Cretaceous *Gorgosaurus*.

Order SAURIA

Family POLYGLYPHANODONTIDAE Gilmore

Nearly complete and partially articulated skeletons of *Polyglyphanodon sternbergi* Gilmore enabled me to describe its skeletal anatomy.[35] Altogether, the remains of nearly 50 individuals of *Polyglyphanodon* have now been assembled, thus making it the best known of all North American lizards. These specimens came from one small area (S. ½ sec. 17, T. 19 S., R. 6 E.) located in the central part of the South Dragon Valley and referred to in this paper as the lizard locality (fig. 13, loc. 3).

Since no fossil lizards are known in the Ojo Alamo or Kirtland formations at the present time, this new lizard has no significance for correlation.

FAMILY UNDETERMINED

The lizard *Paraglyphanodon utahensis* Gilmore also had been described.[36] It was based on a maxillary bone found in association with specimens of *Polyglyphanodon*. A specimen, U. S. Nat. Mus. 16357, consisting of an anterior end of a right dentary containing six teeth, was collected by the 1939 expedition. These six teeth occupy a space 4 millimeters in length, and, as in the upper series, increase in size from front to back. The most anterior tooth is very small, and the tops of all appear to have been much worn, thus obscuring the details of their structure. Two specimens collected in 1940 have the skulls and a few vertebrae preserved. All came from the lizard locality and from practically the same geologic level.

Order RHYNCHOCEPHALIA

The record of *Champsosaurus* in the North Horn formation rests upon the half of a vertebral centrum picked up on the surface on the south side of North Horn Mountain. Since this aquatic reptile has a long geologic range it is of little significance for correlation.

Order CROCODILIA

A single characteristic vertebral centrum picked up on the surface shows that extinct Crocodilia were present in this fauna.

[35] Gilmore, C. W., New fossil lizards from the Upper Cretaceous of Utah: Smithsonian Misc. Coll., vol. 99, no. 16, pp. 1–2, 1940.

[36] Gilmore, C. W., op. cit., p. 3.

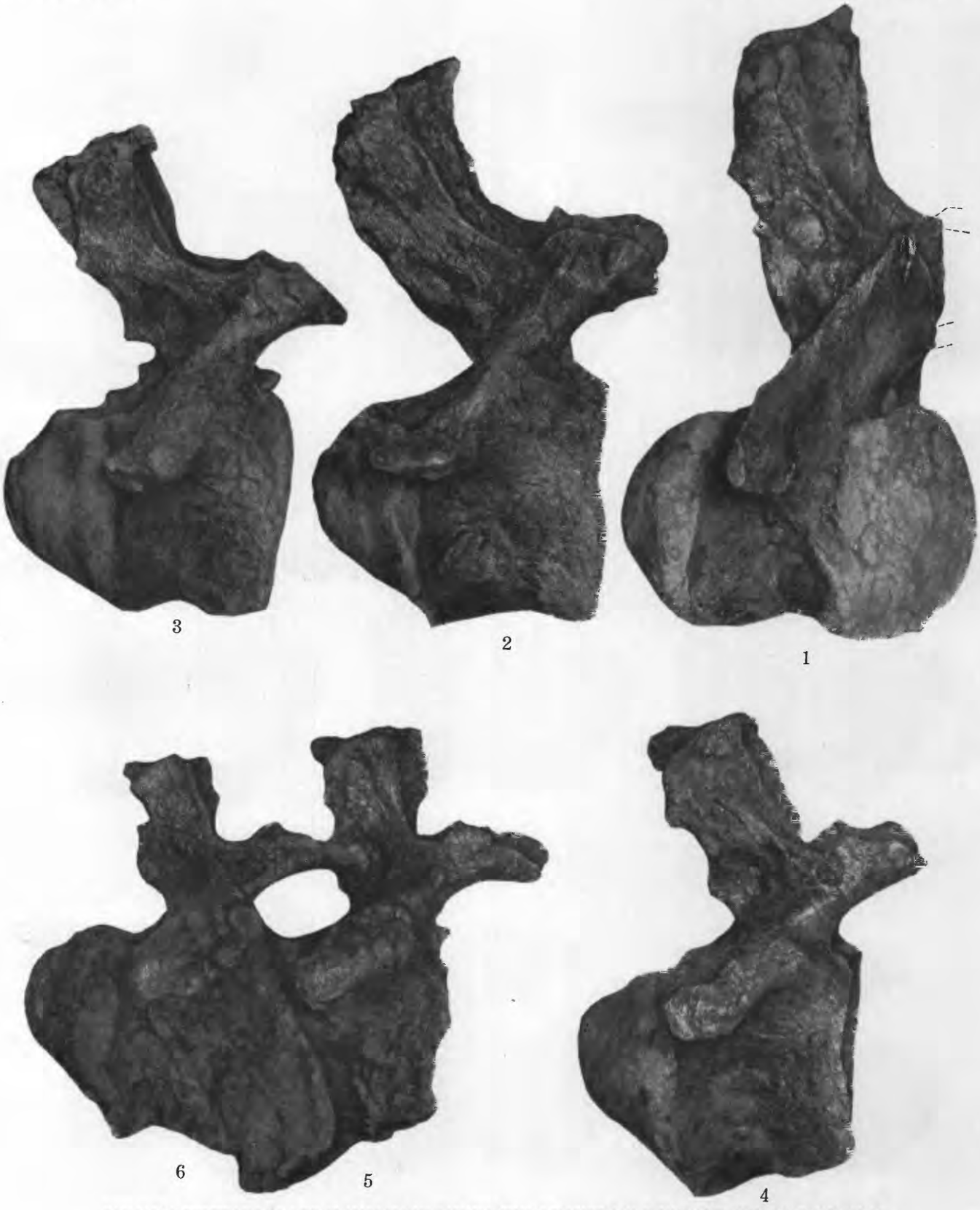
Order CHELONIA

The turtles are represented by scattered fragments that with one exception were found loose on the ground.

A fragmentary part of a carapace of *Basilemys* associated with a few limb and foot bones was found in place at the lizard locality in the South Dragon Valley. The characteristic sculpturing on the fragments of carapace permits recognition also of the presence of *Adocus*, *Compsemys*, and *Aspideretes*. All four genera are present also in the Ojo Alamo.

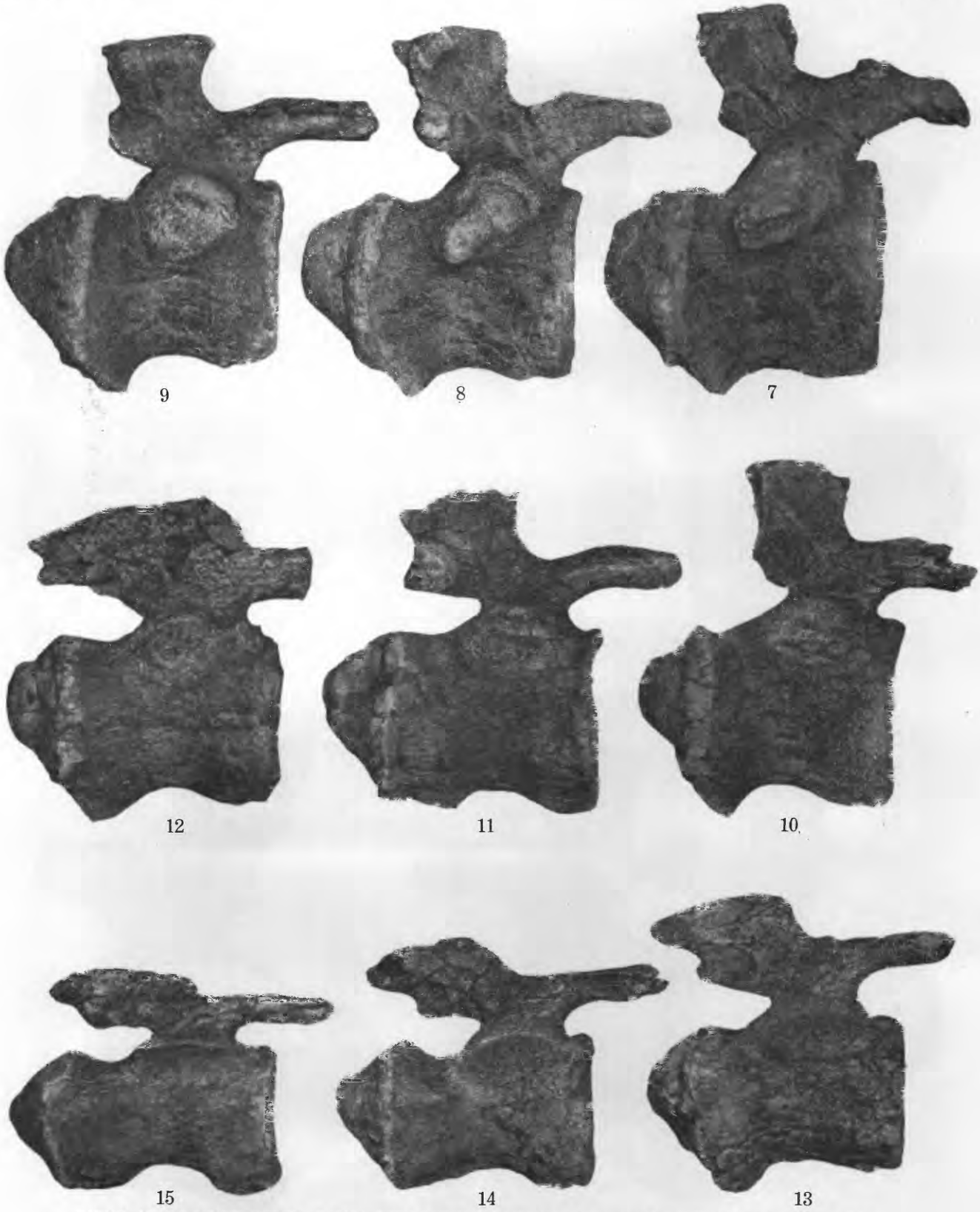
Class PISCES

A single bony lozenge-shaped scale of a ganoid fish from the North Horn formation is referred, according to the usual practice, to the genus *Lepisosteus*.



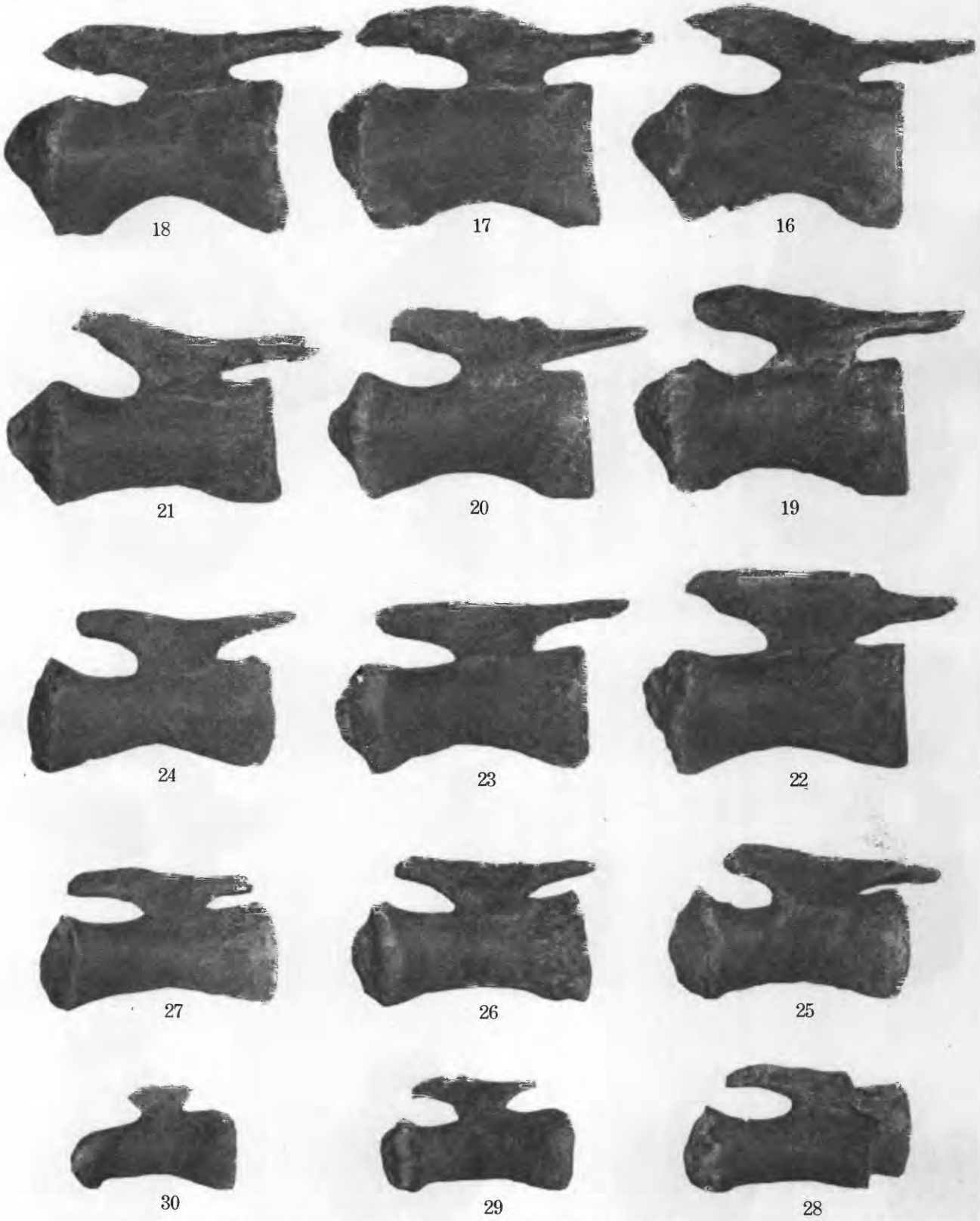
CAUDAL VERTEBRAE 1 TO 6 OF *ALAMOSAURUS SANJUANENSIS* GILMORE (U. S. NAT. MUS. 15560), LATERAL VIEW.

About one-fifth natural size.



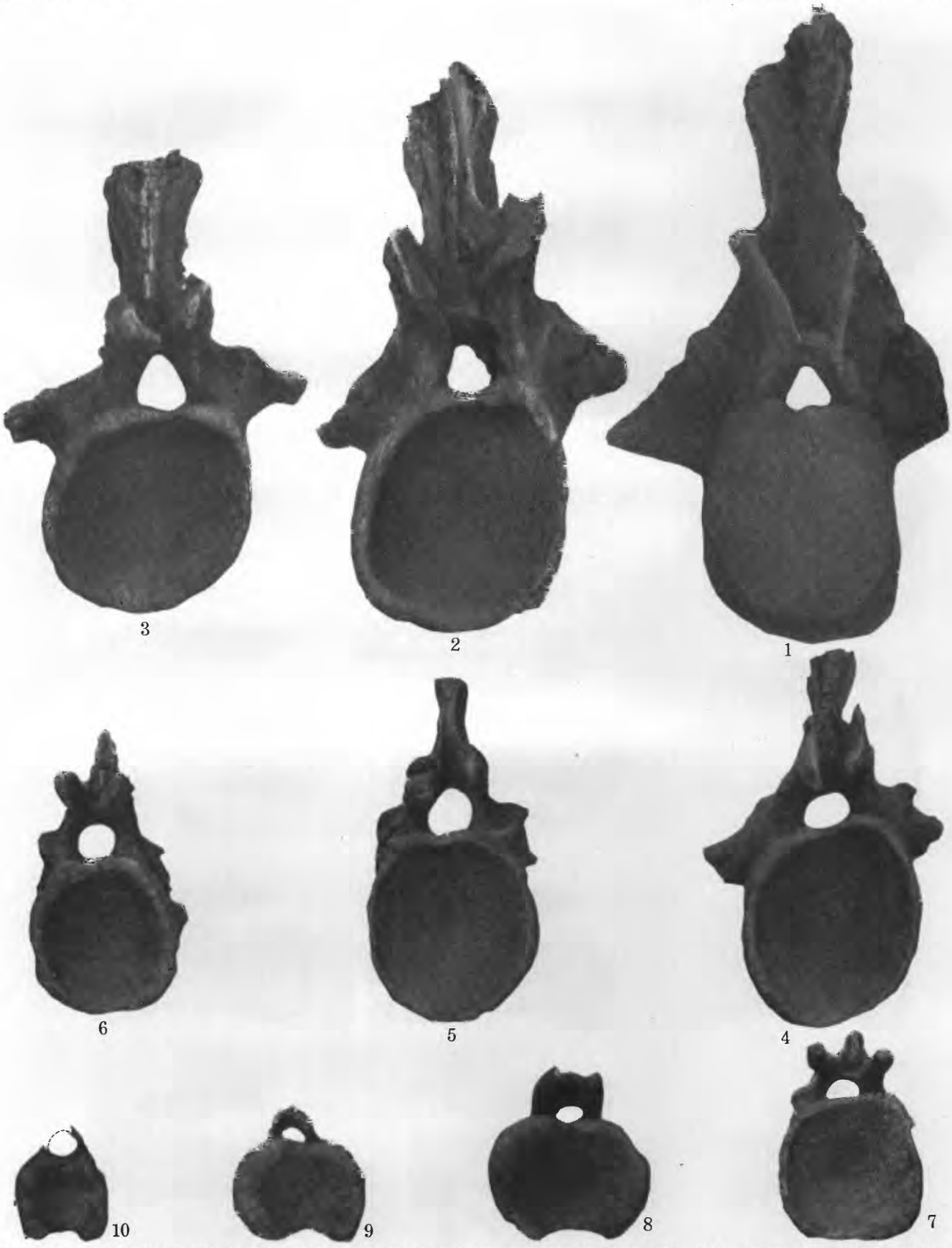
CAUDAL VERTEBRAE 7 TO 15 OF *ALAMOSAURUS SANJUANENSIS* GILMORE (U. S. NAT. MUS. 15560), LATERAL VIEW.

About one-fifth natural size.



CAUDAL VERTEBRAE 16 TO 30 OF *ALAMOSAURUS SANJUANENSIS* GILMORE (U. S. NAT. MUS. 15560), LATERAL VIEW.

About one-fifth natural size.



CAUDAL VERTEBRAE OF *ALAMOSAURUS SANJUANENSIS* GILMORE (U. S. NAT. MUS. 15560), ANTERIOR VIEW.

About one-fifth natural size.

FIGURE 1. CAUDAL 1.
2. CAUDAL 2.
3. CAUDAL 4.
4. CAUDAL 7.
5. CAUDAL 10.
6. CAUDAL 13.
7. CAUDAL 16.
8. CAUDAL 23.
9. CAUDAL 27.
10. CAUDAL 30.

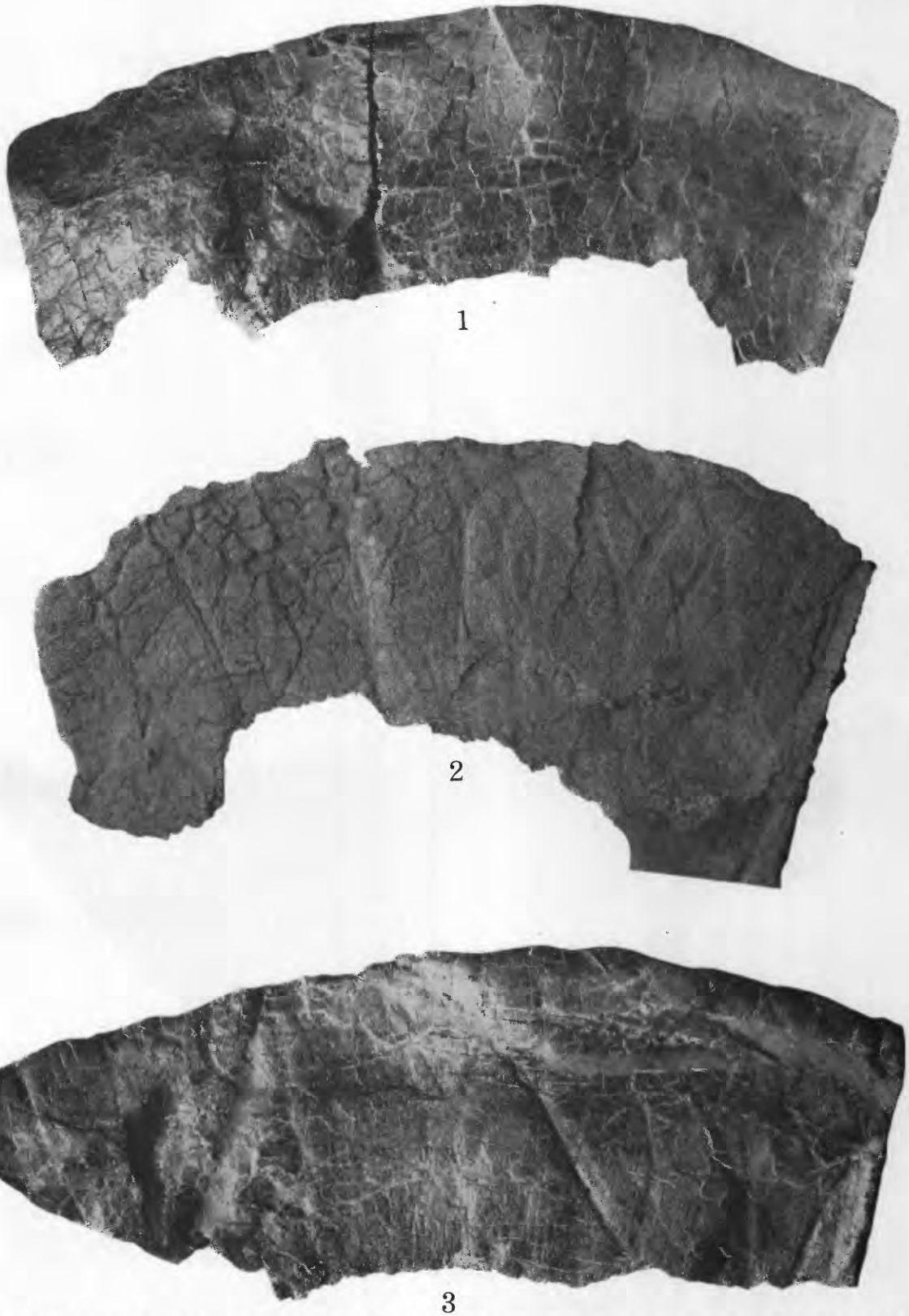
STERNAL PLATES OF *ALAMOSAURUS SANJUANENSIS* GILMORE (U. S. NAT. MUS. 15560), VENTRAL VIEW.

About one-seventh natural size.

FIGURE 1. LEFT SCAPULA OF *ALAMOSAURUS SANJUANENSIS* GILMORE, TYPE (U. S. NAT. MUS. 10486).
About one-seventh natural size.

FIGURE 2. RIGHT ISCHIUM OF *ALAMOSAURUS SANJUANENSIS* GILMORE, PARATYPE (U. S. NAT. MUS. 10487).
About one-tenth natural size.

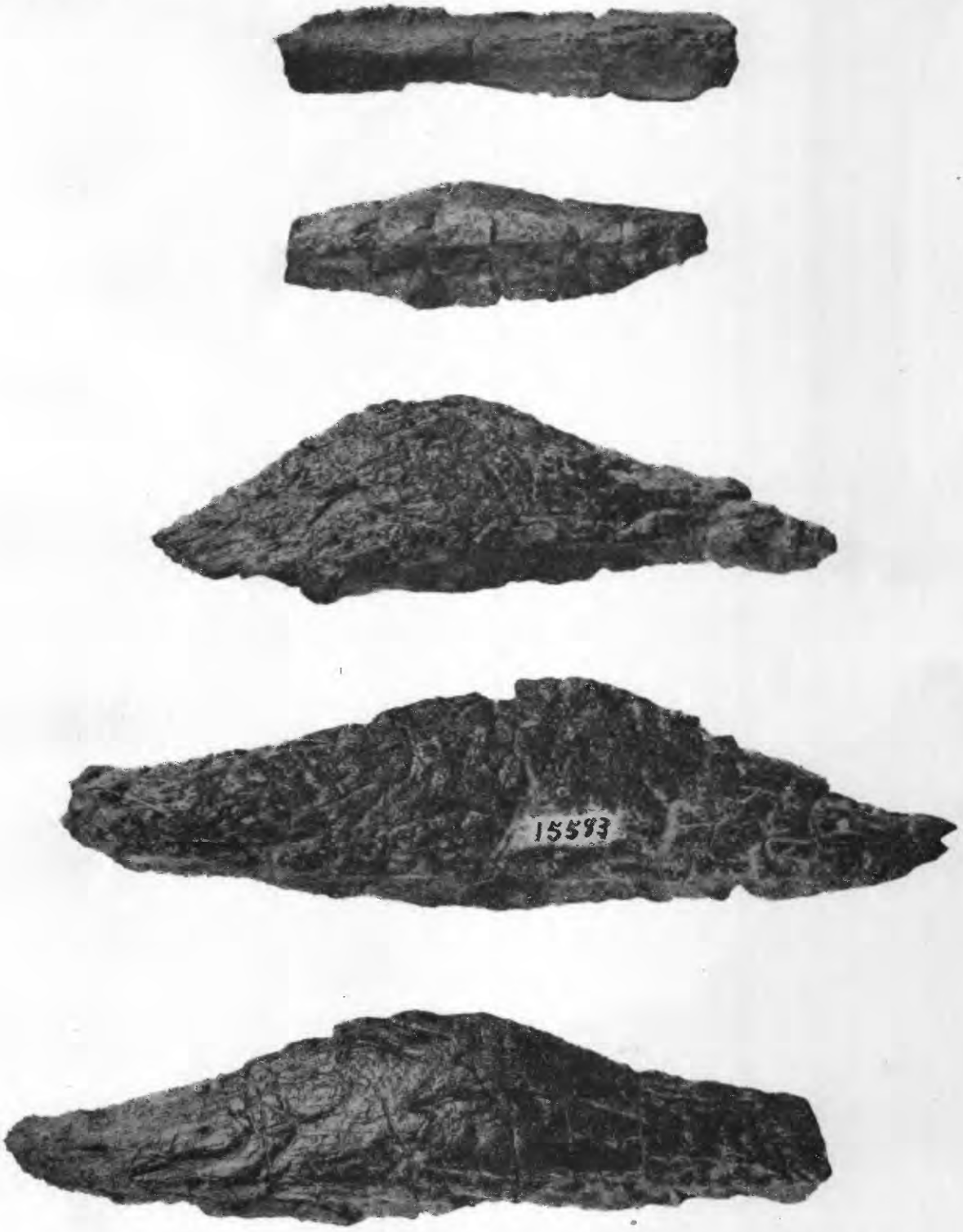
FIGURE 3. CAUDAL CENTRUM OF *ALAMOSAURUS SANJUANENSIS* GILMORE (U. S. NAT. MUS. 15658), LATERAL VIEW.
About 0.42 natural size.



CREST PORTIONS OF THE FRILL OF *ARRHINOCERATOPS? UTAHENSIS* GILMORE, N. SP., VIEWED FROM THE TOP.

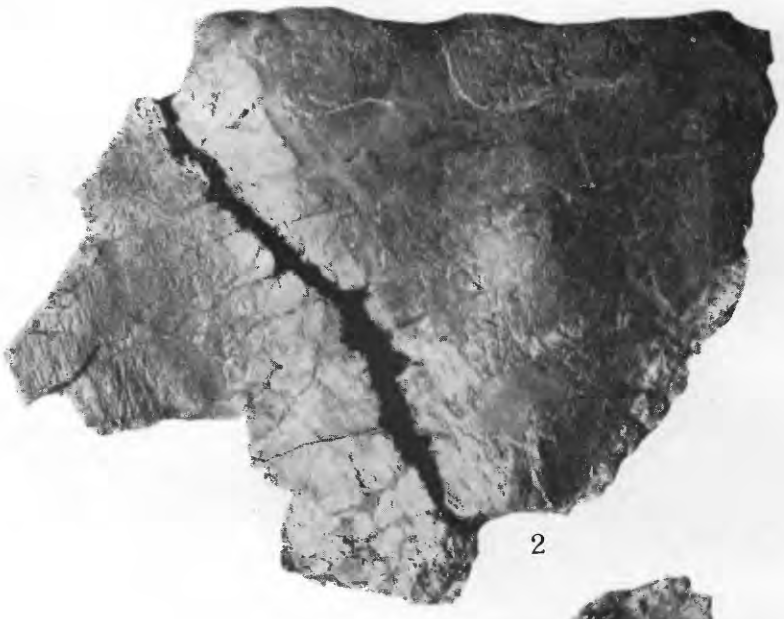
FIGURE 1. TYPE (U. S. NAT. MUS. 15583).
FIGURE 2. PARATYPE (U. S. NAT. MUS. 15875).
FIGURE 3. U. S. NAT. MUS. 16573.
All about one-fourth natural size.

MEDIAN PORTION OF THE SKULL OF *ARRHINOCERATOPS? UTAHENSIS* GILMORE, N. SP., (U. S. NAT. MUS. 16169).
About one-fifth natural size.



EPOCCIPITAL BONES TENTATIVELY REFERRED TO *ARRHINOCERATOPS? UTAHENSIS* GILMORE, N. SP.
Natural size.

1



2

3

4

FIGURE 1. RIGHT FEMUR OF HADROSAURIAN DINOSAUR (U. S. NAT. MUS. 16318), BACK VIEW.
About one-tenth natural size.

FIGURE 2. MEDIAN PORTION OF CERATOPSIAN PARIETAL (U. S. NAT. MUS. 16573), TOP VIEW.
About one-third natural size.

FIGURE 3. LEFT EPIJUGAL OF CERATOPSIAN SKULL (U. S. NAT. MUS. 16577), FRONT VIEW.
About two-fifths natural size.

FIGURE 4. CREST PORTION OF CERATOPSIAN PARIETAL (U. S. NAT. MUS. 16573), TOP VIEW.
About one-third natural size.

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BULIMINA AND RELATED FORAMINIFERAL GENERA

BY

JOSEPH A. CUSHMAN AND FRANCES L. PARKER

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ABSTRACT

This paper describes and illustrates the species belonging to the genera of the first 3 subfamilies of the Family Buliminidae, the Terebralininae, Turrilininae, and Bulimininae except *Entosolenia*. In the Terebralininae the genus *Terebralina* includes 1 species. In the Turrilininae the genus *Turrilina* includes 2 species, *Buliminella* 49 species and varieties, *Buliminoides* 1 species, *Ungulatella* 4 species, *Robertina* 19 species, and *Pseudobulimina* 3 species. In the Bulimininae the genus *Bulimina* includes 196 species and varieties, the subgenus *Desinobulimina* 5 species; 97 other species assigned originally to *Bulimina* have been assigned to other genera or are indeterminate. *Neobulimina* includes 4 species, *Globobulimina* 9 species and varieties. Four species are new and one new name is proposed. Twenty-one species and varieties described since this work was completed are listed in a supplement.

INTRODUCTION

The genus *Bulimina* is represented by many species from the Jurassic to the present time. Other related genera, nine in number, forming the first three subfamilies of the Foraminiferal family Buliminidae, are also included here. The genus *Entosolenia* is not included, as without recourse to the actual types it is very difficult to place many of the species.

A study has been made of the older types, where available, and of other species topotype material has often been examined As a result a great majority of the described species has been studied from actual material. Original figures and descriptions are given for most of the other species for which actual material is not available. During the several years that this study has been carried on, numerous short papers have been published giving descriptions and figures of new species and varieties as well as notes on the older species. Most of the records for the genera and species will be found in the references. References in the literature that are without figures usually have not been included unless original material or material from the same area has been available.

ACKNOWLEDGMENTS

Our thanks are due particularly to Miss Ann Shepard for her careful and accurate drawings of many of the species and redrawing of many of the types of the older species, the results of which appear in the accompanying plates; to Miss Anna Laura Dorsey for help in making up the plates and checking the manuscript; and to Miss Alice E. Cushman for the typing of portions of the manuscript.

Our thanks are due also to Dr. John B. Reeside, Jr., Chief of the Section of Paleontology and Stratigraphy of the Geological Survey, for making possible the completion of this work as part of the regular work of the Survey.

We are indebted to many co-workers for sending us material from various regions. Mr. Bradford C. Adams sent us very fine series of *Bulimina* and related forms from the Tertiary of California. Material from Venezuela was received from Dr. Hollis Hedberg, from Trinidad from Mr. P. W. Jarvis and Dr. H. H. Renz, and from Cuba from Dr. Pedro J. Bermúdez. Our thanks are due to Mr. Arthur Earland of England, Dr. A. Franke of Germany, Mr. W. J. Parr of Australia, Dr. Shoshiro Hanzawa of Japan, and many others for valuable material yielding specimens of *Bulimina* and other related genera.

SYSTEMATIC DESCRIPTIONS

Family BULIMINIDAE

Subfamily 1. TEREBRALININAE

Test in an elongate, close spiral, not divided into chambers; all calcareous, perforate; aperture rounded, subterminal.

Genus TEREBRALINA Terquem, 1866

Terebralina Terquem, Sixième mémoire sur les foraminifères du Lias, p. 473, 1866.

Cushman, Cushman Lab. Foram. Research Contr., vol. 3, p. 65, 1927; idem, Special Pub. 1, p. 243, 1928; idem, Special Pub. 4, p. 216, 1933.

Genotype, *Terebralina regularis* Terquem.

Test consisting of a proloculum and elongate, undivided, tubular, second chamber in an elongate close spiral; wall calcareous, perforate; aperture rounded, terminal. Jurassic.

There is a single species known.

Terebralina regularis Terquem

Plate 15, figure 1

Terebralina regularis Terquem, Sixième mémoire sur les foraminifères du Lias, p. 473, pl. 19, fig. 3, 1866.

Cushman, Cushman Lab. Foram. Research Special Pub. 1, pl. 35, fig. 6; pl. 37, fig. 1, 1928; idem, Special Pub. 4, pl. 22, fig. 1, 1933; idem, Special Pub. 5, pl. 22, fig. 1, 1933.

Test elongate, a close spiral about the vertical axis, undivided into chambers, circular in transverse section; wall calcareous, perforate, smooth; aperture rounded, subterminal, the apertural end somewhat contracted and prolonged.

The types are from the Jurassic, lower Lias, "les Bossons (près de Nohant, Indre)", France. It is recorded as very rare.

Subfamily 2. TURRILININAE

Test an elongate, close spiral, divided into chambers, usually more than three to a whorl, lines of the spiral very distinct.

Genus TURRILINA Andreae, 1884

Turrilina Andreae, Abh. geol. Specialkarte Elsass-Lothringen, vol. 2, pt. 3, p. 120, 1884.

Cushman, Cushman Lab. Foram. Research Contr., vol. 3, p. 65, 1927; idem, Special Pub. 1, p. 246, 1928; idem, Special Pub. 4, p. 217, 1933.

Bulimina (part) of authors.

Genotype, *Turrilina alsatica* Andreae.

Test an elongate, close spiral; chambers three or more in a whorl, spiral suture deep and continuous; wall calcareous, perforate; aperture at basal margin of chamber, broad, little if at all twisted. Jurassic? to Recent?

In this genus the spiral suture is very strongly marked, more so than those between the chambers.

Certain species that have been placed in this genus evidently belong elsewhere. The species referred to by White and others as *"Turrilina trochoides* (Reuss)" (White, Jour. Paleontology, vol. 3, p. 46, pl. 5, fig. 4, 1929) does not belong here. Sandidge has described and figured a species, *"Turrilina angulata"*, from the Cretaceous (Am. Midland Nat., vol. 13, p. 198, pl. 19, figs. 7, 8, 1932) which should not be included in this genus.

Turrilina alsatica Andreae

Plate 15, figure 3

Turrilina alsatica Andreae, Abh. geol. Specialkarte Elsass-Lothringen, vol. 2, pt. 3, p. 120, pl. 8, figs. 18, 19, 1884.

Cushman, Cushman Lab. Foram. Research Special Pub. 5, pl. 27, figs. 3a-c, 1933.

Test small, 1½ to 2 times as long as broad, rapidly tapering, greatest breadth formed by the last whorl, initial end subacute; chambers distinct, inflated, 3 to a whorl, increasing rapidly but uniformly in size as added; sutures distinct, the spiral suture very distinct and depressed; wall smooth; aperture low and broad, at the base of the apertural face, with a distinct margin. Length 0.20 to 0.25 mm.; diameter 0.15 to 0.18 mm.

The types of this species are from the Oligocene of Alsace. We have specimens from Andreae's locality of Lobsann and from other localities in the middle Oligocene of Germany.

Turrilina andreaei Cushman

Plate 15, figure 2

Turrilina andreaei Cushman, Cushman Lab. Foram. Research Special Pub. 5, pl. 27, figs. 2a, b, 1933.

Bulimina acicula Andreae (not Costa, 1856), Abh. Specialkarte Elsass-Lothringen, vol. 2, pt. 3, p. 277, pl. 12, fig. 13, 1884.

Paalzow, Offenbacher Ver. Naturkunde Ber., 1912-24, p. 65, pl. 1, fig. 6, 1912.

Turrilina acicula Cushman, Cushman Lab. Foram. Research Contr., vol. 3, p. 67, pl. 14, fig. 2, 1927; Soc. sci. Seine-et-Oise Bull., ser. 2, vol. 9, p. 52, pl. 2, figs. 5a, b, 1928; Cushman Lab. Foram. Research Special Pub. 4, pl. 22, fig. 2, 1933.

Test elongate, spiral, conical, 3 to 5 whorls in the adult, greatest width formed by the last whorl; chambers distinct, only slightly inflated, 5 or 6 in the adult whorl; sutures distinct, the spiral suture particularly so and more depressed than those between the chambers; wall smooth; aperture a high, arched opening at the base of the truncated or somewhat concave apertural face, with a slight lip. Length 0.25 to 0.40 mm., diameter 0.10 to 0.15 mm.

This species is known from the Oligocene of Alsace-Lorraine from the material described by Andreae, from the Mainz Basin recorded by Paalzow, and from Ormoy in France recorded by Cushman.

Genus BULIMINELLA Cushman, 1911

Buliminella Cushman, U. S. Nat. Mus. Bull. 71, pt. 2, p. 88, 1911; idem, Bull. 104, pt. 3, p. 108, 1922; Cushman Lab. Foram. Research Contr., vol. 3, pt. 1, p. 65, 1927; idem, Special Pub. 1, p. 246, 1928; idem, Special Pub. 4, p. 217, 1933.

Genotype *Bulimina elegantissima* d'Orbigny.

Test an elongate, close spiral, the spiral suture distinct; chambers 3 or usually more in a whorl; wall calcareous, perforate; aperture elongate, loop-shaped, very slightly twisted. Cretaceous to Recent.

Species are numerous in this genus, the earliest of which appear in the Cretaceous. Most species are smooth and the ornamentation, when it occurs, is relatively simple in comparison with the ornate character of many species of *Bulimina*. As a rule the species are relatively short-lived and make good index fossils.

Buliminella obtusa (D'Orbigny) Cushman and Parker

Plate 15, figure 4

Bulimina obtusa D'Orbigny, Soc. Géol. France Mém., ser. 1, vol. 4, p. 39, pl. 4, figs. 5, 6, 1840; Prodrome de Paléontologie, vol. 2, p. 282, No. 1399, 1850.

Buliminella obtusa Cushman and Parker, Cushman Lab. Foram.

Research Contr., vol. 10, p. 28, pl. 5, figs. 1 a, b, 1934; idem., vol. 12, p. 6, pl. 2, figs. 1a-c, 1936.

Brotzen, Sveriges geol. undersökning, ser. c, no. 396, p. 131, pl. 8, figs. 2a, b, 1936.

Test large, slightly tapering, almost twice as long as broad, consisting of 4 to 5 whorls; chambers 4 to a whorl, the last-formed chamber constituting slight, lobular projection; sutures flush with the surface, slightly limbate, appearing as somewhat darkened lines; wall smooth, polished, coarsely perforate; aperture loop-shaped, with a depressed area extending down from it along the suture bounding the apertural face. Length 0.71 mm., diameter 0.42 mm.

This species was described from the Upper Cretaceous of Meudon and Sainte Germaine in the Paris Basin, and of England. We have specimens which may be referred to this species from Bougival, France.

It seems possible that this form may represent a variant of *Buliminella laevis* (Beissel), but lack of evidence makes it advisable to keep the two species separate for the present.

Buliminella imbricata (Reuss) Cushman and Parker

Plate 15, figure 5

Bulimina imbricata Reuss, Haidinger's naturwiss. Abh., vol. 4, p. 22, pl. 3, fig. 7, 1851.

Franke, Preuss geol. Landesanstalt Abh., n. ser., vol. 111, p. 159, pl. 14, fig. 20, 1928.

Buliminella imbricata Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 10, p. 31, pl. 5, figs. 19a, b, 1934; idem., vol. 12, p. 6, pl. 2, figs. 2a-c, 1936.

Test small, somewhat tapering, usually twice as long as broad, with about 4 whorls; chambers 4 to a whorl; sutures distinct, dark, spiral suture slightly depressed; others flush with the surface; wall smooth, very coarsely perforate, somewhat polished; aperture comma-shaped, almost at the apex of the apertural face, which is somewhat rounded. Length 0.18 to 0.28 mm., diameter 0.12 to 0.16 mm.

The species was described from the Upper Cretaceous, Senonian, of Lemberg, Galicia. Our specimens from Lemberg are very much smaller than those described by Reuss. In other respects, however, they appear very similar and it seems best to refer them to this species. One of them is figured here. A few other specimens were found in the Senonian of Germany.

The form is broader and less tapering than *Buliminella pusilla* (Brotzen).

Buliminella laevis (Beissel) Cushman and Parker

Plate 15, figure 6

Bulimina laevis Beissel, Preuss. geol. Landesanstalt Abh., n. ser., vol. 3, p. 66, pl. 12, figs. 39-43, 1891.

Buliminella laevis Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 12, p. 6, pl. 2, figs. 3a-c, 1936.

Brotzen, Sveriges geol. undersökning, ser. c, no. 465, p. 45, 1945.

Bulimina elegans Heron-Allen and Earland (not D'Orbigny), Royal Micr. Soc. Jour., p. 409, pl. 6, fig. 11, 1910.

Bulimina ovulum Franke (not Reuss), Geol. pal. Instit. Univ. Greifswald Abh., vol. 6, p. 25, pl. 2, fig. 17, 1925; Preuss. geol. Landesanstalt Abh., n. ser., vol. 111, p. 157, pl. 14, fig. 14, 1928.

Test large, about 1⅘ times as long as broad, consisting of 3 or more whorls; chambers 4 to a whorl, very slightly inflated; sutures slightly depressed, especially in the earlier whorls, giving the test an irregular appearance, usually flush with the surface in the last whorl; wall smooth, finely perforate, sometimes polished; aperture comma-shaped, broad at the base, near the apex of the apertural face, in some specimens with a small depression extending down from it along the base of the last-formed chamber, sometimes as far as the suture joining the second and third chambers; also in a few specimens a very short, depressed area extending up from the base of the aperture along the same suture. Length 0.54 to 0.91 mm., diameter 0.42 to 0.48 mm. (The occasional dwarfed specimens which are found at some localities were not used in compiling these measurements).

The species was described from Friedrichsberg, near Aachen, Germany. It is common in the Upper Cretaceous, Senonian, of Europe and England. Various authors, including Reuss himself, in later papers have confused this form with *Bulimina ovulum* Reuss (*Bulimina reussi* Morrow), which is distinctly a *Bulimina*. It is a larger species than *Buliminella cushmani* Sandidge and differs from it in the shape of the aperture and the size and shape of the apertural face.

Buliminella pusilla (Brotzen) Cushman and Parker

Plate 15, figure 7; plate 21, figure 5

Bulimina pusilla Brotzen, Sveriges geol. undersökning, ser. c, no. 396, p. 127, pl. 8, fig. 4; text fig. 44, 1936.

Test small, slender, slightly tapering, about 2¼ times as long as broad, consisting of 4 whorls; chambers 4 to a whorl, fairly distinct; sutures slightly depressed; wall smooth, coarsely perforate; aperture loop-shaped, near the apex of the test. Length 0.20 mm., diameter 0.09 mm.

The above description is given of a single syntype of the species sent by Dr. Brotzen. It was originally described from the Upper Cretaceous, lower Senonian, of Eriksdal, Sweden. We have one other specimen similar to this form from Lubitsch, Czechoslovakia.

The species differs from *Buliminella imbricata* (Reuss) is being much more slender and more tapering, and in having the broadest part of the test near the apex.

Buliminella carseyae Plummer

Plate 15, figure 8

Bulimina compressa Carsey (not Bailey, 1851), Texas Univ. Bull. 2612, p. 29, pl. 4, fig. 14, 1926.

Buliminella carseyae Plummer, Texas Univ. Bull. 3101, p. 179, pl. 8, fig. 9, 1931.

Cushman, Jour. Paleontology, vol. 6, p. 340, 1932.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 12, p. 8, pl. 2, figs. 6a-c, 1936.

Loetterle, Nebraska Geol. Survey Bull., 2d ser., Bull. 12, p. 37, pl. 5, figs. 10a, b, June, 1937.

Cole, Florida Dept. Cons. Geol. Bull. 16, p. 35 (list), pl. 4, fig. 2, 1938.

Cushman, Cushman Lab. Foram. Research Contr., vol. 20, p. 12, pl. 2, fig. 24; p. 93, pl. 14, fig. 10, 1944; U. S. Geol. Survey Prof. Paper 206, p. 119, pl. 50, figs. 17-20, 1946.

Buliminella hofkeri Brotzen, Sveriges geol. undersökning, ser. c, no. 396, vol. 30, no. 3, p. 129, pl. 8, fig. 3; text fig. 45, 1936.

Test ovate, about twice as long as broad, initial extremity bluntly pointed; chambers about four in each mature whorl, turgid, smooth; sutures distinctly depressed, disposed at a strong angle to the elongate axis of the test; aperture small, comma-shaped, in a strong depression on the septal face and overhung by a sharp projection of the apex of the last chamber and marked by a minute and very narrow apertural flap extending down the long side of the septal face. Length .39 mm.; diameter .22 mm.—Plummer.

The types of this species are from the Upper Cretaceous, upper part of the Taylor formation, on right bank of Onion Creek near bridge at Moore and Berry's Crossing, 8½ miles in a straight line southeast of the capitol in Austin, Texas.

The species is found in the Upper Cretaceous Navarro group, and the Taylor and Austin formations of Texas. It occurs rarely in the Navarro but is very widespread and abundant in the Taylor. In the Austin the form is not so common and is usually smaller and somewhat shorter in proportion to its length than the typical form. We have specimens also from the Turonian and Senonian of Germany and from the Upper Cretaceous of Gravesend, England. These forms have been referred by Brotzen to the new species *Buliminella hofkeri*. As they appear to us to be in every way identical with the American form, which Brotzen notes that he had no opportunity of seeing, his species is placed in the synonymy under Mrs. Plummer's.

The species is related to *Buliminella laevis* (Beissel) but is much smaller and shows much more inflation of the chambers.

Buliminella carseyae Plummer var. plana Cushman and Parker

Plate 15, figure 9

Buliminella carseyae Plummer var. *plana* Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 12, p. 8, pl. 2, figs. 7a-c, 1936.

Cushman and Hedberg, idem, Contr., vol. 17, p. 94, pl. 22, figs. 26a-c, 1941.

Cushman and Todd, idem, Contr., vol. 19, p. 65, pl. 11, fig. 20, 1943.

Cushman, U. S. Geol. Survey Prof. Paper 206, p. 120, pl. 50, figs. 16, 21, 22, 1946.

Test small, about 1½ times as long as broad, consisting usually of 4 whorls, the last-formed whorl constituting at least half the test; chambers distinct, somewhat inflated; sutures distinct, depressed; wall smooth, perforate; aperture comma-shaped. Length 0.18 to 0.24 mm., diameter 0.10 to 0.15 mm.

This variety was described from the Upper Cretaceous Navarro formation on the San Antonio road, 6 miles east of Castroville, Bexar County, Texas. Our specimens are from the Navarro or formations of equivalent age in the Gulf Coast region of the United States and from the Upper Cretaceous of Columbia.

The variety differs from the typical form in the smaller size of the test and the lesser inflation of the chambers.

Buliminella cushmani Sandidge

Plate 15, figures 10, 11

Buliminella cushmani Sandidge, Jour. Paleontology, vol. 6, p. 280, pl. 42, figs. 18, 19, 1932.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 12, p. 8, 1936.

Cole, Florida Dept. Cons. Geol. Bull. 16, p. 34 (list), pl. 2, fig. 14, 1938.

Cushman and Deaderick, Jour. Paleontology, vol. 18, p. 337, pl. 53, fig. 5, 1944.

Applin and Jordan, idem, vol. 19, p. 132, 1945.

Cushman, U. S. Geol. Survey Prof. Paper 206 p. 119, pl. 50, fig. 15, 1946.

Test medium, tapering, widest portion about ⅔ of the length from the initial end, usually consisting of 4 whorls; chambers distinct, 4 to a whorl, slightly inflated in the first 3 whorls; sutures distinct, spiral suture slightly depressed, others flush with the surface, usually darker in color than the rest of the test; wall smooth, finely perforate; aperture loop-shaped, near apex of the apertural face, which is flaring and somewhat flattened. Specimens from the Upper Cretaceous Kemp clay on a branch of Mustang Creek, 1 mile west-southwest of Noack, 900 feet downstream from road, Williamson County, Texas. Length 0.34 to 0.50 mm., diameter 0.22 to 0.24 mm.

The types of the species are from the Upper Cretaceous Ripley formation in an exposure at the mouth of Boguechitto Creek, Alabama. We have no topotype material, but there seems little doubt that our specimens may be referred to Sandidge's species. This species occurs in the Upper Cretaceous of the Gulf Coast area of the United States in the Saratoga chalk, Corsicana marl, Kemp clay, Marlbrook marl, and Prairie Bluff formation. It occurs also in the Upper Senonian of Germany and France.

Sandidge describes the species as very similar to *Buliminella carseyae* but differing from it in being smaller and more compact, with less inflated chambers and more gracefully curving sutures. It is also similar to *Buliminella laevis* (Beissel), but is smaller, has a broader apertural face and a broader, less curved aperture.

Buliminella vitrea Cushman and Parker

Plate 15, figure 12

Buliminella vitrea Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 12, p. 7, pl. 2, figs. 4a-c, 1936.

Cushman, U. S. Geol. Survey Prof. Paper 206, p. 119, pl. 50, fig. 14, 1946.

Test small, about 1½ times as long as broad, slightly tapering, consisting of 3 to 4 whorls, the last-formed whorl constituting more than half the test; chambers distinct, slightly inflated; sutures distinct, depressed; wall partially transparent, coarsely perforate; aperture comma-shaped. Length 0.16 to 0.25 mm., diameter 0.08 to 0.15 mm.

The species was described from the Upper Cretaceous Selma chalk at a locality 2 miles west of Guntown, Mississippi. It occurs in the Selma chalk of the eastern Gulf region and at one locality in the upper Austin of Texas.

The species resembles *Buliminella imbricata* (Reuss), but differs from it in the more curving sutures, the greater inflation of the chambers, and the transparency of the test.

Buliminella fabilis Cushman and Parker

Plate 15, figure 13

Buliminella fabilis Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 12, p. 7, pl. 2, figs. 5a-c, 1936.

Cushman, U. S. Geol. Survey Prof. Paper 206, p. 119, pl. 50, fig. 13, 1946.

? Buliminella imbricata Cushman (not Reuss), idem, vol. 7, p. 42, pl. 5, figs. 10a-c, 1931.

Test small, about twice as long as broad, tapering, consisting of 4 to 5 whorls, the last-formed whorl taking up about two-thirds of the test; chambers distinct, those in the last whorl very slightly inflated; sutures distinct, slightly depressed; wall smooth, perforate; aperture loop-shaped, near apex of test. Length 0.16 to 0.20 mm., diameter 0.08 to 0.10 mm.

The species was described from the Upper Cretaceous, lower part of the Taylor formation, in the bank of small stream, 45 feet north of Hillsboro-Corsicana road, 14.2 miles east of Hillsboro, Texas. It occurs in the Taylor, Austin, and Eagle Ford formations of Texas.

The form is very close to *Buliminella pusilla* Brotzen, but as we have only a single specimen of the latter, kindly sent by Dr. Brotzen, it seems best not to combine the two.

Buliminella colonensis Cushman and Hedberg

Plate 15, figures 14, 15

Buliminella colonensis Cushman and Hedberg, Cushman Lab. Foram. Research Contr., vol. 6, p. 65, pl. 9, figs. 6, 7, 1930.

Cushman, U. S. Geol. Survey Prof. Paper 206, p. 120, pl. 50, figs. 23, 24, 1946.

Test medium, nearly as broad as long, at least in the microspheric form, initial end pointed, apertural end broadly rounded; chambers 5 or 6 in the last-formed whorl, elongate, rather uniformly increasing in size as added, very slightly inflated; sutures distinct, very slightly depressed; wall smooth; aperture broadly comma-shaped, the greatest breadth at the inner end of the aperture. Length up to 0.40 mm., diameter 0.35 mm.

The types of the species are from the Upper Cretaceous Colon shale in the Department of Escuque, State of Trujillo, Venezuela. The species occurs also in the Upper Cretaceous Velasco shale and Mendez formation of Mexico.

The species is most closely related to *Buliminella cushmani* Sandidge but differs from it in having fewer whorls and in tapering more rapidly.

Buliminella fusiforma Jennings

Plate 30, figure 2

Buliminella fusiforma Jennings, Bull. Am. Paleontology, vol. 23, no. 78, p. 30, pl. 3, fig. 18, 1936.

Test fusiform, initial end pointed, apertural end rounded; about three whorls to a test, the last forming 80 per cent of the test; four chambers to a whorl; sutures distinct, depressed, spiral suture much more strongly depressed than transverse; aperture virguline, in a depression in the septal face forming a strong angle with the axis of the test. Length 0.21–0.32 mm.; width, 0.18 mm.—Jennings.

This species was described from the Upper Cretaceous Navesink marl of New Jersey.

Buliminella irregularis (Terquem) Cushman and Parker

Plate 15, figure 16

Bulimina irregularis Terquem, Soc. Géol. France Mém., ser. 3, vol. 2, p. 112, pl. 12(20), figs. 1a, b, 1882.

?Bulimina scalariformis Terquem, idem, p. 114, pl. 12(20), fig. 13.

Buliminella irregularis Cushman and Parker (part), Cushman Lab. Foram. Research Contr., vol. 13, p. 68, pl. 9, figs. 6a-c (not figs. 7a-c), 1937.

van Bellen, Geol. Stichting Mededeelingen, ser. C-V, No. 4, p. 45, pl. 4, fig. 11, 1946.

Test small, elongate, tapering from the initial end to the greatest breadth made by the last-formed whorl, about 3 times as long as broad, initial end with an acerose spine; chambers distinct, slightly inflated, almost 4 in the adult whorl, increasing very gradually in size as added; sutures distinct, slightly depressed, somewhat limbate;

wall smooth, except above the aperture, where there are numerous radiating lines or slight ridges running down into the apertural face; aperture very small, broadly loop-shaped, at the inner margin of the apertural face, which is strongly depressed and has a rounded lip. Length of Terquem's specimen 0.37 mm., diameter 0.16 mm. Length of our specimen 0.35 mm., diameter 0.14 mm.

The species was described from the Eocene, Vaudancourt, Paris Basin, France. We have a single specimen from the sand of Chaméry, in the Paris Basin.

This species may be distinguished by its tapering test, basal spine, and the depressed apertural face with the radiating ridges.

Buliminella turbinata (Terquem) Cushman and Parker

Plate 15, figures 18-21

Bulimina turbinata Terquem, Soc. Géol. France Mém., ser. 3, vol. 2, p. 113, pl. 12(20), figs. 6, 7, 1882.

Bulimina ovula Terquem (not D'Orbigny), idem, p. 113, pl. 12(20), fig. 5.

Buliminella turbinata Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 13, p. 68, pl. 9, figs. 8a-c, 9a-c, 1937.

Test small, about twice as long as broad, somewhat fusiform, initial end subacute, last-formed whorl composing the greater part of the test; chambers distinct, 6 or 7 to a whorl, elongate and narrow, slightly, if at all, inflated; sutures distinct, usually flush with the surface, slightly limbate; wall smooth, finely perforate; aperture loop-shaped, in a distinct depression on the apertural face, which is otherwise somewhat rounded and formed of clear shell material. Length of Terquem's specimens 0.50 to 0.52 mm., diameter 0.24 to 0.30 mm. Length of our specimens 0.30 to 0.35 mm., diameter 0.10 to 0.15 mm.

Terquem records the species are rare in the Eocene at Vaudancourt, Paris Basin, France. We have specimens from several localities of the Calcaire grossier inférieur and lower Lutétian of the Paris Basin. A single specimen was found in the Oligocene Stampian at Lounandière, France.

The last-formed whorl of this species composes a far greater proportion of the test than that of either *Buliminella intorta* (Terquem) or *B. glomerata* Cushman and Parker and the spiral suture is not depressed. The test is more tapering than that of the former species, and the chambers are somewhat narrower than those of the latter.

Buliminella flexa (Terquem) Cushman and Parker

Plate 16, figure 1

Bulimina flexa Terquem, Soc. Géol. France Mém., ser. 3, vol. 2, p. 115, pl. 12(20), fig. 15, 1882.

Test small, slender, slightly tapering, with a rounded initial end, consisting of 3 or 4 whorls; chambers distinct, 4 to a whorl; sutures distinct, flush with the surface; wall smooth, finely perforate; aperture small, loop-shaped, placed toward the top of the apertural face, which is formed of clear shell material. Length of figured specimen 0.30 mm., diameter 0.13 mm.

The species was described from the Eocene Septeuil, Paris Basin, France. We have specimens from several localities in the Paris Basin.

This form has fewer chambers to the whorl than *Buliminella intorta* (Terquem), and the spiral suture is not depressed.

Buliminella intorta (Terquem) Cushman and Parker

Plate 15, figure 17

Bulimina intorta Terquem, Soc. Géol. France Mém., ser. 3, vol. 2, p. 115, pl. 12(20), fig. 16, 1882.

Bulimina pulchra Terquem (part), idem, p. 114, pl. 12(20), fig. 10 (not figs. 8, 9, 11, 12).

Buliminella irregularis Cushman and Parker (not *Bulimina irregularis* Terquem) (part), Cushman Lab. Foram. Research Contr., vol. 13, p. 68, pl. 9, figs. 7a, b (not figs. 6a-c), 1937.

Test small, somewhat fusiform, consisting of about 3 whorls; chambers distinct, 5 to a whorl, narrow; sutures distinct, spiral suture depressed, others flush with the surface, darker in color than the rest of the test; aperture small, loop-shaped, on the apertural face, which is rounded and does not extend down the side of the test. Length of figured specimen 0.25 mm., diameter 0.10 mm.

The species was described from the Eocene, Septeuil, Paris Basin, France. We have material from Chaméry in the Paris Basin.

This form has narrower, more curving chambers than *Buliminella flexa* (Terquem), and the spiral suture is depressed.

Buliminella conulus (Terquem) Cushman and Parker

Plate 16, figure 2

Bulimina conulus Terquem, Soc. Géol. France Mém., ser. 3, vol. 2, p. 116, pl. 12(20), fig. 17, 1882.

Cushman and Parker, Cushman Lab. Foram Research Contr., vol. 13, p. 73, 1937.

Test conical, pyramidal, rounded at the top, slender and obtuse at the bottom, straight on the sides, covered with very fine perforations arranged in vertical lines, formed of 5 whorls, not projecting, with transverse sutures, the first very close, the last widely separated; chambers smooth, quadrangular, sutures linear, curved; aperture round, in an ovally pointed depression, surrounded by a thick border. Length 0.53 mm., diameter 0.18 mm.

This description is a translation of Terquem's description of the species from the Eocene of Septeuil, Paris Basin, France. We have no typical material.

Buliminella pupa (Terquem) Cushman and Parker

Plate 16, figure 3

Bulimina pupa Terquem, Soc. Géol. France Mém., ser. 3, vol. 2, p. 116, pl. 12(20), figs. 18a, b, 1882.

Bulimina striato-punctata Terquem, idem, p. 116, pl. 12(20), fig. 19.

Buliminella striato-punctata Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 13, p. 69, pl. 10, figs. 3a-c, 1937.

Test small, elongate, 2½ to 3 times as long as broad, sides in the middle portion nearly straight and parallel, initial end subacute, apertural end somewhat truncate; chambers distinct, very slightly inflated, usually 3 to a whorl, with the final chambers somewhat offset from the others; sutures distinct, very slightly curved, very slightly depressed, usually dark in color; wall with rather coarse punctae arranged in longitudinal lines, the bottom part of the test, and sometimes more, ornamented by faint costae; aperture elongate, rounded, at the inner margin of the last-formed chamber in a distinct depression of the apertural face. Length 0.30 to 0.60 mm., diameter 0.12 to 0.16 mm.

The types are from the Eocene at Vaudancourt, Paris Basin, France. The species occurs at several localities in the Paris Basin.

It seems probable that *B. pupa* and *B. striato-punctata* of Terquem should be combined, as specimens resembling the figures of both are found in the same species. The form may be differentiated from others by the punctate test and the faint striations or costae, which are sometimes barely visible unless viewed with cross lighting.

Buliminella semi-nuda (Terquem) Cushman and Parker

Plate 16, figures 4, 9

Bulimina semi-nuda Terquem, Soc. Géol. France Mém., ser. 3, vol. 2, p. 117, pl. 12(20), fig. 21, 1882.

Bulimina obliqua Terquem (not D'Orbigny), idem, p. 118, pl. 12(20), fig. 23.

Cushman and Parker, Cushman Lab. Foram Research Contr., vol. 13, p. 73, 1937.

Bulimina terquemiana Heron-Allen and Earland, Royal Micr. Soc. Jour., 1911, p. 314, pl. 9, figs. 13, 14.

Buliminella semi-nuda Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 13, p. 70, pl. 10, figs. 4a-c, 5a-c, 1937.

Buliminella terquemiana Cushman and Parker, idem, p. 71, pl. 10, fig. 7.

Test of medium size, about 1½ times as long as broad, initial end acute, often with a short, stout spine, greatest breadth at about the middle, rapidly tapering, the last-formed whorl constituting the greater part of the test; chambers indistinct, 6 to 8 in the adult whorl, increasing very gradually in size as added; sutures indistinct, narrow, usually not depressed except for the spiral suture; wall ornamented by numerous, irregular, longitudinal costae which often fade out and become almost untraceable in the upper portion of the test; aperture rounded, in a distinct depression of the inner margin of the broadly flaring apertural face, which is ornamented with fine, radiating ridges. Length of figured specimens 0.33 mm., 0.45 mm.; diameter 0.20 mm., 0.27 mm.

The species was described from the Eocene at Septeuil, Paris Basin, France. It occurs at several localities in the middle Eocene of the Paris Basin, France. We have one specimen from the Ocala limestone, east bank of the Flint River, Mitchell County, Georgia The form described by Cushman as *Buliminella elegantissima* (D'Orbigny) var. *semi-nuda* (Terquem) (U. S. Nat. Mus. Bull. 104, pt. 3, p. 108, pl. 23, fig. 5, 1922) is very similar except for the initial end, which is more rounded; it has well defined costae that extend to the top of the test and was recorded from the Recent material at *Albatross* sta. D2358 in the Caribbean. Bermúdez records this same form from a Recent locality north of Cuba (Soc. cubana hist. nat. Mem., vol. 9, p. 193, 1935). Brady's species of the same name (*Challenger* Rept., Zoology, vol. 9, p. 403, pl. 50, figs. 23, 24, 1884) from the Indo- Pacific may represent this variant, although figure 23 pictures a smooth form that should possibly be referred to *Buliminella madagascariensis* (D'Orbigny).

Bulimina terquemiana Heron-Allen and Earland, recorded as "fossil" from Selsey Bill, England, has been combined with this species, as a study of the Paris Basin specimens of *B. semi-nuda* in appropriate cross-lighting shows invariably that instead of extending only across the bottom half of the test the costae are continuous throughout the test. The specimens of *B. semi-nuda* show a gradation from the faintly costate forms to those having well-developed costae that can be easily seen. The costae and the broadly flaring apertural face differentiate this species from others.

Buliminella pulchra (Terquem) Cushman and Parker

Plate 16, figures 5, 6

Bulimina pulchra Terquem (part), Soc. Géol. France Mém., ser. 3, vol. 2, p. 114, pl. 12(20), figs. 8, 9, 11, 12 (not fig. 10), 1882.

Buliminella pulchra Cushman and Parker (not Tolmachoff), Cushman Lab. Foram. Research Contr., vol. 13, p. 69, pl. 10, figs. 1, 2, 1937.

Test small, about 2½ times as long as broad, composed of 3 or 4 whorls, the last forming about two-thirds of the surface of the test; chambers distinct, slightly, if at all, inflated, 5 or 6 in the adult whorl, fewer in the earlier whorls, increasing very slightly in size as added; sutures distinct, spiral suture depressed, especially in the microspheric form, others usually flush with the surface; wall smooth, very finely perforate; aperture an elongate open-

ing, in a depression at the inner margin of the last-formed chamber, placed toward the upper part of the apertural face, which is narrow and extends well down the side of the test. Length 0.40 to 0.45 mm., diameter 0.18 to 0.20 mm.

The species was described from the Eocene at Septeuil, Paris Basin, France. It is very common in the Paris Basin material. A single specimen was found in the Eocene from Kressenberg, Germany. It occurs also in the London clay at Barton, England.

The species differs from *Buliminella intorta* (Terquem) in having broader chambers and a longer apertural face that extends down the side of the test.

Buliminella alabamensis Cushman

Plate 16, figure 7

Buliminella alabamensis Cushman, Cushman Lab. Foram. Research Contr., vol. 2, p. 32, pl. 4, figs. 8a, b, 1926; U. S. Geol. Survey Prof. Paper 181, p. 34, pl. 13, figs. 6a, b, 1935.

Test small, ovate, broadest in front view slightly above the middle, initial end pointed, apertural end broadly rounded, somewhat obliquely truncated, whole test of 1½ to 2 coils; chambers fairly distinct, not inflated; sutures distinct but not depressed; apertural face with a very large open area somewhat broadening toward the base which reaches to at least the middle of the test; wall very thin and transparent. Length 0.22 mm.—Cushman.

The species was described from the upper Eocene at a locality a quarter of a mile west of Water Valley, Choctaw County, Alabama. It is not known elsewhere.

This species may be easily recognized by the peculiar opening in the apertural face.

Buliminella robertsi (Howe and Ellis) Martin

Plate 16, figure 8

Bulimina robertsi Howe and Ellis, in Howe, Louisiana Dept. Cons. Geol. Bull. 14, p. 63, pl. 8, figs. 32, 33, 1939.

Buliminella robertsi Martin, Stanford Univ. Publ., Univ. Ser., Geol. Sci., vol. 3, no. 3, p. 9 (list), 1943.

Cushman and Herrick, Cushman Lab. Foram. Research Contr., vol. 21, p. 64, pl. 10, fig. 15, 1945.

Cushman and Todd, idem, Contr., vol. 21, p. 94, pl. 15, fig. 12, 1945.

Bulimina guayabalensis Cushman and Thomas (not Cole), Jour. Paleontology, vol. 4, p. 38, pl. 3, figs. 6a, b, 1930.

Test very small, ovate in side view, subcircular in end view, composed of numerous short chambers which are coiled slightly more than three chambers to the whorl, wall thick, smooth; sutures only slightly depressed; aperture a low arched slit at the base of the last chamber.—Howe and Ellis.

Length of holotype 0.16 mm., diameter 0.11 mm.

The types are from the Eocene Cook Mountain formation, St. Maurice, Winn Parish, Louisiana. We have material from the Eocene Claiborne formation of Texas, and from the *Atlantis* cores 12-36 and 21-38 taken off the northeast coast of the United States. It has been recorded from the Eocene Lodo formation of California and McBean formation of Georgia.

The shape of the chambers, the number of chambers to a whorl, and the marked spiral suture are the characteristics which indicate that this species belongs in the genus *Buliminella*. It may be differentiated by its small, relatively round (in transverse section) test, and by the low, arched aperture.

Buliminella basistriata Cushman and Jarvis

Plate 16, figure 10

Buliminella basistriata Cushman and Jarvis, Cushman Lab. Foram. Research Contr., vol. 5, p. 11, pl. 2, figs. 17-19, 1929.

Renz, Proc. 8th Amer. Sci. Congress, p. 541 (list), 1942.

Test small, somewhat fusiform, tapering from the greatest width near the apertural end; chambers distinct, 4 to a whorl, slightly inflated; sutures distinct, slightly depressed; wall, except for the basal portion, smooth, finely perforate, basal portion with very fine striations; aperture large, in a small depression on the apertural face, which is small and rounded. Length 0.30 to 0.40 mm., diameter 0.15 mm.

The types are from the Eocene Mount Moriah beds of Vistabella Quarry, Trinidad. Similar specimens are found in the lower Miocene of the Maracaibo Basin, Venezuela, and the Tertiary of Santa Elena, Ecuador.

This species is much smaller than *Buliminella subfusiformis* Cushman, the chambers are less inflated, and the last-formed whorl makes up a greater proportion of the test.

Buliminella basistriata Cushman and Jarvis var. nuda Howe and Wallace

Plate 16, figure 11

Buliminella basistriata Cushman and Jarvis var. *nuda* Howe and Wallace, Louisiana Dept. Cons. Geol. Bull. 2, p. 60, pl. 11, fig. 4, 1932.

Cushman, Cushman Lab. Foram. Research Special Pub. 16, p. 22, pl. 4, fig. 30, 1946.

Buliminella subfusiformis Ellisor (not Cushman), Am. Assoc. Petroleum Geologists Bull., vol. 17, pl. 3, fig. 1, 1933.

Variety differing from the typical in the lack of ornamentation of the initial end.

The types are from the Eocene Jackson formation, Danville Landing, Ouachita River, Catahoula Parish, Louisiana. The variety occurs also in the Jackson group of Texas.

Buliminella grata Parker and Bermúdez

Plate 16, figure 12

Buliminella grata Parker and Bermúdez, Jour. Paleontology, vol. 11, p. 515, pl. 59, figs. 6a-c, 1937.

Bermúdez, Soc. cubana hist. nat. Mem., vol. 11, p. 342, 1937.

Cushman and Siegfus, Cushman Lab. Foram Research Contr., vol. 15, p. 27, pl. 6, figs. 14a, b, 1939; San Diego Soc. Nat. History Trans., vol. 9, no. 34, p. 411, pl. 16, figs. 37a, b, 1942.

Cushman and Stainforth, Cushman Lab. Foram. Research Special Pub. 14, p. 40, pl. 6, fig. 1, 1945.

Test of medium size, slightly longer than broad, tapering rapidly; consisting of 2 or 3 whorls; chambers 4 to a whorl; sutures distinct, broad, flush with the surface, usually incised to give a scalloped effect (especially noticeable when wet); wall smooth, finely perforate; aperture rounded, with small, narrow, radial depressions extending from it. Length 0.24 to 0.46 mm., diameter 0.18 to 0.38 mm.

The types are from the Eocene at Loma Principe, cut between Calle F and Avenida de los Presidentes, 20 meters west of José M. Gómez monument, Havana, Cuba. Besides the Eocene of Cuba the species occurs in the Eocene of California: in a small canyon, 50 feet stratigraphically above the top of a massive sandstone on the south slope of hill 2217 (Cholame quadrangle), about half a mile east of Tar Canyon, Kings County; and in the Kreyenhagen shale, Garza Creek, Fresno County. It also occurs in the Oligocene Cipero formation of Trinidad.

This species is much larger than *Buliminella robertsi* (Howe and Ellis) and has incised sutures.

Buliminella grata Parker and Bermúdez var. spinosa Parker and Bermúdez

Plate 16, figure 13

Buliminella grata Parker and Bermúdez var. *spinosa* Parker and Bermúdez, Jour. Paleontology, vol. 11, p. 516, pl. 59, figs. 7a-c, 1937.

Bermúdez, Soc. cubana historia nat. Mem., vol. 11, p. 343, 1937.

Variety differing from the typical form in its larger size and in the presence of short, thick, blunt spines in the lower part of the test, often covering the entire test of young specimens. Length 0.48 to 0.78 mm., diameter 0.40 to 0.66 mm.

The types are from the Eocene, north side of Elevador in Noroña, north of Guanajay, on railroad, Pinar del Rio Province, Cuba. It is not known elsewhere.

Buliminella westraliensis Parr

Plate 16, figures 14, 15

Buliminella westraliensis Parr, Royal Soc. West Australia Jour., vol. 24, p. 80, pl. 2, figs. 3, 4, 1937-38.

Test elongate, subcylindrical, more or less twisted in contour, initial end blunt, apertural end rounded; chambers numerous, long and narrow, added obliquely and arranged in a spiral series of about two and a half coils in the adult; sutures distinct, wall smooth; aperture elongate and narrow, in a semi-circular depression just below the end of the test. Length up to 0.40 mm; diameter 0.1 mm.—Parr.

The types are from the Eocene, King's Park bore no. 1, 755 feet, Perth, Western Australia. We have no typical material.

Buliminella obtusata Cushman

Plate 16, figures 16, 17

Buliminella obtusata Cushman, Cushman Lab. Foram. Research Contr., vol. 5, p. 42, pl. 7, figs. 8a, b, 1929.

Cushman and Parker, idem, vol. 13, p. 39, pl. 4 figs. 8, 9a, b, 1937.

Cushman and Todd, idem, vol. 22, p. 91, pl. 15, figs. 21, 22, 1946.

Test elongate, between 2 and 3 times as long as broad, usually not more than 2 whorls; chambers numerous, 7 or more in the last whorl; sutures distinct, flush with the surface except for the spiral suture, which may be depressed, somewhat limbate; aperture in a slight depression of the apertural face, which is large and concave, gradually depressed to its deepest at the aperture. Length up to 0.46 mm., diameter up to 0.20 mm.

The types are from the Oligocene Byram marl, Byram, Mississippi. The species occurs in the Oligocene Vicksburg group and Red Bluff formation of Mississippi; in the Miocene, upper Burdigalian of France, and at Nussdorf in the Vienna Basin, Austria; and the Pliocene of Antwerp, Belgium.

This species differs from *Buliminella elegantissima* (D'Orbigny) in being less fusiform, with a more flaring apertural face, and broader chambers.

Buliminella choctawensis Cushman and McGlamery

Plate 16, figures 18, 19

Buliminella choctawensis Cushman and McGlamery, U. S. Geol. Survey Prof. Paper 189-D, p. 107, pl. 25, figs. 11, 16, 1938.

Test elongate, subcylindrical, of rather uniform diameter throughout, composed of about 3 whorls; chambers distinct, not inflated, 6 to 8 in the adult whorl, rather uniform in shape throughout; sutures distinct, the spiral suture slightly depressed, the others flush with the surface; wall slightly roughened, rather coarsely perforate; aperture an arched, semicircular opening at the base of the apertural face, in the adult sometimes more elongate and terminal. Length 0.30 to 0.40 mm., diameter 0.08 to 0.10 mm.

The species was described from the Oligocene limestone 2 or 3 feet above water level, Choctaw Bluff, Alabama River, Alabama. It is not known elsewhere.

This form may be differentiated by its very slender, elongate test, and the rather coarse perforations.

Buliminella madagascariensis (D'Orbigny) var. spicata Cushman and Parker

Plate 16, figure 20

Bulimina elegantissima D'Orbigny var. *apiculata* Chapman (not Egger), Linnean Soc. London Jour., Zoology, vol. 30, p. 31, pl. 4, fig. 77, 1907.

Sidebottom, Royal Micr. Soc. Jour., 1918, p. 23, pl. 3, fig. 11.

Buliminella elegantissima (D'Orbigny) var. *apiculata* Cushman, Carnegie Inst., Washington Pub. 342, p. 25, 1924.

Buliminella apiculata Cushman, Cushman Lab. Foram. Research Contr., vol. 5, p. 44, pl. 7, figs. 6, 7, 1929.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 13, p. 39, pl. 4, figs. 10a, b, 1937.

Buliminella madagascariensis (D'Orbigny) var. *spicata* Cushman and Parker, (in Cushman), U. S. Nat. Mus. Bull. 161, pt. 3, p. 8, pl. 3, figs. 5, 6, 1942.

Cushman and Todd, Cushman Lab. Foram. Research Contr., vol. 2, p. 91, pl. 15, figs. 23, 24, 1946.

Variety differing from the typical form in its somewhat larger size, and in the presence of a stout, basal spine. Length 0.40 to 0.72 mm., diameter 0.24 to 0.38 mm.

The types are from the Oligocene, Grice's Creek, Balcombe Bay, Kackeraboite Creek, and Altoona Bay Coal Shaft, Victoria, Australia. We have typical material. The variety occurs also in the Oligocene Byram marl, Byram, Mississippi; in the Miocene and Recent of Australia; and in the Recent of the Fiji and Samoan Islands.

This variety has been given a new name because of the priority of Egger's *Bulimina ovata* D'Orbigny var. *apiculata* (1895).

There is a great variation in size. The Recent specimens are especially large and bear a close resemblance to *Buliminella spinigera* Cushman. They differ, however, in lacking the high polish of the latter, in having more numerous, more distinct chambers, and a less regular shape.

Buliminella barbati Cushman and Simonson

Plate 30, figure 1

Buliminella barbati Cushman and Simonson, Jour. Paleontology, vol. 18, p. 197, pl. 32, figs. 10a-c, 1944.

Test fusiform, 2½ to 3 times as long as broad, of 3 to 4 whorls, greatest breadth usually at or below middle, initial end rounded, last whorl much constricted at apertural end; chambers distinct, little if at all inflated, about 5 to a whorl; sutures very slightly depressed; wall smooth; aperture broadly loop-shaped in an obliquely truncate apertural face. Length, 0.30-0.33 mm; diameter, 0.15 mm.

This species differs from *B. brevior* Cushman in the more elongate form, larger number of whorls, rounded base, and more truncate apertural face.—Cushman and Simonson.

The types of this species are from the Oligocene Tumey formation of Fresno County, California.

Buliminella subfusiformis Cushman

Plate 16, figure 21

Buliminella subfusiformis Cushman, Cushman Lab. Foram. Research Contr., vol. 1, pt. 2, p. 33, pl. 5, fig. 12, 1925.

Cushman, Stewart and Stewart, San Diego Soc. Nat. History Trans., vol. 6, p. 64, pl. 4, figs. 8a, b, 1930.

Cushman and Laiming, Jour. Paleontology, vol. 5, p. 106, pl. 11, figs. 14a, b, 1931.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 7, p. 8, pl. 1, fig. 29, 1931.

Barbat and von Estorff, Jour. Paleontology, vol. 7, p. 171, pl. 23, figs. 9a, b, 1933.

Kleinpell, Miocene stratigraphy of California, p. 251, pl. 9, fig. 8; pl. 22, fig. 5(?), Tulsa, 1938.

LeRoy, Natuurk. tijdschr. Ned-Indië, vol. 99, pt. 6, p. 243, pl. 5, figs. 16-18, 1939.

Schenck and Childs, Stanford Univ. Publ., Univ. Ser. Geol. Sci., vol. 3, no. 2, p. 26 (list), 1942.

LeRoy, Colorado School of Mines Quart., vol. 39, no. 3, p. 25, pl. 1, fig. 19, 1944.

Weaver, Washington Univ. [Seattle] Pub. in Geology, vol. 6, no. 1, p. 23 (list), 1944.

Buliminella curta Cushman (not Cushman, 1925), Florida Geol. Survey Bull. 4, p. 43, pl. 8, fig. 4, 1930.

Cushman and Cahill, U. S. Geol. Survey Prof. Paper 175-A, p. 23, pl. 7, fig. 15, 1933.

Test elongate, fusiform, basal end pointed, apertural end somewhat rounded; chambers distinct, 4 in a whorl, inflated; sutures distinct, depressed, slightly curved; wall smooth, with medium sized perforations; aperture very small, in a depression of the apertural face which is small, rounded, and does not extend very far down the side of the test. Length up to 0.62 mm., diameter up to 0.20 mm.

The types are from the Miocene Monterey shale, sec. 24, T. 28 S., R. 14 E., M.D.M., San Luis Obispo County, California.

Kleinpell records the species from the lower Zemorrian to the upper Mohnian in the Miocene of California. It occurs also in the Choctawhatchee, Shoal River, and Oak Grove formations of Florida, and in the Duplin marl of North Carolina. Le Roy records it from the Miocene of Central Sumatra.

This species differs from *Buliminella curta* Cushman in being more fusiform, more elongate, and in having a much smaller, more terminal apertural face. The adult test has more whorls and more inflated chambers than *B. bassendorfensis* Cushman and Parker.

Buliminella curta Cushman

Plate 16, figure 22

Buliminella curta Cushman, Cushman Lab. Foram. Research Contr., vol. 1, pt. 2, p. 33, pl. 5, fig. 13, 1925.

Cushman and Laiming (part), Jour. Paleontology, vol. 5, p. 106, pl. 11, fig. 16 (not fig. 15), 1931.

Cushman and Ponton, Florida Geol. Survey Bull. 9, p. 75, 1932.

Cushman and LeRoy, Jour. Paleontology, vol. 12, p. 125, pl. 22, figs. 17a-c, 1938.

Kleinpell, Miocene stratigraphy of California, p. 248, pl. 7, fig. 3; pl. 15, fig. 4; pl. 16, fig. 8, Tulsa, 1938.

Ellisor, Am. Assoc. Petroleum Geologists Bull., vol. 24, pp. 439, 444 (lists), pl. 4, fig. 4, 1940.

Weaver, Washington Univ. [Seattle] Pub. in Geology, vol. 6, p. 23 (list), 1944.

Test tapering from the broadest part in the last-formed whorl, initial end pointed, apertural end broadly rounded, consisting of about 5 whorls; chambers distinct, inflated, about 4 to a whorl; sutures distinct, depressed; wall smooth, with medium sized perforations; aperture small, in a depression of the apertural face which is semicircular extending somewhat down the side of the test. Length 0.45 to 0.50 mm., diameter 0.25 mm.

The types are from the Miocene Monterey shale, sec. 24, T. 28 S., R. 14 E., M.D.M., San Luis Obispo County, California. Kleinpell records the species from the lower Zemorrian to the lower Delmontian in the Miocene of California. It occurs also in the Chocawhatchee marl, Shoal River and Oak Grove formations of Florida and is recorded by Miss Ellisor from the Miocene in a well core, Baldwin County, Alabama. Very similar specimens were found in the Recent deposits at *Guide* sta. 20(24), Lat. 43° 05′ N., Long. 125° 01′ W., in 640 fathoms, and in the Pliocene of Castel Arquato, Italy.

This species very closely resembles *Buliminella subfusiformis* Cushman, possibly is a variation of that form, It is shorter, more tapering, and has a broader, longer apertural face.

Buliminella curta Cushman var. basispinata R. E. and K. C. Stewart

Plate 16, figure 23

Buliminella curta Cushman var. *basispinata* R. E. and K. C. Stewart, Jour. Paleontology, vol. 4, p. 63, pl. 8, fig. 6, 1930.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 14, p. 59, pl. 10, fig. 10, 1938.

Buliminella inconstans (Egger), var. *basispinata* Coryell and Mossman, Jour. Paleontology, vol. 16, p. 243, pl. 36, fig. 46, 1942.

Variety differing from the typical form in its larger size and the presence of short, blunt spines on the initial portion of the test. Length 0.80 mm., diameter 0.30 mm.

The types are from the Pliocene, upper part of the Pico shales, Kalorama Canyon, Ventura County, California. The variety is found also in the Pliocene, Repetto Hills, Los Angeles, California, and in Cañada de Aliso, Ventura County, California, in gray siltstone 5,320 feet stratigraphically above the base of the first Pico sandstone, 2.7 miles S. 78° E. of La Crosse Junction. We have specimens from the Recent material at *Guide* sta. 20(24), Lat. 43° 05′ N., Long. 125° 01′ W. It is also recorded from the Pliocene Charco Azul formation of Panama.

Buliminella brevior Cushman

Plate 16, figure 24

Buliminella brevior Cushman, Cushman Lab. Foram. Research Contr., vol. 1, pt. 2, p. 33, pl. 5, fig. 14, 1925.

Kleinpell, Miocene stratigraphy of California, p. 247, pl. 12, fig. 10, Tulsa, 1938.

Hanna and Hertlein, State of Calif. Div. of Mines, Bull. 118, fig. 67 [plate] fig. 22, 1941.

Test short, broad, fusiform, the last-formed whorl constituting about three-fourths of the test; chambers distinct, about 5 to a whorl, inflated; sutures distinct, depressed; wall smooth, with perforations of medium size; aperture in a depression of the apertural face that is narrow and extends down the side of the test. Length 0.50 mm., diameter 0.30 mm.

The species was described from the Miocene Monterey shale, sec. 24, T. 28 S., R. 14 E., M.D.M., San Luis Obispo County, California. Kleinpell records it from the upper Zemorrian to the lower Delmontian of the Miocene of California.

This species is more fusiform than *Buliminella curta* Cushman, the chambers are more inflated, the last-formed whorl composes a far greater proportion of the test, and the apertural face is longer. The chambers are more inflated and the apertural face is much narrower than in *B. madagascariensis* D'Orbigny.

Buliminella californica Cushman

Plate 17, figure 1

Buliminella californica Cushman, Cushman Lab. Foram. Research Contr., vol. 1, pt. 2, p. 33, pl. 5, fig. 15, 1925.

Kleinpell, Miocene stratigraphy of California, p. 247, Tulsa, 1938.

Buliminella curta Cushman and Laiming (not Cushman) (part), Jour. Paleontology, vol. 5, p. 106, pl. 11, fig. 15 (not fig. 16), 1931.

Buliminella aff. *B. californica* Kleinpell, Miocene stratigraphy of California, p. 248, Tulsa, 1938.

Test elongate, narrow, slightly fusiform with almost parallel sides, initial end subacute, consisting of 5 or 6 whorls; chambers distinct, about 4 to a whorl, very slightly inflated; sutures distinct, limbate, spiral suture somewhat depressed; wall smooth, with medium sized perforations; aperture in a depression near the top of the apertural face, which is otherwise rounded and small in size. Length 0.50 to 0.55 mm., diameter 0.15 mm.

The types are from the Miocene Monterey shale, sec. 24, T. 28 S., R. 14 E., M.D.M., San Luis Obispo County, California. Kleinpell records the species from the upper Luisian and lower Mohnian of the California Miocene.

It occurs also at Los Sauces Creek, Ventura County, California, in beds of Saucesian and upper Zemorrian age. We have specimens from one locality in the Eocene, Cantua Creek, Fresno County, California, 150 feet below the base of the Temblor formation.

This species has less inflated chambers and is more slender than *Buliminella subfusiformis* Cushman, and the sutures are more limbate.

Buliminella glomerata Cushman and Parker, n. name

Plate 17, figure 2

Buliminella pulchra Tolmachoff (not Terquem), Carnegie Mus. Ann., vol. 23, p. 305, pl. 40, fig. 28, 1934.

Palmer, Bull. Am. Paleontology, vol. 29, no. 115, p. 46, 1945.

Test regularly spiral, of three volutions, the last of which occupies about three-fourths of the whole height of the test. Sutures well marked between the last whorl and the previous one, rather indistinct in earlier stage. The final whorl has five or six chambers separated from each other by distinct sutures. Surface shining, smooth. Aperture elongate, slightly curved. Length about 0.3 mm., the greatest thickness about 0.2 mm.—Tolmachoff.

The type is from the Miocene on the Atrato River, Colombia, South America. We have no typical material. Mrs. Palmer has recently recorded it from the Miocene Bowden marl of Jamaica.

Tolmachoff relates this species to *Buliminella turbinata* (Terquem) saying that it differs from Terquem's first figure in having fewer chambers in the last whorl and from the second figure in being less slender. He says that the last whorl of his species is smaller than that of *B. colonensis* Cushman and Hedberg, but that the two have very much the same general shape.

As Terquem's *"Bulimina pulchra"* described in 1882 is a *Buliminella,* a new name is here proposed for Tolmachoff's species.

Buliminella dubia Barbat and Johnson

Plate 17, figures 3, 4

Buliminella dubia Barbat and Johnson, Jour. Paleontology, vol. 8, p. 13, pl. 1, figs. 14, 15, 1934.

Kleinpell, Miocene stratigraphy of California, p. 249, pl. 16, fig. 7, Tulsa, 1938.

Test spiral, consisting of about three and one-half whorls, tapering or fusiform, greatest width near apertural end, initial end pointed, apertural end rounded, periphery slightly lobulate; chambers distinct, about four in a whorl, almost as broad as long, more or less inflated; spiral suture not very distinct, other sutures well-marked, slightly depressed; wall calcareous, smooth, very finely perforate; aperture comma-shaped, located in a depression of the last-formed chamber. Length 0.31 mm.; width 0.17 mm.

This species has fewer chambers than *Buliminella curta,* and the chambers are broader in proportion to their length.—Barbat and Johnson.

This species was described from the Miocene Reef Ridge shale, Leland Stanford Junior Univ. no. 696, Ohio Oil Company well, Bearstate no. 23, Belridge field, Kern County, California, McKittrick quadrangle, sec. 30, T. 28 S., R. 21 E., M.D.M., depth 2,266-2,286 feet. Kleinpell records it from the lower Mohnian to the lower Delmontian of the Miocene of California. We have no typical material. One specimen in our collection, from the Pliocene in the Cañada de Aliso, Ventura County, California, in gray siltstone 3,200 feet stratigraphically above the base of the first Pico sandstone, 2.4 miles S. 88° E. of La Crosse Junction, is probably referable to it.

This species is apparently much smaller than the others described from the Miocene of California.

Buliminella henryana Cushman and Kleinpell

Plate 17, figure 5

Buliminella henryana Cushman and Kleinpell, Cushman Lab. Foram. Research Contr., vol. 10, p. 4, pl. 1, figs. 11a, b, 1934.

Kleinpell, Miocene stratigraphy of California, p. 250, pl. 20, figs. 8, 15, 16, Tulsa, 1938.

Test comparatively short, about twice as long as broad, the periphery somewhat lobulate; chambers distinct, four or five in the adult whorl, of rather uniform shape but increasing gradually in size and length as added; sutures distinct, very slightly depressed, somewhat limbate, especially toward the upper end; wall smooth, finely perforate; aperture an elongate, comma-shaped opening in a depression of the somewhat obliquely truncated apertural face. Length 0.40 mm.; breadth 0.20 mm.—Cushman and Kleinpell.

The species was described from the Miocene Monterey shale, Henry Ranch, Graves Creek, San Luis Obispo County, California. It is not known elsewhere.

The authors describe this species as resembling *Buliminella californica* Cushman but having a shorter, stouter test, and more inflated chambers.

Buliminella bassendorfensis Cushman and Parker

Plate 17, figure 6

Buliminella bassendorfensis Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 13, pp. 40, 53, pl. 4, figs. 13a, b, 1937; idem, p. 53.

Test elongate, fusiform, 2½ times as long as broad, consisting of about 5 whorls; chambers distinct, about 4 to a whorl, somewhat inflated; sutures distinct, depressed, somewhat limbate; wall smooth, finely perforate; aperture at the top of the apertural face, which is small and rounded. Length 0.55 mm., diameter 0.20 mm.

The types are from the Miocene, south side of Alsea Bay, Lincoln County, Oregon (Loc. A. 198, see Schenck, Univ. California, Dept. Geol. Sci. Pub., Bull., vol. 18, no. 1, p. 33, Nov. 30, 1928). The species is not known elsewhere.

This species is similar to *Buliminella subfusiformis*

Cushman but has longer, less inflated chambers. It is more fusiform, with more inflated chambers than *B. californica* Cushman.

Buliminella semihispida Kleinpell

Plate 17, figure 7

Buliminella semihispida Kleinpell, Miocene stratigraphy of California, p. 250, pl. 20, figs. 8, 15, 16, Tulsa, 1938.

Test short, broad, composed of about two whorls, the last-formed whorl of many distinct chambers; sutures distinct, slightly depressed; wall finely perforate, lower half of test covered with numerous short, thick, blunt spines; aperture at base of slightly concave face of ultimate chamber. Length, 0.75 mm.; breadth, 0.50 mm.—Kleinpell.

The species was described from the Miocene Monterey shale (sample N-49), near Naples, Santa Barbara County, California. We have no typical material.

Buliminella multicamera Cushman and Parker

Plate 17, figures 8, 9

Buliminella multicamera Cushman and Parker, Cushman Lab. Foram Research Contr., vol. 14, p. 60, pl. 10, figs. 11, 12, 1938.

Test elongate, about 2½ times as long as broad, tapering, greatest width toward the apertural end which is truncate, initial end rounded; chambers numerous, very elongate, with a slight tendency toward becoming irregularly biserial, little, if at all, inflated; sutures distinct, limbate, not depressed; wall smooth, very finely perforate; aperture rounded, slightly elongate, in a rather deep depression in the center of the base of the apertural face which is somewhat flaring and extends well down the side of the test. Length 0.40 to 0.45 mm., diameter 0.15 to 0.18 mm.

The types are from the Pliocene of Castel Arquato, Italy. We have specimens of Recent age from the Mediterranean off Port Said, from the Red Sea, and from Madagascar. They do not show the biserial chambers but are otherwise similar.

The species has narrower chambers than *Buliminella madagascariensis* (D'Orbigny), and is less fusiform, with a broader apertural face, than *B. elegantissima* (D'Orbigny).

Buliminella elegantissima (D'Orbigny) Cushman

Plate 17, figures 10-12

Bulimina elegantissima D'Orbigny, Voyage dans l'Amérique méridionale, vol. 5, pt. 5, Foraminifères, p. 51, pl. 7, figs. 13, 14, 1839.

Williamson, Recent Foraminifera of Great Britain, p. 64, pl. 5, figs. 134, 135, 1858.

Schlumberger, Feuille jeunes nat., vol. 12, pl. 1, fig. 14, 1881.

H. B. Brady, *Challenger* Rept., Zoology, vol. 9, p. 402, pl. 50, figs. 20-22, 1884.

Reade, Geol. Mag., dec. 4, vol. 7, pp. 100, 101 (lists), pl. 5, fig. 6, 1900.

Sidebottom, Manchester Lit. Philos. Soc. Mem. and Proc., vol. 49, no. 5, p. 11, pl. 2, fig. 6, 1905.

Bagg, U. S. Geol. Survey Bull. 513, p. 38, pl. 9, figs. 8a-c, 1912.

Heron-Allen and Earland, *Discovery* Repts., vol. 4, p. 351, pl. 8, figs. 35-37, 1932.

Buliminella elegantissima Cushman, U. S. Nat. Mus. Proc., vol. 56, p. 606, 1919; idem, Bull. 100, vol. 4, p. 168, 1921; Cushman Lab. Foram. Research Contr., vol. 1, pt. 2, p. 40, pl. 6, figs. 5a, b, 1925.

Cushman and Wickenden, U. S. Nat. Mus. Proc., vol. 75, art. 9, p. 8, pl. 3, figs. 12a, b, 1929.

Cushman and Kellett, idem, vol. 75, art. 25, p. 6, pl. 3 figs. 1-3, 1929.

Cushman, Stewart and Stewart, San Diego Soc. Nat. History Trans., vol. 6, p. 64, pl. 4, figs. 7a, b, 1930.

Cushman, Florida Geol. Survey Bull. 4, p. 42, pl. 8, figs. 2, 3, 1930.

Cole, idem, Bull. 6, p. 39, pl. 2, fig. 8, 1931.

Cushman and Parker, U. S. Nat. Mus. Proc., vol. 80, art. 3, p. 13, pl. 3, figs. 12, 13, 1931.

Howe and Wallace, Louisiana Dept. Cons. Geol. Bull. 2, p. 61, pl. 11, fig. 3, 1932.

Cushman and Ponton, Florida Geol. Survey Bull. 9, p. 75, 1932.

Cushman, Cushman Lab. Foram. Research Special Pub. 4, pl. 22, fig. 3, 1933; idem, Special Pub. 5, pl. 27, figs. 4a, b, 1933.

Cushman and Cahill, U. S. Geol. Survey Prof. Paper 175-A, p. 23, pl. 7, figs. 13, 14, 1933.

Barbat and Johnson, Jour. Paleontology, vol. 8, p. 12, pl. 1, figs. 12, 13, 1934.

Bermúdez, Soc. cubana hist. nat. Mem., vol. 9, p. 193, 1935.

Cushman, Geol. Soc. America Bull., vol. 47, p. 431, 1936.

Chapman and Parr, Australasian Antarctic Exped., ser. C, vol. 1, pt. 2, p. 79, 1937.

Kleinpell, Miocene stratigraphy of California, p. 249, pl. 16, fig. 10, Tulsa, 1938.

Cushman and Henbest, U. S. Geol. Survey Prof. Paper 196-A, pl. 9, fig. 20, 1940.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 16, p. 21, 1940.

Hanna and Hertlein, State of Calif., Div. of Mines Bull. 118, p. 178, fig. 67 [plate], figs. 5-7, 1941.

Macfadyen, Geol. Mag., vol. 79, p. 135, 1942.

Cushman, Cushman Lab. Foram. Research Special Pub. 12, p. 27, pl. 3, figs. 43, 44, 1944; idem, Contr., vol. 21, p. 7, pl. 2, fig. 6, 1945.

Buliminella cf. *B. elegantissima* Cushman and Ponton, Cushman Lab. Foram. Research Contr., vol. 8, p. 67, pl. 8, figs. 20, 21, 1932.

Cushman and McGlamery, U. S. Geol. Survey Prof. Paper 189-D, p. 107, pl. 25, fig. 15, 1938.

Palmer, Soc. cubana hist. nat. Mem., vol. 14, p. 294, 1940.

Test small, fusiform, consisting of 2 or 3 whorls, initial end bluntly pointed in the megalospheric form, much sharper in the microspheric; chambers distinct, 7 to 10 in the final whorl, narrow, slightly inflated; sutures dis-

tinct, slightly depressed, somewhat curved; wall smooth, finely perforate; aperture elongate, narrow, placed near the top of the apertural face, which is narrow, somewhat depressed, and flaring, extending well down the side of the test. Length of specimens from off Payta, Peru, 0.23 to 0.40 mm., diameter 0.13 to 0.18 mm.

The species was described from Recent material off Payta, Peru; Cobija in Bolivia; and off Valparaiso, Chile. It is a very widely ranging form, both vertically and horizontally. It is known from the Eocene Wilcox group of Alabama and Jackson group of Texas and Louisiana; the Oligocene Meson formation of Mexico, and Oligocene beds at Choctaw Bluff, Alabama; and the Miocene deposits of the Coastal Plain of the eastern United States. It was recorded by Kleinpell from the Whiterock Bluff shale (uppermost part at type locality), Monterey shale at the type locality, basal Margarita formation in San Luis Obispo County, and sample E92, Reliz Canyon, Monterey County, California. It is known from the Pliocene San Pedro formation and beds in Humboldt County, California; the Pliocene of Florida; Pleistocene beds in England and Florida; and the Recent seas along the east and west coasts of South America, Falkland Islands, Dry Tortugas, Antigua, British Isles, Mediterranean, Philippine Islands, and off British Columbia. It is also recorded from the late Tertiary of the Georges Bank canyons in the western Atlantic Ocean.

This species may be distinguished by its small, fusiform test and numerous, narrow chambers.

Buliminella elegantissima (D'Orbigny) Cushman var. cochlea Wiesner

Plate 17, figure 13

Buliminella elegantissima (D'Orbigny) var. *cochlea* Wiesner, Deutsche Südpolar-Exped., vol. 20, Zoology, p. 124, pl. 19, fig. 237, 1929.

Wiesner describes this variety as having an open corkscrew type of coiling.

The types are from sta. 56, 385 meters, Lat. 66° 2′ S., Long. 89° 38′ W.

It seems very possible that this variety represents the microspheric form of *Buliminella elegantissima* (D'Orbigny) but as we have no specimens to verify this point the two forms have not been combined.

Buliminella elegans (D'Orbigny) Cushman and Parker

Plate 17, figure 14

Bulimina elegans D'Orbigny, Annales sci. nat., vol. 7, p. 270, no. 10, Modèles, no. 9, 1826.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 14, p. 93, pl. 16, fig. 13, 1938.

The type of the species is from the Recent, Rimini, Italy. It probably belongs to the genus *Buliminella*, as a model has the characteristic apertural face and spiral suture of that genus. The details are too indefinite, however, for any known material to be definitely referred to it.

Buliminella punctata (D'Orbigny) Cushman and Parker

Plate 17, figure 31

Bulimina punctata D'Orbigny, Annales sci. nat., vol. 7, p. 270, no. 11, 1826.

Fornasini, Accad. sci. Ist. Bologna Mem., ser. 5, vol. 9, p. 374, text fig. 6, 1901.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 14, p. 93, pl. 16, fig. 14, 1938.

The type is from the Recent, Rimini, Italy. We have no material referable to the species but it seems probable that it should be placed in this genus.

Buliminella madagascariensis (D'Orbigny) Cushman and Parker

Plate 17, figures 15-17

Bulimina madagascariensis D'Orbigny, Annales sci. nat., vol. 7, p. 270, no. 17, 1826.

Fornasini, Accad. sci. Ist. Bologna Mem., ser. 6, vol. 5, p. 47, pl. 1, figs. 13, 13a, 1908.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 14, p. 94, pl. 16, figs. 19, 20, 1938.

?Bulimina elegantissima D'Orbigny var. *fusiformis* Sidebottom (not Williamson), Royal Micr. Soc. Jour., 1918, p. 23, pl. 3, figs. 8-10.

Bulimina elegantissima Heron-Allen and Earland (not D'Orbigny), Linnean Soc. London Jour., Zoology, vol. 35, p. 620, pl. 35, figs. 23, 24, 1924.

Bulimina seminuda Heron-Allen and Earland (not Terquem), *Discovery* Repts., vol. 4, p. 351, pl. 8, figs. 38-41, 1932.

Buliminella apiculata (Chapman) var. *hebetata* Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 13, p. 40, pl. 4, figs. 11, 12, 1937.

Test composed of 2 or 3 whorls, small, tapering in the microspheric form, almost cylindrical in the megalospheric; chambers fairly numerous, 6 to 8 in the adult whorl, distinct; sutures distinct, somewhat limbate, flush with the surface; wall smooth, polished, finely perforate; aperture rounded, with a tooth-like process extending up over it, near the top of the apertural face, which is convex around the outside and depressed toward the aperture. Length of figured specimens 0.33 to 0.55 mm., diameter 0.20 to 0.25 mm.

The type is from the Recent of Madagascar. The species occurs in the Oligocene of Australia, and in the Byram marl, Byram, Mississippi, and in the Recent seas near Australia, New Zealand, and Madagascar. One very similar specimen was found off the coast of Brazil. It has been recorded also from off the Falkland Islands.

It has been found that the Recent forms are identical with the fossil forms, and for that reason D'Orbigny's

name must be used. The species is very variable in shape, but the number of chambers to a whorl, their size, and shape all remain the same. The peculiar tooth-like projection over the aperture is an important characteristic. The chambers are broader than those of *Buliminella obtusata* Cushman, and the apertural face does not extend so far down the side of the test as in that species. The test is less fusiform than that of *B. elegantissima* D'Orbigny, the apertural face is more flattened, and the chambers are broader.

Buliminella spinigera Cushman

Plate 17, figures 18, 19

Buliminella spinigera Cushman, U. S. Nat. Mus. Bull. 104, pt. 3, p. 113, pl. 23, figs. 1-4, 1922.

Test large, fusiform, the initial end terminated by a long, stout spine, apertural end rounded; chambers indistinct, 6 or 7 in the adult whorl; sutures indistinct, flush with the surface, limbate; wall very smooth, highly polished, very finely perforate; aperture near the top of the broad, flat apertural face, with a flat plate-like tooth extending up over it. Length (including spine) 0.43 to 0.80 mm., diameter 0.23 to 0.43 mm.

The types are from *Albatross* sta. D2677, in 478 fathoms, off the coast of North Carolina. The species is known only from this locality and one other *Albatross* station in this region.

This species is somewhat larger than *Buliminella madagascariensis* (D'Orbigny) var. *spicata* Cushman and Parker, has less distinct, somewhat fewer chambers, and a much more highly polished wall.

Buliminella milletti Cushman

Plate 17, figures 20, 21

Buliminella milletti Cushman, Cushman Lab. Foram. Research Contr., vol. 9, p. 78, pl. 8, figs. 5, 6, 1933; U. S. Nat. Mus. Bull. 161, pt. 3, p. 7, pl. 3, figs. 1-4, 1942.

Bulimina elegantissima var. Sidebottom, Manchester Lit. Philos. Soc. Mem. and Proc., vol. 49, no. 5, p. 11, pl. 2, figs. 7-12; pl. 3, figs. 1, 2, 1905.

Test small, tapering, initial end bluntly rounded, increasing in diameter toward the apertural end, consisting of 2 or 3 whorls; chambers distinct, 4 or more making up the last whorl, slightly inflated; sutures distinct, flush with the surface or slightly depressed, especially the spiral suture, slightly limbate; wall smooth, very finely perforate; aperture a semi-elliptical opening at the base of the apertural face which is broadly rounded, with slight ridges running into the depressed area at the center. Length 0.30 mm., diameter 0.15 to 0.20 mm.

The types are from Mokaujar Anchorage, Fiji. The species occurs at various localities in the Fiji Islands; Pago Pago Harbor, Samoa; Zanzibar; Montego Bay, Jamaica; the Dry Tortugas; and St. Johns, Antigua. It has been reported by Sidebottom from the Island of Delos.

The species is larger, more tapering, and has fewer whorls than *Buliminella parallela* Cushman and Parker.

Buliminella parallela Cushman and Parker

Plate 17, figure 22

Buliminella parallela Cushman and Parker, U. S. Nat Mus. Proc., vol. 80, art. 3, p. 13, pl. 3, figs. 15a-c, 1931.

Bermúdez, Soc. cubana hist. nat. Mem., vol. 9, p. 193, 1935.

?Bulimina elegantissima D'Orbigny var. *compressa* Millett (not Bailey), Royal Micr. Soc., Jour., 1900, p. 277, pl. 2, fig. 5.

?Bulimina elegantissima Millett (not D'Orbigny), idem, p. 276, pl. 2, fig. 4.

Test elongate, slender, the sides usually nearly parallel for most of their length, both ends broadly rounded, nearly circular in transverse section, consisting of 3 or more whorls; chambers distinct, 5 or more in each whorl, not much, if at all, inflated; sutures distinct, the spiral suture somewhat irregularly crenulate, slightly limbate, flush with the surface; wall smooth, polished, very finely perforate; aperture rounded, with very slightly raised costae running in toward it on the surrounding depressed area of the apertural face, which is small and rounded. Length 0.25 mm., diameter 0.08 to 0.10 mm.

The types are from the Recent deposits off Ilha Paqueta, Rio de Janeiro Harbor, Brazil. The species occurs in the Recent seas near Dry Tortugas; St. Johns, Antigua; off the north coast of Cuba; at two localities in Rio de Janeiro Harbor; and at one locality in the Falkland Islands. Millett's specimens from the Malay Archipelago are questionably placed here.

The species differs from *Buliminella milletti* Cushman in its more slender, parallel sided test, greater number of whorls, and smaller size.

Genus BULIMINOIDES Cushman, 1911

Buliminoides Cushman, U. S. Nat. Mus. Bull. 71, pt. 2, p. 90, 1911; Smithsonian Misc. Coll., vol. 77, no. 4, p. 36, 1925; Cushman Lab. Foram. Research Contr., vol. 3, pt. 1, p. 65, 1927; idem, Special Pub. 1, p. 246, 1928; idem, Special Pub. 4, p. 217, 1933; U. S. Nat. Mus. Bull. 161, pt. 3, p. 8, 1942.

Bulimina (part) of authors.

Genotype *Bulimina williamsoniana* H. B. Brady.

Test subcylindrical, elongate, spirally twisted; chambers in a spiral, several chambers in a whorl, largely obscured by the heavy longitudinal costae; wall calcareous, perforate; aperture terminal, central, circular, in a depression at the end of the test. Recent.

A single species is known, rather widely distributed in the Indo-Pacific and rare in the Gulf of Mexico. It is not known as a fossil.

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Buliminoides williamsoniana (H. B. Brady) Cushman

Plate 17, figures 23, 24

Bulimina williamsoniana H. B. Brady, Quart. Jour. Micr. Sci., vol. 21, p. 56, 1881; *Challenger* Rept., Zoology, vol. 9, p. 408, pl. 51, figs. 16, 17, 1884.

Millett, Royal Micr. Soc. Jour., 1900, p. 279, pl. 2, fig. 8.

Bagg, U. S. Nat. Mus. Proc., vol. 34, p. 136, 1908.

Heron-Allen and Earland, Zool. Soc. London Trans., vol. 20, p. 641, 1915; British Antarctic Exped., Zoology, vol. 6, p. 130, 1922.

Buliminoides williamsoniana Cushman, U. S. Nat. Mus. Bull. 71, pt. 2, p. 90, text fig. 144, 1911; Carnegie Inst. Washington Pub. 311, p. 31, pl. 3, fig. 7, 1922; U. S. Nat. Mus. Bull. 104, pt. 3, p. 113, 1922; Cushman Lab. Foram. Research Special Pub. 4, pl. 22, fig. 5, 1933; idem, Special Pub. 5, pl. 27, figs. 6, 7, 1933.

Bermúdez, Soc. cubana hist. nat. Mem., vol. 9, p. 194, 1935.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 16, p. 22, 1940.

Cushman, U. S. Nat. Mus. Bull. 161, pt. 3, p. 8, pl. 3, figs. 7-9, 1942.

Test elongate, subcylindrical, composed of numerous chambers which are not distinct when viewed from the surface; wall ornamented with longitudinal costae, usually somewhat spirally twisted, running from the initial end to the apertural face and across it to the aperture itself, making a radiate pattern; aperture small, circular, terminal, in the center of the depressed apertural face. Length up to 0.80 mm., diameter 0.18 to 0.22 mm.

This is mainly an Indo-Pacific species but occurs rarely in the western tropical Atlantic. Indo-Pacific records are as follows: From the *Challenger* stations given by Brady, "Port Stephens and Port Jackson, New South Wales, 2-10 fathoms; off Levuka, Fiji, 12 fathoms; off the New Hebrides, 125 fathoms; Torres Strait, 155 fathoms; Humboldt Bay, Papua, 37 fathoms; Nares Harbor, Admiralty Islands, 17 fathoms." Millett records it from two localities in the Malay region, and Bagg from a single *Albatross* station, H4694, in 865 fathoms, and Cushman from H2922, in 268 fathoms, both off the Hawaiian Islands. Heron-Allen and Earland record it from the Kerimba Archipelago, off the eastern coast of Africa. Cushman records it from off Samoa in 9 to 50 fathoms. Heron-Allen and Earland record it also from "Spirits Bay, near North Cape, New Zealand, in 11-20 fathoms," and "7 miles E. of North Cape, New Zealand, in 70 fathoms". We have a very typical specimen from *Albatross* sta. D5230, 118 fathoms, between Bohol and Leyte, Philippines.

In the Atlantic it has been recorded by Cushman from off the Dry Tortugas, Florida, and by Bermúdez from off the north coast of Cuba.

There are a number of other species that show this same general distribution in the Atlantic and Pacific.

Yabe and Asano have described a new species from the Pliocene of Java as *Buliminoides bantamensis* (Tohoku Imp. Univ. Sci. Repts., 2d ser., Geol., vol. 19, p. 121, pl. 17, fig. 20, 1937) but no specimens have been available for comparison.

Genus UNGULATELLA Cushman, 1931

Ungulatella Cushman, Cushman Lab. Foram. Research Contr., vol. 7, p. 81, 1931; idem, Special Pub. 4, p. 217, 1933; idem, Contr., vol. 10, p. 102, 1934.

Genotype, *Ungulatella pacifica* Cushman.

Test with the early portion conical and probably consisting of a series of spirally coiled chambers, later chambers uniserial, forming an elongate, subcylindrical test, or somewhat compressed toward the apertural end; wall calcareous, rather coarsely perforate; aperture a loop-shaped opening in the flattened or somewhat concave terminal face. Recent, Pacific.

This genus is probably derived from *Buliminella* or *Buliminoides* by the development of uniserial chambers in the adult stage. From what is known of the species it probably has developed in very recent times in the Indo-Pacific region. No fossil forms are known.

Ungulatella pacifica Cushman

Plate 17, figures 25, 26

Ungulatella pacifica Cushman, Cushman Lab. Foram. Research Contr., vol. 7, p. 82, pl. 10, figs. 11, 12, 1931; idem, Special Pub. 4, pl. 22, fig. 6, 1933; idem, Special Pub. 5, pl. 27, figs. 8a-c, 1933; idem, Contr., vol. 10, p. 102, pl. 13, figs. 3, 4, 1934.

Test elongate, the early portion abruptly tapering, later portion in front view with the sides nearly parallel, in side view somewhat progressively compressed toward the apertural end; chambers in the adult uniserial, low and broad, becoming somewhat oblique in the apertural face, flattened or slightly concave; sutures distinct, very slightly limbate, flush with the surface; wall with numerous, comparatively large and distinct perforations except on the apertural face, which is smooth; aperture somewhat comma-shaped, at or near the ventral side of the apertural face. Length 0.35 mm., diameter 0.12 to 0.14 mm., thickness at the apertural end 0.08 to 0.10 mm.

The types are from shallow water off the Island of Rangiroa in the south Pacific, where it is fairly common. The shape of the early portion and the aperture show that it is probably derived from the *Buliminella* group.

Ungulatella peregrina Cushman

Plate 17, figure 27

Ungulatella peregrina Cushman, Cushman Lab. Foram. Research Contr., vol. 10, p. 102, pl. 13, figs. 5a-c, 1934.

Test short and broad, much compressed, initial end with a large, stout spine, remainder of test composed of a spirally coiled tube, the last 1 or 2 whorls tending to

show partial divisions into half coils, attached face much flattened and oblique, concave in the middle, with an outer flange-like rim; suture marked by a raised, sharp ridge, representing the peripheral flange at that stage; wall roughened on the outer side of the coils, very smooth and polished on the apertural face; aperture apparently opening on the open umbilical area. Length 0.20 mm., diameter 0.15 mm.

The types of this species are from off the Island of Rangiroa in the south Pacific, and it has not been recorded elsewhere. The species is small and scale-like, and with its prominent initial spine and raised ridges is easily distinguished.

Ungulatella conoides Cushman

Plate 17, figures 28, 29

Ungulatella conoides Cushman, Cushman Lab. Foram. Research Contr., vol. 10, p. 102, pl. 13, figs. 6, 7, 1934.

Test small, short and broad, conical, initial end pointed, with a large, stout, solid spine, greatest breadth of test at the apertural end which is somewhat expanded into a flaring lip or flange, sides of the test uneven in length, making the flattened, apertural end at a decided angle to the elongate axis; sutures mostly indistinct; wall very closely perforate, or even slightly papillate, the pores often partially arranged in lines, giving a peculiar ornate appearance to the surface; apertural face smooth and polished, slightly concave, especially in the middle, which has a circular depression; last-formed whorl often partially subdivided into two half coils. Length 0.15 mm., diameter 0.15 to 0.20 mm.

The types of this species are from off the Island of Rangiroa in the south Pacific. It has not been recorded elsewhere.

Ungulatella capistra Cushman

Plate 17, figure 30

Ungulatella capistra Cushman, Cushman Lab. Foram. Research Contr., vol. 10, p. 103, pl. 13, figs. 8a-c, 1934.

Test with the main portion a broad cone, but with a thin, high flange rising even above the initial end which is smooth and rounded, the coiled chamber seeming to be partially divided toward the end into portions half a coil in length, apertural face smooth, the central portion concave; wall coarsely perforate on the exterior of the sides. Length, including flange, 0.25 mm., diameter, including flange, 0.30 mm.

The types are from off the Island of Rangiroa in the south Pacific and the species has not been recorded elsewhere.

This is a very peculiar form with the flange very highly developed.

Genus ROBERTINA D'Orbigny, 1846

Robertina D'Orbigny, Foraminifères fossiles du bassin tertiaire de Vienne, p. 202, 1846.

Cushman, Cushman Lab. Foram. Research Contr., vol. 3, p 65, 1927; idem, Special Pub. 1, p. 246, 1928; idem, Special Pub. 4, p. 218, 1933.

Cushman and Parker, idem, Contr., vol. 12, p. 92, 1936.

Glaessner, Studies in micropaleontology, vol. 1, fasc. 1, p. 23. 1937.

Cushman, U. S. Nat. Mus. Bull. 161, pt. 3, p. 9, 1942.

Bulimina (part) of authors

Cassidulina (part) of authors.

Genotype, *Robertina arctica* D'Orbigny, 1846.

Test an elongate, close spiral, the spiral suture distinct; chambers several in each whorl, in microspheric young like *Buliminella*, later forming a double series; wall calcareous, finely perforate; apertures 2 in number, the primary one elongate, loop-shaped, at basal margin of the chamber, extending into the apertural face, the secondary one at the basal margin extending between the last-formed chambers of the upper and lower series, usually smaller than the primary one. Eocene to Recent.

The genus is variable, even within the limits of a species. The best criteria for establishing a species are the position and angle of the primary aperture, the number of chambers to a whorl, and their shape. The genus has developed along two main lines from the Eocene forms, one with few chambers, compact and close coiled with more or less straight sides; the second with many chambers, and a more open coil, which is much more twisted.

This genus has been placed by Glaessner close to *Ceratobulimina* in a new family *Ceratobuliminidae*. Its early stages, however, are very similar to *Buliminella* and it seems to have developed from that genus. The primary opening, as described here, has been questioned by Glaessner, who describes it as a fold extending down to the previous chamber. A study of *Robertina arctica* D'Orbigny and other species, however, seems to show that this opening is a definite aperture into the chamber and that the species is related to *Buliminella*.

Robertina wilcoxensis Cushman and Ponton

Plate 18, figure 1

Robertina wilcoxensis Cushman and Ponton, Cushman Lab. Foram. Research Contr., vol. 8, p. 66, pl. 8, figs. 19a, b, 1932.

Cushman and Parker, idem, Contr., vol. 12, p. 96, pl. 16, figs 13a, b, 1936.

Cushman and Garrett, idem, Contr., vol. 15, p. 82, pl. 14, fig. 16, 1939.

Cushman and Todd, idem, Contr., vol. 18, p. 36, pl. 6, figs. 22, 23, 1942.

Cushman, idem, Contr., vol. 20, p. 42, pl. 7, fig. 9, 1944; Am Jour. Sci., vol. 242, p. 11, pl. 1 fig. 17, 1944.

Test about twice as long as broad, slightly compressed, fusiform, greatest breadth slightly above the middle, initial end sharply pointed and evenly tapering, apertural end narrowed; chambers slightly inflated, about 5 pairs in the adult whorl, increasing rather rapidly but evenly in size as added; sutures slightly, if at all, depressed, very slightly limbate; wall smooth, very finely perforate; aperture narrow, running about one-third of the way across the apertural face, about in the vertical axis of the test, secondary aperture slight. Length 0.30 to 0.40 mm., diameter 0.15 to 0.18 mm.

The types of this species are from the Eocene Wilcox group in a railroad cut 1 mile north of Ozark, Alabama. It occurs also at Woods Bluff, Clarke County, Alabama, and in the Paleocene, Naheola formation of Alabama.

This species is smaller than *Robertina angusta* (Cushman) and is more pointed at the ends. It probably represents the ancestral form of that species. This form and *R. ovigera* (Terquem) furnish the oldest records of the genus.

Robertina mcguirti Howe

Plate 18, figure 2

Robertina mcguirti Howe, Louisiana Dept. Cons. Geol. Bull. 14, p. 82, pl. 8, figs. 23, 24, 1939.

Test elongate, narrow, apparently composed of about two whorls, but only a very small portion of the initial whorl visible; chambers numerous, distinct; sutures distinct, slightly limbate, in some views faintly depressed; wall smooth; aperture a high slit in a depression of the apertural face extending upward from the base of the chamber. Length 0.26 mm., breadth 0.11 mm.—Howe.

The types are from the Eocene Cook Mountain formation, left bank of Saline Bayou beneath the Louisiana and Arkansas Railroad bridge at St. Maurice, sec. 15, T. 9 N., R. 6 W., L.M., Winn Parish, Louisiana. We have no typical material.

Robertina plummerae Cushman and Parker

Plate 18, figure 3

Robertina plummerae Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 14, p. 73, pl. 13, figs. 1a, b, 1938.

Howe, Louisiana Dept. Cons. Geol. Bull. 14, p. 82, pl. 8, figs. 43, 44, 1939.

Test almost 2½ times as long as broad, greatest breadth at the middle, initial end subacute, apertural end tapering, rounded; chambers, 6 pairs in the final whorl, increasing gradually in size as added; sutures distinct, slightly depressed; wall smooth; aperture elliptical, short, supplementary aperture almost as large. Length 0.46 to 0.66 mm., diameter 0.20 to 0.24 mm.

The types are from the Eocene Crockett formation of the Claiborne group, Shipp's Ford on the Colorado River, 3¾ miles due east of Smithville, Bastrop County, Texas. Howe records it from the Eocene Cook Mountain formation in Louisiana.

This species differs from *Robertina wilcoxensis* Cushman and Ponton in being longer, more twisted, less ovate in shape, and in having a larger secondary aperture.

Robertina ovigera (Terquem) Cushman and Parker

Plate 18, figure 4

Bulimina ovigera Terquem (part), Soc. Géol. France Mém., ser. 3, vol. 2, p. 108, pl. 11(19), figs. 17, 20 (not figs. 18, 19), 1882.

Robertina ovigera Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 12, p. 98, pl. 16, figs. 15a, b, 1936.

Cushman and Todd, idem, Contr., vol. 21, p. 16, pl. 4, fig. 4, 1945.

Test nearly twice as long as broad, greatest breadth toward the apertural end which is broadly rounded, initial end subacute, rapidly tapering; chambers somewhat inflated, about 5 pairs in the adult whorl, increasing rather rapidly but regularly in size as added; sutures distinct, slightly depressed; not limbate; wall smooth, finely perforate; aperture elongate, narrow, slightly curved, running less than halfway into the apertural face; supplementary aperture small, low. Length 0.29 to 0.34 mm., diameter 0.15 to 0.20 mm.

Terquem describes this species as rare in the Eocene calcaire grossier of the Paris Basin, at Vaudancourt and Septeuil. We have specimens from Grignon, Mouchy, Fontenay, and St. Félice in the Paris Basin.

This species is very variable, but the general characters seem to remain the same. It is smaller than the other known species.

Robertina washingtonensis Beck

Plate 30, figures 3, 4

Robertina washingtonensis Beck, Jour. Paleontology, vol. 17, p. 604, pl. 107, figs. 17, 19, 24, 1943.

Test nearly three times as long as broad, initial end sharply pointed, evenly tapering, fusiform, greatest breadth slightly above middle; chambers slightly inflated; 5 pairs in adult whorl, increasing in size as added; sutures moderately depressed; wall smooth, very finely perforate; aperture narrow, comma-shaped, extending about two-thirds of way across apertural face, slightly oblique to vertical axis of test, supplementary aperture indistinct. Length, 0.57 mm.; breadth, 0.20 mm.

The general shape and chamber arrangement of this species is similar to *R. wilcoxensis* Cushman and Ponton (1932, p. 66, pl. 8, figs. 19a, b) except that it is narrower. Its aperture, however, is more than twice as long, and is curved, and oblique to the long axis of the test.—Beck.

The types of this species are from the Eocene of Cowlitz River, Lewis County, Washington.

Robertina germanica Cushman and Parker

Plate 18, figure 5

Robertina germanica Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 14, p. 73, pl. 13, figs. 2a, b, 1938.

Robertina angusta Cushman and Parker (not Cushman) (part), Cushman Lab. Foram. Research Contr., vol. 12, p. 96, 1936.

Test twice as long as broad, initial end bluntly pointed, apertural end flattened; chambers, 7 to 8 pairs in the final whorl, slowly increasing in size as added; sutures distinct, slightly limbate, not depressed; wall smooth; aperture narrow, elliptical, reaching about halfway into the apertural face, supplementary aperture deeply cut, narrow. Length 0.46 to 0.83 mm., diameter 0.22 to 0.40 mm.

The types are from the lower Oligocene of Calbe, near Magdeburg, Germany. The species is found also in the lower Oligocene of Brundhorst, near Bünde and Weinkeine near Alzey, Mainz Basin, Germany.

This species resembles *Robertina angusta* (Cushman) but differs from it in its greater length in proportion to its breadth, more pointed initial end, and its slightly more twisted test.

Robertina angusta (Cushman) Cushman and Parker

Plate 18, figure 6

Buliminella subteres (H. B. Brady) var. *angusta* Cushman, U. S. Geol. Survey Prof. Paper 129-F, p. 127, pl. 29, figs. 8, 9, 1922; idem, Prof. Paper 133, p. 24, 1923.

Howe, Jour. Paleontology, vol. 2, p. 174 (list), 1928.

Cushman, Cushman Lab. Foram. Research Contr., vol. 5, p. 42, pl. 7, fig. 4, 1929.

Cushman and Ponton, Florida Geol. Survey Bull. 9, p. 76, pl. 11, figs. 9a, b, 1932.

Robertina angusta Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 12, p. 96, pl. 16, figs. 11a, b, 1936.

Cushman and McGlamery, U. S. Geol. Survey Prof. Paper 197-B, p. 70, pl. 5, fig. 15, 1942.

Cushman and Frizzell, Cushman Lab. Foram. Research Contr., vol. 19, p. 85, pl. 14, fig. 15, 1943.

Test usually more than twice as long as broad, irregularly fusiform, initial end somewhat more pointed than the apertural; chambers, about 7 pairs in the final whorl, increasing rather slowly in size as added, all of one series meeting in the median line on the ventral side; sutures distinct, limbate, not depressed; wall smooth; aperture elongate, elliptical, almost closed near the base, more open toward the inner end, which reaches more than halfway across the apertural face; supplementary aperture very small and low. Length 0.32 to 0.60 mm., diameter 0.22 to 0.34 mm.

The types are from the Oligocene Mint Spring marl, Chickasawhay River, 1¼ miles southwest of Boice, Mississippi. The species also occurs in the Oligocene Red Bluff clay, Byram marl, and Chickasawhay marl of Mississippi, and the Lincoln formation of Washington. Less typical specimens occur in the Twiggs clay member of the Barnwell formation of Georgia. Specimens from the Miocene of Florida seem to be very close to this species.

As in the other early species, *Robertina wilcoxensis*, the aperture is broader than in most later species and the supplementary aperture relatively inconspicuous.

Robertina declivis (Reuss) Cushman and Parker

Plate 18, figure 7

Bulimina declivis Reuss, Akad. Wiss. Wien Sitzungsber., vol. 48, pt. 1, p. 55, pl. 6, figs. 70a, b; pl. 7, fig. 71, 1863; idem vol. 62, pt. 1, p. 484, 1870 (Von Schlicht, Foram. Septarienthones Pietzpuhl, pl. 23, figs. 8-12, 1870).

Robertina declivis Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 12, p. 94, pl. 16, figs. 5a, b, 1936.

Beck, Jour. Paleontology, vol. 17, p. 604, pl. 107, figs. 1, 7, 25, 1943.

Test somewhat longer than broad, broadly fusiform, initial end subacute, apertural end broadly rounded; chambers distinct, inflated, 4 to 5 pairs in the adult whorl, increasing rapidly in size as added; sutures distinct, depressed; wall smooth, polished; aperture elongate, distinctly curved, secondary aperture very distinct, often nearly as broad as the primary. Length 0.41 mm., diameter 0.22 mm.

The types are from the Oligocene Septarienthon of Offenbach, Germany. We have specimens from the middle Oligocene at Hermsdorf, near Berlin, Germany. Reuss also records this species from a few other German Oligocene localities. It has been recently recorded from the Eocene of Cowlitz River, Lewis Co., Washington.

Robertina austriaca Reuss

Plate 18, figures 8, 22

Robertina austriaca Reuss, Akad. Wiss. Wien Denkschr., vol. 1, p. 375, pl. 47, fig. 15, 1850.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 12, p. 94, pl. 16, figs. 2, 3, 1936.

Test broadly conical, only slightly longer than broad, not much compressed, expanding only slightly toward the apertural end, initial end either very bluntly pointed or rounded; chambers slightly inflated, about 5 pairs in the final whorl; sutures distinct, slightly depressed; wall very finely perforate, smooth; aperture elongate, slightly curved, and obliquely placed at the base of the apertural face, with a secondary aperture at the basal margin. Length 0.46 to 0.55 mm., diameter 0.31 to 0.32 mm.

Reuss described this species from the Miocene at Grinzing, near Vienna. We have specimens from the Miocene of Perchtoldsdorf and Baden, Vienna Basin, Austria.

Robertina imperatrix (Karrer) Cushman and Parker

Plate 18, figures 9, 10

Bulimina imperatrix Karrer, Akad. Wiss. Wien Sitzungsber., vol. 57, pt. 1, p. 176, pl. 4, fig. 11, 1868.

Robertina imperatrix Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 12, p. 95, pl. 16, figs. 6, 7, 1936.

Glaessner, Studies in Micropaleontology, vol. 1, fasc. 3, p. 24, pl. 2, fig. 30, 1937.

Test longer than broad, fusiform, greatest breadth at about the middle, initial end acute, tapering, apertural end broadly rounded; chambers distinct, very slightly inflated, 5 or 6 pairs in the last-formed whorl, increasing rapidly in size as added; sutures distinct, very slightly, if at all, depressed, strongly limbate; wall smooth, polished; aperture elongate, narrow, running at least halfway into the apertural face, secondary aperture distinct, elongate, nearly as broad as the primary. Length 0.41 to 0.60 mm., diameter 0.30 mm.

The types are from the Miocene of Kostej, in the Banat region of Hungary. The species is not known elsewhere.

Robertina californica Cushman and Parker

Plate 18, figure 11

Robertina californica Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 12, p. 97, pl. 16, figs. 14a, b, 1936.

Test nearly twice as long as broad, initial end subacute, tapering, apertural end broadly rounded; chambers only slightly inflated, increasing gradually in size in the final whorl, which consists of 8 or more pairs, all the chambers of one series reaching the middle line on the ventral side; sutures strongly limbate, little, if at all, depressed; aperture very narrow, elongate, running more than halfway into the apertural face, little, if at all, curved; supplementary aperture elongate, low. Length 0.32 to 0.64 mm., diameter 0.14 to 0.31 mm.

The types are from the Pliocene of Santa Barbara, California. The species occurs also in Pliocene material from Timms Point, San Pedro, California.

This species is related to, and probably the ancestral form of, *Robertina charlottensis* Cushman, differing from that species in the more regular form and outline, less twisted elongate axis, and less prominent spire.

Robertina arctica D'Orbigny

Plate 18, figure 12

Robertina arctica D'Orbigny, Foraminifères fossiles du bassin tertiaire de Vienne, p. 203, pl. 21, figs. 37, 38, 1846.

Schlumberger, Feuille jeunes nat., vol. 12, pl. 2, fig. 2, 1881.

Cushman, Cushman Lab. Foram. Research Special Pub. 1, p. 246, pl. 35, figs. 13, 14, 1928; idem, Special Pub. 4, pl. 22, fig. 4, 1933; idem, Special Pub. 5, pl. 27, figs. 10a, b, 1933.

Earland, *Discovery* Repts., vol. 10, p. 123, pl. 5, figs. 52, 53, 1934.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 12, p. 93, pl. 16, figs. 1a, b, 1936.

Bulimina subteres Goës (not H. B. Brady), K. svenska. vetensk. akad. Handl., vol. 25, no. 9, p. 46, pl. 9, figs. 445-453, 1894.

Test in a loose spiral, generally conical, expanding toward the apertural end, initial end bluntly pointed; chambers arranged in a double series in each whorl, giving an alternating appearance to the dorsal side, numerous, as many as 12 to 15 in the final whorl in the adult; sutures distinct, usually not depressed; wall very finely perforate, smooth; aperture a straight or slightly curved, slit-like opening in the middle of the base of the apertural face, nearly at right angles to the line of the base of the chamber; secondary aperture distinct, but shorter than the primary. Length 0.44 to 0.56 mm., diameter 0.26 to 0.28 mm.

D'Orbigny described this species from the Arctic, north of Siberia. The species is common in the collections made by Capt. R. A. Bartlett off northeast Greenland. Like certain other Arctic species this one seems to occur also in the Antarctic.

Robertina charlottensis (Cushman) Cushman

Plate 18, figure 14

Cassidulina charlottensis Cushman, Cushman Lab. Foram. Research Contr., vol. 1, pt. 2, p. 41, pl. 6, figs. 6, 7, 1925; idem, Contr., vol. 1, pt. 3, p. 53, pl. 8, figs. 17, 18, 1925.

Robertina charlottensis Cushman, idem, Special Pub. 5, pl. 27, figs. 9a, b, 1933.

Cushman and Parker, idem, Contr., vol. 12, p. 97, pl. 16, figs. 12a, b, 1936.

Test about twice as long as broad, strongly spiral, greatest breadth at about the middle, in front view one side nearly straight, the other strongly convex, initial end subacute, rapidly tapering, apertural end obliquely rounded, truncate; chambers slightly, if at all, inflated, increasing gradually and regularly in size as added, 9 or more pairs in the final whorl, all those on one side reaching the median line on the ventral side; sutures strongly limbate; aperture elongate, somewhat open, running halfway into the apertural face of the test, slightly curved; supplementary aperture elongate, low. Length nearly up to 1.00 mm., diameter 0.55 mm.

This species was described from Queen Charlotte Sound, in 20-25 fathoms.

It is evidently derived from *Robertina californica* Cushman and Parker and is a still more specialized species, with the whorls strongly marked. It also seems related to *R. subteres* (H. B. Brady) but is broader and larger, with more chambers to a whorl.

Robertina subcylindrica (H. B. Brady) Cushman and Parker

Plate 18, figure 13

Bulimina subcylindrica (H. B. Brady), Quart. Jour. Micr. Sci., vol. 21, p. 56, 1881; *Challenger* Rept., Zoology, vol. 9, p. 404, pl. 50, figs. 16a, b, 1884.

Millett, Royal Micr. Soc. Jour., 1900, p. 277, pl. 2, fig. 6.

Sidebottom, idem, 1918, p. 122, pl. 3, fig. 7.

Robertina subcylindrica Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 12, p. 95, pl. 16, figs. 10a, b, 1936.

Chapman and Parr, Australasian Antarctic Exped., ser. C, vol. 1, pt. 2, p. 79, 1937.

Thalmann, Eclogae geol. Helvetiae, vol. 30, p. 341, 1937.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 16, p. 22, 1940.

Cushman, U. S. Nat. Mus. Bull. 161, pt. 3, p. 9, pl. 3, figs. 14a, b, 1942.

Test subcylindrical, broadly rounded at both ends, about 4 pairs of chambers in the last-formed whorl, the chambers of the lower series much more elongate than those of the upper ones, somewhat inflated; sutures distinct, slightly depressed, somewhat limbate; wall smooth, thin, translucent; aperture comparatively short, narrow, nearly in the line of the elongate axis; supplementary aperture very inconspicuous. Length 0.50 mm., diameter 0.24 mm.

Brady's types of this species were from *Challenger* sta. 120, off Pernambuco, Brazil. It has been recorded from the Indo-Pacific and Australian regions. We have a typical specimen from 98 fathoms, off the Big King, New Zealand, and one specimen from off the Philippines.

Robertina translucens Cushman and Parker

Plate 18, figure 15

Robertina translucens Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 12, p. 99, pl. 16, figs. 8a, b, 1936.

Test somewhat longer than broad, rather regularly fusiform, greatest breadth at about the middle, initial end subacute, apertural end rounded; chambers distinct, very slightly inflated, about 4 pairs in the last-formed whorl, very rapidly increasing in size as added, the next to the last chamber in the apertural view pinched out from the median line by the preceding chamber of its series; sutures distinct, somewhat limbate, slightly if at all depressed; wall smooth, translucent; aperture elongate, distinctly curved, nearly in the elongate axis of the test, secondary aperture very small and inconspicuous. Length 0.40 to 0.52 mm., diameter 0.20 to 0.25 mm.

The types are from Recent material from 1,000 fathoms, off southwest Ireland. The species occurs also southwestward to the eastern coast of the United States, and southward to Brazil.

This species differs from *Robertina arctica* D'Orbigny in the fewer chambers to the whorl, much more rounded chambers, more strongly curved and less oblique aperture, and in the great extension of the chambers toward the base.

Robertina bradyi Cushman and Parker

Plate 18, figure 16

Robertina bradyi Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 12, p. 99, pl. 16, figs. 9a, b, 1936.

Thalmann, Eclogae geol. Helvetiae, vol. 30, p. 341, 1937.

Bulimina subteres H. B. Brady (part), *Challenger* Rept. Zoology, vol. 9, p. 403, pl. 50, fig. 18 (not fig. 17), 1884.

Buliminella subteres Cushman (not H. B. Brady), U. S. Nat. Mus. Bull. 71, pt. 2, p. 89, text fig. 142, 1911; U. S. Nat. Mus. Bull. 104, pt. 3, p. 110, pl. 22, figs. 3-5, 1922.

Buliminella subteres (H. B. Brady) var. Cushman, idem, p. 112, pl. 22, fig. 6, 1922.

Test somewhat longer than broad, fusiform, initial end bluntly pointed, apertural end broadly rounded; chambers slightly inflated, 4 to 5 pairs in the last-formed whorl, increasing rapidly in size as added, the next to the last chamber in the series with the apertural chamber meeting the median line; sutures distinct, slightly depressed, strongly limbate; wall smooth, polished, fairly thick; aperture very elongate, open, only slightly curved in the median line of the axis, supplementary aperture short, fairly high. Length 0.35 to 0.50 mm., diameter 0.24 to 0.30 mm.

The types are from Recent material at *Albatross* sta. D2150, 382 fathoms, Caribbean Sea, Lat. 13° 34′ 45″ N., Long. 81° 21′ 10″ W. The species ranges south to the coast of Brazil.

This species differs from *Robertina arctica* D'Orbigny in the fewer chambers, much broader form, more elongate and more open aperture. It differs from *R. translucens* Cushman and Parker in the apertural view, by the much shorter chambers, and in having the chamber before the apertural chamber meeting the median line instead of being pinched out.

Robertina oceanica Cushman and Parker, n.sp.

Plate 18, figure 18

Bulimina declivis H. B. Brady (not Reuss), *Challenger* Rept., Zoology, vol. 9, p. 404, pl. 50, figs. 19a, b, 1884.

?Egger, K. bayer. Akad. Wiss. Abh., cl. 2, vol. 18, p. 290, pl. 8, figs. 64, 65, 1893.

Sidebottom, Royal Micr. Soc. Jour., 1918, p. 122, pl. 3, figs. 4-6.

Test slightly longer than broad, very broadly fusiform, initial end subacute to rounded, apertural end broadly rounded; chambers distinct, much inflated, 3 to 4 pairs in the adult whorl, increasing very rapidly in size as added; wall smooth, polished; aperture elongate, distinctly curved, narrow; secondary aperture very distinct, about

half as long as the primary. Length 0.70 to 0.80 mm., breadth 0.55 to 0.60 mm.

Holotype (Cushman Coll. No. 35847), from Recent material at 75 fathoms, off North Cape, New Zealand.

Brady's figured specimen is from a *Challenger* station off the Ki Islands in the Pacific and Sidebottom's were from off Australia. We have specimens from other localities off New Zealand. A single specimen from off the Philippines seems to be very close to this species.

This species has been included under Reuss' name, as given above, but is a broader, more inflated form, with deeper sutures and more inflated chambers.

Robertina parkeri (Terquem and Terquem) Cushman and Parker

Plate 18, figure 17

Bulimina parkeri Terquem and Terquem, Soc. Zool. France Bull., vol. 11, p. 334, pl. 11, fig. 19, 1886.

Robertina parkeri Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 16, p. 22, 1940.

This species was described from the region south of Norway. It is evidently a *Robertina,* but we have no material that seems identical with it. The type figure is given on our plate.

Robertina subteres (H. B. Brady) Cushman and Parker

Plate 18, figure 19 .

Bulimina subteres H. B. Brady, Quart. Jour. Micr. Sci., vol. 21, n.ser., p. 55, 1881.

Wright, Belfast Nat. Field Club Proc., 1880-81, App., p. 180, pl. 8, figs. 2, 2a, 1882.

H. B. Brady (part), *Challenger* Rept., Zoology, vol. 9, p. 403, pl. 50, fig. 17? (not fig. 18).

Bulimina presli Reuss var. *elegantissima* Parker and Jones, Philos. Trans., vol. 155, p. 374, pl. 15, figs. 12-17, 1865.

Robertina convoluta Cushman and Parker (not Williamson), Cushman Lab. Foram. Research Contr., vol. 12, p. 94, pl. 16, figs. 4a, b, 1936.

Thalmann, Am. Midland Naturalist, vol. 28, p. 464, 1942.

Test elongate, 2½ times as long as broad, slightly compressed, initial end somewhat pointed; chambers distinct, slightly inflated, 6 or 7 pairs in the final whorl, rather elongate and narrow; sutures distinct, very slightly depressed, strongly limbate; wall smooth, polished, translucent; aperture elongate, narrow, slightly curved, the upper end slightly expanded; supplementary aperture at the base very narrow, inconspicuous. Length 0.39 mm., diameter 0.16 mm.

In his notes on this species published in 1881 Brady refers the figures of Parker and Jones to his species and again in the synonymy of the *Challenger* Report. This form is common about the British Isles and in the north Atlantic and may be taken as typical of this species. He mentions its relationship as close to *Robertina arctica* D'Orbigny. Our figured specimen is from the coast of Ireland. There has been much confusion in regard to this species, as the figures shown under *B. subteres* in the *Challenger* Report of specimens from the south Pacific are not of the same species as that from the north Atlantic.

We referred the figured specimens to *"Robertina convoluta* (Williamson)," but that species is different and will be discussed separately.

Genus PSEUDOBULIMINA Earland, 1934

Pseudobulimina Earland, *Discovery* Repts., vol. 10, p. 133, 1934. *Bulimina* (part) of authors.

Genoholotype, *Bulimina chapmani* Heron-Allen and Earland.

Test free, consisting of two series of chambers of very different dimensions, rapidly increasing in size and arranged side by side in a helicoid spiral of more than one convolution; wall calcareous, perforate; aperture a narrow opening at the inner edge of the chamber, with a longer opening in the apertural face. Eocene to Recent.

This peculiar form is in some respects similar to *Robertina,* particularly in the apertural characters. It may possibly be related to the Cassidulinidae.

Glaessner places this genus and *Robertina* in his new family Ceratobuliminidae. He states that the so-called primary aperture in this and *Robertina* is not a true aperture but a fold connecting with the previous chamber, but our studies of *Robertina arctica* do not confirm this.

Pseudobulimina chapmani (Heron-Allen and Earland) Earland

Plate 18, figure 20

Bulimina chapmani Heron-Allen and Earland, British Antarctic Exped., Zoology, vol. 6, p. 130, pl. 4, figs. 18-20, 1922.

Robertina chapmani Wiesner, Deutsche Süd-Polar-Exped., vol. 20, Zool., p. 124, pl. 20, fig. 239, 1929.

Pseudobulimina chapmani Earland, *Discovery* Repts., vol. 10, p. 134, pl. 6, figs. 11-14, 1934.

Chapman and Parr, Australasian Antarctic Exped., ser. C, vol. 1, pt. 2, p. 80, 1937.

Glaessner, Studies in micropaleontogy, vol. 1, fasc. 3, p. 23, pl. 2, figs. 23, 24, 1937.

Test free, perforate, helicoid, consisting of a double series of chambers, arranged in a rapidly increasing spiral, the outer series being largely predominant and increasing in size much more rapidly than the inner series. Sutural lines flush, but often thick, and showing as bands of clear shell-substance. The oral face of the final chamber flat, containing the aperture, which is a well-marked cleft, running halfway across the septal face. Size (across oral face): Length up to .80 mm.; breadth up to .60 mm.; thickness up to .50 mm.—Heron-Allen and Earland.

The species was described from the Antarctic and has been since recorded several times from that region. We

have no material. Heron-Allen and Earland refer the specimen figured from the Antarctic, by Chapman as "*Bulimina seminuda* Terquem" to their species. (Chapman, British Antarctic Exped., Geol., vol. 2, p. 29, pl. 2, figs. 9a, b, 1916.)

Pseudobulimina glaessneri Howe and Roberts

Plate 18, figure 21

Pseudobulimina glaessneri Howe and Roberts, in Howe, Louisiana Dept. Cons. Geol. Bull. 14, p. 81, pl. 11, figs. 9-11, 1939.

Cushman and Todd, Cushman Lab. Foram. Research Contr., vol. 21, p. 20, pl. 4, figs. 19, 20, 1945.

Test spirally coiled, with a double set of chambers which show both dorsally and ventrally; 10 or 11 chambers in the last coil; wall thick and shiny as in *Ceratobulimina;* early sutures flush with the surface, later ones depressed; aperture an oblique slit in the apertural face. Holotype, length 0.40 mm.; thickness 0.16 mm.—Howe and Roberts.

The types of this species are from the Eocene Cook Mountain formation, left bank of Saline Bayou beneath Louisiana and Arkansas Railroad bridge at St. Maurice, Winn Parish, Louisiana.

The type figures, given on our plate, do not give clear details of the structure of this species, and it is questionably placed in this genus until more is known concerning its detailed structure. Similar forms were found in the Eocene Lisbon formation of Monroe County, Alabama.

Pseudobulimina convoluta (Williamson)

Cushman and Parker

Bulimina pupoides D'Orbigny var. *convoluta* Williamson, Recent Foraminifera of Great Britain, p. 63, pl. 5, figs. 132, 133, 1858.

Bulimina convoluta H. B. Brady, *Challenger* Rept., Zoology, vol. 9, p. 409, pl. 113, figs. 6a, b, 1884.

Egger, K. bayer. Akad. Wiss. Abh., cl. 2, vol. 18, p. 288, pl. 8, figs. 83, 84, 1893.

Millett, Royal Micr. Soc. Jour., 1900, p. 279, pl. 2, fig. 9.

Buliminella convoluta Cushman, U. S. Nat. Mus. Bull. 104, pt. 3, p. 109, pl. 18, figs. 4, 5, 1922.

Pseudobulimina convoluta Glaessner, Studies in micropaleontology, vol. 1, fasc. 3, p. 23, pl. 2, figs. 26, 27, 1937.

Brotzen, Sveriges geol. undersökning, ser. c, no. 451, p. 37, text figs. 12, 16, 1942.

Thalmann, Am. Midland Naturalist, vol. 28, p. 464, 1942.

No definite description of this species can be given, as the original figure by Williamson is too obscure to provide information on details. It is also probably not correctly drawn. The figures given by Brady in the *Challenger* Report of specimens obtained from Torres Strait are probably not of a species identical with that of Williamson and perhaps do not belong to *Pseudobulimina.* The species is evidently rare in the region of the British Isles to judge by our examination of material from that area. Other references are given above, but it is very doubtful if they all refer to one species or whether they really belong to this genus. In some respects they resemble *Cushmanella.* Few of them show the primary aperture well developed. Glaessner has placed these forms with *Ceratobulimina* and described the family Ceratobuliminidae, which contains a varied group of genera, the close relationships of which seem very questionable. The group needs much detailed study.

Subfamily 3. BULIMININAE

Test spiral, usually triserial, becoming involute and finally, in *Entosolenia,* single chambered; wall calcareous, finely perforate; aperture loop-shaped, the larger end away from the inner margin (or rounded in *Entosolenia*), usually with a distinct tooth and internal tube or trough connecting the chambers (or in *Entosolenia* free at the inner end).

In this study *Entosolenia* has not been included, as many of the species are difficult to place until the actual types can be examined for their internal structure.

Genus BULIMINA D'Orbigny, 1826

Bulimina D'Orbigny, Annales sci. nat., vol. 7, p. 269, 1826.

H. B. Brady, *Challenger* Rept., Zoology, vol. 9, p. 397, 1884.

Chapman, The Foraminifera, p. 172, 1902.

Cushman, U. S. Nat. Mus. Bull. 71, pt. 2, p. 76, 1911; Smithsonian Misc. Coll., vol. 77, no. 4, p. 35, 1925.

Galloway and Wissler, Jour. Paleontology, vol. 1, p. 73, 1927.

Cushman, Cushman Lab. Foram. Research Contr., vol. 3, pt. 1, p. 65, 1927; idem, Special Pub. 1, p. 247, 1928.

White, Jour. Paleontology, vol. 3, p. 46, 1929.

Cushman, Cushman Lab. Foram. Research Special Pub. 4, p. 220, 1933; U. S. Nat. Mus. Bull. 161, pt. 3, p. 10, 1942.

Pleurites Ehrenberg, Mikrogeologie, 1854.

Cucurbitina Costa, Accad. pontaniana Atti, vol. 7, pt. 2, p. 363, 1856.

Genotype, *Bulimina marginata* D'Orbigny.

Test an elongate spiral, generally triserial; chambers inflated, spiral suture more or less obsolete; wall calcareous, perforate; aperture loop-shaped, with a tooth or plate at one side and an internal spiral trough connecting through the chambers between the apertures. Jurassic to Recent.

The earliest occurrence of the genus is in the Jurassic. The species there are simple, so far as can be made out from the figures and descriptions. In the Upper Cretaceous the species become ornate, and the same types of ornamentation persist in the species of the present oceans. For the most part the ornamentation consists of longitudinal costae or ridges, sometimes continuous over the whole length of the test but more usually broken at the sutures. Spines are frequently developed at the basal border of the chambers and at the initial end.

Many of the species are relatively short-lived and make good index fossils. Some species have wide geographic distributions but are distinctly restricted, so far as is known, at the present time.

Bulimina antiqua Terquem and Berthelin

Plate 19, figure 1

Bulimina antiqua Terquem and Berthelin, Soc. Géol. France Mém., ser. 2, vol. 10, pt. 3, p. 65, pl. 5, fig. 16, 1875.

Cast of pyrite, elongate, narrow, straight, composed of 3 vertical series, containing 6 whorls of spherical chambers. Very rare. Length 0.26 mm.; diameter 0.09 mm.—Terquem and Berthelin (translated).

The species was described from the lower Lias of Essay-les-Nancy, France.

No specimens referable to this species were found in available collections. It is more than possible that the form is not a *Bulimina*. The original figure is reproduced.

Bulimina incurva Terquem

Plate 19, figures 2, 3

Bulimina incurva Terquem, Cinquième Mémoire sur les foraminifères du système oolithique, p. 387, pl. 45, figs. 10, 11, 1883.

Test elongate, smooth, obtuse at both ends, consisting of an oblique spire, twisted, of 5 or 6 whorls; chambers projecting, round, arranged in 3 straight or curved rows, increasing regularly. Length (of figured specimens) 0.28, 0.32, 0.38 mm.; diameter 0.14, 0.12, 0.22 mm.—Terquem (translated).

The species was described from the Jurassic, *Ammonites parkinsoni* zone, Fontoy, France.

Terquem's figures are reproduced. Three specimens were found in Jurassic material from Metz, France, which may be tentatively referred to this species. One of these is figured. The later chambers do not show the inflation of Terquem's species, and the chambers are not spherical.

Bulimina intricata Terquem

Plate 19, figure 4

Bulimina intricata Terquem, Cinquième mémoire sur les foraminifères du système oolithique, p. 388, pl. 45, figs. 14a, b, 1883.

Test elongate, oval, smooth, tapering, rounded at the initial end, consisting of an indistinct spire, with more or less numerous whorls, the early chambers flat, overlapping, very small and numerous, later ones more or less inflated, round. Length 0.29 mm., diameter 0.16 mm.—Terquem (translated).

The types are from the Jurassic, *Ammonites parkinsoni* zone, Fontoy, Moselle, France.

We have no typical material. Terquem's figures are reproduced.

Bulimina muricata Terquem

Plate 19, figures 5, 6

Bulimina muricata Terquem, Cinquième mémoire sur les foraminifères du système oolithique, p. 388, pl. 45, figs. 12, 13, 1883.

Test elongate, conical, almost circular in transverse section, smooth, obtuse at both ends, formed of a straight spire of 4 to 6 whorls, chambers in 2 or 3 rows, projecting, more or less involute, the last sometimes regularly oval. Length 0.26, 0.28 mm.; diameter 0.17, 0.16 mm.—Terquem (translated).

The types of the species are from the Jurassic, *Ammonites parkinsoni* zone of Fontoy, Moselle, France.

We have no material referable to the species. Terquem's figures are reproduced.

Bulimina prima Terquem

Plate 19, figures 7-9

Bulimina prima Terquem, Cinquième mémoire sur les foraminifères du système oolithique, p. 387, pl. 45, figs. 7-9, 1883.

Test elongate, conical, smooth, inflated at the apertural end, more or less tapering, obtuse at the initial end, consisting of a straight spire, composed of 4 to 7 whorls, chambers projecting, inflated, rounded, arranged in 3 rows, increasing regularly. Length 0.31, 0.32, 0.37 mm.; diameter 0.16, 0.14, 0.14 mm.—Terquem (translated).

The types are from the Jurassic, *Ammonites parkinsoni* zone, Fontoy, Moselle, France. We have no typical material. Terquem's figures are reproduced.

Bulimina nannina Tappan

Plate 19, figure 10

Bulimina nannina Tappan, Jour. Paleontology, vol. 14, p. 116, pl. 19, figs. 4a, b, 1940; idem, vol. 17, p. 507, pl. 81, fig. 15, 1943.

Test minute, triserial, chambers inflated, last series much larger than the earlier chambers, final pair of chambers forming one-half the test; sutures distinct, depressed; wall calcareous, smooth; aperture loop-shaped, in the face of the last formed chamber. Length of holotype, 0.21 mm.; breadth, 0.14 mm.—Tappan.

The types are from the Lower Cretaceous Grayson formation, lower part of zone 1, Grayson Bluff on Denton Creek, 3½ miles northeast of Roanoke, 2 miles by road east of the Fort Worth-Denton highway, Denton County, Texas. The species has also been recorded from the Lower Cretaceous Duck Creek formation of Oklahoma and Texas.

Bulimina nannina was originally compared with "*B. ovula* Reuss" (*B. reussi* Morrow) but was distinguished as being smaller, with more gradually increasing chambers. It is very close to *B. reussi* Morrow var. *navarroensis* Cushman and Parker, but is less tapering and has a more rounded initial end.

Bulimina brevis D'Orbigny

Plate 21, figure 3

Bulimina brevis D'Orbigny, Soc. géol. France Mém., ser. 1, vol. 4, p. 41, pl. 4, figs. 13, 14, 1840; Prodrome de paléontologie, vol. 2, p. 282, No. 1402, 1850.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 10, p. 28, 1934.

Egger, K. bayer. Akad. Wiss. Abh., cl. 2, vol. 21, pt. 1, p. 49, pl. 15, figs. 42, 43, 1899.

Bulimina intermedia Reuss (part), Haidinger's Naturwiss. Abh., vol. 4, p. 23, pl. 3, fig. 11, 1851.

Egger, K. bayer. Akad. Wiss. Abh., cl. 2, vol. 21, pt. 1, p. 51, pl. 15, figs. 3, 4, 1899.

Bulimina murchisoniana Franke (not D'Orbigny), Geol. pal. Inst. Univ. Greifswald Abh., vol. 6, p. 27, pl. 2, figs. 22a, b, 1925; Preuss. geol. Landesanstalt Abh., n. ser., vol. 111, p. 160, pl. 14, figs. 22a, b, 1928.

Test almost as long as broad, 2 or 3 whorls, the last-formed whorl making up about three-fourths of the test; chambers few, earlier ones indistinct, those of last whorl distinct, inflated; sutures distinct, depressed in last whorl, earlier sutures indistinct; wall coarsely perforate, smooth; aperture long, comma-shaped, near the apex of the test. Length of figured specimen 0.88 mm., diameter 0.72 mm.

The types of the species are from the Upper Cretaceous near Meudon, Saint-Germain, and Sens of the Paris Basin, France. We have no material from D'Orbigny's localities, but specimens from Gravesend, England, appear to be identical. The species occurs also at various localities in the Senonian of Germany.

The original reference to *Bulimina brevis* was made by D'Orbigny in 1826 (Annales sci. nat., vol. 7, p. 270, no. 13, 1826) with Rimini, Italy, given as the type locality. At this time the name was merely listed, with no specific description. In 1840 D'Orbigny gave the name to a Cretaceous form, described, and figured it. His earlier listing of the Rimini species, together with Fornasini's later reproduction of D'Orbigny's unpublished figure (Accad. sci. Ist. Bologna Mem., ser. 5a, vol. 9, p. 6, text fig. 7, 1901) therefore, must be discarded in favor of the Upper Cretaceous form, as the latter was the first valid application of the specific name.

The species resembles *Bulimina intermedia* Reuss, from the Turonian of Germany, but is much larger, with fewer whorls, and with the aperture differing both in position and shape. It differs from *B. murchisoniana* D'Orbigny, of which we have only one questionable specimen, in the less marked inflation of the last-formed chambers, in having less depressed sutures, in the position and shape of the aperture, and in its somewhat larger size.

Bulimina murchisoniana D'Orbigny

Plate 19, figure 11

Bulimina murchisoniana D'Orbigny, Soc. géol. France Mém., ser. 1, vol. 4, p. 41, pl. 4, figs. 15, 15', 1840; Prodrome de paléontologie, vol. 2, p. 282, no. 1403, 1850.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 10, p. 29, pl. 5, figs. 7a, b, 1934.

Fahrion, Paleontographica, Suppl., 2. Reihe, pt. 2, no. 2, p. 199, 1937.

Macfadyen, Geol. Mag., vol. 79, p. 139, 1942.

Test large, rounded; chambers distinct, last-formed chambers inflated, corresponding chambers of each whorl aligned; earlier sutures indistinct, later ones depressed; wall slightly rough, almost papillate; aperture indistinct, placed at the suture joining the second and third chambers, loop-shaped. Length of figured specimen 0.70 mm., diameter 0.64 mm.

The types are from the Upper Cretaceous, of Saint-Germain, Paris Basin, France, and of England.

One specimen was found in material from Gravesend, England, which may be referred to this species. It is figured here. A discussion of the resemblance of this species to *Bulimina intermedia* Reuss will be found under the latter species and need not be repeated here. It also bears some resemblance to *B. brevis* D'Orbigny. D'Orbigny recognized this and in his description says that it is related to *B. brevis* by its rounded chambers and short form. He adds that this species can be distinguished by its elongate spire, which is pointed and not obtuse, and by its chambers, which are more widely separated throughout and are arranged in three rows.

Bulimina amphicona Von Hagenow

Bulimina amphicona Von Hagenow, Neues Jahrb., 1842, p. 570.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 10, p. 36, 1934.

Test conically pointed at both ends, sharper at the upper end, regularly coiled; chambers inflated as in *Helix*, their junction, in a zigzag line, visible on only one side of the test.

Von Hagenow's description is summarized. The species was described from the Upper Cretaceous of Rügen. The description is not sufficiently full to identify any specimens we have with the species and no figures are given.

Bulimina tumida Reuss

Bulimina tumida Reuss, Geogn. Skizzen Böhmen, vol. 2, pt. 1, p. 215, 1844.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 10, p. 29, 1934.

Test about as long as broad, broadly egg-shaped, very tumid, apertural end truncated, initial end pointed, distinctly coiled, with 4 whorls, each with 3 chambers; chambers of the last portion inflated, with deep sutures; the earlier chambers one-third to one-fourth the size of the later, less inflated, sutures indistinct, the last whorl making up the larger portion of the test; aperture a straight opening, at right angles to the last spiral suture. Length one-fourth to 1 line (? 0.5 to 2.1 mm.)

The species is related to *Bulimina murchisoniana* D'Orbigny.

The original description of Reuss is summarized above. The species was described from the Upper Cretaceous Plänerkalk of Kuschlin and Kosstitz, Bohemia. No figures were given.

Bulimina intermedia Reuss

Plate 19, figures 12-15

Bulimina intermedia Reuss, Die Verstein. böhm. Kreide, pt. 1, p. 37, pl. 13, fig. 71, 1845; Paleontographica, vol. 20, pt. 2, p. 108, 1874.

Bulimina murchisoniana Reuss (not D'Orbigny), Die Verstein. böhm. Kreide., pt. 1, p. 37, pl. 8, figs. 69, 72; pl. 13, fig. 70, 1845; in Geinitz, Grundr. Verstein., p. 672, pl. 24, fig. 61, 1845-6.

Test of medium size, rapidly tapering, consisting of 3 to 5 whorls; chambers distinct, those of the last whorl much inflated and occupying about half the test, corresponding chambers in each whorl aligned; sutures distinct, slightly depressed; wall coarsely perforate; aperture loop-shaped, either directly at, or very slightly above, the suture joining the second and third chambers. Length of specimens from Luschitz 0.34 to 0.54 mm., diameter 0.30 to 0.42 mm.

We have a few specimens from the Upper Cretaceous Plänermergel of Luschitz, Bohemia, Reuss' type locality, as well as specimens from Kosstitz and other Turonian localities of Germany and Bohemia.

In the Naturhistorisches Museum in Vienna specimens of this species, named by Reuss and presumably from Luschitz, were seen and drawings of two of the specimens are reproduced here (pl. 19, figs. 14, 15). This form is close to *Bulimina murchisoniana* D'Orbigny and it is possible that it should be placed in the synonymy under this species, but as we have only one specimen of the latter from the Senonian of Gravesend, England, it seems best to keep the species separate. Reuss describes *B. murchisoniana* from Kosstitz but does not give this locality for *B. intermedia.* Our specimens from there, however, agree well with those seen in Vienna, and two of them are figured here (pl. 19, figs. 12, 13). A study of Reuss' figures of D'Orbigny's species shows that he may have misunderstood the form. In comparing the two he describes *B. intermedia* as not having such deeply cut sutures, and in a later paper (Palaeontographica, vol. 20, pt. 2, p. 108, 1874) he describes it as a shorter, stouter form of *B. murchisoniana.* Actually it is a smaller form, the largest specimen being considerably less than two-thirds of a millimeter, the length given by D'Orbigny for his species.

Bulimina cenomana D'Orbigny

Bulimina cenomana D'Orbigny, Prodrome de paléontologie, vol. 2, p. 185. No. 759, 1850.

Cushman and Parker, Cushman Lab. Foram Research Contr., vol. 10, p. 36, 1934.

Species close to *B. prolea,* but shorter and more rugose.—D'Orbigny (translated).

The types are from the Upper Cretaceous, Le Mans, France. The species was not figured.

Bulimina sarthacensis D'Orbigny

Bulimina sarthacensis D'Orbigny, Prodrome de paléontologie, vol. 2, p. 185, no. 760, 1850.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 10, p. 36, 1934.

Species related to *B. rugosa,* but larger and more pupoid.—D'Orbigny (translated).

D'Orbigny's brief description of the species, from the Upper Cretaceous, Cenomanian, of Le Mans, France, in the absence of figures is wholly inadequate, especially as there seem to be no other references to *"B. rugosa"* in the literature.

Bulimina acuta Reuss

Plate 19, figure 16

Bulimina acuta Reuss, Haidinger's Naturwiss. Abh., vol. 4, pt. 1, p. 38, pl. 3, fig. 8, 1851.,

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 10, p. 31, pl. 5, fig. 21, 1934.

Test 2½ times as long as broad, very slightly tapering, consisting of 4 to 5 whorls; chambers indistinct, not inflated; sutures indistinct, very slightly depressed; wall smooth, coarsely perforate; aperture narrow, loop-shaped, at apex of test. Length of figured specimen 0.52 mm., diameter 0.20 mm.

The types are from the Upper Cretaceous, upper Senonian, of Lemberg, Galicia.

The species resembles *Bulimina kickapooensis* Cole but is smaller, with fewer whorls, and is much more coarsely perforate. Only two specimens were found in material from Lemberg. A larger suite of specimens might show a greater resemblance to Cole's species.

Bulimina parva Franke

Plate 19, figure 17

Bulimina parva Franke, Preuss. geol. Landesanstalt. Abh., n. ser., vol. 111, p. 157, pl. 14, fig. 13, 1928.

Test small, tapering, consisting of 4 to 5 whorls; chambers fairly distinct, those of the last-formed whorl making up at least half of the test; sutures slightly depressed; wall smooth, perforate, somewhat polished; aperture loop-shaped, at apex of test. Length of figured specimen 0.24 mm., diameter 0.13 mm.

The species was described from the Upper Cretaceous, upper Senonian, Himmelberg, near Ahlen, Germany. Our

figured specimen is from Mersch, near Hamm, Germany. It is smaller than some of the specimens found. The species is fairly common in the Senonian of Germany.

This form differs from *Bulimina reussi* Morrow in its smaller size, narrower test, and the lack of inflation of the last-formed chambers. It is longer in proportion to its width than *B. exigua* Cushman and Parker, and the last-formed whorl makes up a far greater proportion of the test.

Bulimina minuta (Marsson) Cushman

Plate 21, figure 4

Tritaxia minuta Marsson, Naturwiss. Ver. Neu-Vorpommern Rügen Mitt., Jahrb. 10, p. 162, pl. 4, figs. 31a-d, 1878.

Bulimina minuta Cushman (not Hantken), Cushman Lab. Foram. Research Special Pub. 7, p. 29, 1937.

Bulimina marssoni Cushman and Parker, idem, Contr., vol. 16, p. 46, pl. 8, fig. 17, 1940.

Test small, triangular in transverse section, consisting of 5 whorls, rapidly tapering; chambers indistinct, meeting in a zigzag line on the somewhat concave sides; sutures slightly depressed, dark in color; wall coarsely perforate, smooth; aperture loop-shaped, at apex of test. Length of figured specimen 0.28 mm., diameter 0.12 mm.

This species was described from the Upper Cretaceous, Senonian, of Rügen. It has not been recorded elsewhere.

The specimens used for study were compared to Marsson's type in Vienna in 1932 by Cushman. The species resembles *B. rudita* Cushman and Parker but differs from it in its smaller size, more regular character, smooth wall, and less depressed sutures.

Bulimina exigua Cushman and Parker

Plate 19, figure 18

Bulimina exigua Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 11, p. 99, pl. 15, figs. 7a, b, 1935.

Cushman, U. S. Geol. Survey Prof. Paper 206, p. 122, pl. 51, fig. 18, 1946.

Test very small, about twice as long as broad, gradually tapering, usually consisting of 5 whorls; chambers distinct, overlapping, somewhat inflated; sutures distinct, depressed throughout, forming a slight angle with the horizontal; wall smooth, perforate; aperture rounded. Length 0.10 to 0.17 mm., diameter 0.08 to 0.11 mm.

The types of the species are from the Upper Cretaceous Brownstown marl (near base), Paris-Clarksville highway, 1.85 miles southeast of Bagwell, Texas. It occurs also in the lower part of the Taylor marl and the Austin chalk and its equivalents in Texas.

The species resembles most closely *Bulimina reussi* Morrow var. *navarroensis* Cushman and Paker but differs from it in its smaller size, in having the last-formed chambers less inflated, and in the more gradual increase in the size of the chambers towards the apertural end.

Bulimina kickapooensis Cole

Plate 19, figures 19, 20

Bulimina kickapooensis Cole, Florida Dept. Cons. Geol. Bull. 16, p. 45, pl. 3, fig. 5, 1938.

Cushman and Hedberg, Cushman Lab. Foram. Research Contr., vol. 17, p. 94, pl. 22, figs. 28a-c, 1941.

Cushman and Deaderick, Jour. Paleontology, vol. 18, p. 337, pl. 53, fig. 7, 1944.

Cushman, U. S. Geol. Survey Prof. Paper 206, p. 123, pl. 51, figs. 11, 12, 14; pl. 66, fig. 12, 1946.

?Bulimina elegans Chapman (not D'Orbigny), Quart. Jour. Geol. Soc., vol. 48, p. 516 (list), pl. 15, fig. 9, 1892.

?Egger, K. bayer. Akad. Wiss. Abh., cl. 2, vol. 21, pt. 1, p. 50, pl. 15, fig. 44, 1899.

?Bulimina obtusa Egger (not D'Orbigny), K. bayer. Akad. Wiss. Abh., cl. 2, vol. 21, pt. 1, p. 50, pl. 15, fig. 51, 1899.

Bulimina quadrata Cushman and Parker (part) (not Plummer), Cushman Lab. Foram. Research Contr., vol. 11, p. 100, pl. 15, figs. 13, 14 (not 12, 15, 16), 1935.

Test about 2½ times as long as broad, megalospheric form tapering very slightly, microspheric rapidly, consisting of 5 or 6 whorls; chambers numerous, distinct, slightly inflated, sharply angled; sutures distinct, slightly depressed; wall smooth, perforate; aperture loop-shaped at apex of test, with a thin, plate-like tooth. Length of holotype 0.72 mm., diameter 0.28 mm.

The types are from the Upper Cretaceous, upper part of Taylor marl, branch of Kickapoo Creek, 1200 feet south of public road, 1.8 miles northwest of Annona, Red River County, Texas. The species occurs in formations of Navarro age in Arkansas, Tennessee and Texas; those of Taylor age in Texas; in the deep well in Florida cited by Cole; and in the Upper Cretaceous of Colombia. It also occurs questionably in the Moreno shale of California. It is found in the Senonian of Germany.

This species was named by Cole from specimens described by Cushman and Parker (Cushman Lab. Foram. Research Contr., vol. 11, p. 100, 1935). Cole designated the specimens figured by Cushman and Parker on plate 15, figures 13, 14 and 16. Figure 16, however, represents quite a different form from the others and is here referred to *Bulimina aspera* Cushman and Parker; it is smaller, having less sharply angled, more inflated chambers, with the wall of the earlier chambers somewhat roughened, and usually with one or more terminal spines. *B. kickapooensis* closely resembles *B. (Desinobulimina) quadrata* Plummer but does not have the terminal aperture.

Bulimina kickapooensis Cole var. pingua Cushman and Parker

Plate 19, figures 21, 22

Bulimina kickapooensis Cole var. *pingua* Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 16, p. 44, pl. 8, figs. 13, 14, 1940.

Cushman and Hedberg, idem, vol. 17, p. 95, pl. 22, fig. 29, 1941.

Cushman and Todd, idem, vol. 19, p. 66, pl. 11, figs. 24a, b, 1943.

Cushman, U. S. Geol. Survey Prof. Paper 206, p. 123, pl. 51, figs. 8, 9; pl. 66, figs. 15, 16, 1946.

This variety differs from the typical form in being shorter and broader, and in having more inflated chambers and more depressed sutures. Length 0.50 to 0.67 mm., diameter 0.30 to 0.35 mm.

The variety was described from the Upper Cretaceous Corsicana marl, Mexia highway at forks of Wortham road, 2.8 miles east southeast of Cooledge, Limestone County, Texas. It also occurs at other localities in the Corsicana marl, in the Kemp clay of Texas, and in the Prairie Bluff chalk of Mississippi. It has been recorded from the Colon formation, Santander del Norte, Colombia. It occurs in great abundance at some localities and serves as an excellent marker.

Bulimina taylorensis Cushman and Parker

Plate 19, figures 23, 24

Bulimina taylorensis Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 11, p. 96, pl. 15, figs. 3a, b, 1935.

Cushman, U. S. Geol. Survey Prof. Paper 206, p. 123, pl. 52, figs. 1, 2, 1946.

Test small, slightly tapering, about 1½ times as long as broad in the megalospheric form, in the rare microspheric form twice as long as broad; 4 to 5 whorls in the megalospheric form, more in the microspheric; chambers fairly distinct, overlapping; sutures deep, their presence, except in the last-formed whorl, chiefly indicated by the sharp undercutting of the chambers; wall finely perforate, with irregular costae spaced rather far apart, causing an irregular fluting of the sharp margins of the chambers, the initial end of the test with one or more spines; aperture an elongate, loop-shaped opening, with a distinct lip, at the inner margin of the last-formed chamber. Length 0.27 to 0.32 mm., diameter 0.20 to 0.21 mm.

The types are from the Upper Cretaceous, upper part of Taylor formation, branch of Kickapoo Creek, 1200 feet south of the public road, 1.8 miles northwest of Annona, Red River County, Texas. The species is found only in the upper Taylor.

It is a distinctive form and bears no close resemblance to any other Upper Cretaceous species.

Bulimina triangularis Cushman and Parker

Plate 19, figure 25

Bulimina triangularis Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 11, p. 97, pl. 15, figs. 4a, b, 1935.

Cole, Florida Dept. Cons. Geol. Bull. 16, p. 35 (list), pl. 4, fig. 1, 1938.

Cushman, Cushman Lab. Foram. Research Contr., vol. 20, p. 93, pl. 14, fig. 11, 1944.

Cushman, U. S. Geol. Survey Prof. Paper 206, p. 122, pl. 51, fig. 23, 1946.

Test small, 1⅓ times as long as broad, triangular in transverse section with rounded angles and slightly concave sides, consisting of about 5 whorls; chambers indistinct; sutures very indistinct, showing only as slightly darkened lines; wall of the bottom half of the test covered with short, irregular, longitudinal ridges which sometimes become slightly spinose, the upper half of the test smooth, coarsely perforate; aperture loop-shaped, with a slight lip. Length 0.21 to 0.28 mm., diameter 0.15 to 0.17 mm.

The types are from the Upper Cretaceous Taylor formation, 3.9 miles east of Farmersville, Collin County, Texas, on the Greenville road. The species is found in the upper beds of Taylor age in Texas, Mississippi, and Alabama, with a single occurrence in the Corsicana marl of Texas. It has been recorded by Cole from a deep well in Florida in material of Taylor age. From Germany we have specimens of Senonian age.

The species is larger than *Bulimina rudita* Cushman and Parker, is shorter in proportion to its length, has less distinct and fewer chambers, and is ornamented only on the lower part of the test.

Bulimina referata Jennings

Plate 30, figure 7

Bulimina referata Jennings, Bull. Am. Paleontology, vol. 23, no. 78, p. 31, pl. 3, figs. 21a, b, 1936.

Test minute, elongate, triangular in cross-section; four or more whorls, three chambers to a whorl; chambers short; sutures distinct, depressed; wall smooth; aperture virguline and fairly large. Length, from 0.15-0.25 mm.; width, 0.09-0.15 mm.—Jennings.

This species was described from the Upper Cretaceous Mt. Laurel sand and Navesink marl of New Jersey. We have not seen type material but it resembles *Bulimina triangularis* Cushman and Parker.

Bulimina rudita Cushman and Parker

Plate 19, figure 26

Bulimina rudita Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 12, p. 45, 1936.

Cushman, U. S. Geol. Survey Prof. Paper 206, p. 122, pl. 51, fig. 24, 1946.

Bulimina ornata Cushman and Parker (not Egger), Cushman Lab. Foram. Research Contr., vol. 11, p. 97, pl. 15, figs. 4a, b, 1935.

Test small, triangular in transverse section with the angles rounded and the sides distinctly concave, occasionally slightly twisted on its axis, consisting of 5 or 6 whorls; chambers distinct, somewhat inflated, arranged in

regular series, with the adjacent series meeting in a zigzag line; sutures distinct, depressed, sigmoid, slanting at an angle of 45° with the horizontal; wall, except for the central portion of the chambers in the last-formed whorl, covered with short spines, perforate; aperture loop-shaped, with a slight lip. Length 0.20 to 0.26 mm., diameter 0.11 to 0.16 mm.

The types of the species are from the Upper Cretaceous Taylor formation, Paris highway, 1.8 miles east of Deport, Red River County, Texas. It is fairly common at several localities in the Austin and Taylor formations of Texas, in the Prairie Bluff chalk of Mississippi, and in the Selma chalk of Alabama, Mississippi, and Tennessee.

This species is unique and bears little resemblance to other species of the genus.

Bulimina pectinata Cushman and Parker

Plate 19, figure 27

Bulimina pectinata Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 16, p. 45, pl. 8, figs. 20a-c, 1940.

Cushman, U. S. Geol. Survey Prof. Paper 206, p. 123, pl. 52, fig. 10, 1946.

Test medium, triangular in transverse section, somewhat twisted on its axis, broadest part near the apertural end, initial end bluntly pointed; consisting of about 6 whorls; chambers made somewhat indistinct by the ornamentation, except in the central part of the sides of the test; sutures indistinct except at the sides, flush with the surface, somewhat darker in color than the rest of the test; wall ornamented along the edges of the chambers by a bluntly toothed border which gives a somewhat fringed appearance to the test, finely perforate; aperture loop-shaped, at apex of test. Length of adult specimens 0.32 to 0.38 mm., diameter 0.18 to 0.20 mm.

The types are from the Upper Cretaceous, upper part of Taylor marl, road cut, east bank, near crest of hill, 14.4 miles south of Paris, 0.9 mile north of Lake City, Delta County, Texas. The species has been found only at the type locality.

The form resembles no other species. It is somewhat similar in shape to *Bulimina rudita* Cushman and Parker, but tapers less rapidly and is easily differentiated by the fringe-like ornamentation.

Bulimina aspera Cushman and Parker

Plate 19, figures 28-30; plate 21, figures 1, 2

Bulimina aspera Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 16, p. 44, pl. 8, figs. 18, 19, 1940.

Cushman and Todd, idem, Contr., vol. 19, p. 66, pl. 11, figs. 22, 1943.

Frizzell, Jour. Paleontology, vol. 17, p. 349, pl. 57, fig. 1, 1943.

Cushman, U. S. Geol. Survey Prof. Paper 206, p. 121, pl. 51, figs. 7, 10, 13, 15, 16, 1946.

Bulimina pupoides Carsey (not D'Orbigny), Univ. Texas Bull. 2612, p. 29, pl. 4, fig. 3, 1926.

Plummer, idem, Bull. 3101, p. 180, pl. 9, fig. 15, 1931.

?Sandidge, Jour. Paleontology, vol. 6, p. 280, pl. 43, fig. 1, 1932.

Bulimina obtusa Cushman and Church (not D'Orbigny), California Acad. Sci. Proc., ser. 4, vol. 18, p. 513, pl. 39, figs 17-19, 1929.

Cushman, Tennessee Geol. Survey Bull. 41, p. 47, pl. 7, figs 17, 18, 1931; Jour. Paleontology, vol. 5, p. 309, pl. 35, figs 15a, b, 1931.

Bulimina subornata Sandidge (not H. B. Brady), Jour. Paleontology, vol. 6, p. 280, pl. 43, fig. 2, 1932.

?Bulimina elongata Sandidge (not D'Orbigny), Jour. Paleontology, vol. 6, p. 281, pl. 43, fig. 3, 1932.

Bulimina quadrata W. Berry and Kelley (not Plummer), U. S. Nat. Mus. Proc., vol. 76, art. 19, p. 5, pl. 2, fig. 7, 1929.

Cushman and Parker (part), Cushman Lab. Foram. Research Contr., vol. 11, p. 100, pl. 15, figs. 12, 15, 16 (not figs. 13, 14), 1935.

Bulimina kickapooensis Cole (part), Florida Dept. Cons. Geol. Bull. 16, p. 45, 1938.

Test medium, 2 or more times as long as broad, slightly tapering, consisting of 4 to 5 whorls, initial end bluntly pointed, sometimes with 1 or 2 short basal spines; chambers joined at an angle of about 90° or less, slightly inflated; sutures distinct, slightly depressed; wall of initial part of test somewhat roughened, perforate, with the perforations often arranged in regular lines; aperture elongate, at apex of test, with a small, plate-like tooth. Length of specimens fom type locality 0.38 to 0.50 mm., diameter 0.16 to 0.26 mm.

The types are from the Upper Cretaceous, upper part of Taylor formation, 6.15 miles from Kaufman on the road to Crandall, Kaufman County, Texas. The species is very widespread, occurring in the Upper Cretaceous sediments of Taylor and Navarro ages thoughout the Gulf Coast region of the United States. It is also recorded from the Upper Cretaceous Mal Paso shale of Peru.

The specimens from the upper part of the Navarro group differ from those of the lower part of the Navarro and from the Taylor formation in not having the small initial spines; in other respects they appear to be identical. The species differs from *Bulimina pupoides* D'Orbigny in the angled character of the chambers, in the much slighter inflation of the chambers, and in the shape of the test, which tapers less and has a more blunt initial end. It differs from *B. kickapooensis* Cole in the smaller size, greater inflation of the chambers, in the roughened early portion of the test, and in the usual presence of one or two short spines.

Bulimina reussi Morrow

Plate 19, figure 31; plate 20, figures 1-5

Bulimina reussi Morrow, Jour. Paleontology, vol. 8, p. 195, pl. 29, fig. 12, 1934.

Cushman and Parker, Cushman Lab. Foram Research Contr., vol. 11, p. 99, pl. 15, figs. 8a, b, 10, 1935.

Cushman and Hedberg, idem, Contr., vol. 17, p. 95, pl. 22, figs. 30a-c, 1941.

Frizzell, Jour. Paleontology, vol. 17, p. 350, pl. 57, fig. 2, 1943.

Cushman and Deaderick, idem, vol. 18, p. 337, pl. 53, fig. 6, 1944.

Cushman, Cushman Lab. Foram. Research Contr., vol. 20, p. 12, pl. 2, fig. 25, 1944; U. S. Geol. Survey Prof. Paper 206, p. 120, pl. 51, figs. 1-5, 1946.

Bulimina ovulum Reuss (not *ovula* D'Orbigny), Geog. Skizzen Böhmen, vol. 2, pt. 1, p. 215, 1844; Die Verstein. böhm. Kreide, pt. 1, pl. 8, fig. 57; pl. 13, fig. 73, 1845-6.

Alth, Haidinger's Naturwiss. Abh., vol. 3, p. 264, pl. 13, fig. 18, 1850.

Reuss, idem, vol. 4, p. 38, pl. 3, fig. 9, 1851.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 10, p. 29, pl. 5, figs. 10, 11, 1934.

Bulimina murchisoniana Cushman (not D'Orbigny), Jour. Paleontology, vol. 5, p. 309, pl. 35, figs. 14a, b, 1931; Jour. Paleontology, vol. 6, p. 340, 1932.

Bulimina brevis Franke (not D'Orbigny), Geol. pal. Inst. Greifswald Abh., vol. 6, p. 25, pl. 2, fig. 18, 1925; Preuss. geol. Landesanstalt. Abh., n. ser., vol. 111, p. 157, pl. 14, fig. 12, 1928.

Cushman, Cushman Lab. Foram. Research Contr., vol. 7, p. 40, pl. 5, figs. 9a-c, 1931.

Bulimina ventricosa Brotzen, Sveriges geol. undersökning, ser. c, no. 396, p. 124, pl. 8, figs. 1a-c, text figs. 42, 43, 1936.

Bulimina lwowensis Brotzen, idem, p. 126.

Test small, ovate, globular, subcircular in transverse section with greatest breadth above the middle, tapering evenly to a rather sharply rounded initial end; chambers triserial throughout, obscure, enlarging very rapidly in size as they are added; sutures very slightly depressed; wall smooth, very finely perforate; aperture small, subterminal. Height 0.28 mm.; breadth 0.16 mm.—Morrow.

The species was described by Reuss from the Upper Cretaceous Plänermergel of Luschitz, Rannay, and Brozan in "Bohemia". The form has a wide range of occurrence both geographically and stratigraphically. It is found in the Upper Cretaceous of Europe ranging from the Turonian to the upper Senonian. In North America it occurs in formations of Navarro, Taylor, and Austin ages throughout the Gulf Coast region. It is also found in the Niobrara formation of Kansas, Velasco shale of Mexico, and Upper Cretaceous of Colombia and Peru. The forms found in the Austin chalk are usually shorter and broader than those occurring higher in the section.

A study has been made of specimens from various Turonian localities of "Bohemia" and from Senonian localities of Sweden, Germany, and England, and it does not seem to us advisable to subdivide the group as some authors have tried to do. Brotzen names two new species from this group. The first, *Bulimina ventricosa*, represents in our opinion a form so close to Reuss' species that it is difficult to separate the two. A suite of specimens sent by Brotzen shows tendencies towards a shorter type of test with fewer whorls, but many Turonian specimens may be found so close to it that we have found it impossible to differentiate them; at best, evolution towards a different form may be at work. *B. lwowensis*, the name given by Brotzen to Reuss' citation of *B. ovulum* (in Haidinger's Naturwiss. Abh., vol. 4, p. 38, pl. 3, fig. 9, 1851) from the Senonian of Lemberg, Germany, also seems to represent the same species. A specimen from Lemberg that agreed exactly with Reuss' figure agrees almost exactly with one of Brotzen's syntypes of *B. ventricosa* and also with Turonian specimens.

The species lacks the trihedral character of *Bulimina trihedra* Cushman, has a shorter, less tapered test, and less inflated chambers.

Bulimina reussi Morrow var. navarroensis Cushman and Parker

Plate 20, figure 6

Bulimina reussi Morrow var. *navarroensis* Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 11, p. 100, pl. 15, figs. 11a, b, 1935.

Cushman and Todd, idem, vol. 19, p. 66, pl. 11, fig. 21, 1943.

Cushman, U. S. Geol. Survey Prof. Paper 206, p. 121, pl. 51, fig. 6, 1946.

This variety differs from the typical form in the smaller size of the test, in the much slighter inflation of the last-formed chambers, and in the much smaller proportion of the whole test which these chambers form. Length 0.16 to 0.25 mm., diameter 0.10 to 0.13 mm.

The types are from the Upper Cretaceous Navarro formation, chalky marl member, San Marcos River, half a mile below Martindale, Caldwell County, Texas. It occurs in formations of Navarro age including the Selma chalk of Tennessee, the Kemp clay, Corsicana marl, and Neylandville marl of Texas.

This variety is very easily differentiated from the typical *Bulimina reussi* Morrow by its much smaller size.

Bulimina prolixa Cushman and Parker

Plate 20, figures 7, 8

Bulimina prolixa Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 11, p. 98, pl. 15, figs. 5a, b, 1935.

?Toulmin, Jour. Paleontology, vol. 15, p. 598, pl. 80, fig. 27, 1941.

Cushman and Todd, Cushman Lab. Foram. Research Contr., vol. 19, p. 66, pl. 11, fig. 23, 1943.

Schenck, Jour. Paleontology, vol. 17, p. 62, 1943.

Cushman and Deaderick, idem, vol. 18, p. 337, pl. 53, fig. 8, 1944.

Cushman and Goudkoff, Cushman Lab. Foram. Research Contr., vol. 20, p. 58, pl. 10, fig. 1, 1944.

Cushman, U. S. Geol. Survey Prof. Paper 206, p. 122, pl. 51, figs. 19-22, 1946.

Bulimina puschi Cushman (not Reuss), Tennessee Geol. Survey Bull. 41, p. 47, pl. 7, figs. 19a, b, 1931; Cushman Lab. Foram. Research Contr., vol. 7, p. 42, pl. 5, figs. 11a-c, 1931.

Bulimina speciosa Brotzen, Sveriges geol. undersökning, ser. c, no. 396, p. 128, pl. 8, fig. 5, 1936.

Test long and narrow, about 2½ times as long as broad, tapering very slightly throughout the entire length, triangular in transverse section with the angles broadly rounded, often somewhat twisted on its axis toward the initial end, consisting of 6 to 7 whorls; chambers distinct, those of successive whorls placed directly over each other with adjacent series meeting in a zigzag line; sutures distinct, very slightly depressed; wall smooth, coarsely perforate; aperture elongate, placed well above the junction of the second and third chambers. Length 0.25 to 0.27 mm., diameter 0.11 to 0.12 mm.

The types of the species are from the Upper Cretaceous Selma chalk, New Corinth highway, 13½ miles east of Selmer, McNairy County, Tennessee. It is found in formations of Navarro and later Taylor ages in Texas, Arkansas, Tennessee, and California. We have specimens also from the Upper Cretaceous of the Gotzreuther Graben, near Siegsdorf, Germany. Doubtful specimens have been recorded from the Eocene Salt Mountain limestone of Alabama.

As was pointed out in an earlier paper, this species has been wrongly identified in the United States as *Bulimina puschi* Reuss. Brotzen in his description of *B. speciosa* definitely states that it is identical with the Tennessee form described by Cushman as *B. puschi*.

Bulimina arkadelphiana Cushman and Parker

Plate 20, figures 9, 10

Bulimina arkadelphiana Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 11, p. 96, pl. 15, figs. 1a, b, 2, 1935.

Cushman, U. S. Geol. Survey Prof. Paper 206, p. 124, pl. 52, figs. 3, 4, 1946.

Test small to medium, the megalospheric form considerably smaller than the microspheric, tapering, consisting of about 5 whorls in the megalospheric form, 8 in the microspheric; chambers numerous, later ones inflated; sutures distinct, deep; wall, except for the last 3 chambers, covered with sharp spines, especially at the margins of the chambers, the last formed whorl with spines at the margins of the chambers and with only an occasional spine above, finely perforate; aperture typically elongate, with a small lip. Length 0.33 to 0.50 mm., diameter 0.23 to 0.30 mm.

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The types are from the Upper Cretaceous Arkadelphia clay, 6 miles north by west of Hope, Hempstead County, Arkansas. The species was found at several localities in the Arkadelphia clay.

This form differs from *Bulimina cooperensis* Cushman in having longer spines and no costae.

Bulimina tortilis Reuss

Plate 20, figure 14

Bulimina tortilis Reuss, Akad. Wiss. Wien Sitzungsber, vol. 44, pt. 1, p. 338, pl. 8, figs. 3a, b, 1861 (1862).

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 10, p. 31, pl. 6, figs. 1a, b, 1934.

Uvigerina tortilis Egger, K. bayer. Akad. Wiss. Math.-naturh. Abt., Abh., Kl. 2, vol. 21, pt. 1, p. 133, pl. 15, figs. 52-54, 1899.

A peculiar, small species, pyramidal, three-sided, the sides concave, the ridges somewhat blunt, the whole test slightly twisted, composed of 5 whorls, the earliest small, the later increasing gradually in size; chambers semicircular, the earliest indistinct, the later rapidly increasing in size and strongly arched; aperture short, narrowly elliptical, beginning below the short, truncate end of the last-formed chamber and running down the flat side of the chamber. Maximum length 0.52 mm.

A summary of Reuss' description is given above. The species was described from the Upper Cretaceous, "Senonian Greensands" of New Jersey. We have no specimens which can be identified with it. Egger figures a similar form from the Cretaceous of Europe.

Bulimina velascoensis (Cushman) White

Plate 20, figure 11

Gaudryina velascoensis Cushman, Cushman Lab. Foram. Research Contr., vol. 1, p. 20, pl. 3, fig. 7, 1925; Am. Assoc. Petroleum Geologists Bull. vol. 10, p. 587, pl. 16, fig. 9, 1926; Jour. Paleontology, vol. 1, p. 149, pl. 28, fig. 2, 1927.

Bulimina velascoensis White, Jour. Paleontology, vol. 3, p. 50, pl. 5, fig. 3, 1929.

Cushman, U. S. Geol. Survey Prof. Paper 206, p. 124, pl. 52, fig. 8, 1946.

Test almost twice as long as broad, broadest toward the apertural end, early portion somewhat triangular in transverse section, later portion with the angles broadly rounded in transverse section, consisting of about 7 whorls; chambers indistinct except in the later portion of the test; sutures indistinct, very slightly depressed; wall perforate, with the fairly large perforations often arranged in longitudinal lines, giving the impression of faint striations; aperture elongate, loop-shaped, with a slight lip.

The types are from the Upper Cretaceous Velasco shale, Tamalte Arroyo, Hacienda El Limon, San Luis

Potosi, Mexico. The species appears to be characteristic of the Velasco shale.

The form described and figured by White in some respects resembles *Bulimina tabascoensis* Galloway and Morrey, but the triangular character of the early portion of the test and the similarity of size make it more probable that it should be referred to this species.

Bulimina incisa Cushman

Plate 20, figures 12, 13

Bulimina incisa Cushman, Am. Assoc. Petroleum Geologists Bull., vol. 10, p. 592, pl. 17, figs. 9a, b, 1926.

Cushman, U. S. Geol. Survey Prof. Paper 206, p. 124, pl. 52, fig. 7, 1946.

Bulimina declivis Galloway and Morrey (not Reuss), Jour. Paleontology, vol. 5, p. 351, pl. 40, figs. 8, 9, 1931.

Test small, oval, circular in transverse section, greatest breadth toward the apertural end, initial end rounded, consisting of 4 to 5 whorls; chambers comparatively few, distinct, especially the later chambers; sutures distinct, usually depressed toward the apertural end, usually darker in color than the rest of the test, broad, the basal edge of each chamber with numerous reentrants, which are apparently cut in along the suture lines; wall of last whorl smooth, early portion often with occasional spines, some specimens showing faint, longitudinal lines; aperture broadly oval, at apex of test. Length of holotype 0.46 mm., diameter 0.30 mm.

The types are from the Upper Cretaceous Velasco shale in well samples from Hacienda El Limon, Vera Cruz, Mexico. It occurs also at other localities in the Velasco shale of Mexico.

This species is related to *Bulimina tuxpamensis* Cole but is much smaller. The sutures are more strongly marked and have larger reentrants cut in from them. It may be differentiated also by the spinose character of the initial portion of the test. The original description does not refer to these spines, but a study of the holotype reveals their presence. The holotype is refigured, together with a specimen from the Tamesí formation, Tantoyuquita, on the Rio Tamesí, Mexico.

Bulimina trihedra Cushman

Plate 20, figure 15

Bulimina trihedra Cushman, Am. Assoc. Petroleum Geologists Bull., vol. 10, p. 591, pl. 17, figs. 6a, b, 1926; Jour. Paleontology, vol. 1, p. 160, pl. 27, fig. 5, 1927.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 11, p. 100, pl. 15, figs. 9a, b, 1935.

Cushman, U. S. Geol. Survey Prof. Paper 206, p. 122, pl. 51, fig. 17, 1946.

Test small, distinctly trihedral, angles rounded, sides nearly flat or slightly convex; chambers numerous, distinct, inflated, somewhat higher than broad; sutures distinct, depressed; wall smooth and polished, very finely perforate; aperture an elongate, oval-shaped opening with a slight lip, near the apex of the test. Length of holotype 0.43 mm., diameter 0.23 mm.

The types of the species are from the Upper Cretaceous Velasco shale, Hacienda El Limon, Vera Cruz, Mexico (M. hole Z, 105 feet, Marland Oil Company of Mexico). It occurs also in the Upper Cretaceous Annona chalk of Texas, and the middle part of the Selma chalk of Mississippi.

This species most closely resembles *Bulimina reussi* Morrow, but differs from it in its trihedral character, longer, more tapered test, and in its more inflated and more numerous chambers.

Bulimina trinitatensis Cushman and Jarvis

Plate 20, figures 16, 17

Bulimina trinitatensis Cushman and Jarvis, Cushman Lab. Foram. Research Contr., vol. 4, p. 102, pl. 14, figs. 12a, b, 1928; U. S. Nat. Mus. Proc., vol. 80, art. 14, p 44, pl. 13, figs. 4a, b, 1932.

Cushman, U. S. Geol. Survey Prof. Paper 206, p. 124, pl. 52, fig. 9, 1946.

Test somewhat longer than broad, rounded in transverse section, consisting of about 5 whorls; chambers distinct, with the lower border extended into an overhanging plate marked on the upper side by an irregular network of reticulate areas, the outer angles ending in short spines; wall coarsely perforate, the upper part of the last-formed chamber smooth; aperture comma-shaped, usually near the apex of the test. Length of holotype 0.54 mm., diameter 0.34 mm.

The types are from the Upper Cretaceous of Lizard Springs, near Guayaguayare, southeastern Trinidad. It occurs also in a well sample from Lizard Springs and in the Velasco shale of Mexico.

The species is very distinct. It differs from *Bulimina taylorensis* Cushman and Parker in its larger size, more distinct chambers, and the definite reticulation of the wall of the chambers.

Bulimina spinata Cushman and Campbell

Plate 20, figure 21

Bulimina spinata Cushman and Campbell, Cushman Lab. Foram. Research Contr., vol. 11, p. 72, pl. 11, fig. 11, 1935.

Test triserial, short and broad, rapidly enlarging from the acute, initial end to the greatest breadth formed by the last whorl; chambers distinct, strongly inflated, enlarging rapidly as new whorls are developed, each undercut at the base, leaving a distinct ridge near the lower margin; sutures distinct, depressed; wall of the early chambers with numerous, distinct, spinose projections running back onto the chamber wall as raised costae, becoming greatly reduced, and disappearing on the main body of the chamber, last-formed whorl of chambers with the wall smooth; aperture, an elongate, narrow opening, running into the base of

the last-formed chamber, with a trace of a lateral tooth. Length 0.50 mm.; diameter 0.35 mm.—Cushman and Campbell.

The species was described from the Upper Cretaceous Moreno shale, at a depth of 4500 feet in well, 1 mile north of Tracy, California. Similar forms are found in the Velasco shale of Mexico.

Bulimina laddi Cushman and Hedberg

Plate 30, figure 5

Bulimina laddi Cushman and Hedberg, Cushman Lab. Foram. Research Contr., vol. 17, p. 94, pl. 22, figs. 27a-c, 1941.

Cushman, U. S. Geol. Survey Prof. Paper 206, p. 124, pl. 66, fig. 11, 1946.

Test about three times as long as broad, fusiform, consisting of about three whorls, initial end tapering to a point, with a short but distinct spine; chambers distinct, somewhat inflated, rounded, increasing rapidly in height as added, those of the last-formed whorl in the adult making up nearly two-thirds of the size of the test; sutures distinct, depressed; wall smooth, perforate; aperture narrow, elongate, with a slight lip. Length 0.50-0.55 mm.; diameter 0.18-0.20 mm.

This species differs from *B. kickapooensis* Cole in the more slender form, higher and narrower chambers, and pointed, spinose initial end.—Cushman and Hedberg.

The types are from the Upper Cretaceous, upper zone of the Colon formation, Quebrada Mito Juan, Colombia.

Bulimina petroleana Cushman and Hedberg

Plate 30, figure 6

Bulimina petroleana Cushman and Hedberg, Cushman Lab. Foram. Research Contr., vol. 17, p. 95, pl. 22, figs. 31a-c, 1941.

Cushman and Goudkoff, idem, vol. 20, p. 59, pl. 10, fig. 2, 1944.

Cushman, U. S. Geol. Survey Prof. Paper 206, p. 125, pl. 66, fig. 13, 1946.

Test about 1½ times as long as broad, consisting of 6-8 whorls, the greatest diameter above the middle formed by the last whorl of chambers which makes up about half the test, rapidly tapering to the subacute initial end which occasionally has a short spine; chambers distinct, inflated in the later portion, increasing rapidly in size as added; sutures distinct, later ones strongly depressed; wall of the earlier portion ornamented with numerous fine costae, last whorl usually smooth; aperture broadly loop-shaped. Length 0.40-0.45 mm.; diameter 0.25 mm.

This species differs from *B. arkadelphiana* Cushman and Parker, in the more regularly tapering test, the very fine costae and the unornamented last whorl.—Cushman and Hedberg.

The types are from the Upper Cretaceous Colon formation, Quebrada La Petrolea, Colombia. Besides occurring in both zones of the Colon formation, this species also occurs in the Upper Cretaceous of California.

Bulimina limbata White

Plate 20, figure 19

Bulimina limbata White, Jour. Paleontology, vol. 3, p. 48, pl. 5, figs. 9a, b, 1929.

Cushman, U. S. Geol. Survey Prof. Paper 206, p. 124, pl. 52, fig. 5, 1946.

Test large, triangular in transverse section, with a rounded apertural end, consisting of about 6 whorls; chambers angular, curved, with raised sutures giving the effect of a series of arches; sutures distinct, strongly raised; aperture loop-shaped, at apex of test. Length of figured specimen 0.84 mm., diameter 0.62 mm.

White described this species from the Upper Cretaceous Mendez formation, 900 meters west of International Petroleum Company's well Cacalilao no. 75, Mexico, and from the uppermost beds of the Papagallos shale. We have specimens also from the Velasco shale of Mexico.

Bulimina mendezensis White

Plate 20, figure 20

Bulimina mendezensis White, Jour. Paleontology, vol. 3, p. 49, pl. 5, fig. 10, 1929.

Cushman, U. S. Geol. Survey Prof. Paper 206, p. 124, pl. 52, fig. 6, 1946.

Test broadly oval; wall smooth, last chambers relatively large; characterized by a relatively large, round aperture, with a number of slight folds radiating from it. Height of type specimen, 0.55 mm.; greatest diameter, 0.35 mm.—White.

The species was described from the Upper Cretaceous Mendez shale of Mexico, where it is rare.

The type specimen has been lost, and it is impossible to compare the available specimens with it. We have material which agrees well with the figure and description, except that the folds radiating from the aperture are less pronounced.

Bulimina globocapitata Chapman

Plate 20, figure 18

Bulimina globocapitata Chapman, New Zealand Geol. Survey, Paleontology, Bull. 11, p. 38, pl. 8, figs. 16a, b, 1926.

Test minute, consisting of a sharply tapering aboral series, which rapidly enters into an inflated subglobular terminal series with typical bulimine segments. The aboral end is usually strongly curved or twisted to one side. Surface smooth or polished. Length of holotype, 0.38 mm.; greatest width, 0.27 mm.—Chapman.

Chapman's species is from the Upper Cretaceous and Eocene of New Zealand. We have no material that can be referred to it. Copies of the original figures are given and it seems probable that the specimen figured is an abnormal one.

Bulimina callahani Galloway and Morrey

Plate 20, figures 22, 23

Bulimina callahani Galloway and Morrey, Jour. Paleontology, vol. 5, p. 350, pl. 40, fig. 6, 1931.

Martin, Stanford Univ. Publ., Univ. Ser., Geol. Sci., vol. 3, no. 3, p. 9 (list), 1943.

Bulimina cf. *B. callahani* Kelley, Am. Assoc. Petroleum Geologists Bull., vol. 27, p. 8 (list), 1943.

Test robust, ovate; apical end with an angle of about 90°; apertural end rounded; chambers 6 to 8, very little inflated, rapidly increasing in size as added; sutures very little depressed, not limbate; surface of apical end ornamented with numerous, small costae which disappear in the last two or three chambers, and which curve and join others; between the costae are small ridges, giving a reticulate or coarsely punctate appearance; the apertural end is smooth excepting for medium-sized punctae; aperture a broad and short virguline opening, rarely with short tooth. Length, 0.31 mm.; breadth, 0.24 mm.

This species is differentiated from all other described species of the genus by its ornamentation. It resembles *B. velascoensis* (Cushman) but the early portion is conical rather than pyramidal, the striae are stronger, reach higher but are less regular, and in having the cross bars between the striae.—Galloway and Morrey.

The species was described from the "Upper Cretaceous" near Puenta Piedra, on the Rio Puscatan, 19 kilometers south of Macuspana, Tabasco, Mexico.

We have, from a Mexican locality described as exhibiting reworked Papagallos shale, one specimen that is similar to a specimen in Galloway and Morrey's type slide. It differs in having less well defined costae and a more pointed initial end. It is figured, together with a copy of the original figure.

The species is recorded from the Eocene of California.

Bulimina tabascoensis Galloway and Morrey

Plate 20, figure 24; plate 21, figure 6

Bulimina tabascoensis Galloway and Morrey, Jour. Paleontology, vol. 5, p. 352, pl. 40, fig. 11, 1931.

Test robust, pyriform, apical end bluntly pointed, apertural end inflated; chambers six to eight, slightly inflated, rapidly increasing in size as added; wall thick, coarsely perforate; surface of apical end covered with about sixteen short, obscure costae which fade out in the last third of the test; aperture a broad comma-shaped opening on the inner face of the last chamber. Length, 0.2-0.35 mm.; breadth, 0.14-0.28. mm. Common.

This species differs from *B. buchiana* (D'Orbigny) in having a wider angle at the apical end, less regular costae, and more rounded apical end. It differs from *B. velascoensis* (Cushman) in not being triangular, the sutures are distinct, and the costae are coarser. It differs from *B. callahani* n. sp. in the finer but more regular costae, making the surface sculpture much less ornate. It might be considered as a variety of *B. callahani*.—Galloway and Morrey.

The species was described from the Cretaceous(?), near Puenta Piedra, on the Rio Puscatan, 19 kilometers south of Macuspana, Tabasco, Mexico. We have two specimens from the Velasco shale of Mexico that resemble this species. One of these is figured here and a copy of the original figure is also given.

Bulimina ezoensis Yokoyama

Plate 20, figure 25

Bulimina ezoënsis Yokoyama, Palaeontographica, vol. 36, p. 190, pl. 24, figs. 5a-c, 1890.

Test broadly fusiform, rounded at both ends, rounded in transverse section; chambers of last-formed whorl inflated, the 2 last-formed making up the greater part of the test, sharply separated by deep sutures, covering about two-thirds of the preceding chambers; apertural face oval, with a comma-shaped aperture; wall polished. Length of largest specimen 1.60 mm.

A summary of Yokoyama's description is given. The species was described from the "Cretaceous" of Poronai and Ezo, Japan. As there is no typical material available it is impossible to verify the age.

Bulimina schwageri Yokoyama

Plate 20, figures 26-28

Bulimina schwageri Yokoyama, Palaeontographica, vol. 36, p. 190, pl. 24, figs. 6a, b, 7a, b, 8a, b, 1890.

Test elongate, cylindrical, rounded at the sides, the smaller chambers giving an irregular appearance; early chambers rounded, inflated, increasing rapidly, later ones uniform, in 2 rows about the elongate axis; sutures deeply excavated; aperture oblique, comma-shaped, in a depression of the high, semicircular apertural face.

A summary of Yokoyama's description of the species from the "Cretaceous" of Ezo and Poronai, Japan, is given. The age is questionable, but a lack of topotype material makes it impossible to verify it. The species appears to be identical with *Bulimina elongata* D'Orbigny.

Bulimina baccata Yokoyama

Plate 20, figure 29

Bulimina baccata Yokoyama, Palaeontographica, vol. 36, p. 190, pl. 24, figs. 9a-c, 1890.

Test an elongate oval spiral, increasing rapidly in size from the early stage to the later rounded chambers, which appear to be sharply separated by the deeply depressed sutures; apertural face semicircular, the aperture, in the specimens examined, not clearly defined. *Bulimina baccata* may be distinguished from previously described species by its more inflated chambers and their more rapid increase in size.

A summary of Yokoyama's original description is given. The species was described from the "Cretaceous" of Ezo, Japan. There is some question as to whether the material is actually Cretaceous or not, but as we have no material a definite decision cannot be made.

Bulimina capitata Yokoyama

Plate 20, figure 30

Bulimina capitata Yokoyama, Palaeontographica, vol. 36, p. 190, pl. 24, fig. 10, 1890.

Test with nearly spherical chambers distinguished from previously described Buliminas by the rapidly taper-

ing initial end, the large size of the last-formed chamber, which makes up a large proportion of the test, and the triangular shape of the test. The test is characteristically curving, the later chambers increasing rapidly in size, but not to the extent seen in *Bulimina baccata* Yokoyama. The apertural face is large, semicircular, and obliquely placed, but the aperture itself was not observed. Length 0.26 mm.

This is a summary of Yokoyama's description of a form from the "Cretaceous" of Ezo and Poronai, Japan. Lack of material makes a definite determination of age impossible.

Bulimina polymorphinoides Yokoyama

Plate 20, figure 31

Bulimina polymorphinoides Yokoyama, Palaeontographica, vol. 36, p. 191, pl. 24, fig. 11, 1890.

Test broadly fusiform, both ends bluntly pointed, resembling in general a narrow, *Polymorphina*-like form, distinguished from *Bulimina capitata* by the lateral position of the broadly elongate chambers, the pointed upper end, and the aperture which broadens at the lower end. This form has a rounded transverse section, a polished wall, and consists of very rapidly increasing, inflated, elongate, oval chambers, the last 2 making up the greater part of the test. The sutures are indistinct in the early stages, more distinct in the later portion. The aperture is small and comma-shaped. Length 0.15 to 0.25 mm.

Yokoyama's description of the species from the "Cretaceous" of Ezo, Japan is summarized. Lack of material makes it impossible to check the age, which is questionable.

Bulimina truncana Gümbel

Plate 21, figures 7, 8

Bulimina truncana Gümbel, K. bayer. Akad. Wiss. Abh., cl. 2, vol. 10, p. 644, pl. 2, figs. 77a, b, 1870.

Hantken, K. ungar. geol. Anstalt. Mitt. Jahrb., vol. 4, p. 61, pl. 7, fig. 5, 1881.

Protescu, Soc. Nat. Roumania, Pub. 11, p. 26, pl. 4, figs. 11-13, 1932.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 13, p. 66, pl. 9, fig. 3, 1937.

Colom, Inst. Invest. Geol., Num. 2 Estudios Geologicos, p. 70, pl. 4, figs. 83, 84, 1945.

?*Bulimina rostrata* Cushman (not H. B. Brady), Cushman Lab. Foram. Research Contr., vol. 5, p. 94, pl. 13, fig. 32, 1929.

Bulimina corrugata Cushman (not Cushman and Siegfus), Cushman Lab. Foram. Research Contr., vol. 15, p. 64, 1939.

Test small, about 1½ times as long as broad, very rapidly tapering to the acute, initial end, somewhat triangular in transverse section, apertural end obliquely truncate; chambers indistinct, little if at all inflated, regularly triserial; sutures indistinct; wall ornamented by 10 to 12 longitudinal, acute costae, running from the initial end to the base of the smooth, last-formed chamber, independent of the sutures and chambers; aperture broadly loop-shaped, with a slight lip. Length up to 0.40 mm., diameter up to 0.20 mm.

The types are from the Eocene of Hammer, Bavaria. The species is found in the *Clavulina szaboi* beds of Hantken, near Budapest, Hungary. We have specimens from the Eocene of Biarritz, France which are somewhat larger and more slender than the typical. It occurs in the Eocene of the *Atlantis* cores 12-36 and 21-38 taken off the eastern coast of the United States. The specimens in the former have been recorded as *Bulimina corrugata* Cushman and Siegfus.

A comparison of this species with *Bulimina alazanensis* Cushman is given under the latter species.

Bulimina truncana Gümbel var. angusta Grzybowski

Bulimina truncana Gümbel var. *angusta* Grzybowski, Akad. umiej., Wydz. Mat.-Przyr., Rozpr. vol. 9, p. 189, pl. 2, fig. 11 [pl. 1 in text], Krakow, 1894.

The types of the variety are from the Eocene? of Dukla, Hungary. The figures are so poor that a positive identification is impossible. It is impossible even to state definitely to what genus they should be referred, although the character of the aperture and the arrangement of the chambers are apparently not bulimine.

Bulimina truncana Gümbel var. denticulata Protescu

Bulimina truncana Gümbel var. *denticulata* Protescu, Soc. Nat. Roumania, Pub. 11, p. 26, pl. 4, fig. 16, 1932.

In addition to our examples of *Bulimina truncana* Gümbel a few specimens are found which differ from the typical by the larger, shorter test, formed of more inflated chambers, ornamented with longitudinal costae which stop halfway up the test and are terminated at the bottom by spines.—Protescu (translated).

The types of the variety are from the Eocene of the Tintea region (District Prahova), Roumania. We have no material referable to it. The figure given is almost unrecognizable.

Bulimina simplex Terquem

Plate 21, figure 9

Bulimina simplex Terquem, Soc. géol. France Mém., ser. 3, vol. 2, p. 109, pl. 11(19), figs. 23, (24?), 1882.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 13, p. 67, pl. 9, fig. 4, 1937.

Cushman and Todd, idem, vol. 21, p. 17, pl. 4, fig. 5, 1945.

Test of medium size, elongate, tapering from the acute initial end to the greatest breadth at the last-formed whorl, about 2½ times as long as broad, consisting of 5 or 6 whorls in the adult; chambers distinct, inflated,

regularly triserial, increasing rather uniformly in size as added; sutures distinct, depressed; wall smooth, very finely perforate; aperture large, somewhat quadrate, with a slight tooth and a slight, but definite, lip, in a distinct depression of the apertural face. Length of Terquem's figured specimens 0.29 mm., 0.30 mm.; diameter 0.14 mm., 0.18 mm.. Length of our specimens 0.30 to 0.40 mm., diameter 0.13 to 0.17 mm.

The types of the species are from the Eocene of the Paris Basin at Vaudancourt. We have specimens from various localities of the Paris Basin. The figured specimens are from Cuise La Motte. Specimens that appear identical were found in the Eocene Lisbon formation of Monroe Co., Alabama.

The form is very close to *Bulimina elongata* D'Orbigny but differs from it in the regular triserial arrangement of the chambers, the broader aperture, and in the shape of the test, which is usually more tapering, with a broader apertural end. The two species both occur in the Eocene of the Paris Basin but are easily differentiated by the above characteristics.

Bulimina longiscata Terquem

Plate 21, figures 10, 11

Bulimina longiscata Terquem, Soc. géol. France Mém., ser. 3, vol. 2, p. 109, pl. 11(19), figs. 25, 26, 1882.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 13, p. 72, 1937.

Test elongate, straight, slightly conical, rounded at the ends, with subparallel sides, consisting of 5 indistinct whorls; chambers short, inflated; aperture funnel-shaped. Length of figured specimens 2.00 mm., 0.58 mm.; diameter 0.54 mm., 0.16 mm.—Terquem (translated).

The types are from the Eocene of the Paris Basin at Vaudancourt. We have no typical material.

Terquem's description of the aperture as "funnel-shaped" suggests that the form may belong to the *Uvigerina* group. Terquem's figures are reproduced here.

Bulimina obscura Terquem

Plate 21, figure 12

Bulimina obscura Terquem, Soc. géol. France Mém., ser. 3, vol. 2, p. 111, pl. 11(19), figs. 32a, b, 1882.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 13, p. 72, 1937.

Test conical, smooth, subangular at the bottom, wider at the top, all the whorls and chambers indistinct, the last 4 chambers rounded on the top; aperture round, very small, in a round depression without a definite edge. Length 0.61 mm., diameter 0.44 mm.—Terquem (translated).

The types are from the Eocene of the Paris Basin at Vaudancourt. We have no material referable to the species.

It seems doubtful if this species belongs to the genus *Bulimina*. Terquem's figures are reproduced.

Bulimina oviformis Terquem

Plate 21, figure 13

Bulimina oviformis Terquem, Soc. géol. France Mém., ser. 3, vol. 2, p. 112, pl. 12(20), fig. 3, 1882.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 13, p. 72, 1937.

Test regularly oval, rounded at the top, narrow and obtuse at the bottom, composed of 4 whorls with non-inflated chambers; chambers curved; sutures filiform, indistinct; aperture an elongate slit, placed in a cavity at the front. Length 0.64 mm.; diameter 0.36 mm.—Terquem (translated).

The types are from the Eocene of the Paris Basin at Septeuil. We have no material referable to the species. Terquem's figure is reproduced.

Bulimina glanduliformis Terquem

Plate 21, figure 15

Bulimina glanduliformis Terquem, Soc. géol. France Mém., ser. 3, vol. 2, p. 113, pl. 12(20), fig. 4, 1882.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 13, p. 72, 1937.

Test oval, glandular in shape, equally rounded at the ends, curved on the sides, polished, translucent, consisting of indistinct whorls; chambers smooth, curved, the 2 chambers surrounding the aperture slightly projecting at the top; aperture linear, in a depression which is oval at the top and pointed at the bottom, placed in the middle of the front side of the test. Length 0.48 mm.; diameter 0.21 mm.—Terquem (translated).

The types are from the Eocene of the Paris Basin at Septeuil.

The figure given by Terquem is reproduced, though it is poor and obviously inaccurate.

Bulimina splendens Terquem

Plate 21, figure 14

Bulimina splendens Terquem, Soc. géol. France Mém., ser. 3, vol. 2, p. 117, pl. 12(20), fig. 20, 1882.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 13, p. 73, 1937.

Test incomplete, elongate, white, polished, translucent, ornamented with very fine, numerous perforations, rounded at the top, with straight sides, composed of projecting, oval chambers; aperture quadrate, in an oblique depression, ovally pointed, placed at the front of the apertural face. Length 0.42 mm.; diameter 0.16 mm.—Terquem (translated).

The types are from the Eocene of the Paris Basin at Septeuil.

The single specimen described by Terquem is inadequate for definite identification. His figure is reproduced.

Bulimina decorata Terquem

Plate 21, figure 16

Bulimina decorata Terquem, Soc. géol. France Mém., ser. 3, vol. 2, p. 117, pl. 12(20), fig. 22, 1882.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 13, p. 73, 1937.

Test regularly oval, rounded at the top and obtuse at the bottom, curved on the sides, ornamented by fine, curved costae, consisting of indistinct whorls; chambers inflated, projecting, depressed, irregularly arranged; aperture rounded, placed between two chambers. Length 0.54 mm.; diameter 0.35 mm.—Terquem (translated).

The types are from the Eocene of the Paris Basin at Septeuil. We have no typical material.

It is possible that the form is a variation of *Bulimina tenuistriata* Terquem. His figure is reproduced.

Bulimina tenuistriata Terquem

Plate 21, figure 17

Bulimina tenuistriata Terquem, Soc. géol. France Mém., ser. 3, vol. 2, p. 118, pl. 12(20), figs. 24, 25, 1882.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 13, p. 70, pl. 10, figs. 6a-c, 1937.

Test of medium size, tapering, the initial end subacute or slightly rounded, apertural end broadly truncate, about 1½ times as long as broad; chambers in early portion indistinct and slightly inflated, in later one distinct, more inflated; sutures, except in the later portion, indistinct, slightly depressed in the later portion; wall ornamented by fine lines or ridges, usually parallel to the middle longitudinal line of the chamber, those of each chamber distinct from adjacent ones; aperture small, in a distinct depression of the apertural end of the test. Length of Terquem's figured specimens 0.50 mm., 0.54 mm.; diameter 0.35 mm., 0.36 mm. Length of our specimens 0.34 to 0.45 mm., diameter 0.20 to 0.30 mm.

The types are from the Eocene of the Paris Basin at Vaudancourt. We have specimens from several localities in the Paris Basin.

The species bears no close resemblance to any other. Some of the characteristics approach *Buliminella,* namely the four-chambered whorl and the character of the aperture, but the complete absence of a spiral suture makes it inadvisable to place it in that genus.

Bulimina trigona Terquem

Plate 21, figure 18

Bulimina trigona Terquem, Soc. géol. France Mém., ser. 3, vol. 2, p. 110, pl. 11(19), figs. 28, 29, 1882.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 13, p. 67, pl. 9, fig. 5, 1937.

Cushman and Todd, idem, Contr., vol. 21, p. 17, pl. 4, fig. 6, 1945.

Test nearly twice as long as broad, regularly triserial, rather regularly tapering from the subacute initial end to the greatest breadth formed by the last 2 chambers, periphery rounded; chambers distinct, inflated, increasing rapidly in height and size as added, the last whorl in front view making up nearly the whole surface of the test; sutures distinct, depressed; wall smooth; aperture a rounded opening, somewhat longer than broad, with a slight lip, narrowest at the base of the apertural face. Length 0.42 to 0.58 mm., diameter 0.28 to 0.35 mm.

The types are from the Eocene of the Paris Basin at Vaudancourt. We have specimens from Vaudancourt and Beauves which agree in size and character with Terquem's species, with the exception of the aperture, which, in his figure, is quite obviously inaccurately drawn. The species occurs in the Eocene Lisbon formation of Monroe Co., Alabama.

The rapidly tapering test, the regularly arranged chambers, and the large proportion of the test occupied by the last whorl differentiate this form.

Bulimina bellardii Hantken

Bulimina bellardii Hantken, Ertek. Termész. köreböl, vol. 13, p. 27, pl. 2, figs. 2a, b, 1883; Math. Naturwiss. Ber. Ungarn., vol. 2, p. 148, 1884.

The species was described from the Eocene, *Clavulina szaboi* beds of Hungary. We have no typical material.

Bulimina "minuta Hantken"

Bulimina minuta Hantken (not Marsson), Ertek. Termész. köreböl., vol. 13, p. 28, pl. 1, figs. 6a, b, 1883; Math. Naturwiss. Ber. Ungarn., vol. 2, p. 148, 1884

Hantken figures this species from the Eocene *Clavulina szaboi* beds of Hungary. We have no material referable to it. The name is a homonyn of *B. minuta* (Marsson) 1878, but it does not seem desirable to replace it now.

Bulimina selseyensis Heron-Allen and Earland

Plate 21, figures 19, 20

Bulimina selseyensis Heron-Allen and Earland, Royal Micr. Soc. Jour., 1911, p. 313, pl. 10, figs. 1, 2.

The authors describe this species as similar to *Uvigerina selseyensis* but state that it has the *Bulimina* type of aperture and a broader, stouter test, consisting of "four or five convolutions of heart-shaped chambers arranged around a spiral axis," and that it has deeply undercut sutural lines. The length is given as 0.25 mm., diameter 0.20 mm. ("nearly").

The species is described from shore-sands of Selsey Bill, England, and as Eocene in age. We have no material referable to it.

The structure of the test seems to be entirely uvigerine with the exception of the aperture.

Bulimina versa Cushman and Parker

Plate 21, figures 21, 22

Bulimina versa Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 16, p. 47, pl. 8, figs. 15a-c, 16a-c, 1940.

Test small, triangular in transverse section, with rounded angles and slightly concave sides, somewhat twisted about the vertical axis, with a small, well developed, basal spine; chambers distinct, somewhat inflated; sutures distinct, depressed; wall of first half of test very finely costate, latter half coarsely perforate, almost punctate in appearance; aperture small, loop-shaped, at apex of test. Length 0.25 to 0.30 mm., diameter 0.12 to 0.15 mm.

The types are from Eocene, Montian, Les Moulineaux, Department of Seine, France. The species is not known elsewhere.

The triangular character of the test, the finely costate initial end, and the basal spine make it easy to recognize this form.

Bulimina eccentrica Cushman and Parker

Plate 21, figure 23

Bulimina eccentrica Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 16, p. 46, pl. 8, figs. 12a-c, 1940.

Test of medium size, slightly less than twice as long as broad, tapering, with the widest portion at the middle of the last-formed whorl, initial end bluntly rounded, consisting of 4 whorls, the last-formed whorl making up at least ⅔ of the test; chambers distinct, those of early whorls not inflated, the last whorl very much inflated, so the sudden increase in diameter between the early whorls and the last is very marked; sutures distinct, those of last whorl depressed; wall smooth, rather coarsely perforate; aperture large, broadly loop-shaped. Length of holotype 0.65 mm., diameter 0.25 mm.

The types of this species are from the Eocene, Calcaire Grossier inférieur, St. Félice, Department of Oise, France. It occurs at many localities in the Paris Basin Eocene.

The species is easily differentiated from others by the sudden inflation of the last-formed whorl.

Bulimina thanetensis Cushman and Parker, n.sp.

Plate 21, figure 26

Test long, slender, slightly tapering, initial portion somewhat angled with rounded angles, consisting of 6 to 8 whorls of regularly arranged chambers, test somewhat twisted on its elongate axis; chambers distinct, angled, very slightly inflated; sutures distinct, slightly depressed; wall transculent, coarsely perforate; aperture elongate, narrow, at the apex of the test. Length up to 0.43 mm., diameter up to 0.25 mm.

Holotype (Cushman coll. no. 35855) from the Eocene, Thanet beds, Pegwell Bay, England. Besides the type locality we have one specimen from the Eocene of Gotzreuther Graben, Germany.

The species is much more elongate and slender than *Bulimina tuberculata* Egger, is more rounded in transverse section, has less globular chambers, and a smaller aperture on the smaller, more narrow apertural end. The wall, though coarsely perforate, does not have the punctate character of Egger's species.

Bulimina arkadelphiana Cushman and Parker var. midwayensis Cushman and Parker

Plate 21, figures 24, 25

Bulimina arkadelphiana Cushman and Parker var. *midwayensis* Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 12, p. 42, pl. 7, figs. 9, 10, 1936.

Cole, Florida Dept. Cons. Geol. Bull. 16, p. 32 (list), pl. 1, fig. 14, 1938.

Kline, Mississippi Geol. Survey Bull. 53, p. 47, pl. 7, fig. 9, 1943.

Bulimina aculcata Plummer (not D'Orbigny), Univ. Texas Bull. 2644, p. 73, pl. 4, fig. 3, 1927.

This variety differs from the typical form in the more inflated and higher last-formed whorl, and in the presence of a basal spine.

The types are from the Paleocene Midway formation, road cut south of Reservoir, 3½ miles southeast of Corsicana, Texas. The species is found at several localities in the Midway formation.

Bulimina cacumenata Cushman and Parker

Plate 21, figure 27

Bulimina cacumenata Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 12, p. 40, pl. 7, figs. 3a-c, 1936.

Cushman and Todd, idem, vol. 18, p. 37, 1942.

Kline, Mississippi Geol. Survey Bull. 53, p. 47, pl. 7, fig. 8, 1943.

Cushman and Todd, Cushman Lab. Foram. Research Contr., vol. 22, p. 59, pl. 10, fig. 20, 1946.

Bulimina cf. *cacumenata* Cushman, idem, Special Pub. 16, p. 23, pl. 5, fig. 3, 1946.

Test small, somewhat fusiform, greatest width slightly above the middle, gradually tapering to a long, subacute point, consisting of 6 to 7 whorls; chambers arranged in a slightly twisted series, those of adjacent series meeting in a zigzag line, those of the last whorl somewhat inflated; sutures distinct in the upper part, obscure in the lower part of the test, very slightly depressed; wall, except for the last whorl and occasionally for the next to the last, covered with irregular, low, closely set costae, last whorl smooth, coarsely perforate; aperture loop-shaped, with a slight lip. Length 0.20 to 0.23 mm., diameter 0.10 to 0.11 mm.

The types of the species are from the Paleocene Midway formation, 3 miles above bridge over Cedar Creek, on Austin-Red Rock road, Bastrop County, Texas. We have specimens also from the Eocene, Pit in San Mateo,

Santa Elena, Ecuador. It has also been recorded from the Paleocene Naheola formation of Alabama.

This species differs from *Bulimina semicostata* Nuttall in the much smaller, narrow test, the more inflated chambers, and in the shape of the chambers, which are distinctly angled. It is much smaller and more coarsely costate than *B. microcostata* Cushman and Parker.

Bulimina kugleri Cushman and Renz

Plate 30, figure 13

Bulimina kugleri Cushman and Renz, Cushman Lab. Foram. Research Contr., vol. 18, p. 9, pl. 2, figs. 9a-c, 1942.

Test elongate, fusiform, about twice as long as broad, greatest breadth at about the middle; chambers distinct, slightly inflated, elongate; sutures distinct, very slightly depressed; wall smooth; aperture a high, arched, slightly curved opening at the base of the inner margin of the last-formed chamber. Length of holotype 0.50 mm.; diameter 0.23 mm.

Our species differs from *B. quadrata* Plummer in the more distinctly fusiform shape, subacute at the ends; and the high, curved aperture.—Cushman and Renz.

The types of this species are from the Paleocene of Soldado Rock, Trinidad.

Bulimina semicostata Nuttall

Plate 21, figures 28, 29

Bulimina semicostata Nuttall, Jour. Paleontology, vol. 4, pp. 274, 285, pl. 23, figs. 15, 16, 1930.

Parker and Bermúdez, Jour. Paleontology, vol. 11, p. 513, pl. 58, figs. 3a-c, 1937.

Bermúdez, Soc. cubana historia nat. Mem., vol. 11, p. 342, 1937.

Renz, 8th Am. Sci. Congress Proc., p. 537 (list), 1942.

Test of medium size, fusiform, 2 or more times as long as broad, initial end pointed, consisting of about 5 whorls; chambers indistinct except for those of last whorl; sutures indistinct except for last whorl, very slightly depressed; wall, except for last whorl, covered with fine, low, irregular costae, last whorl smooth, perforate; aperture loop-shaped, with a slight lip. Length 0.40 to 0.60 mm., diameter 0.28 to 0.32 mm.

The types of the species are from the Eocene Aragon formation of Mexico, Grimsdale 409 (Francia-Aragon), 720 meters S. 70° W. of La Antigua. Nuttall also describes it as being frequent in the Chapapote formation and rare in the Guayabal. Besides Nuttall's localities it has been reported from the Eocene of Cuba and Trinidad. A similar form occurs in the Eocene material of the *Atlantis* core 21-38, taken off the eastern coast of North America.

This species differs from *Bulimina cacumenata* Cushman and Parker in its much larger size. It differs from *B. jarvisi* Cushman and Parker in being smaller, more fusiform, less triangular in transverse section, and in having less inflated and less globular chambers that are somewhat more angled.

Bulimina semicostata Nuttall var. crassicosta Parker and Bermúdez

Plate 22, figure 1

Bulimina semicostata Nuttall var. *crassicosta* Parker and Bermúdez, Jour. Paleontology, vol. 11, p. 513, pl. 58, figs. 4a-c, 1937.

Bermúdez, Soc. cubana historia nat. Mem., vol. 11, p. 342, 1937.

Variety differing from the typical form in its larger size and the presence of fewer, heavier costae. Length 0.44 to 0.80 mm., diameter 0.24 to 0.38 mm.

The types are from the Eocene Alturas de Almendares quarry, Havana, Cuba. The variety is known only from the Eocene of Cuba.

Bulimina corrugata Cushman and Siegfus

Plate 22, figure 2

Bulimina corrugata Cushman and Siegfus, Cushman Lab. Foram. Research Contr., vol. 11, p. 92, pl. 14, figs. 7a, b, 1935.

Cushman, idem, vol. 15, p. 64, 1939.

Cushman and Siegfus, San Diego Soc. Nat. History Trans., vol. 9, no. 34, p. 411, pl. 16, figs. 38a, b, 1942.

Curran, Am. Assoc. Petroleum Geologists Bull., vol. 27, pp. 1378, 1381 (lists), 1943.

Weaver, Washington Univ. [Seattle] Pub. in Geology, vol. 6, no. 1, p. 23 (list), 1944.

Test elongate, slightly tapering, fusiform, greatest breadth above the middle, somewhat triangular in transverse section, angles bluntly rounded; chambers indistinct except for the last 3 which are somewhat inflated, rather low, and only slightly overlapping; sutures indistinct except in the later portion, where they are depressed; wall covered by longitudinal costae, which are high and sharp, running from the initial end to the base of the last-formed chamber, continuous over the sutures; last-formed chamber smooth, distinctly perforate; aperture a rather broad, elongate opening, slightly, if at all, curved, with a slight lip. Length 0.35 to 0.45 mm., diameter 0.25 mm.

The types of the species are from the Eocene Kreyenhagen shale, Lower Garza Creek, California, 573 feet below the top of the Kreyenhegen. Besides the type locality it occurs at Gaviota Canyon, Santa Barbara County, California, about 400 feet stratigraphically below the top of a massive sandstone bed carrying *Turritella variata* Conrad and other California localities. It also occurs in Eocene material from one of the *Atlantis* cores.

This species most closely resembles *Bulimina rostrata* H. B. Brady but differs from it in having a bluntly rounded initial end and a more flattened, less pointed apertural end.

Bulimina bradyi Weinzierl and Applin

Plate 22, figure 3

Bulimina bradyi Weinzierl and Applin, Jour. Paleontology, vol. 3, p. 404, pl. 43, fig. 7, 1929.

?Bulimina cf. *B. sculptilis* Cushman and McMasters, Jour. Paleontology, vol. 10, p. 513, pl. 75, figs. 27a, b, 1936.

Test of medium size, 1⅓ times as long as broad, tapering fairly rapidly from the widest point approximately one-fifth of the distance from the top of the test, consisting of about 6 whorls; chambers distinct, slightly inflated, those of last whorl composing about three-fifths of the test; sutures distinct, very slightly depressed, showing as dark lines; wall ornamented by 10, low, regular, plate-like costae which extend from the initial end to halfway up the last-formed whorl, finely perforate; aperture loop-shaped, with a distinct lip. Length of holotype 0.44 mm., diameter 0.32 mm.

The types of the species are from the Eocene Claiborne group, Rio Bravo Oil Company's well, Deussen B. 1, 4010 feet, South Liberty Dome, Liberty County, Texas. The form recorded by Cushman and McMasters from the Eocene Llajas formation, Ventura County, California, is tentatively placed here.

The species differs from *Bulimina jacksonensis* Cushman in having a larger number of lower, more regular costae. It is much smaller and more tapering than *B. sculptilis* Cushman, though it seems possible that it might represent an immature specimen of the latter species. The form has been described from the holotype, which is the only specimen we have definitely referable to the species. It is refigured here.

Bulimina mauricensis Howe

Plate 22, figure 4

Bulimina mauricensis Howe, Louisiana Dept. Cons. Geol. Bull. 14, p. 62, pl. 8, figs. 29, 30, 1939.

Test short-fusiform, pointed at both ends, broadest in the middle, composed of a few elongate, somewhat inflated chambers, smooth; sutures depressed; aperture an oblique slit, subterminal, with a tendency to form a lip on either side of the slit.—Howe.

Length of holotype 0.40 mm., diameter 0.20 mm.

The types are from the Eocene Cook Mountain formation, St. Maurice, Winn Parish, Louisiana. We have no typical material.

The species seems to bear a close resemblance to *Bulimina ovata* D'Orbigny, which occurs in the Jackson formation.

Bulimina winniana Howe

Plate 22, figure 5

Bulimina winniana Howe, Louisiana Dept. Cons. Geol. Bull. 14, p. 64, pl. 8, fig. 31, 1939.

Bulimina ovata Cole and Gillespie (not D'Orbigny), Bull. Am. Paleontology, vol. 15, no. 57b, p. 10(132), pl. 2, fig. 5, 1930.

?Bulimina pyrula Ellisor (not D'Orbigny), Am. Assoc. Petroleum Geologists Bull., vol. 17, pl. 3, fig. 2, 1933.

Test small, ovate, broadest below the middle, with a short, broad initial end and a more tapering apertural end; composed of a few smooth chambers; wall thin, perforate; aperture a high slit extending into the apertural face from the base of the last chamber.—Howe.

Length of holotype 0.33 mm., diameter 0.20 mm.

The types are from the Eocene Cook Mountain formation sample no 37, St. Maurice, Winn Parish, Louisiana. The species occurs, questionably, in the Eocene Jackson formation of Texas. It occurs in the Oligocene Meson formation of Mexico, and similar forms are found in the Red Bluff clay at Hiwannee, Mississippi.

Howe differentiates this form from *Bulimina guayabalensis* Cole and separates the Guayabal specimens entirely. He describes the latter as being more elongate, with the chambers tending to be added at greater distances from the initial end. We have, however, specimens from the Guayabal formation referable to both species. *B. winniana* is smaller, more fusiform, and has fewer, more ovate chambers.

Bulimina curtissima Cushman and Siegfus

Plate 22, figure 6

Bulimina curtissima Cushman and Siegfus, Cushman Lab. Foram. Research Contr., vol. 11, p. 93, pl. 14, figs. 9a, b, 1935; San Diego Soc. Nat. Hist. Trans., vol. 9, p. 412, pl. 17, figs. 2a, b, 1942.

Test short and broad, only slightly longer than broad, fusiform in front view, greatest breadth somewhat below the middle, thence tapering to either end, initial end acute and spinose; chambers comparatively few, strongly inflated, increasing rapidly in size as added, the last whorl making a very large part of the surface of the test, greatly overlapping; sutures distinct, slightly depressed; wall ornamented, at the base of the chambers, by a few, short spines, otherwise smooth, finely perforate; aperture elongate, slightly curved, with a slight lip. Length 0.30 to 0.35 mm., diameter 0.22 to 0.25 mm.

The species was described from the Eocene Kreyenhagen shale, Upper Garza Creek, California, 83 feet below the top of the Kreyenhagen. It is known only from the type locality.

This species differs from *Bulimina cooperensis* Cushman in being much shorter, more fusiform, and in having no costae.

Bulimina garzaensis Cushman and Siegfus

Plate 22, figure 7

Bulimina garzaensis Cushman and Siegfus, Cushman Lab. Foram. Research Contr., vol. 11, p. 93, pl. 14, figs. 8a, b, 1935; San

Diego Soc. Nat. Hist. Trans., vol. 9, no. 34, p. 412, pl. 17, figs. 1a, b, 1942.

Test fusiform, greatest breadth above the middle, nearly circular in transverse section, initial end subacute or acute with a short spine, apertural end usually somewhat truncately rounded; chambers fairly distinct, especially toward the apertural end where they are inflated; sutures of the earlier portion indistinct, later somewhat depressed; wall except for the last whorl of chambers ornamented by longitudinal costae which are largely confined to the individual chamber to form an irregular reticulate pattern of variously shaped, depressed areas; aperture somewhat longer than broad, slightly curved, with a raised lip. Length 0.50-1.00 mm.; diameter 0.30-0.65 mm.—Cushman and Siegfus.

The types are from the Eocene Kreyenhagen shale, Garza Creek, California. We have no other material referable to the species.

A study of the type specimens shows that the holotype differs considerably from the paratypes. The latter have been referred to *Bulimina consanguinea* Parker and Bermúdez. The holotype bears considerable resemblance to *Bulimina corrugata* Cushman and Siegfus but has a thicker-walled test with heavier, more irregular costae.

Bulimina adamsi Cushman and Parker

Plate 22, figure 8

Bulimina adamsi Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 12, p. 41, pl. 7, figs. 6a-c, 1936.

Kelley, Am. Assoc. Petroleum Geologists Bull., vol. 27, p. 11 (list), 1943.

Test small, triangular in transverse section, the angles truncated, not more than 1½ times as long as broad, consisting of about 5 whorls; chambers somewhat obscured by the surface ornamentation, adjacent series meeting in a very sharply angled, zigzag line; sutures depressed except at the initial end; wall ornamented with 3 irregular, elongate costae at each corner of the triangular test, extending the whole length, the flat sides of the test ornamented with irregular costae, giving a reticulate appearance, coarsely perforate; aperture loop-shaped, with a distinct lip, placed on the flattened top of the test. Length 0.24 to 0.34 mm., width of one side 0.20 to 0.24 mm.

The types of the species are from the Eocene, 225 feet stratigraphically below the Domengine sandstone, Oil Canyon, just east of Oil City, Fresno County, California. It has also been recorded from the Eocene of Santa Barbara County, California.

The species differs from *Bulimina truncana* Gümbel and *B. rostrata* H. B. Brady in the triangular shape of the test and the irregular reticulation of the costae.

Bulimina microcostata Cushman and Parker

Plate 22, figure 9

Bulimina microcostata Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 12, p. 39, pl. 7, figs. 2a-c, 1936.

LeRoy, Natuurk. tijdschr. Ned. Indië, vol. 99, pt. 6, p. 244, pl. 1, figs. 20, 21, 1939.

Kelley, Am. Assoc. Petroleum Geologists Bull., vol. 27, p. 11 (list), 1943.

?Bulimina cf. *B. semicostata* Church (not Nuttall), Mining in California, vol. 27, pl. B, fig. 4(5, 6?), 1931.

Test of medium size, more than twice as long as broad, consisting of 6 to 8 whorls, the last-formed whorl forming ⅓ or more of the test; chambers toward the initial end increasingly narrow, arranged in series with a slight offset twist and with the adjacent series joined in a zigzag line, very slightly inflated; sutures distinct, slightly depressed; wall of the lower part of the test covered with very fine costae, the upper part smooth, finely perforate; aperture a long narrow, loop-shaped opening, with a slight lip. Length 0.34 to 0.48 mm., diameter 0.19 to 0.24 mm.

The types are from the Eocene Kreyenhagen shale, NE ¼ sec. 2, T. 1 N., R. 1 E., M.D.M., in center of exposure in abandoned shale quarry, 1½ miles northeast of Sommersville, Contra Costa County, California. It has also been recorded from Santa Barbara County, California and from the Miocene of Sumatra.

This species differs from *Bulimina semicostata* Nuttall in having finer costae and more numerous chambers that are arranged in series, are more inflated, and narrower. It differs from *B. cacumenata* Cushman and Parker in its much greater size, more inflated chambers, more uniform width, and finer costae.

Bulimina lirata Cushman and Parker

Plate 22, figure 10

Bulimina lirata Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 12, p. 43, pl. 8, figs. 2a-c, 1936.

Curran, Am. Assoc. Petroleum Geologists Bull., vol. 27, pp. 1378, 1381 (lists), 1943.

Kelley, idem, vol. 27, p. 11 (list), 1943.

Martin, Stanford Univ. Publ., Univ. Ser., Geol. Sci., vol. 3, no. 3, p. 9 (list), 1943.

Cushman and Simonson, Jour. Paleontology, vol. 18, p. 198, pl. 32, fig. 13, 1944.

Bulimina cf. *B. lirata* Cushman and Siegfus, San Diego Soc. Nat. History Trans., vol. 9, no. 34, p. 413, pl. 17, fig. 3, 1942.

Test large, usually less than 1½ times as long as broad, rapidly tapering, consisting of 4 whorls, the last-formed constituting about half the test; chambers indistinct except in the last-formed whorl; last-formed chambers inflated; sutures depressed; wall of last-formed chambers mostly smooth, finely perforate, remainder of test coarsely costate, with thin, plate-like, low costae, 11 or more in number, sometimes extending part way onto the chambers of the last-formed whorl, continuous throughout; aperture loop-shaped, with a slight lip. Length of holotype 0.57 mm., diameter 0.40 mm.

The types are from the Eocene, gray clay shale, 450 feet stratigraphically above the base of the Avenal sandstone, Coal Mine Canyon, sec. 26, T. 20 S., R. 14 E., M.D.M., Fresno County, California. The species is recorded from several localities in the Eocene and Oligocene of California.

This form differs from *Bulimina instabilis* Cushman and Parker in the shorter, broader shape of the test, less numerous chambers, and their somewhat different shape. It differs from *B. jacksonensis* Cushman in the shape of the test and the more numerous, lower costae.

Bulimina excavata Cushman and Parker

Plate 22, figure 11

Bulimina excavata Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 12, p. 41, pl. 7, figs. 4a-c, 1936.

Kelley, Am. Assoc. Petroleum Geologists Bull., vol. 27, p. 8 (list), 1943.

Test of medium size, somewhat triangular in transverse section, about 1½ times as long as broad, consisting of about 5 whorls; chambers fairly distinct, inflated; sutures distinct, depressed, with small depressions extending from them upward into the chambers, usually 1 to each chamber; wall smooth, finely perforate; aperture loop-shaped. Length 0.26 to 0.34 mm., diameter 0.21 to 0.22 mm.

The types are from the lower Eocene, about 3 miles N. 45° E. of Santa Susana, in Poison Oak Canyon, north of Simi Valley, Ventura County, California. They are found 2710 feet stratigraphically above the Cretaceous contact, in brown shale, mapped by Kew as the Martinez formation. It is also recorded from the Eocene Anita shale, Santa Barbara County, California.

This species resembles the Mexican Upper Cretaceous species *Bulimina incisa* Cushman, but differs from it in the more angled character of the test, the depressed sutures, and the inflation of the chambers. It is known only from the type locality.

Bulimina guayabalensis Cole

Plate 22, figure 12

Bulimina guayabalensis Cole, Bull. Am. Paleontology, vol. 14, no. 57, p. 24, pl. 1, figs. 1, 2, 1927.

Cushman and Siegfus, San Diego Soc. Nat. History Trans., vol. 9, no. 34, p. 413, pl. 16, fig. 39, 1942.

Bulimina sp. Cushman, Am. Assoc. Petroleum Geologists Bull., vol. 9, p. 301, pl. 7, fig. 9, 1925.

Cushman and Applin, idem, vol. 10, p. 169, pl. 7, figs. 10, 11, 1926.

Bulimina capitata? Cushman and Dusenbury (not Yokoyama), Cushman Lab. Foram. Research Contr., vol. 10, p. 61, pl. 8, figs. 10a, b, 1934.

Kelley, Am. Assoc. Petroleum Geologists Bull., vol. 27, p. 11 (list), 1943.

Bulimina pupoides Nuttall (not D'Orbigny), Jour. Paleontology, vol. 9, p. 127, pl. 14, fig. 22, 1935.

Bulimina pyrula Coryell and Embich (not D'Orbigny), idem, vol. 11, p. 304, pl. 42, fig. 18, 1937.

Test compact, ovate, broadest near the apertural end, chambers few, large, inflated, smooth; sutures strongly depressed aperturally, very slightly depressed in the initial chambers; aperture long, narrow. Length 0.42 mm. Width 0.26 mm.—Cole.

The types are from the Eocene Guayabal formation of Mexico. Records referable to this species are given from the Eocene Poway conglomerate and Kreyenhagen shale of California; the upper Eocene of Venezuela and Panama; the Eocene, Moctezuma River, Vera Cruz, Mexico; and from the Eocene Jackson formation of Texas.

Cole describes this species as differing from *Bulimina pupoides* D'Orbigny in the fewer chambers, more compact form, and slightly different arrangement of chambers. The one topotype specimen we have seems to bear out this analysis. It is interesting to note that forms apparently identical with *B. pupoides* occur higher up in the Mexican section which makes it possible that this species represents the ancestral form.

Bulimina guayabalensis Cole var. ampla Cushman and Parker

Plate 22, figure 13

Bulimina guayabalensis Cole var. *ampla* Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 12, p. 43, pl. 8, figs. 1a-c, 1936.

Bulimina ampla Bandy, Jour. Paleontology, vol. 18, p. 377, pl. 62, figs. 8a, b, 1944.

Bulimina cf. *B. socialis* Cushman and Hobson (not Bornemann), Cushman Lab. Foram. Research Contr., vol. 11, p. 62, pl. 9, figs. 2a, b, 1935.

Variety differing from the typical form in the larger test, which is much broader in proportion to its width; and in the chambers, which are somewhat more inflated. Length 0.40 to 0.61 mm., diameter 0.30 to 0.45 mm.

The types of the variety are from the Eocene Kreyenhagen shale, NE ¼ sec. 2, T. 1 N., R. 1 E., M.D.M., in center of exposure in abandoned shale quarry, 1½ miles northeast of Sommersville, Contra Costa County, California. It occurs also in the Oligocene San Lorenzo formation of California. It is recorded by Bandy from the Eocene of Cape Blanco, Oregon.

This form is close to *Bulimina pupoides* D'Orbigny but is shorter and broader and has fewer, somewhat more inflated chambers.

Bulimina bradburyi Martin

Plate 30, figure 9

Bulimina bradburyi Martin, Stanford Univ. Publ., Univ. Ser., Geol. Sci., vol. 3, no. 3, p. 19, pl. 6, figs. 4a, b, 1943.

Test small, triserial, tapering, greatest width at next to last-formed whorl just below last chamber; about twice as long as wide; sub-rounded in cross section; wall calcareous smooth, finely

perforate; periphery round; chambers inflated, increasing rapidly in size as added; sutures distinct, depressed; aperture an elongate, wide, comma-shaped slit extending from just below terminal edge of last chamber to spiral suture. Length 0.52 mm.; greatest width 0.28 mm.

This species is similar to *Bulimina prolixa* Cushman and Parker (1935) but differs in its more compactly arranged and more inflated chambers and in its more spiral and oblique sutures.—Martin.

The types are from the Eocene Lodo formation of California.

Bulimina debilis Martin

Plate 30, figure 10

Bulimina debilis Martin, Stanford Univ. Publ., Univ. Ser., Geol. Sci., vol. 3, no. 3, p. 20, pl. 6, figs. 1a-c, 1943.

Test small, elongate, fusiform, irregularly triserial, greatest width just above middle, about twice as long as broad, subcircular in cross section; wall calcareous, thin, smooth, hyaline, finely perforate; slightly roughened at initial end; periphery round; chambers inflated, increasing rapidly in size as added, somewhat embracing; sutures distinct, slightly depressed; initial end of test bluntly pointed; aperture a comma-shaped opening at top of last-formed chamber, extending to spiral suture, bordered on inner curve by a raised lip. Length 0.37 mm.; greatest width 0.2 mm.

This species is similar to *Bulimina ovata* D'Orbigny of Cushman and Ponton (1932) but differs in being less fusiform, also smaller in size, and in having squarer chambers.—Martin.

The types are from the Eocene Lodo formation of California.

Bulimina whitei Martin

Plate 30, figure 11

Bulimina whitei Martin, Stanford Univ. Publ., Univ. Ser., Geol. Sci., vol. 3, no. 3, p. 20, pl. 6, figs. 5a, b, 1943.

Test small, tapering, triserial, greatest width across apertural end; cross section triangular, angles bluntly rounded; wall calcareous, hyaline, finely perforate, ornamented with low, sharp, longitudinal costae extending from pointed initial end about halfway up last-formed chamber; generally three to four costae along each blunt angle, occasionally one or more on face of each side; chambers increasing rapidly in size as added; sutures distinct, slightly depressed; aperture an elongate, elliptical, slightly depressed opening at center of inside face of last-formed chamber. Length 0.23 mm.; greatest width 0.17 mm.

This species is similar to *Bulimina corrugata* Cushman and Siegfus (1935) but differs in having fewer and lower costae, which continue to the last-formed chamber, and distinctly visible early chambers.—Martin.

The types are from the Eocene Lodo formation of California.

Bulimina jacksonensis Cushman

Plate 22, figures 14-16

Bulimina jacksonensis Cushman, Cushman Lab. Foram. Research Contr., vol. 1, p. 6, pl. 1, figs. 6, 7, 1925; idem, p. 65, 1925.

Cushman and Applin, Am. Assoc. Petroleum Geologists Bull., vol. 10, p. 168, pl. 7, figs. 8a, b, 1926.

Howe and Wallace, Louisiana Dept. Cons. Geol. Bull. 2, p. 59, pl. 11, fig. 5, 1932.

Ellisor, Am. Assoc. Petroleum Geologists Bull., vol. 17, pl. 7, fig. 5, 1933.

Cushman, U. S. Geol. Survey Prof. Paper 181, p. 35, pl. 13, figs. 7-9, 1935.

Nuttall, Jour. Paleontology, vol. 9, p. 127, pl. 15, fig. 1, 1935.

?Coryell and Embich, Jour. Paleontology, vol. 11, p. 304, pl. 42, fig. 17, 1937.

Renz, 8th Am. Sci. Congress Proc., p. 541 (list), 1942.

Cushman, Cushman Lab. Foram. Research Special Pub. 16, p. 23, pl. 5, fig. 1, 1946.

Bulimina? sp. Church, Mining in California, vol. 27, pl. B, figs. 2, 3, 1931.

Test elongate, tapering, the initial end acute, apertural end broadly rounded, in the adults somewhat contracted, consisting of as many as 7 or 8 whorls; chambers fairly distinct; sutures flush with the surface or slightly depressed; surface ornamented by 6 to 8 very prominent, plate-like, longitudinal costae, continuous from the apical end to almost the top of the last-formed chambers, the outer margin more or less serrate; aperture elongate, comma-shaped, with a lip. Average length 0.90 mm.

The types are from the upper Eocene yellow clay in the Tantoyuca formation, Palacho Hacienda, south of Panuco-Tampico railroad, Vera Cruz, Mexico. The holotype is much smaller than the typical adult specimens from the Eocene of the United States. It is refigured here, together with specimens from the Cocoa sand member of the Jackson formation of Cocoa Post Office, Alabama. We have specimens from various localities of Jackson age throughout the Gulf Coast region. The species is found also in Eocene material from Gaviota Canyon, Santa Barbara County, California, about 400 feet stratigraphically below the top of a massive sandstone bed carrying *Turritella variata* Conrad. It has been recorded by Nuttall from the upper Eocene of Venezuela and by Renz from the San Fernando formation of Trinidad. The record of Coryell and Embich from the upper Eocene of Panama is placed here questionably. In addition we have specimens from the middle Eocene of Egypt.

The species differs from *Bulimina sculptilis* Cushman in having fewer costae, which are higher, more plate-like, and more serrate.

Bulimina jacksonensis Cushman var. cuneata Cushman

Plate 22, figures 17, 18

Bulimina jacksonensis Cushman var. *cuneata* Cushman, Cushman Lab. Foram. Research Contr., vol. 2, p. 35, 1926; U. S. Geol. Survey Prof. Paper 181, p. 35, pl. 13, figs. 10, 11, 1935.

Bulimina cuneata Beck, Jour. Paleontology, vol. 17, p. 605, pl. 107, figs. 3, 9, 1943.

Detling, idem, vol. 20, p. 356, pl. 49, figs. 13, 15, 16, 1946.

Variety differing from the typical form in the larger

number of costae, 10 to 12, the more tapering form, and the very serrate character of the edges of the costae. Length of holotype 0.80 mm., diameter 0.34 mm.

The types of the variety are from the Eocene, 2 to 3 feet below the base of the Red Bluff formation, half a mile southeast of Melvin, Choctaw County, Alabama. Cushman records the variety in the Cooper marl of South Carolina. Beck records a similar form from the Eocene of Washington.

In some respects this form is closer to *Bulimina sculptilis* Cushman than to *B. jacksonensis*, especially as regards the shape of the test and the number of costae. The character of the costae, however, and the form and character of the chambers seem to ally it more closely with the latter.

Bulimina cooperensis Cushman

Plate 22, figure 19

Bulimina cooperensis Cushman, Cushman Lab. Foram. Research Contr., vol. 9, p. 12, pl. 1, figs. 32a, b, 1933; U. S. Geol. Survey Prof. Paper 181, p. 35, pl. 13, figs. 12-14, 1935; Cushman Lab. Foram. Research Contr., vol. 21, p. 8, 1945.

Test elongate, tapering, 2½ to 3 times as long as broad, greatest breadth toward the apertural end; chambers distinct, inflated, considerably overlapping; sutures deep, distinct; wall of the basal half of the chambers with plate-like costae that end in sharp points, the initial end of the test often with a spine; aperture elongate, with a slightly depressed border, and a distinct lip. Length 0.40 to 0.50 mm., diameter 0.18 to 0.20 mm.

The types of the species are from the Eocene Cooper marl, 1 mile south of Moncks Corner, Berkeley County, South Carolina. It also occurs in the Eocene Twiggs Clay of Washington County, Georgia.

This species is easily distinguishable on account of its costate character and numerous, overhanging chambers. It differs from *Bulimina arkadelphiana* Cushman and Parker var. *midwayensis* Cushman and Parker in the above characters, the latter having spines but no costae and the chambers, while somewhat undercut, not projecting so far. It is also much larger.

Bulimina instabilis Cushman and Parker

Plate 23, figure 1

Bulimina instabilis Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 12, p. 44, pl. 8, figs. 3a-c, 1936.

Test large, about 1½ times as long as broad, consisting of 6 to 8 whorls; chambers distinct, last-formed chambers inflated, arranged in fairly regular series; sutures distinct, very slightly depressed; wall in the adult with several, thin, plate-like, somewhat jagged costae, with low costae between, extending up to the last-formed whorl; in young forms the costae not well developed, sometimes resembling spines and again almost entirely absent; last-formed chambers smooth, coarsely perforate; aperture loop-shaped, with a slight lip. Length of holotype 0.71 mm., diameter 0.43 mm.

The types are from Eocene material at 2058 feet depth in the Lillis Welch well no. 1, drilled by Western Gulf Oil Company, located 680 feet north and 990 feet east of southwest corner sec. 26, T. 15 S., R. 12 E., M.D.M., Fresno County, California.

The species is very variable. The arrangement and form of the chambers remains the same, but the costae in some specimens are very definite, whereas in others they appear only intermittently or may even be completely absent. There seems to be no logical way however, in which the species can be further subdivided. It differs from *Bulimina buchiana* D'Orbigny in having more chambers and much lower costae. It is longer and more slender than *B. lirata* Cushman and Parker, and has more chambers, which are somewhat differently shaped.

Bulimina schencki Beck

Plate 30, figure 16

Bulimina schencki Beck, Jour. Paleontology, vol. 17, p. 605, pl. 107, figs. 28, 33, 1943.

Test small, about twice as long as broad, fusiform, greatest width through middle, initial end subacute; chambers few, last three make up more than one-half of entire test, inflated; sutures distinct, deeply incised; wall smooth; aperture set in broad opening at top of last chamber. Length 0.33 mm.; diameter 0.18 mm.

These specimens are identical with *Bulimina capitata?* of Cushman and Dusenbury (1934) and differ from the original figure of *B. capitata* Yokoyama (1890) in having less inflated chambers that are largest at the apertural end.—Beck.

The types are from the Eocene of Cowlitz River, Lewis County, Washington.

Bulimina ovata D'Orbigny var. cowlitzensis Beck

Plate 30, figure 15

Bulimina ovata D'Orbigny var. *cowlitzensis* Beck, Jour. Paleontology, vol. 17, p. 605, pl. 107, fig. 22, 1943.

This subspecies differs from the typical form in having more inflated chambers, and a coarsely punctate wall. Length, 0.45 mm.; diameter 0.25 mm.—Beck.

The types are from the Eocene of Cowlitz River, Lewis County, Washington.

Bulimina macilenta Cushman and Parker

Plate 23, figures 2, 3

Bulimina macilenta Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 15, p. 93, 1939.

Cushman and Stainforth, idem, Special Pub. 14, p. 40, pl. 6, fig. 3, 1945.

Cushman, idem, Special Pub. 16, p. 23, pl. 5, fig. 4, 1946.

?*Bulimina inflata* Galloway and Morrey (not Seguenza), Bull. Am. Paleontology, vol. 15, p. 37, pl. 5, fig. 13, 1929.

?Coryell and Embich, Jour. Paleontology, vol. 11, p. 304, pl. 42, fig. 19, 1937.

Bulimina denticulata Cushman and Parker (not *B. truncana* Gümbel var. *denticulata* Protescu), Cushman Lab. Foram. Research Contr., vol. 12, p. 42, pl. 7, figs. 7, 8, 1936.

Cushman, Cushman Lab. Foram. Research Contr., vol. 15, p. 64, 1939.

Kelley, Am. Assoc. Petroleum Geologists Bull., vol. 27, p. 8 (list), 1943.

Curran, idem, vol. 27, p. 1379 (list), 1943.

Martin, Stanford Univ. Publ., Univ. Ser., Geol. Sci., vol. 3, no. 3, p. 9 (list), 1943.

Test of medium size, usually less than 1½ times as long as broad, rapidly tapering, consisting of about 4 whorls, the last-formed whorl forming one-half to three-fourths of the test; chambers fairly distinct, slightly undercut at the base, much inflated; sutures, in the last-formed whorl, distinct, depressed, obscured in the earlier portion of the test; wall of last whorl smooth, perforate; the margins of the chambers cut into more or less regular flutings or scallops that apparently cover the whole of the bottom of the test because of the narrowness of the chambers, the marginal character of the flutings being plain, however, in the last-formed whorl and often in the preceding one; aperture loop-shaped. Length 0.24 to 0.38 mm., diameter 0.20 to 0.34 mm.

The types of the species are from the Eocene, about 3 miles N. 45° E. of Santa Susana, in Poison Oak Canyon, north of Simi Valley, Ventura County, California, from brown shale 2710 feet stratigraphically above the Cretaceous contact, in strata mapped as Martinez. There are several other records from the Eocene of California. Similar specimens were found in material collected by Vaughan from Rio Buena Vista, Vera Cruz, Mexico, and called by him Alazan. A single specimen occurs in the Eocene material in the *Atlantis* core 12-36, 880 meters, N. Lat. 39° 50′; W. Long. 70° 58′. Galloway and Morrey's species from the upper Eocene(?) of Manta, Ecuador has been placed here questionably, and also that of Coryell and Embich from the Eocene of Panama. It also occurs in the Oligocene Cipero formation of Trinidad.

This form resembles most closely *Bulimina spinata* Cushman and Campbell but is much smaller and has the fluted margins of the chambers much more sharply defined and coarser. It seems probable that *B. spinata* may be the ancestral form.

Bulimina stalacta Cushman and Parker

Plate 23, figure 4

Bulimina stalacta Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 12, p. 42, pl. 7, figs. 5a-c, 1936.

?*Bulimina inflata* Cole (not Seguenza), Bull. Am. Paleontology, vol. 14, no. 51, p. 25, pl. 3, fig. 12, 1927.

Test large, about 1½ times as long as broad, gradually tapering, terminated by a spine; chambers distinct in upper part of test, very slightly inflated; sutures distinct, somewhat depressed; wall of last-formed whorl smooth, finely perforate, lower part ornamented by blunt spines, often alined and appearing as remnants of jagged costae, some specimens having costae as well as spines; aperture loop-shaped, with a slight lip. Length of holotype 0.58 mm., diameter 0.33 mm.

The types are from the Eocene beds in a small canyon, 50 feet stratgraphically above the top of a massive sandstone, on the south slope of hill 2217 (Cholame topographic sheet), about 1½ miles east of Tar Canyon, Reef Ridge, Kings County, California. Specimens questionably referable to this species were found in the Alazan shale of Mexico (collected by T. W. Vaughan) and Eocene material in the *Atlantis* cores 12-36 and 21-38, collected off the eastern coast of the United States. Similar forms occur in the Eocene at Biarritz, and at Kiscell, Hungary. Cole's species from the Eocene Guayabal formation of Mexico is placed here questionably.

This species differs from *Bulimina macilenta* Cushman and Parker in the more spinose character of the test and in the more fusiform shape.

Bulimina consanguinea Parker and Bermúdez

Plate 23, figure 5

Bulimina consanguinea Parker and Bermúdez, Jour. Paleontology, vol. 11, p. 515, pl. 59, figs. 2a-c, 1937.

Bermúdez, Soc. cubana historia nat. Mem., vol. 11, p. 342, 1937.

Bulimina garzaensis Cushman and Siegfus (part), Cushman Lab. Foram. Research Contr., vol. 11, p. 93, 1935.

Test large, about 1⅓ times as long as broad, tapering evenly, usually with a short, blunt, basal spine, consisting of 4 to 6 whorls; chambers distinct in last-formed whorl only, although frequently distinguishable in portions of the remainder of the test; sutures distinct in last whorl only, very slightly depressed; wall smooth in the upper part of the last whorl, the remainder ornamented by longitudinal, plate-like costae with jagged edges, 6 to 8 visible on the front of the test, finely perforate; aperture loop-shaped, with a lip. Length 0.80 mm., diameter 0.50 to 0.76 mm.

The types of the species are from the Eocene, north side of Elvador in Noroña, north of Guanajay, on railroad, Pinar del Rio Province, Cuba. We have a single specimen from the Alazan clay, Rio Buena Vista, just south of crossing of Alazan to Moyutla road, Vera Cruz, Mexico. Specimens ascribed to *Bulimina garzaensis* Cushman and Siegfus from the Eocene Kreyenhagen shale of Garza Creek, California belong under this species. In addition it is found in the Eocene of Turin, Italy.

This form most closely resembles *Bulimina sculptilis* Cushman var. *laciniata* Cushman and Parker but differs from it in the shape of the chambers, which are less inflated, less pronounced. and fewer in number, in the costae which are more jagged, and in the basal spine which is more pronounced.

Bulimina impendens Parker and Bermúdez

Plate 23, figures 6, 7

Bulimina impendens Parker and Bermúdez, Jour. Paleontology, vol. 11, p. 514, pl. 58, figs. 7a-c, 8a-c, 1937.

Bermúdez, Soc. cubana historia nat. Mem., vol. 11, p. 342, 1937.

Test small, about 1⅓ times as long as broad, very slightly tapering, consisting of 3 to 4 whorls; chambers distinct in last whorl only, those of each whorl overhanging those previously formed to give a decidedly collared effect; sutures distinct in last whorl, slightly depressed, previous sutures obscured by surface ornamentation; wall spinose or fluted at the lower margin of the last 2 whorls, the remainder of the test covered by short, irregular spines; aperture loop-shaped, with a slight lip. Length 0.20 to 0.45 mm., diameter 0.20 to 0.35 mm.

The types are from the Eocene Alturas de Almendares quarry, Havana, Cuba. Besides the type locality, we have a single specimen from the Eocene, in a small canyon, 50 feet stratigraphically above the top of a massive sandstone on the slope of hill 2217, about half a mile east of Tar Canyon, Reef Ridge, Kings County, California.

The species differs from *Bulimina curtissima* Cushman and Siegfus in being much more spinose, in having more chambers, and in the very marked overhang of the chambers.

Bulimina palmerae Parker and Bermúdez

Plate 23, figure 8

Bulimina palmerae Parker and Bermúdez, Jour. Paleontology, vol. 11, p. 514, pl. 59, figs. 1a-c, 1937.

Test of medium size, 1½ times as long as broad, tapering, with a well developed, blunt, basal spine, consisting of 4 to 6 whorls; chambers distinct, last-formed chambers somewhat inflated; sutures distinct, depressed, incised; wall with blunt spines at the edges of the chambers, remainder of wall smooth, perforate; aperture loop-shaped, with a well defined lip. Length 0.48 to 0.80 mm., diameter 0.32 to 0.56 mm.

The types of the species are from the Eocene, one kilometer north of Arroyo Arenas, on road to Jaimanitas (water well), Havana Province, Cuba. It has not been recorded elsewhere.

This species differs from *Bulimina arkadelphiana* Cushman and Parker var. *midwayensis* Cushman and Parker in being much larger, having coarser spines and fewer of them. It differs from *B. stalacta* Cushman and Parker in its more spinose character, lack of costae, and the slight overhang of the chambers.

Bulimina tarda Parker and Bermúdez

Plate 23, figure 9

Bulimina tarda Parker and Bermúdez, Jour. Paleontology, vol. 11, p. 514, pl. 58, figs. 6a-c, 1937.

Bermúdez, Soc. cubana historia nat. Mem., vol. 11, p. 342, 1937.

Cushman, Cushman Lab. Foram. Research Contr., vol. 15, p. 64, 1939.

Test small, tapering, consisting of 4 to 5 whorls, the last-formed whorl forming one-third or more of the test; chambers few, those of last whorl slightly inflated; sutures fairly distinct, very slightly depressed, showing as dark lines with occasional small, incised areas; wall smooth, coarsely perforate; aperture loop-shaped, with a slight lip. Length 0.30 to 0.35 mm., diameter 0.21 to 0.23 mm.

The types of the species are from the Eocene, Loma Principe, cut between calle F and Avenida de los Presidentes, 20 meters west of José M. Gómez monument, Havana, Cuba. Besides the Eocene occurrence in Cuba, it has been recorded from the Eocene material in the *Atlantis* cores 12–36 and 21–38, taken off the east coast of the United States, and from the Eocene, 3 miles N. 46° E. of Santa Susana, Poison Oak Canyon, north of Simi Valley, Ventura County, California, from brown shale, 1040 feet stratigraphically above the Cretaceous contact, in strata mapped by Kew as Martinez.

This form resembles *Bulimina tuxpamensis* Cole but is much smaller, more rapidly tapering, and has a smoother wall.

Bulimina jarvisi Cushman and Parker

Plate 23, figure 10; plate 24, figure 1

Bulimina jarvisi Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 12, p. 39, pl. 7, figs. 1a-c, 1936.

Parker and Bermúdez, Jour. Paleontology, vol. 11, p. 513, pl. 58, figs. 2a-c, 1937.

Cushman and Stainforth, Cushman Lab. Foram. Research Special Pub. 14, p. 41, pl. 6, fig. 5, 1945.

Test large, more than twice as long as broad, tapering throughout, the lower half triangular in transverse section with rounded angles, somewhat twisted, consisting of 6 to 7 whorls; chambers inflated; sutures distinct, depressed; wall of the lower one-half to two-thirds of the test covered with fine, irregular costae, the upper part very coarsely perforate, giving the surface a rough appearance; aperture loop-shaped, with a slight lip. Length 0.80 to 0.96 mm., diameter 0.30 to 0.40 mm.

The types are from the Eocene "Lower Marl", Cipero

sect. sta. no. 10, Trinidad, B. W. I. The species has been recorded from the Eocene, Alturas de Almendares quarry, Cuba. We have specimens from the Eocene, approximately 5250 feet N. 62° W. of road intersection at Las Cruces, El Jaro Canyon, Santa Barbara County, California. Specimens from the Eocene of Häring in the Tyrol seem identical.

Bulimina heathensis W. Berry

Plate 24, figure 2

Bulimina heathensis W. Berry, Eclogae geol. Helvetiae, vol. 25, no. 1, p. 28, pl. 3, figs. 6, 7, 1932.

Test elongate, nearly uniform diameter for most of its length, about two and one quarter times as long as wide; chambers indistinct; sutures depressed; wall smooth, polished; aperture elongate, irregular. Length 0.53 mm.; diameter 0.24 mm.—W. Berry.

The species was described from the Oligocene Heath formation in Quebrada Heath, northwestern Peru.

We have no material referable to this form. Berry's figures are reproduced. It seems possible from the figures that the form may be a *Buliminella.*

Bulimina tuxpamensis Cole

Plate 24, figure 6

Bulimina tuxpamensis Cole, Bull. Am. Paleontology, vol. 14, p. 212, pl. 1, fig. 23, 1928.

Parker and Bermúdez, Jour. Paleontology, vol. 11, p. 513, pl. 58, figs. 1a-c, 1937.

Bermúdez, Soc. cubana historia nat. Mem., vol. 11, p. 342, 1937.

Cushman and Stainforth, Cushman Lab. Foram. Research Special Pub. 14, p. 41, pl. 6, fig. 6, 1945.

Colom, Inst. Invest. Geol., Num. 3 Estudios Geologicas, p. 60, pl. 4, figs. 122, 123, 1946.

Test stout, tapering, very regular in outline, broadest near the apertural end, very finely perforate; chambers but slightly inflated, numerous; sutures in most specimens relatively wide, limbate; aperture loop-like or comma shaped, extremely terminal, the most extreme specimens having the aperture almost straight across the end of the test. Length 0.75 mm.—Cole.

The types are from the Eocene material in the Huasteca Petroleum Company's well, Cerro Azul no. 75, Tampico, Mexico, at the depth of 1040 feet. We have no typical material. Parker and Bermúdez found specimens in the Eocene of Cuba, 4.5 kilometers west of Guanajay on the road to Mariel, Pinar del Rio Province, which seem to resemble this form closely except that the lower part of the test is somewhat roughened. Similar specimens occur in the Eocene near Siegsdorf, Germany, and at Gassino, near Turin, Italy. It also occurs in the Oligocene Cipero formation of Trinidad.

The species is larger than *Bulimina tarda* Parker and Bermúdez, less sharply tapered, and has more sharply angled chambers.

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Bulimina pupula Stache

Plate 24, figures 7, 8

Bulimina pupula Stache, *Novara*-Exped., Geol. Theil, vol. 1, pt. 2, p. 265, pl. 24, fig. 13, 1865.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 13, p. 66, pl. 9, figs. 1, 2, 1937.

Curran, Am. Assoc. Petroleum Geologists Bull., vol. 27, p. 1378 (list), 1943.

Bulimina ovata Stache (not D'Orbigny), *Novara*-Exped., Geol. Theil, vol. 1, pt. 2, p. 266, pl. 24, fig. 14, 1865.

Chapman, New Zealand Geol. Survey, Paleontology, Bull. 11, p. 39, pl. 5, figs. 13, 14, 1926.

Bulimina aperta Stache, *Novara*-Exped., Geol. Theil, vol. 1, pt. 2, p. 266, pl. 24, fig. 15, 1865.

Bulimina propinqua Stache, idem, p. 267, pl. 24, fig. 16, 1865.

Bulimina affinis Chapman, New Zealand Geol. Survey, Paleontology, Bull. 11, p. 37, pl. 5, figs. 15, 16, 1926.

Test large, 2½ times as long as broad, fusiform, greatest breadth at, or above, the middle, initial end subacute or rounded; chambers distinct, only slightly inflated, tending to become somewhat biserial in the adult; sutures distinct, slightly depressed, curved; wall smooth, distinctly perforate, thick; aperture narrow, elongate, with a distinct tooth and slight lip. Length up to 1.25 mm., diameter 0.50 mm.

The types are from the Eocene, Whaingaroa Bay, New Zealand. The species occurs at various localities in the Eocene of New Zealand and has also been recorded from the Miocene there. It is also listed from the Eocene of California.

There seems little doubt that the various species of Stache given in the synonymy refer to the same species. The figures show variations which are within the range of variation of the specimens in our collection. The form is close to *Bulimina pupoides* D'Orbigny but is larger, has less inflated chambers, and a thicker wall.

Bulimina cylindrica Roemer

Plate 24, figure 4

Bulimina cylindrica Roemer, Neues Jahrb., 1838, p. 387, pl. 3, fig. 44.

Cylinder-shaped, with 4 whorls and globular chambers.—Roemer (translated).

Roemer described the species from the younger Tertiary "Meersand" of North Germany. We have no material referable to it, but the figure resembles *Bulimina elongata* D'Orbigny.

Bulimina uva Roemer

Plate 24, figure 5

Bulimina uva Roemer, Neues Jahrb., 1838, p. 387, pl. 3, fig. 43.

Oval, botryoidal, with many spirally arranged, rounded, arched chambers.—Roemer (translated).

Roemer described the species from the Tertiary "Meersand" of North Germany. We have no material referable to it and it is somewhat questionable whether the form belongs to this genus. The original figure is reproduced here.

Bulimina socialis Bornemann

Plate 24, figure 3

Bulimina socialis Bornemann, Deutsche geol. Gesell. Zeitschr., vol. 7, p. 342, pl. 16, fig. 10. 1855.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 13, p. 36, pl. 4, figs. 1a-c, 1937.

Galloway and Heminway, New York Acad. Sci., Sci. Survey Porto Rico and Virgin Islands, vol. 3, p. 423, pl. 31, figs. 9a, b, 1941.

Test of medium size, about 1½ times as long as broad, somewhat oval in shape, with the widest part at about the middle of the test; chambers few, distinct, the last whorl forming the greater part of the test, inflated; sutures distinct, depressed; wall thin, perforate; aperture elongate, loop-shaped, with a slight lip, extending from the margin of the last-formed chamber, well above the suture joining the second and third chambers. Length 0.47 mm., diameter 0.30 mm.

The species was described from the Oligocene of Hermsdorf, near Berlin, Germany. We have only one poorly preserved specimen from that locality, but good material from the middle Oligocene of Ratingen, near Dusseldorf, Germany. One of these specimens is figured. It is recorded from the Ponce formation of Puerto Rico.

The species resembles *Bulimina winniana* Howe but is larger, with more rounded, inflated chambers. The chambers are more inflated and fewer in number than those of *B. ovata* D'Orbigny.

Bulimina coprolithoides Andreae

Plate 24, figure 9

Bulimina coprolithoides Andreae, Geol. Specialkarte Elsass-Lothringen Abh., vol. 2, pt. 3, p. 213, pl. 6, figs. 4a-d, 1884.

Cushman, Soc. sci. Seine-et-Oise Bull., ser. 2, vol. 9, p. 52(6), pl. 2, figs. 4a, b, 1928.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 13, p. 37, pl. 4, figs. 2a-c, 1937.

Test small, somewhat longer than broad, tapering from the broadest part in the middle of the last whorl, consisting of about 3 whorls, the last-formed composing almost three-fourths of the test; chambers distinct, inflated, arranged in regular series; sutures distinct, depressed; wall polished, translucent, finely perforate; aperture broad, loop-shaped, deepset, with a slight lip, just above the junction of the second and third chambers. Length 0.22 mm., diameter 0.16 mm.

The types are from the Oligocene of Rufach, Alsace. The species occurs also in the Oligocene at Ormoy and Dax, Seine-et-Oise, France.

The species resembles *Bulimina simplex* Terquem but is less elongate and slender, has fewer whorls, and more inflated chambers. It is broader and shorter than *B. elongata* D'Orbigny and the more globular chambers are arranged in regular series.

Bulimina alsatica Cushman and Parker

Plate 24, figures 10, 11

Bulimina alsatica Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 13, p. 39, pl. 4, figs. 6, 7, 1937.

Colom, Real Soc. Española Hist. Nat. Bol., vol. 41, p. 419, pl. 27, figs. 10-12, 1943.

?Bulimina buchiana Reuss (not D'Orbigny), Akad. Wiss. Wien Sitzungsber., vol. 62, pt. 1, p. 484, 1870 (Von Schlicht, Foraminiferen des Septarienthones von Pietzpuhl, p. 66, no. 383, pl. 22, figs. 30-33, Berlin, 1870).

Bulimina inflata Andreae (not Seguenza), Geol. Specialkarte Elsass-Lothringen Abh., vol. 2, pt. 3, p. 119, pl. 9, figs. 6a-c, 7, 1884.

?Cushman, Florida Geol. Survey Bull. 4, p. 43, pl. 8, figs. 6a, b, 1930.

?Cushman and Ponton, idem, Bull. 9, p. 77, 1932.

?Cushman and Cahill, U. S. Geol. Survey Prof. Paper 175-A, p. 24, pl. 8, figs. 1a, b, 1933.

Test small, about 1½ times as long as broad, tapering, the initial end of the test having 1 or more short spines; chambers indistinct except for those of the last whorl; sutures indistinct, depressed; wall of most of the last whorl smooth, the rest of the test with plate-like costae ending in plate-like spines, bent downward to give a hooked appearance, the costae usually not crossing the sutures; aperture loop-shaped with a well defined lip, well above the junction of the second and third chambers. Length 0.34 to 0.57 mm., diameter 0.22 to 0.44 mm.

The types of the species are from the Oligocene of Hartmannsweiler, Alsace. It occurs also in the Oligocene at Hermsdorf, near Berlin, Germany. Very similar specimens occur in the Miocene Choctawhatchee marl of Florida, and in the Miocene of San Miniato, Italy. It is also recorded by Colom from the Miocene of Spain.

This form can be recognized by the hook-like spines. It differs from *Bulimina inflata* Seguenza in this respect as well as in not having the pronounced, often continuous costae of the latter. It differs from *B. stalacta* Cushman and Parker in the shorter, more tapered test and in the more projecting, hooked spines. It is more spinose and has fewer, much less distinct chambers than *B. rinconensis* Cushman and Laiming. The chambers are less distinct and the costae and spines less heavy and pronounced than in *B. bleeckeri* Hedberg.

Bulimina sculptilis Cushman

Plate 24, figure 12

Bulimina sculptilis Cushman, U. S. Geol. Survey Prof. Paper 133, p. 23, pl. 3, fig. 3, 1923.

Cushman and Schenck, California Univ., Dept. Geol. Sci., Bull., vol. 17, p. 311, pl. 43, fig. 16, 1928.

Cole and Ponton, Florida Geol. Survey Bull. 5, p. 38, pl. 9, fig. 11, 1930.

Nuttall, Jour. Paleontology, vol. 6, p. 19, pl. 5, fig. 1, 1932.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 13, p. 37, pl. 4, figs. 3a-c, 1937.

Renz, 8th Am. Sci. Congress Proc., p. 553 (list), 1942.

Howe, Jour. Paleontology, vol. 16, p. 267 (list), 1942.

Franklin, idem, vol. 18, p. 314, pl. 45, fig. 15, 1944.

Cushman and Ellisor, idem, vol. 19, p. 562, pl. 75, fig. 14, 1945.

Test elongate, at least twice as long as broad, tapering, subacute at the initial end; chambers numerous, distinct; sutures slightly depressed, distinct; wall finely perforate, ornamented with about 10, thin, low, longitudinal costae, extending from halfway down the last-formed whorl to the base of the test without a break, but often with slight depressions at the sutures, giving a somewhat scalloped effect; aperture long, comma-shaped, with a well developed lip, placed somewhat above the junction of the second and third chambers. Length 0.77 mm., diameter 0.40 mm.

The types are from the Oligocene Red Bluff clay, Hiwannee, Mississippi. The species occurs in the lower Oligocene of the Coastal Plain region of the United States. Specimens recorded by Nuttall from the Alazan clay of Mexico are placed here, although his form has higher, more plate-like costae that somewhat approach those of *Bulimina jacksonensis* Cushman in character; the shape of the test and character of the chambers, however, seem to ally it more definitely with *B. sculptilis*. Somewhat similar specimens occur in the Eocene of Häring, in the Austrian Tyrol. It has also been recorded by Howe from the type locality of the Oligocene Glendon formation in Alabama. Other records include the Oligocene and Miocene of Venezuela.

Bulimina sculptilis Cushman var. laciniata Cushman and Parker

Plate 24, figure 13

Bulimina sculptilis Cushman var. *laciniata* Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 13, p. 38, pl. 4, figs. 4a-c, 1937; idem, p. 53.

Variety differing from the typical form in the more tapered test, usually terminated by a blunt spine; in the chambers which are more inflated, especially those of the last whorl; and in the jagged costae. Length 0.56 to 0.80 mm., diameter 0.40 to 0.44 mm.

The types are from the Miocene, south side of Alsea Bay, Lincoln County, Oregon (Loc. A. 198, Schenck, California Univ., Dept. Geol. Sci., Bull., vol. 18, no. 1, p. 33, Nov. 30, 1928). The variety is found also in the Oligocene Bassendorf shale, Coos County, Oregon (Loc. A. 93, idem, p. 18).

Bulimina alazanensis Cushman

Plate 24, figures 14-16

Bulimina alazanensis Cushman, Jour. Paleontology, vol. 1, p. 161, pl. 25, fig. 4, 1927.

Parker and Bermúdez, Jour. Paleontology, vol. 11, p. 514, pl. 58, figs. 5a-c, 1937.

Bermúdez, Soc. cubana historia nat. Mem., vol. 11, p. 341, 1937.

Cushman and Stainforth, Cushman Lab. Foram. Research, Special Pub. 14, p. 40, pl. 6, fig. 2, 1945.

?Bulimina presli Reuss var. *buchiana* Parker and Jones (not D'Orbigny), Philos. Trans., vol. 155, p. 374, pl. 17, fig. 71, 1865.

Test small, somewhat longer than broad, greatest breadth near the apertural end, thence tapering to the initial end; chambers and sutures obscured by the ornamentation which consists of prominent, longitudinal costae terminated at the basal end by somewhat spinose projections; surface often slightly corrugated between the costae; aperture elongate, somewhat comma-shaped. Length 0.50 mm. or less.

The types are from the Alazan clay, Rio Buena Vista, just south of crossing of the Alazan-to-Moyutla road, Vera Cruz, Mexico. The species has been recorded in the Eocene of Cuba and the Oligocene Cipero formation of Trinidad. Similar forms are found in the Pliocene of Lomita Quarry, Palos Verdes Hills, California. The form described as *Bulimina rostrata* H. B. Brady(?) by Cushman, Stewart and Stewart (San Diego Soc. Nat. History Trans., vol. 6, p. 65, pl. 5, fig. 1, 1930) from the Pliocene of Humboldt County, California, is a somewhat larger form and is questionably referred to this species. We have a few Recent specimens from the north Pacific and from the north Atlantic near Ireland that closely resemble this form.

The species is very close to *Bulimina truncana* Gümbel. A comparison of suites of specimens, however, shows certain definite differences. *B. alazanensis* has fewer, somewhat coarser, more irregular costae.

Bulimina alazanensis Cushman var. spatiosa Cushman and Todd

Plate 30, figure 19

Bulimina alazanensis Cushman var. *spatiosa* Cushman and Todd, Cushman Lab. Foram. Research Special Pub. 15, p. 40, pl. 6, fig. 12, 1945.

Variety differing from the typical in the larger size, more prominent basal spine, and higher and somewhat less regular costae.—Cushman and Todd.

The types are from the Miocene, half a mile east of Buff Bay, Jamaica.

Bulimina bicona W. Berry

Plate 24, figure 19

Bulimina bicona W. Berry, Eclogae geol. Helvetiae, vol. 25, no. 1, p. 28, pl. 3, figs. 13, 14, 1932.

Test nearly fusiform, apical end abruptly rounded, apertural end with a rounded point, bases of chambers appearing above the apex, the last one extending from the apertural end to about half-way back on the test; chambers slightly inflated; sutures depressed; aperture a comma-shaped slit, often broken. Length 0.33 mm.—W. Berry.

The species was described from the Oligocene Heath formation in Quebrada Heath, northwestern Peru.

We have no material referable to the species. Berry says that the form may be recognized by its distinctive shape, which is almost biconical. The original figures are reproduced.

Bulimina jugosa Cushman and Parker

Plate 25, figure 1

Bulimina jugosa Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 13, p. 38, pl. 4, figs. 5a-c, 1937.

Test small, rapidly tapering, about 1½ times as long as broad, consisting of 3 to 4 whorls; chambers very indistinct; sutures indistinct, slightly depressed; wall coarsely perforate, sometimes slightly translucent, ornamented by numerous longitudinal, low, rounded costae; aperture somewhat deepset, loop-shaped, with a very slight lip, placed just above the junction of the second and third chambers. Length 0.30 to 0.48 mm., diameter 0.20 to 0.30 mm.

The types of the species are from the Oligocene(?) Punta Bianca shales, Sea Cliff, near village of Rio Seco, 1° 10′ south of the Equator, 9.25 kilometers southwest of Manta, Ecuador. It is known only from the type locality.

The species differs from *Bulimina alazanensis* Cushman in its much heavier test, heavier, more rounded costae, and blunt initial end.

Bulimina bleeckeri Hedberg

Plate 24, figure 17

Bulimina bleeckeri Hedberg, Jour. Paleontology, vol. 11, p. 675, pl. 91, figs. 12, 13, 1937.

Palmer, Soc. cubana hist. nat. Mem., vol. 14, p. 295, 1940.

Franklin, Jour. Paleontology, vol. 18, p. 314, pl. 46, fig. 14, 1944.

Cushman and Ellisor, idem, vol. 19, p. 562, pl. 75, fig. 16, 1945.

Cushman and Stainforth, Cushman Lab. Foram. Research Special Pub. 14, p. 41, pl. 6, fig. 4, 1945.

?*Bulimina inflata* Nuttall (not Seguenza), Quart. Jour. Geol. Soc., vol. 84, p. 77, pl. 3, fig. 19, 1928.

Nuttall, Jour. Paleontology, vol. 6, p. 20, pl. 5, fig. 2, 1932.

?Cushman, Cushman Lab. Foram. Research Contr., vol. 5, p. 94, pl. 13, fig. 31, 1929.

Variably top-shaped, with last three chambers usually making angles of at least 30 degrees with axis of test. Chambers numerous; as many as 18 visible on some specimens. Strongly overlapping; chambers of each whorl superimposed exactly above those of preceding whorl. Lower edges of chambers straight, at right angles to axis of test; each with 3 to 6 strong costae or crenulations which extend downward beyond the base of the chamber as blunt spines. On the last three chambers these costae are developed only near the lower margin, but are probably more extensive over the earlier chambers though largely concealed by overlap. Sutures distinct. Aperture in a deep embayment of the last chamber margin, near where it overlaps the suture separating the second and third to the last chambers. Holotype from Sample E-4022. Length, 0.38 mm., maximum diameter, 0.28 mm.—Hedberg.

The types are from the Oligocene Carapita formation, District of Libertad, State of Anzoategui, Venezuela. It occurs also in the Oligocene Alazan formation of Mexico, Cipero formation of Trinidad, Cojimar formation of Cuba, and in the Punta Bianca shale, near Manta, Ecuador.

This form is very close to *Bulimina alsatica* Cushman and Parker but has heavier, more pronounced costae and spines, and much more distinct chambers. The costae are higher and not arranged in regular lines, as in *B. inflata* Seguenza var. *alligata* Cushman and Laiming. It is more tapering and not so fusiform as *B. rinconensis* Cushman and Laiming. The costae are heavier and not so regular as in *B. subacuminata* Cushman and Stewart. Hedberg's figured specimens have been studied, and the holotype is refigured here.

Bulimina rugifera Glaessner

Plate 24, figure 18

Bulimina rugifera Glaessner, Problems of paleontology, Moscow Univ., vols. 2-3, p. 372, pl. 2, fig. 19, 1937.

Under this name Glaessner has described and figured a specimen from the Tertiary of the Caucasus region. We have no specimens of this species and from the figure alone it is difficult to place it.

Bulimina pyrula D'Orbigny

Plate 25, figure 2

Bulimina pyrula D'Orbigny, Foraminifères fossiles du bassin tertiaire de Vienne, p. 184, pl. 11, figs. 9, 10, 1846.

Terrigi, Com. geol. italiana Mem., vol. 4, pt. 1, p. 71, pl. 1, figs. 18, 19, 1891.

Silvestri, Accad. sci. Acireale Atti e Rend., vol. 5, p. 12, pl. 5, figs. 74-82, 1893.

Egger, Naturh. Ver. Passau Jahresber. 16, p. 16, pl. 4, figs. 1a-c, 1895.

?Howe and Wallace, Louisiana Dept. Cons. Geol. Bull. 2, p. 60, pl. 11, fig. 6, 1932.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 13, p. 46, pl. 6, fig. 1, 1937.

LeRoy, Natuurk. tijdschr. Ned-Indië, vol. 99, pt. 6, p. 244, pl. 5, figs. 19, 20, 1939; Colorado School of Mines Quart., vol. 39, no. 3, p. 26, pl. 5, fig. 14, 1944.

Silvestri and Zangheri, Soc. geol. italiana Boll., vol. 61, p. 87, 1942.

Bulimina sp. aff. *B. pupoides* Schwager (not D'Orbigny), Com. geol. italiana Boll., vol. 9, p. 523, pl. 1, fig. 10a, 1878.

Bulimina pyrula D'Orbigny var. *spinescens* Amicis (not H. B. Brady), Soc. geol. italiana Boll., vol. 12, pt. 3, p. 59, pl. 3, figs. 8a, b, 1893.

Egger, Naturh. Ver. Passau Jahresber. 16, p. 17, pl. 4, figs. 2, 3, 1895.

Test of medium size, about 1½ times as long as broad, acuminate at both ends, consisting of 2 to 3 whorls, the last-formed whorl composing about seven-eighths of the test; chambers slightly inflated, early chambers very narrow owing to the great involution; sutures slightly depressed; wall smooth, polished, often translucent, frequently ornamented with one or more small spines at the base, coarsely perforate; aperture loop-shaped, with a well-defined lip and tooth. Length of specimens from Baden 0.36 to 0.64 mm., diameter 0.26 to 0.40 mm.

The types are from the Miocene at Baden, Vienna Basin, Austria. The earliest record for the species is from the Eocene Jackson formation of Louisiana. We have material from the Yazoo clay of Mississippi which yields a form very close to D'Orbigny's species though not absolutely identical. It occurs questionably in the Eocene of Biarritz and in the Alazan clay of Mexico. In the Miocene it is found at several localities in the Vienna Basin and in Germany. We have material from the Pliocene of Castel Arquato and Coroncina, Italy, and specimens with a somewhat more rounded base, from gray siltstone 280 feet stratigraphically above the base of the first Pico sandstone, 2$\frac{1}{10}$ miles N. 74° E. of La Crosse Junction, Cañada de Aliso, Ventura County, California. It is recorded by LeRoy from the Miocene of Sumatra.

Considerable confusion prevails in the literature regarding this species. Many forms that have been recorded, especially from the Recent, belong to the genus *Globobulimina,* which is an involute form developed from *Bulimina,* showing only the last three chambers, at least in the adult. *Bulimina pyrula* approaches the *Globobulimina* type and it seems probable that it represents an ancestral form of that genus. The early chambers, however, though very narrow are easily seen. The presence of the occasional spines does not seem to be a specific character. The species is easily differentiated from other forms by its highly involute character, which makes the last whorl predominant. It differs from the species of *Globobulimina* in being acuminate at both ends, with the early whorls visible.

Bulimina pyrula D'Orbigny var. lata Seguenza

Bulimina pyrula D'Orbigny var. *lata* Seguenza, R. accad. Lincei Atti, ser. 3, vol. 6, p. 147, 1880.

Wider forms with the initial portion not prominent but rather flattened.—Seguenza (translated).

Seguenza described the variety from the Miocene Tortonian of Calabria, Italy. It was not figured.

Bulimina pupoides D'Orbigny

Plate 25, figures 3-7

Bulimina pupoides D'Orbigny, Foraminifères fossiles du bassin tertiaire de Vienne, p. 185, pl. 11, figs. 11, 12, 1846.

H. B. Brady, *Challenger* Rept., Zoology, vol. 9, p. 400, pl. 50, figs. 15a, b, 1884.

Terrigi, Com. geol. italiana Mem., vol. 4, pt. 1, p. 72, pl. 1, fig. 22, 1891.

Egger, Naturh. Ver. Passau Jahresber. 16, p. 14, pl. 4, figs. 6a, b, 7, 8, 1895.

Flint, U. S. Nat. Mus. Rept. for 1897, p. 290, pl. 37, fig. 3, 1899.

Nuttall, Jour. Paleontology, vol. 4, p. 285, 1930.

Macfadyen, Egypt. Geol. Survey, 1930, p. 52, pl. 1, fig. 11, 1931; ?Geol. Mag., vol. 69, p. 494, pl. 34, fig. 4, 1932.

Nuttall, Jour. Paleontology, vol. 6, p. 19, pl. 2, fig. 9, 1932.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 13, p. 47, pl. 6, figs. 2, 3, 1937.

Ellisor, Am. Assoc. Petroleum Geologists Bull., vol. 24, pp. 439 (list), 444 (list), pl. 4, fig. 5, 1940.

LeRoy, Colorado School of Mines Quart., vol. 36, no. 1, p. 32, pl. 1, figs. 93, 94, 1941.

Coryell and Mossman, Jour. Paleontology, vol. 16, p. 242, pl. 36, fig. 43, 1942.

Bandy, idem, vol. 18, p. 377, pl. 62, fig. 9, 1944.

LeRoy, Colorado School of Mines Quart., vol. 39, no. 3, p. 26, pl. 1, figs. 1, 4; pl. 4, fig. 10; p. 84, pl. 2, fig. 2, 1944.

Cushman and Ellisor, Jour. Paleontology, vol. 19, p. 562, pl. 75, fig. 13, 1945.

Bulimina cf. *B. pupoides,* Parker and Bermúdez, Jour. Paleontology, vol. 11, p. 515, pl. 59, figs. 3a-c, 4a-c, 5a-c, 1937.

Bulimina pitecusana Costa, Accad. pontaniana Atti, vol. 7, pl. 15, fig. 5, 1856.

Bulimina incrassata Karrer, Akad. Wiss. Wien Sitzungsber., vol. 58, p. 177, pl. 4, fig. 12, 1868.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 13, p. 52, 1937.

?Bulimina affinis H. B. Brady (not D'Orbigny), *Challenger* Rept., Zoology, vol. 9, p. 400, pl. 50, figs. 14a, b, 1884.

Terrigi, Com. geol. italiana Mem., vol. 4, pt. 1, p. 72, pl. 1, fig. 21, 1891.

?Cushman, U. S. Nat. Mus. Bull. 71, pt. 2, p. 79, text fig. 130, 1911; idem, Bull. 100, vol. 4, p. 165, 1921.

Bulimina ovata Burrows and Holland (not D'Orbigny), Geol. Assoc. Proc., vol. 15, p. 32, pl. 2, fig. 11, 1897.

?Bulimina elegans Nuttall (not D'Orbigny), Jour. Paleontology, p. 285, pl. 23, fig. 12, 1930.

Test of medium size, twice as long as broad or less, very slightly tapering, consisting of about 5 whorls; chambers somewhat inflated; sutures distinct, depressed, running at right angles to the vertical axis; wall smooth, often somewhat transparent, perforate; aperture loop-shaped, with a well defined lip, and often with a tooth. Length of specimens from Baden 0.30 to 0.80 mm., diameter 0.20 to 0.40 mm.

The types are from the Miocene of Nussdorf and Baden, in the Vienna Basin, Austria. This species has a wide range both vertically and horizontally. The earliest known specimens are from the Eocene of Hungary; Biarritz, France; the Thanet beds of Pegwell Bay in the Isle of Wight; and Cuba. It has been recorded by Nuttall from the Eocene Aragon formation and the Oligocene Alazan clay of Mexico. It occurs in the Miocene of Austria, Hungary, Germany, Egypt, and Texas. In the Pliocene we have material from Coroncina and Castel Arquato, Italy. It has been recorded by Macfayden from the Pliocene and Pleistocene of East Anglia. In the eastern Pacific it occurs from Lat. 32° N. south to the coast of Patagonia, and we have a few specimens from the vicinity of the Philippine Islands. It has been recorded by Flint from the Gulf of Mexico. His figures seem to represent the form although we have no material to verify the identification.

This is a variable species. Specimens from Baden show a wide range of variation in respect to length, width, number of whorls, etc. The only absolutely fixed characters are the angle that the sutures make with the vertical axis of the test, the shape of the chambers, and the position of the aperture. The species differs from *Bulimina ovata* D'Orbigny in the shape of the test, which is slightly tapering, not oval; and in the shape of the chambers, which is more angled. It is more difficult to separate the form from *B. affinis* D'Orbigny, but it differs in the shape of the apertural face, which does not extend so far down the side of the test and is less protuberant; in the shape of the test, which is narrower in proportion to the width; and in the greater number of chambers, the last whorl making up a smaller proportion of the test. It is sometimes difficult, however, to identify definitely certain of the Pacific forms that seem to have some of the characteristics of both groups.

Bulimina ovata D'Orbigny

Plate 25, figures 8, 9

Bulimina ovata D'Orbigny, Foraminifères fossiles du bassin tertiaire de Vienne, p. 185, pl. 11, figs. 13, 14, 1846.

H. B. Brady, *Challenger* Rept., Zoology, vol. 9, p. 400, pl. 50, figs. 13a, b, 1884. (See *Bulimina notovata* Chapman).

Terrigi, Com. geol. italiana Mem., vol. 4, pt. 1, p. 72, pl. 1, fig. 20, 1891.

Egger, Naturh. Ver. Passau Jahresber. 16, p. 15, pl. 3, figs. 11a, b, 1895.

Sidebottom, Royal Micr. Soc. Jour., 1918, p. 122, pl. 3, figs. 1-3.

Cushman, U. S. Nat. Mus. Bull. 100, vol. 4, p. 164, text fig. 4, 1921; Cushman Lab. Foram. Research Contr., vol. 2, p. 55, pl. 7, fig. 1, 1926.

Macfadyen, Egypt Geol. Survey, 1930, p. 53, pl. 1, fig. 13, 1931.

?Nuttall, Jour. Paleontology, vol. 6, p. 19, pl. 2, fig. 8, 1932.

?Cushman and Ponton, Cushman Lab. Foram. Research Contr., vol. 8, p. 67, pl. 9, figs. 1, 2, 1932; ?Florida Geol. Survey Bull. 9, p. 78, pl. 11, fig. 11, 1932.

Cushman, U. S. Geol. Survey Prof. Paper 181, p. 35, pl. 13, figs. 15, 16, 1935.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 13, p. 47, pl. 6, figs. 4, 5, 1937.

?Kleinpell, Miocene stratigraphy of California, p. 255, pl. 12, figs. 14a, b; ("aff.") pl. 2, fig. 9, Tulsa, 1938.

LeRoy, Colorado School of Mines Quart., vol. 36, no. 1, p. 32, pl. 1, figs. 95, 96; p. 79, pl. 2, fig. 14, 1941.

Toulmin, Jour. Paleontology, vol. 15, p. 597, pl. 80, figs. 25, 26, 1941.

Silvestri and Zangheri, Soc. geol. italiana Boll., vol. 61, p. 88, 1942.

ten Dam and Reinhold, Geol. Stichting Mededeelingen, ser. C-V, no. 2, p. 80, 1942.

ten Dam, idem, no. 3, p. 111, pl. 3, figs. 10, 11, 1944.

Cushman, Cushman Lab. Foram. Research Contr., vol. 20, p. 24, pl. 4, figs. 21, 22, 1944; idem, Special Pub. 16, p. 23, pl. 5, fig. 2, 1946.

Colom, Inst. Invest. Geol., Num. 3 Estudios Geologicos, p. 158, pl. 10, fig. 151, 1946.

Bulimina cf. *B. ovata* Israelsky, 6th Pacific Sci. Congress Proc., p. 577, pl. 6, fig. 10, 1939.

Bulimina laevigata D'Orbigny, Annales sci. nat., vol. 7, p. 270, no. 14, 1826.

Fornasini, Soc. geol. italiana Boll., vol. 20, p. 182, text fig. 4, 1901; Accad. sci. Ist. Bologna Mem., ser. 5, vol. 9, p. 374, 1901; idem, vol. 10, p. 154, 1901.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 14, p. 94, pl. 16, fig. 16, 1938.

Bulimina semistriata D'Orbigny, Annales sci. nat., vol. 7, p. 270, no. 15, 1826.

Fornasini, Soc. geol. italiana Boll., vol. 20, p. 200, text fig. 5, 1901.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 14, p. 61, 1938.

Bulimina ellipsoides Costa, Accad. pontaniana Atti, vol. 8, pt. 2, p. 265, pl. 15, fig. 9, 1856.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 14, p. 61, 1938.

Bulimina affinis Rzehak (not D'Orbigny), Naturf. Ver. Brünn Verh., vol. 14, pt. 1, pp. 80, 90, pl. 1, fig. 2, 1885.

Egger, Naturh. Ver. Passau Jahresber. 16, p. 14, pl. 4, figs. 4, 5, 1895.

Bulimina pupoides Cushman (not D'Orbigny), U. S. Nat. Mus. Bull. 100, vol. 4, p. 161, pl. 31, fig. 8, 1921.

Bulimina sp. Cushman and Applin, Am. Assoc. Petroleum Geologists Bull., vol. 10, p. 169, pl. 7, figs. 10, 11, 1926.

Test of medium size, not more than twice as long as broad, oval in shape, the broadest portion about one-third

of the way down from the apertural end, consisting of 2 or 3 whorls, the last-formed whorl forming one-half or more of the test; chambers somewhat inflated; sutures distinct, depressed; wall smooth, somewhat translucent, perforate, the perforations sometimes arranged in regular lines to give a faintly striate appearance; aperture loop-shaped, with a well defined lip and tooth. Length of specimens from Baden 0.38 to 0.64 mm., diameter 0.26 to 0.34 mm.

The species was described from the Miocene at Nussdorf, in the Vienna Basin, Austria. It is a widely ranging form, occurring in the Eocene of Biarritz, France, and of Hungary, and in the Jackson group of Texas, Salt Mountain limestone of Alabama, and Aquia formation of Virginia. Somewhat questionable forms occur in the Oligocene of Mexico. In the Miocene it is found at several localities in Austria, Hungary and Germany. Cushman records it in the Monterey shale of California, Kleinpell from the Luisian of Reliz Canyon, Monterey County and questionably from many other California Miocene localities. A similar form occurs in the Miocene of Florida. In the Pliocene we have specimens from several localities in Italy and Spain, and similar, though somewhat larger, less inflated specimens were found 300 feet above the base of the Pico sandstone, in Cañada de Aliso, Ventura County, California. It is found in Recent seas at Rimini, Italy and at various localities near the Philippine Islands.

Bulimina semistriata D'Orbigny has been placed in the synonymy under this species, as specimens in the Pliocene of Italy that were referable to it were identical with the forms from the Vienna Basin. They showed very plainly the faint striations caused by the alining of the perforations, a characteristic which may be seen also in the Austrian specimens. The Recent specimens from Rimini, which may be referred to *B. laevigata* D'Orbigny, were also identical with *B. ovata*. *B. ellipsoides* Costa has been identified with this species. Although his figure is poor, the general characters seem to point very definitely to the same form.

This species is closely related to *Bulimina pupoides* D'Orbigny but differs from it in the oval form of the test, the angle of the sutures, which curve downward rather than extending at right angles to the vertical axis. This latter character is especially true of the megalospheric form. The specimens at any one locality vary greatly, and this accounts, up to a point, for the variety of figures given in the literature. We have included in the synonymy only such forms as can be checked with a reasonable degree of accuracy, either by a study of topotype material or of material of the same general region and age.

Chapman has given a new name, *"Bulimina notovata,"* to Brady's figured specimens from off New Zealand.

Bulimina arcuata D'Orbigny

Plate 25, figure 10

Bulimina arcuata D'Orbigny, Annales sci. nat., vol. 7, p. 270, no. 12, 1826

Fornasini, Accad. sci. Ist. Bologna Mem., ser. 6, vol. 5, p. 46, pl. 1, figs. 12, 12a, 1908.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 13, p. 53, 1937.

The type is from the Miocene, near Dax, France.

It is impossible to tell definitely from the figure to what genus this species belongs. The only clue we have is in D'Orbigny's description of *Bulimina patagonica* in which he compares that species to *B. arcuata,* saying that the Recent form has a comma-shaped aperture instead of a round one, and is spinose. Aside from the question of the aperture the species seems to have the characteristics of a *Buliminella.*

Bulimina buchiana D'Orbigny

Plate 25, figures 11, 12

Bulimina buchiana D'Orbigny, Foraminifères fossiles du bassin tertiaire de Vienne, p. 186, pl. 11, figs. 15-18, 1846.

Macfadyen, Egypt Geol. Survey, 1930, p. 55, pl. 1, fig. 21, 1931.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 13, p. 48, pl. 6, figs. 6, 7, 1937.

ten Dam and Reinhold, Geol. Stichting Mededeelingen, ser. C-V, no. 2, p. 81, 1942.

Colom, Inst. Invest. Geol., Num. 3 Estudios Geologicos, p. 159, pl. 10, figs. 157, 158, 1946.

Test of medium size, about twice as long as broad, gradually tapering, broadest portion somewhat above the middle, consisting of 5 or 6 whorls in the adult form, sometimes with a well developed basal spine; chambers numerous, distinct in the later portion; sutures in the smooth part of the test distinct, depressed; wall of most of the last-formed whorl smooth, perforate, the rest of the test with longitudinal costae usually extending unbroken across at least 2 chambers, sometimes more; aperture loop-shaped, with a distinct lip. Length of specimens from Baden 0.34 to 0.90 mm., diameter 0.22 to 0.44 mm.

The types of the species are from the Miocene of Nussdorf and Baden, Vienna Basin, Austria, and Boholth, Styria. It occurs also in the Miocene of Bulgaria and Egypt.

This is a larger species than *Bulimina costata* D'Orbigny, the costae are somewhat finer, more numerous, and more regular. The chambers are not typically undercut at the sutures to give a collared effect to the test, although some forms show a slight tendency in that direction.

Bulimina buchiana D'Orbigny var. calabra Seguenza

Plate 25, figure 13

Bulimina buchiana D'Orbigny var. *calabra* Seguenza, R. accad. Lincei Atti, ser. 3, vol. 6, p. 146, pl. 13, fig. 34, 1880.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 13, p. 51, pl. 6, fig. 8, 1937.

Bulimina buchiana Terrigi (not D'Orbigny), Pont. accad. sci. Nuovi Lincei Atti, vol. 33, p. 73, pl. 2, fig. 37, 1880.

Variety differing from the typical form in having more whorls and somewhat more overhanging chambers. Length of figured specimen 0.60 mm., diameter 0.30 mm.

The variety was described from the Miocene Tortonian of Calabria, Italy. We have material from the Tortonian of Varpolata, Hungary, the upper Miocene of France, and the Recent deposits of Rimini and Venice, Italy.

This variety approaches the form of *Bulimina costata* D'Orbigny, but the chambers are not so collared, there are many more whorls, and the test is much larger.

Bulimina elongata D'Orbigny

Plate 25, figures 14-17

Bulimina elongata D'Orbigny, Annales sci. nat., vol. 7, p. 269, no. 9, 1826; Foraminifères fossiles du bassin tertiaire de Vienne, p. 187, pl. 11, figs. 19, 20, 1846.

Hantken, K. ungar. geol. Anstalt Mitt. Jahrb., vol. 4, p. 61, pl. 10, figs. 7a, b, 1875.

Terquem, Soc. géol. France Mém., ser. 3, vol. 2, p. 109, pl. 11 (19), figs. 21a, b, 22, 1882.

Egger, K. bayer. Akad. Wiss. Abh., cl. 2, vol. 18, p. 284, pl. 8, figs. 75, 76, 105, 106, 1893; Naturh. Ver. Passau Jahresber. 16, p. 15, pl. 3, figs. 12a, b, 1895.

?Chapman, California Acad. Sci. Proc., ser. 3 (Geology), vol. 1, p. 243, pl. 29, fig. 1, 1900.

?Fornasini (part), Accad. sci. Ist. Bologna Mem., ser. 5, vol. 9, p. 373, text fig. 5, 1901; idem, p. 376, pl. 0, fig. 10 (not figs. 12, 20, 37).

?Paalzow, Offenbacher Ver. Naturkunde Ber., 1912-24, p. 15, pl. 1, figs. 8, 9, 1924.

Macfadyen, Egypt Geol. Survey, 1930, p. 54, pl. 1, fig. 17, 1931.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 13, p. 49, pl. 7, figs. 1-3, 1937.

ten Dam and Reinhold, Geol. Stichting Mededeelingen, ser. C-V, no. 2, p. 80, pl. 5, fig. 11, 1942.

Bulimina ariminensis D'Orbigny, Annales sci. nat., vol. 7, p. 269, no. 8, 1826.

Fornasini, Soc. geol. italiana Boll., vol. 20, p. 178, text fig. 3, 1901.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 14, p. 92, pl. 16, figs. 11a, b, 1938.

Bulimina inconstans Egger, Neues Jahrb., 1857, p. 283, pl. 12, figs. 1-3, 8, 9.

?Buliminella inconstans Coryell and Mossman, Jour. Paleontology, vol. 16, p. 243, pl. 36, fig. 45, 1942.

Bulimina pupoides Williamson (not D'Orbigny), Recent Foraminifera of Great Britain, p. 61, pl. 5, figs. 124, 125, 1858.

Terrigi, Pont. accad. sci. Nuovi Lincei Atti, vol. 33, p. 71, pl. 2, figs. 30-34, 1880; R. accad. Lincei Atti, ser. 4, Mem., vol. 6, p. 110, pl. 5, fig. 6, 1893.

Bulimina scabriuscula Reuss, Akad. Wiss. Wien Sitzungsber., vol. 42, p. 360, pl. 2, fig. 13, 1860.

?Bulimina eocena Hantken, K. ungar. geol. Anstalt Mitt. Jahrb., vol. 1, p. 136, pl. 2, fig. 16, 1871-72.

Bulimina elegans Jones (not D'Orbigny), Crag Foraminifera, Palaeont. gr. Soc. Mon., pt. 2, p. 163, pl. 6, fig. 19, 1895.

Bulimina fusiformis Fornasini (not Williamson) (part), Accad. sci. Ist. Bologna Mem., ser. 5, vol. 9, p. 377, pl. 0, figs. 6, 9, 41 (not figs. 1, 3, 4, 16, 18, 21, 23, 27, 36, 40), 1901.

Liebus, K.-k. geol. Reichsanstalt Jahrb., vol. 52, pl. 5, fig. 7, 1902.

Bulimina fusiformis Williamson var. *pupoides* Fornasini (not D'Orbigny), Accad. sci. Ist. Bologna Mem., ser. 5, vol. 9, p. 378, pl. 0, figs. 13, 17, 1901.

?Bulimina imbricata Reuss var. *procera* Liebus, Geol. Bund. Jahrb., vol. 77, p. 368, pl. 13, figs. 8a, b, 1927.

Bulimina gracilis Cushman, Florida Geol. Survey Bull. 4, p. 43, pl. 8, figs. 5a, b, 1930.

Cushman and Ponton, idem, Bull. 9, p. 76, 1932.

Cushman and Cahill, U. S. Geol. Survey Prof. Paper 175-A, p. 24, pl. 7, figs. 16a, b, 1933.

Cushman, Geol. Soc. America Bull., vol. 47, p. 431, pl. 5, figs. 8a, b, 1936.

Ellisor, Am. Assoc. Petroleum Geologists Bull., vol. 24, p. 439 (list), pl. 5, fig. 18, 1940.

Bulimina schwageri(?) Cushman and Dusenbury (not Yokoyama), Cushman Lab. Foram. Research Contr., vol. 10, p. 62, pl. 8, figs. 11a, b, 1934.

Test long and slender, 3 or more times as long as broad, width practically uniform throughout the test except in the microspheric form where the last-formed chambers are inflated, consisting of 5 or 6 whorls; chambers distinct, slightly inflated, angled; sutures distinct, depressed; wall smooth, polished, often translucent, very finely perforate; aperture a long loop-shaped opening, with a well defined lip. Length of specimens from Baden and Nussdorf 0.28 to 0.67 mm., diameter 0.14 to 0.22 mm.

The types of the species are from the Miocene at Nussdorf, in the Vienna Basin, Austria. We have specimens from various localities in the Vienna Basin, including Nussdorf. The species is variable and long ranging, occurring from the Eocene to the Recent. Slight variations can be seen in specimens from different localities, but the species is so variable, even at the type locality, that it does not seem expedient to try to subdivide it further. We have material from the Eocene of the Paris Basin and Biarritz, France; from Neustift near Ofen, Hungary; from 480 feet below the base of the Tecuya formation, and from the Poway conglomerate of California; and from the Alazan(?) shale of Mexico. Paalzow records it from the Oligocene of Germany. We have material from the Miocene of Germany and France, from the Choctawhatchee formation of Florida, and various localities in Maryland. Chapman records it from the

Miocene of California and Macfadyen from the Miocene of Egypt. We have specimens from the Pliocene of Belgium, Sicily, Castel Arquato in Italy, near Nice in France, and questionably from the Kalimnen of Australia. Jones records it, as *Bulimina elegans,* from the Coralline Crag of England. In the Recent seas it is recorded from Zanzibar, Rimini in Italy, Bognor in England, and from the Red Sea. It has been recorded also from about the British Isles, although all our material from there seems to be varietal.

Various species of authors have been placed in the synonymy under this form. *Bulimina ariminensis* D'Orbigny, although the older name, was a *nomen nudum* until figured by Fornasini in 1901. Specimens from the Miocene of Dingden in Westphalia, one of the type localities for *B. scabriuscula* Reuss, were typical *B. elongata.* Specimens from Ortenburg, Germany, near Egger's locality for *B. inconstans,* were also typical. The specimens from the Miocene of Florida called *B. gracilis* Cushman are somewhat more slender and attenuated but identical ones may be found in the Vienna Basin material. The specimens from the Miocene of Chesapeake Beach, Maryland, are very typical.

The species may be recognized by its long, narrow test with angled chambers that are not arranged in regular series, and its rounded base.

Bulimina elongata D'Orbigny var. tenera Reuss

Plate 25, figure 18

Bulimina tenera Reuss (part), Akad. Wiss. Wien Sitzungsber., vol. 55, pt. 1, p. 94, pl. 4, figs. 11a, b, (not fig. 12), 1867.

Bulimina elegans Macfadyen (not d'Orbigny), Egypt Geol. Survey, 1930, p. 53, pl. 1, fig. 14, 1931.

Bulimina elongata D'Orbigny var. *tenera* Reuss, Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 13, p. 50, pl. 7, fig. 5, 1937.

Bulimina cf. *B. elongata* D'Orbigny var. *tenera* Cushman and Herrick, idem, vol. 21, p. 64, pl. 10, fig. 16, 1945.

Variety differing from the typical form in that the last-formed whorl constitutes a large proportion of the test, usually about two-thirds, in the more pointed apertural end, and broader aperture.

The types are from the Miocene, Wieliczka, Galicia. We have no topotype material, but specimens from the Miocene of the Vienna Basin, Austria, appear to be identical. The variety occurs also in the Eocene of Germany and Hungary, the Miocene of France, Germany, Egypt, and Florida (Choctawhatchee marl) in the United States. Less typical specimens occur in the Eocene McBean formation of Georgia.

This form is apparently a variety of *Bulimina elongata* D'Orbigny. The initial portion of the test is identical with that of the latter, the variation coming only in the last-formed whorl.

Bulimina elongata D'Orbigny var. subulata Cushman and Parker

Plate 26, figures 1, 2

Bulimina elongata D'Orbigny var. *subulata* Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 13, p. 51, pl. 7, figs. 6, 7, 1937.

LeRoy, Colorado School of Mines Quart., vol. 36, no. 1, p. 32, pl. 3, figs. 72, 73, 1941.

Cushman, U. S. Nat. Mus. Bull. 161, p. 11, pl. 3, figs. 13a, b, 1942.

Colom, Inst. Invest. Geol., Num. 3 Estudios Geologicos, p 158, pl. 10, figs. 159, 160, 1946.

Bulimina aff. *elongata* D'Orbigny var. *subulata* LeRoy, Colorado School of Mines Quart., vol. 39, no. 3, p. 84, pl. 2, fig. 4, 1944.

Bulimina aculeata Reuss (not D'Orbigny), Akad. Wiss. Wien Denkschr., vol. 1, p. 374, pl. 47, fig. 13, 1850.

Egger, Naturh. Ver. Passau Jahresber. 16, p. 17, pl. 3, figs 8, 10, 13, 14, 1895.

Macfadyen, Egypt Geol. Survey, 1930, p. 55, pl. 1, fig. 19, 1931.

Hofker (part), Sta. Zool. Napoli Pub., vol. 12, pt. 1, p. 121, figs. 33-35, 1932.

Bulimina spinosa Seguenza, Accad. gioenia sci. nat. Atti, ser. 2, vol. 18, p. 23, pl. 1, figs. 8, 8a, 1862.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 14, p. 62, 1938.

Bulimina ovata Parker and Jones (not D'Orbigny), Philos. Trans., vol. 155, p. 374, pl. 17, figs. 67a, b, 1865.

Bulimina elongata H. B. Brady (not D'Orbigny), *Challenger* Rept., Zoology, vol. 9, p. 401, pl. 51, figs. 1, 2, 1884.

Bulimina elegans Egger (not D'Orbigny), K. bayer. Akad. Wiss. Abh., cl. 2, vol. 18, p. 284, pl. 8, figs. 66, 67, 1893; Naturh. Ver. Passau Jahresber. 16, p. 16, pl. 3, fig. 9, 1895.

Variety differing from the typical form in having well developed spines at the base of the test, varying in length and number. Length of specimens from Baden 0.32 to 0.57 mm., diameter 0.20 to 0.24 mm.

The types of the variety are from the Miocene of Baden, Vienna Basin, Austria. It occurs at various other localities in the Vienna Basin. We have material from the Miocene of Hungary, Germany, France, Italy, and Egypt; from the Pliocene of France and Italy; and from Recent material from the Mediterranean Sea, Ireland, northeast coast of the United States, Juan Fernandez Island, Chile, and the Fiji Islands. LeRoy records it from the late Tertiary of Borneo and Java.

The variety is easily recognized. It differs from *Bulimina gibba* Fornasini in its more parallel-sided test, more irregular chambers, and rounded base.

Bulimina elongata D'Orbigny var. lappa Cushman and Parker

Plate 25, figure 19

Bulimina elongata D'Orbigny var. *lappa* Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 13, p. 51, pl. 7, fig. 8, 1937.

Variety differing from the typical form in having a much shorter, broader test, with thicker walls, the initial portion of the test covered with very short, blunt spines. Length 0.30 to 0.54 mm., diameter 0.20 to 0.28 mm.

This variety was described from the Miocene at Nussdorf, Vienna Basin, Austria. We have material from several localities in the Vienna Basin, from the Miocene of Hungary and Egypt, and from the Pliocene of Italy.

The variety is easily distinguished by its short, broad test and its very short spines, which often appear as a roughening of the lower portion of the test.

Bulimina buccinoides Egger

Plate 26, figure 3

Bulimina buccinoides Egger, Neues Jahrb., 1857, p. 282, pl. 10, figs. 9-11.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 13, p. 52, 1937.

Test ovate, pointed at both ends, middle portion inflated; consisting of 5 whorls, first chambers narrow, arched, later ones very large, long, arched; aperture thin and pointed. Length 0.75 mm.

A summary of Egger's description of the species from the Miocene of Hausbach is given. We have no material referable to it. The original figures are reproduced.

Bulimina tuberculata Egger

Plate 26, figures 4, 5

Bulimina tuberculata Egger, Neues Jahrb., 1857, p. 284, pl. 12, figs. 4-6 (not fig. 7).

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 13, p. 50, pl. 7, figs. 4a-c, 1937.

?Bulimina aff. *B. minuta* Glaessner (not *"Tritaxia minuta* Marsson"), Problems of paleontology, Moscow Univ., vols. 2-3, p. 370, pl. 2, figs. 18a, b, 1937.

Test small, about twice as long as broad, triangular in transverse section with rounded angles, slightly tapering, consisting of about 5 whorls; chambers fairly distinct, arranged in series with the adjacent chambers joined in a zigzag line, later chambers somewhat inflated; sutures distinct, early sutures flush with the surface, later sutures depressed; aperture a broad, loop-shaped opening. Length of specimens from a locality near Ortenburg, Germany, 0.24 to 0.42 mm., diameter 0.12 to 0.20 mm.

The types are from the Miocene at Hausbach, near Ortenburg, Germany. We have specimens from Egger's Miocene localities in Germany; from Kostej, near Banat, Hungary; from two localities in the Miocene of France; and a single specimen from Nussdorf in the Vienna Basin, Austria. The species appears to be confined to the Miocene.

The last figure given by Egger (pl. 12, fig. 7) does not refer to this species but probably to a *Bitubulogenerina* which occurs at the same locality. The species differs from *Bulimina minuta* (Marsson) in being larger, more elongate, less tapered, with more rounded angles and more inflated chambers.

Bulimina bulbiformis Seguenza

Plate 26, figure 6

Bulimina bulbiformis Seguenza, R. accad. Lincei Atti, ser. 3, vol. 6, p. 146, pl. 13, fig. 35, 1880.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 13, p. 52, 1937.

Seguenza describes this species as egg-shaped, rounded at the apertural end, pointed at the initial end, with the sutures very slightly depressed and indistinct.

The types are from the Miocene Tortonian of Calabria, Italy. We have no material referable to it.

Bulimina calcarata Seguenza

Plate 26, figures 7-9

Bulimina calcarata Seguenza, R. accad. Lincei Atti, ser. 3, vol. 6, p. 146, pl. 13, fig. 36, 1880.

Bulimina ovata D'Orbigny var. *apiculata* Egger, Naturh. Ver. Passau Jahresber. 16, p. 17, pl. 3, fig. 15, 1895.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 14, p. 55, pl. 9, fig. 5, 1938.

Test of medium size, somewhat fusiform, short and broad, consisting of about 3 whorls, initial end usually bluntly pointed with 1 or 2 heavy, short spines; chambers distinct, inflated; sutures distinct, depressed; wall smooth, perforate; aperture loop-shaped, with a lip, and well developed tooth. Length of figured specimen 0.60 mm., diameter 0.40 mm.

The species was described from the Miocene Tortonian of Calabria, Italy. We have no topotype material but specimens from several localities in the Miocene of the Vienna Basin, Austria seem typical. Specimens from the Pliocene of Castel Arquato, Italy are more fusiform, with somewhat less inflated chambers, but otherwise appear identical.

The species resembles *Bulimina pupoides* D'Orbigny but has fewer, more inflated chambers and the short, basal spines. The chambers do not slope downward as in *B. pyrula* D'Orbigny, are more inflated, and the spines are heavier than those occasionally seen in the latter species.

Bulimina triquetra Franzenau

Bulimina triquetra Franzenau, Termeszetrajzi Füzetek, vol. 15, p. 139, 1892.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 13, p. 52, 1937.

Franzenau in describing this species from the Miocene of Romhány, Hungary, says that it bears more resem-

blance to the genus *Verneuilina* than *Bulimina*. He describes it as elongate, elliptical, pointed at both ends, sharply three-cornered, with somewhat concave sides; the initial chambers distinct, arranged in 3 rows, the youngest chamber composing the whole top of the test; sutures in the initial portion distinct, depressed, later portion indistinct; aperture elongate, comma-shaped, placed vertically on the last chamber; wall finely perforate.

He compares the species to *Bulimina arcuata* Stache (not D'Orbigny), from the Eocene of Whaingaroa, but says that Stache's form is more textularian in character. *B. arcuata* Stache does not belong to *Bulimina*, and it seems quite possible, from the description, that *B. triquetra* belongs to the genus *Tritaxia* or some related genus. As no figures were given, the point cannot be definitely settled.

Bulimina parvula Franzenau

Bulimina parvula Franzenau, Termeszetrajzi Füzetek, vol. 15, p. 139, 1892.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 13, p. 52, 1937.

This species, from the Miocene of Romhány, Hungary, is described as elongate, fusiform, with the apertural end sharply pointed, the initial end bluntly pointed, consisting of 4 rapidly increasing whorls; chambers inflated, with deep sutures; aperture an arched, elongate opening, at the inner margin of the last chamber, surrounded by a bordering ridge.

No figures are given of this species, and the description is too brief to make a definite identification possible.

Bulimina porrecta Franzenau

Bulimina porrecta Franzenau, Glasnik. hrv. nar. druztva, vol. 7, pt. 6, pl. 5, figs. 1a, b, 1894.

The figures of this species, described from the Miocene, Marcusevec, Croatia, show a form very similar to *Bulimina pupoides* D'Orbigny. Lack of any material referable to it, however, makes a positive identification impossible.

Bulimina cuspidata Franzenau

Bulimina cuspidata Franzenau, Glasnik. hrv. nar. druztva, vol. 7, pt. 6, pl. 5, figs. 2, 3, 1894.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 13, p. 52, 1937.

The figures of this species from the Miocene of Marcusevec, Croatia, show a form with few whorls, globular chambers, and with a sharp, basal spine. We have no material referable to it.

Bulimina affinis D'Orbigny var. tenuissimestriata Schubert

Plate 26, figures 10, 11

Bulimina affinis D'Orbigny var. *tenuissimestriata* Schubert, K.-k. geol. Reichsanstalt Jahrb., vol. 53, p. 416, pl. 19, figs. 5a-c, 1903.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 13, p. 53, 1937.

Schubert differentiates this variety by the fine striations, as well as by the arrangement of the chambers. He states that it bears a greater resemblance to *"Bulimina ovulum"* Reuss, (*Bulimina reussi* Morrow), than to the typical Recent examples of *B. affinis*.

The species is described from the Miocene "Welser Schlier," in a well-boring near Wels, Austria. We have no material referable to it. The original figures are reproduced here.

Bulimina rotula Schubert

Plate 26, figure 12

Bulimina rotula Schubert, K.-k. geol. Reichsanstalt Jahrb., vol. 53, p. 416, pl. 19, figs. 7a, b, 1903.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 13, p. 53, 1937.

Schubert differentiates this species from others by its cylinder-shaped test and compact chambers. He compares it to *Bulimina subornata* H. B. Brady, from which it differs by the shape and position of the aperture and by the costae, which are much finer and cover the whole test. He says that in shape it resembles *"Bulimina puschi"* Reuss (*Arenobulimina puschi* (Reuss)) and *"Bulimina imbricata"* Reuss (*Buliminella imbricata* (Reuss)) but differs in the construction of the chambers.

The species was described from the Miocene "Welser Schlier," in a well-boring near Wels, Austria. We have no specimens referable to it. The original figures are reproduced here.

Bulimina pseudotorta Cushman

Plate 26, figure 13

Bulimina pseudotorta Cushman, Cushman Lab. Foram. Research Contr., vol. 2, p. 55, pl. 7, fig. 3, 1926.

Cushman, Stewart and Stewart, San Diego Soc. Nat. History Trans., vol. 6, p. 66, 1930.

Kleinpell, Miocene stratigraphy of California, p. 258, Tulsa, 1938.

Test of medium size, rapidly tapering from the broadly rounded, or somewhat truncate, apertural end, initial end narrow, rounded; chambers few, slightly inflated, angular in shape; sutures distinct, depressed; wall smooth, finely perforate; aperture elongate, comma-shaped. Length of holotype 0.90 mm., diameter 0.66 mm.

This species was described from the Miocene Monterey shale, sec. 24, T. 28 S., R. 14 E., M.D.M., San Luis Obispo County, California. It is recorded by Cushman, Stewart and Stewart from the Miocene of Humboldt County,

California, and by Kleinpell from the upper Relizian and lower Luisian at various Californian localities.

The species most closely resembles *Bulimina (Desinobulimina) montereyana* Kleinpell but differs from it in being more tapered and in not having the terminal aperture. It seems very probable that it represents the ancestral form of Kleinpell's species.

Bulimina alligata Cushman and Laiming

Plate 26, figure 14

Bulimina inflata Seguenza var. *alligata* Cushman and Laiming, Jour. Paleontology, vol. 5, p. 107, pl. 11, figs. 17a, b, 1931.

Kleinpell, Miocene stratigraphy of California, p. 254, pl. 7, fig. 1, Tulsa, 1938.

Schenck and Childs, Stanford Univ. Publ., Univ. Ser., Geol. Sci., vol. 3, no. 2, p. 26 (list), 1942.

Weaver, Washington Univ. [Seattle] Pub. in Geology, vol. 6, no. 1, p. 23 (list), 1944.

Test about twice as long as broad, tapering, consisting of about 6 whorls; chambers indistinct, later chambers slightly inflated, sutures indistinct in early portion of the test, depressed in later portion; wall of most of last whorl smooth, remainder of test ornamented by low costae arranged in straight lines but broken at the sutures, with occasional shorter costae interpolated; aperture loop-shaped, with the base practically at the junction of the second and third chambers. Length 0.60 mm., diameter 0.35 mm.

The types are from the Miocene of Los Sauces Creek, Ventura County, California. Kleinpell records the species from the upper and lower Saucesian and questionably from the upper Luisian of California. It occurs in the Pliocene, above the base of the first Pico sandstone, Cañada de Aliso, Ventura County, California: at 210 and 260 feet stratigraphically above the base, 2$\frac{3}{10}$ miles N. 75° E. of La Crosse Junction; and at 3140 feet stratigraphically above the base, 2$\frac{2}{5}$ miles S. 88° E. of La Crosse Junction. It has also been recorded from the Miocene Gallaway formation and the Oligocene Sandholdt formation of California.

This form has been given specific rank, as it does not seem to be varietally related to *Bulimina inflata* Seguenza. The chambers are arranged in more regular series and are more rounded and inflated, the costae are arranged in more definite longitudinal lines and are very definitely broken at the sutures. The costae are more definite and regular than in *B. rinconensis* Cushman and Laiming, the test is less fusiform, and the aperture is placed lower.

Bulimina rinconensis Cushman and Laiming

Plate 26, figure 15

Bulimina rinconensis Cushman and Laiming, Jour. Paleontology, vol. 5, p. 107, pl. 11, figs. 18a, b, 1931.

Kleinpell, Miocene stratigraphy of California, p. 258, Tulsa, 1938.

Renz, 8th Am. Sci. Congress Proc., p. 556 (list), 1942.

Weaver, Washington Univ. [Seattle] Pub. in Geology, vol. 6, no. 1, p. 23 (list), 1944.

Bulimina cf. *B. rinconensis* Cushman and Hobson, Cushman Lab. Foram. Research Contr., vol. 11, p. 62, pl. 9, figs. 4a, b, 1935.

Test about twice as long as broad, with the greatest breadth toward the apertural end, somewhat fusiform, consisting of 5 or 6 whorls; chambers fairly distinct except in early portion of the test, arranged in regular series, inflated, somewhat angular; sutures distinct, depressed; wall ornamented by bluntly pointed, low, broad, rounded costae, at the base of the chambers in the last-formed whorls and across the whole chamber in the earlier ones; aperture fairly long, loop-shaped, placed at the apex of the test, well above the junction of the second and third chambers. Length 0.50 mm., diameter 0.25 mm.

The types are from the Miocene on Los Sauces Creek, Ventura County, California. The species occurs in the Oligocene(?) San Lorenzo formation of California. Kleinpell records it from the Miocene, lower Saucesian and upper and lower Zemorrian, of California. In the Pliocene it is found at several localities above the base of the first Pico sandstone in Cañada de Aliso, Ventura County, California: at 260 feet stratigraphically above the base in brown siltstone, 2$\frac{3}{10}$ miles N. 75° E. of La Crosse Junction; at 3140 feet stratigraphically above the base in gray siltstone, 2$\frac{2}{5}$ miles S. 88° E. of La Crosse Junction; and at 8240 feet stratigraphically above the base in a shaly parting of a conglomerate member, 2$\frac{3}{4}$ miles S. 72° E. of La Crosse Junction. It occurs also in the Pliocene on the west side of Atlantic Blvd., 1275 feet N. 13° E. of northwestern corner of intersection of Harding Ave., Los Angeles, California. The species has been recorded, but without figures, from the Oligocene of Trinidad and Costa Rica, and from the Miocene of Trinidad.

The species differs from *Bulimina alligata* Cushman and Laiming in the more fusiform test, in the placing of the aperture nearer the apex of the test, and in the less regular, bluntly pointed costae. The costae are more rounded than in *Bulimina subacuminata* Cushman and R. E. Stewart, and it lacks an initial spine.

Bulimina delreyensis Cushman and Galliher

Plate 26, figure 16

Bulimina delreyensis Cushman and Galliher, Cushman Lab. Foram. Research Contr., vol. 10, p. 25, pl. 4, figs. 8a, b, 1934.

Bulimina buchiana Cushman and Ponton (not D'Orbigny), Florida Geol. Survey Bull. 9, p. 78, pl. 12, figs. 1a, b, 1932.

Test about twice as long as broad, tapering from the subacute initial end to the greatest breadth at the last whorl, rounded in transverse section; chambers distinct, slightly inflated, increasing uniformly in size as added;

sutures distinct, very slightly depressed; wall ornamented with a few, distinct, longitudinal costae, independent of the chambers, with secondary costae coming in between the primary costae as growth progresses, the uppermost part of the last 2 chambers smooth; aperture very narrow, elongate, on the somewhat flattened apex of the test. Length 1.00 mm., diameter 0.50 mm.

The species was described from the Miocene Monterey shale in the diatomite quarry, 4 miles east of Del Monte, south side of Canyon Del Rey, California.

The form from the *Yoldia* zone of the Choctawhatchee formation of Florida, described by Cushman and Ponton as *Bulimina buchiana* D'Orbigny is very close to this species except that the test is somewhat more ovate.

The species somewhat resembles *Bulimina buchiana* D'Orbigny but differs from it in having fewer, more regular costae that extend well up onto the chambers of the last whorl, in having the chambers of the last whorl forming a much smaller proportion of the whole test, and in the flattened character of the apex of the test, which in *B. buchiana* is somewhat ovate.

Bulimina carnerosensis Cushman and Kleinpell

Plate 26, figure 17

Bulimina carnerosensis Cushman and Kleinpell, Cushman Lab. Foram. Research Contr., vol. 10, p. 5, pl. 1, figs. 12a, b, 1934.

Kleinpell, Miocene stratigraphy of California, p. 252, Tulsa, 1938.

Weaver, Washington Univ. [Seattle] Pub. in Geology, vol. 6, p. 23 (list), 1944.

Test short, ovate, somewhat compressed, periphery slightly lobulate, greatest breadth toward the apertural end; chambers fairly distinct, somewhat inflated, increasing in height as added; sutures fairly distinct, somewhat depressed, very slightly oblique, becoming nearly horizontal in the last-formed portion; wall ornamented by low, longitudinal, regular costae independent of the individual chambers, lapping over the outer end of the last 2 chambers; aperture elongate, nearly straight, running well into the terminal face. Length 0.40 mm., diameter 0.20 mm.

The species was described from the Miocene on Carneros Creek, California, 295 feet stratigraphically above the base of the Temblor formation. Kleinpell records it from the upper and lower Zemorrian of California and Weaver from Gallaway formation, near Point Arena, California.

This species is, in some ways, similar to *Bulimina buchiana* D'Orbigny but differs from it in having fewer, heavier costae that are continuous almost to the top of the last-formed whorl. It also resembles *Bulimina delreyensis* Cushman and Galliher, differing from it in being much smaller and in having a more ovate test.

Bulimina carnerosensis Cushman and Kleinpell var. mahoneyi Cushman and Kleinpell

Plate 26, figure 18

Bulimina carnerosensis Cushman and Kleinpell var. *mahoneyi* Cushman and Kleinpell, Cushman Lab. Foram. Research Contr., vol. 10, p. 5, pl. 1, figs. 13a, b, 1934.

The variety differs from the typical form in its larger size, greater length in proportion to its width, and in the sutures, which become more oblique in the later portion of the test.

This variety was described from the Miocene on Carneros Creek, California, 310 feet stratigraphically above the base of the Temblor formation. It occurs 15 feet above the typical form and evidently represents a development from it.

Bulimina uvigerinaformis Cushman and Kleinpell

Plate 26, figure 19

Bulimina uvigerinaformis Cushman and Kleinpell, Cushman Lab. Foram. Research Contr., vol. 10, p. 5, pl. 1, figs. 14a, b, 1934.

?Kleinpell, Miocene stratigraphy of California, p. 261, Tulsa, 1938.

Test fusiform, greatest breadth near the middle, rounded in transverse section, periphery somewhat lobulate; chambers numerous, distinct, inflated, later chambers globular; sutures distinct, depressed; wall ornamented by longitudinal costae, more or less independent on each chamber, somewhat broken at the sutures; aperture in the adult elongate, somewhat curved, with a slight lip, sometimes terminal, not reaching to the base of the chamber. Length 1.10 mm., diameter 0.45 mm.

The types are from the Miocene, 335 feet stratigraphically above the top of a prominent chert bed, 10 feet thick, exposed at base of ocean bluffs, immediately east of mouth of Dos Pueblos Creek, west of Naples, California. Kleinpell records somewhat similar specimens, having continuous, more numerous costae, from the Monterey shale near El Toro, California.

This species represents an intermediate form between the genus *Uvigerina* and *Bulimina*. In many respects it more closely approaches the former in the shape and arrangement of the chambers and the presence of a terminal aperture. The aperture, however, has no neck, and is elongate and slit-like in shape. This uvigerine character makes it easily separable from other known species.

Bulimina pseudoaffinis Kleinpell

Plate 26, figure 20

Bulimina pseudoaffinis Kleinpell, Miocene stratigraphy of California, p. 257, pl. 9, fig. 9, Tulsa, 1938.

Weaver, Washington Univ. [Seattle] Pub. in Geology, vol. 6, p. 23 (list), 1944.

Test of medium size, somewhat tapering, with the broadest portion just above the middle, periphery slightly lobulate; consisting of about 3 whorls, the last-formed whorl forming as much as four-fifths of the test; chambers distinct, inflated; sutures distinct, depressed; wall smooth, finely perforate; aperture elongate, comma-shaped. Length of holotype 0.64 mm., diameter 0.40 mm.

The species was described from the Miocene, lower Relizian, Reliz Canyon, Monterey County, California (sample C.4, Leland Stanford Junior Univ. loc. 691). Kleinpell also records it from the upper Saucesian, lower and upper Relizian of Reliz Canyon. A study of the plesiotypes of two forms recorded as *Bulimina ovula* D'Orbigny shows specimens closely related to Kleinpell's species except that they have more tapered tests. They were found in the Monterey shale, San Luis Obispo County, (Cushman, Cushman Lab. Foram. Research Contr., vol. 2, p. 55, pl. 7, fig. 2, 1926) and the Vaqueros formation of Simi Valley, California (Cushman and LeRoy, Jour. Paleontology, vol. 12, p. 125, pl. 22, fig. 18, 1938). Weaver records it from the Point Arena formation of California.

This form is less tapered, with more rounded chambers than *Bulimina pseudotorta* Cushman. It is much smaller and has more inflated chambers than *B. affinis* D'Orbigny. It is more tapering, with a more flattened apertural end than *B. pupoides* D'Orbigny. Kleinpell relates it to *B. ovula* D'Orbigny, but the latter species is broadly ovate, very involute, and has a well-developed tooth.

Bulimina delmonteensis Kleinpell

Plate 26, figure 21

Bulimina montereyana Kleinpell var. *delmonteensis* Kleinpell, Miocene stratigraphy of California, p. 255, pl. 16, fig. 9, Tulsa, 1938.

Test of medium size, rapidly tapering, somewhat ovate with the broadest portion about one-third of the distance from the apertural end, consisting of 2 to 3 whorls; chambers distinct, those of last-formed whorl slightly inflated; sutures distinct, very slightly depressed; aperture loop-shaped, very slightly curved, placed at the apex of the test, with a slight tooth. Length of holotype 0.58 mm., diameter 0.38 mm.

The types are from the Miocene, lower Delmontian, Reliz Canyon (Leland Stanford Junior Univ. loc. 691), California. The species has been recorded by Kleinpell from the Miocene, ranging from the upper Luisian to the lower Delmontian of California. Our material is from the Miocene Tice shale of Contra Costa County, California, at which locality Kleinpell records the species in abundance.

This species seems to have more than a varietal difference from *Bulimina* (*Desinobulimina*) *montereyana* Kleinpell. It shows no sign of having a terminal aperture, has less inflated, somewhat differently shaped chambers, is more tapered, and the apertural end is not truncate. It differs from *B. pseudotorta* Cushman in being much shorter, more ovate, and in having less inflated, less angled chambers.

Bulimina ovula D'Orbigny var. pedroana Kleinpell

Plate 26, figure 22

Bulimina ovula D'Orbigny var. *pedroana* Kleinpell, Miocene stratigraphy of California, p. 257, pl. 22, fig. 13, Tulsa, 1938.

Variety differing from the typical form in the more tapering, less fusiform test, which has more whorls and a broader base, and in the more inflated chambers and depressed sutures. Length 0.70 mm., diameter 0.56 mm.

The types are from the Miocene, lower Delmontian, Malaga mudstone of San Pedro, California.

This variety is much less involute than the typical form. The chambers are more inflated and increase much less rapidly in height as added than those of "*Bulimina ovula* Cushman and Moyer" from the Recent of San Pedro, California (referred by us to *B. affinis* D'Orbigny), a form which Kleinpell says is close to his variety.

Bulimina microlongistriata, LeRoy

Plate 30, figure 14

Bulimina microlongistriata LeRoy, Colorado School of Mines Quart., vol. 36, no. 1, p. 32, pl. 1, figs. 97, 98, 1941.

Glaessner, Royal Soc. Victoria Proc., vol. 55 (n. ser.), pt. 1, p. 68 (list), 1943.

LeRoy, Colorado School of Mines Quart., vol. 39, no. 3, p. 26, pl. 1, fig. 2; pl. 5, fig. 11; p. 84, pl. 2, fig. 3, 1944.

Test medium, about twice as long as broad, widest in upper two-thirds, tapers rather gradually; chambers distinct, slightly inflated toward apertural end; sutures distinct, slightly depressed; wall transparent, covered with very minute longitudinal striae the entire length of test, although on some specimens the last chamber is smooth; aperture a narrow loop. Length 0.68 mm., height 0.38 mm.

In general characteristics and outline this species appears to be closely related to *Bulimina subornata* Brady but differs from it primarily in that it lacks the basal spine.—LeRoy.

This species was described from the late Tertiary (uppermost Miocene or early Pliocene) of the Sangkoelirang Bay area on the east coast of Borneo. It has been recorded from the Miocene of central Sumatra and west Java.

Bulimina echinata D'Orbigny

Plate 26, figures 23, 24

Bulimina echinata D'Orbigny, Annales sci. nat., vol. 7, p. 269, no. 5, 1826.

Fornasini, Soc. geol. italiana Boll., vol. 20, p. 176, text fig. 2, 1901; Accad. sci. Ist. Bologna Mem., ser. 5, vol. 9, p. 379, pl. 0, fig. 38, 1901.

Heron-Allen and Earland, Linnean Soc. London Trans., vol. 2, ser. 2, p. 235, pl. 41, fig. 3, 1916.

Cushman, U. S. Nat. Mus. Bull. 104, pt. 3, p. 99, pl. 15, fig. 6, 1922.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 14, p. 54, pl. 9, figs. 3, 4, 1938.

Parr, Min. and Geol. Jour., vol. 1, no. 4, p. 67, pl., fig. 7, 1939.

Test medium in size, elongate, with almost parallel sides in the megalospheric form, shorter and much more tapering in the microspheric, consisting of 4 to 5 whorls; chambers distinct, inflated; sutures distinct, depressed; wall of upper part of test smooth, finely perforate, lower part covered with short, very fine, sharp spines which occasionally extend up to cover all the test except for the upper part of the last-formed whorl, with occasional shaped, with a well defined lip. Length 0.45 to 0.60 mm., longer spines at the initial end; aperture broad, loop-diameter 0.25 to 0.30 mm.

The types are from the Pliocene near Siena, Italy. The species occurs in the Miocene of San Rufillo, near Bologna, Italy; from several localities in the Pliocene of Italy; from the Pliocene of Garrobo, southern Spain, and the Pliocene of Victoria, Australia. It is found in the present ocean off Rimini, Italy, and has been recorded from off the west coast of Scotland.

This species resembles *Bulimina elongata* D'Orbigny var. *lappa* Cushman and Parker but is more tapering, has more depressed sutures, and sharper spines, which usually cover a greater part of the test. It is closely related to the *B. elongata* group but is much more spinose in character and has more deeply depressed sutures.

Bulimina costata D'Orbigny

Plate 27, figures 2, 3

Bulimina costata D'Orbigny, Annales sci. nat., vol. 7, p. 269, no. 1, 1826.

Fornasini, Soc. geol. italiana Boll., vol. 20, p. 174, fig. 1, 1901.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 14, p. 54, pl. 9, figs. 1, 2, 1938.

?Bulimina buchiana Egger (not D'Orbigny), Naturh. Ver. Passau Jahresber. 16, p. 18, pl. 4, figs. 9, 10 (fig. 11?), 1895.

Bulimina inflata H. B. Brady (not Seguenza) (part), *Challenger* Rept., Zoology, vol. 9, p. 406, pl. 51, figs. 11, 13 (not figs. 10, 12), 1884.

Macfadyen, Egypt Geol. Survey, 1930, p. 55, pl. 1, fig. 20, 1931.

Test small, about twice as long as broad, microspheric form gradually tapering, megalospheric with the widest portion about halfway up the test, consisting of about 5 whorls in the adult form; chambers fairly distinct, especially in the last-formed whorls, somewhat undercut; sutures distinct, depressed; wall of upper part of last whorl smooth, otherwise ornamented with longitudinal costae, usually broken at the sutures with a sharp point, occasionally crossing the sutures, perforate; aperture loop-shaped, narrow, with a distinct lip. Length 0.40 to 0.50 mm., diameter 0.22 to 0.28 mm.

The types of the species are from the Pliocene of Coroncina, Italy. It occurs in the Miocene of Hungary, the Vienna Basin, Italy, and Egypt, with similar specimens in the Miocene of Venezuela; in the Pliocene of Italy, France, and Sicily; in the Pleistocene of Malaga, Spain; and in Recent material from Rimini, Italy, and near Ireland.

This species is smaller than *Bulimina buchiana* D'Orbigny and has more irregular, broken costae, which make what D'Orbigny calls a "keeled" effect at the suture. It is more definitely costate than *B. alsatica* Cushman and Parker. The species is very variable and it is sometimes difficult to separate the non-typical specimens of these three species.

Bulimina acanthia Costa

Plate 26, figures 25-27; plate 27, figure 1

Bulimina acanthia Costa, Accad. pontaniana Atti, vol. 8, pt. 2, p. 335, pl. 13, figs. 35, 36, 1856.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 14, p. 61, 1938.

Bulimina etnea Seguenza, Accad. gioenia sci. nat. Atti, ser. 2, vol. 18, p. 24, pl. 1, fig. 9, 1862.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 14, p. 59, pl. 10, figs. 6-9, 1938.

Bulimina marginata Terrigi (not D'Orbigny), Pont. accad. sci. Nuovi Lincei Atti, vol. 33, p. 72, pl. 2, figs. 35, 36, 1880.

Test of medium size, tapering, usually terminated by a small spine or spines, about twice as long as broad, consisting of 4 to 7 whorls; chambers distinct, those of last whorl inflated, in the adult forms with a distinct overhang in the last 1 or 2 whorls in the microspheric form, and sometimes throughout the test in the megalospheric; sutures distinct, depressed; wall smooth, polished, finely perforate, the overhanging chambers having a very slight scalloping along the edge with occasional small spines; aperture a broad, loop-shaped opening, with a distinct lip. Length up to 0.65 mm., diameter up to 0.30 mm.

The types are from the Pliocene of Lequile and Notaresco, Italy. The species occurs at several localities in the Pliocene of Italy and Sicily. The species described as *Bulimina pulchella* by Cushman and Moyer (not D'Orbigny) (Cushman Lab. Foram. Research Contr., vol. 6, p. 56, pl. 7, fig. 19, 1930) from the Recent off San Pedro, California is very close to this form.

This species resembles *Bulimina marginata* D'Orbigny but even the most advanced megalospheric specimens do not show the uniform undercutting of the chambers seen in that species. The chambers are more undercut

than in *B. gibba* Fornasini, and the basal portion of the test is not angled. The species is very variable. Several figures are given in an attempt to show some of the variations.

Bulimina pustulosa Costa

Plate 27, figure 5

Bulimina pustulosa Costa, Accad. pontaniana Atti, vol. 8, pt. 2, p. 268, pl. 15, fig. 8 (incorrectly referred to figs. 6, 7, in text), 1856.

Costa describes this species as ovately conical, more or less elongate, initial end acute, apertural end obtuse, rounded; 5 to 9 chambers, large, inflated, subglobular; wall finely papillate. Length 0.70 mm.

The types are from the Pliocene, near Naples, Italy. The figure and description suggest *Dorothia globosa* (D'Orbigny).

Bulimina pedunculata Costa

Plate 27, figure 6

Bulimina pedunculata Costa, Accad. pontaniana Atti, vol. 8, pt. 2, p. 336, pl. 18, fig. 13 (incorrectly referred to fig. 16, in text), 1856.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 14, p. 62, 1938.

Test oval, pointed at the bottom, initial end obtuse; 4 or 5 chambers, the first two separated by a transverse suture, later ones large, involute, the last prolonged into a sort of peduncle, at the end of which is the slit-like aperture. Length 1.00 mm.

A summary of Costa's description of the species from the Pliocene of Cannitello near Naples, Italy, is given. It is doubtful if it belongs in *Bulimina*.

Bulimina peucetia Costa

Plate 27, figure 4

Bulimina peucetia Costa, Accad. pontaniana Atti, vol. 8, pt. 2, p. 338, pl. 18, fig. 15 (*peucetiae affinis* in expl.), 1856.

Bulimina "peucetiae affinis" Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 14, p. 62, 1938.

Test subovate, somewhat pointed at the initial end, apertural end obtuse or almost truncate; composed of 7 or 8 chambers, inflated, almost biserial but slightly coiled, distinct with deep sutures, last chamber almost covering the two preceding ones; aperture elongate. Length 1.00 mm.

This species was described from the Pliocene of Bari, near Naples, Italy. It is doubtful whether it belongs in *Bulimina*. A summary of Costa's description is given.

Bulimina subcalva Cushman and K. C. Stewart

Plate 27, figure 7

Bulimina subcalva Cushman and K. C. Stewart, in Cushman, Stewart and Stewart, San Diego Soc. Nat. History Trans., vol. 6, p. 65, pl. 4, figs. 11a, b, 1930.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 14, p. 55, pl. 9, figs. 8a-c, 1938.

Test slightly longer than broad, rapidly tapering from the greatest width near the apertural end to the acute initial end, with a distinct, basal spine, consisting usually of 4 or 5 whorls; chambers distinct, somewhat inflated, those of successive whorls alined in series; sutures distinct, depressed; wall of the chambers ornamented by distinct, somewhat plate-like costae that do not cross the sutures and are terminated by slightly spinose projections, upper part of last whorl smooth, finely perforate; aperture elongate, loop-shaped, placed above the junction of the second and third chambers, with a slight lip. Length of holotype 0.53 mm., diameter 0.35 mm.

The types are from the Pliocene of Scotia Bluffs, about 160 yards southward from north line of SE ¼ sec. 5, T. 1 N., R. 1 E., H. M., Humbolt County, California. The species occurs also in the Pliocene of Lomita Quarry, Palos Verdes Hills, California.

The species differs from *Bulimina subacuminata* Cushman and R. E. Stewart in being typically less fusiform, and in having the costae less pronounced and with somewhat spinose projections. It differs from *B. alligata* Cushman and Laiming in having the spinose projections and a basal spine.

Bulimina subacuminata Cushman and R. E. Stewart

Plate 27, figure 8

Bulimina subacuminata Cushman and R. E. Stewart, in Cushman, Stewart and Stewart, San Diego Soc. Nat. History Trans., vol. 6, p. 65, pl. 5, figs. 2, 3a, b, 1930.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 14, p. 56, pl. 9, fig. 9, 1938.

Hanna and Hertlein, State of Calif., Div. of Mines, Bull. 118, p. 180, fig. 67 [plate], fig. 39, 1941.

Test about twice as long as broad, somewhat fusiform, tapering from the broadest portion near the base of the last-formed whorl, with a well developed basal spine, consisting of 6 whorls in the adult; chambers fairly distinct, those of last whorl slightly inflated; sutures fairly distinct, depressed; wall perforate, upper part of last-formed whorl smooth, remainder of test ornamented by thin, high, plate-like costae, usually broken at the sutures but occasionally continuous across them, the lower end of the costae often angled; aperture loop-shaped, placed well above the junction of the second and third chambers. Length 0.50 mm., diameter 0.28 mm.

The types are from the Pliocene on Bear River, NE ¼ sec. 20, T. 1 N., R. 2 W., H. M., Humboldt County, Calif. Similar, though more tapered, specimens were found at 1,030 feet and 1,175 feet stratigraphically above the base of the first Pico sandstone, in brown sandy shale near the base of a conglomerate member, and in gray siltstone respectively, 2⅖ miles N. 77° E. of La Crosse Junction, Cañada de Aliso, Ventura County, California.

The species differs from *Bulimina rinconensis* Cushman and Laiming in the thinner, higher costae and in having a basal spine.

Bulimina pagoda Cushman var. hebespinata R. E. and K. C. Stewart

Plate 27, figures 9, 10

Bulimina pagoda Cushman var. *hebespinata* R. E. and K. C. Stewart, Jour. Paleontology, vol. 4, p. 63, pl. 8, figs. 3a, b, 1930.
Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 14, p. 55, pl. 9, figs. 6, 7, 1938.

Variety differing from the typical form in having much heavier, blunter spines that are the continuation of rather indistinct, short costae and that do not project as far as those of the typical form. Length of holotype 0.40 mm., diameter 0.30 mm.

The types are from the Pliocene, lower part of Pico formation, at a drilling depth of 5,348 feet in the Miley H. & H. no. 1 well of the Richfield Oil Company of California, Rincon Oil Field, sec. 17, T. 3 N., R. 24 W., S. B. M., Ventura County, Calif. The variety occurs also 5,175 feet above the base of the first Pico sandstone, Cañada de Aliso, Ventura County, California, and at the south side of Garvey Blvd., 100 yards west of intersection with Atlantic Blvd., Repetto Hills, Los Angeles, California.

It differs from *Bulimina rinconensis* Cushman and Laiming in having a more tapered test and projecting spines.

Bulimina fossa Cushman and Parker

Plate 27, figure 11

Bulimina fossa Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 14, p. 56, pl. 9, fig. 10, 1938.

Test nearly twice as long as broad, tapering from the greatest breadth at the last-formed whorl to the subacute initial end, apertural end broadly rounded, consisting of 6 or more whorls; chambers slightly inflated, increasing very gradually and rather regularly in size; sutures distinct, only slightly depressed; wall with distinct, longitudinal costae which are only slightly raised, continuous across the sutures from the base to the lower part of the last-formed whorl, divided as growth proceeds; aperture loop-shaped, with a distinct, raised lip. Length of holotype 0.30 mm., diameter 0.18 mm.

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The types are from the Pliocene, in brown siltstone, 210 feet stratigraphically above the base of the first Pico sandstone, Cañada de Aliso, 2.3 miles N. 75° E. of La Crosse Junction, Ventura County, California. It is not known elsewhere.

The species is more elongate and has finer, more numerous costae than *Bulimina alazanensis* Cushman. The chambers are more inflated and the costae are lower than in *B. truncana* Gümbel, and the test is narrower in proportion to the length.

Bulimina marginospinata Cushman and Parker

Plate 27, figure 12

Bulimina marginospinata Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 14, p. 57, pl. 9, fig. 11, 1938

Test fusiform, greatest breadth somewhat below the middle, nearly twice as long as broad, initial end acute, consisting of about 5 whorls in the adult; chambers distinct, somewhat inflated, the last 3 in the adult making up much the larger part of the test, increasing rapidly in size as added, greatly overlapping; sutures distinct, only slightly depressed; wall mostly smooth, finely perforate, with a small number of short spines at the basal margin of the chambers; aperture elongate, with a distinct, raised lip. Length 0.40 to 0.45 mm., diameter 0.25 to 0.28 mm.

The types are from the Pliocene, first gully north of Lomita Quarry, Palos Verdes Hills, Los Angeles County, California. It is found also in the Pliocene of the Repetto Hills, Los Angeles County, California.

This species has more chambers than *Bulimina pyrula* D'Orbigny, and a more tapered test with shorter, broader chambers than *B. ovata* D'Orbigny.

Bulimina denudata Cushman and Parker

Plate 27, figures 13, 14

Bulimina pagoda Cushman var. *denudata* Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 14, p. 57, pl. 10, figs. 1a-c, 2a-c, 1938.
Bulimina marginata Galloway and Wissler (not D'Orbigny), Jour. Paleontology, vol. 1, p. 73, pl. 11, fig. 17, 1927.
Bulimina pulchella Cushman (not D'Orbigny), Scripps Inst. Oceanography Bull., Tech. ser., vol. 1, p. 152, pl. 2, fig. 13, 1927.

Test 2 or more times as long as broad, fusiform in the megalospheric form, tapering from the broadest part near the apex of the test in the microspheric, initial end sometimes with a small basal spine, consisting of as many as 7 whorls; chambers distinct, early chambers not inflated, later chambers inflated, undercut at the margins, not increasing very much in height as added so the last whorl is shallow and often projecting; sutures distinct, flush with the surface in the initial portion, later portion depressed; wall of the margin of the undercut chambers very slightly

and irregularly toothed, remainder smooth, finely perforate; aperture loop-shaped, at apex of test. Length 0.32 to 0.57 mm., diameter 0.12 to 0.27 mm.

The types are from the Pliocene of Cañada Seca, 2,300 feet stratigraphically above the base of a bluish-gray shale, 3.6 miles S. 50° E. of La Crosse Junction, Ventura County, California. The species is found also in the Pliocene of Cañada de Aliso, Ventura County, California, 2.4 miles S. 88° E. of La Crosse Junction, in gray siltstone 3,200 feet stratigraphically above the base of the first Pico sandstone, and 2.4 miles N. 77° E. of La Crosse Junction in brown sandy shale, near base of a conglomerate member, 1,030 feet stratigraphically above base of the first Pico sandstone. It occurs in the Pliocene of San Pedro, California and in the Pleistocene of Lomita Quarry, Palos Verdes Hills, 2 miles south of Lomita, Los Angeles County, California. It is found in Recent material 1½ miles south of Scripps Institution Pier, La Jolla, California, at a depth of 9 feet.

This species was originally described as a variety of *Bulimina pagoda* Cushman. There seems, however, to be a specific difference between the two forms. In *B. denudata* the margins of the chambers are undercut sharply so that the chambers overhang, in *B. pagoda* the chambers are undercut so they project but do not overhang the preceding ones. The latter is much shorter in proportion to its length and tapers more rapidly.

Bulimina denudata has many of the characteristics of *B. marginata* D'Orbigny but differs from it in the much shallower character of the last whorl, which projects more and gives a pagoda-like effect, in the lack of undercutting of the early chambers, and in the less regularly toothed margin of the chambers.

Bulimina denudata Cushman and Parker var. deformata Cushman and Parker

Plate 27, figure 15

Bulimina pagoda Cushman var. *deformata* Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 14, p. 58, pl. 10, figs. 3a-c, 1938.

Bulimina pagoda Cushman, Stewart and Stewart (not Cushman), San Diego Soc. Nat. History Trans., vol. 6; p. 66, pl. 5, figs. 6a-c, 1930.

Variety differing from the typical form in the chambers, which are undercut almost throughout the test, have a more crenulated margin with occasional spines, are more projecting, and sometimes somewhat twisted.

The types are from the Pliocene of Charley Hill Gulch (Branch of Ryan's Slough), center of W½ sec. 5, T. 4 N., R. 1 E., H. M., Humboldt County, California. The variety is not known elsewhere.

This variety differs from *Bulimina marginata* D'Orbigny in the shallow character of the last-formed whorls and having more projecting chambers.

Bulimina inflata Seguenza

Plate 27, figures 16, 17

Bulimina inflata Seguenza, Accad. gioenia sci. nat. Atti, ser. 2, vol. 18, p. 25, pl. 1, fig. 10, 1862.

?Brady, Parker, and Jones, Zool. Soc. London Trans., vol. 12, p. 220, pl. 43, fig. 9, 1888.

Silvestri, Accad. sci. Acireale Atti e Rend., vol 5, p. 12, pl. 5, figs. 68, 69, 1893.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 14, p. 58, pl. 10, figs. 4, 5, 1938.

Phleger, Geol. Soc. America Bull., vol. 50, p. 1422, pl. 3, fig. 25, 1939.

Cushman and Henbest, U. S. Geol. Survey Prof. Paper 196-A, pl. 9, fig. 18, 1940.

Valk, in Rutten and Hotz, Geol. Petr. and Pal. Results of Explorations in the island of Ceram, 3d ser., Geol., no. 1, p. 23, 1945.

Bulimina inflata Seguenza var. Schwager, Com. geol. italiana, Boll., vol. 9, p. 529, pl. 1, fig. 19, 1878.

Test of medium size, widest near top, about 1½ times as long as broad, consisting of 4 to 5 whorls, the last-formed whorl forming at least one-third of the test; chambers fairly distinct, those of last whorl inflated; sutures distinct in upper portion of test, somewhat depressed; wall of uppermost part of last-formed chamber smooth, otherwise costate, with numerous plate-like costae which are sometimes broken at the sutures but are often continuous across them, coarsely perforate; aperture loop-shaped, with a distinct lip, either at, or just above, the junction of the second and third chambers. Length 0.45 to 0.55 mm., diameter 0.30 to 0.40 mm.

The types are from the Pleistocene of Catania, Sicily. We have material from the Pliocene of Calabria, Messina, and the clay pit behind the Vatican, Rome, Italy; and from Garrobo, Spain. In the Miocene the species occurs at Niederlies, Austria; on the sea coast near Manta, Ecuador; and in Venezuela. In the Recent seas it occurs at Rimini, Italy, and near Ireland. It has been recorded from the Abrohlos Bank, Brazil, by Brady, Parker and Jones, but this record is subject to question, and it is possible that their form represents *Bulimina striata* D'Orbigny var. *mexicana* Cushman. It is also recorded from deep sea cores in the North Atlantic.

This species differs from *Bulimina buchiana* D'Orbigny and *B. costata* D'Orbigny in its test, which is rapidly tapering instead of fusiform and in the much larger proportion of the test occupied by the last-formed whorl. It differs from *B. striata* D'Orbigny in the lack of a basal spine, in the much less marked break in the costae at the sutures, and in the resulting lack of the effect of marginal overhang of the chambers.

There are numerous other records for this species but the figures given show that the specimens must be restudied before they can be placed with certainty.

Bulimina striata D'Orbigny

Plate 28, figures 1-3

Bulimina striata D'Orbigny, Annales sci. nat., vol. 7, p. 269, no. 2, 1826.

Guérin-Ménéville's Cuvier, Iconographie, Mollusques, p. 9, pl. 2, fig. 16, 1829-1843.

Fornasini, Accad. sci. Ist. Bologna Mem., ser. 5, vol. 9, p. 371, fig. 1, 1901.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 14, p. 90, pl. 16, figs. 1-3, 1938.

LeRoy, Colorado School of Mines Quart., vol. 39, no. 3, p. 26, pl. 1, fig. 5, 1944.

Bulimina inflata Flint (not Seguenza) (part), U. S. Nat. Mus. Rept., 1897, p. 291, pl. 37, fig. 5, 1899.

Test medium in size, composed of about 5 whorls, tapering from the widest portion near the top of the last-formed whorl, with a short, stout basal spine; chambers distinct, especially in the last-formed whorl, increasing regularly in size as added, those of each whorl slightly overhanging the previous ones, slightly inflated; sutures distinct in the last whorl, slightly depressed; wall ornamented with heavy, low longitudinal costae that extend up almost to the top of the last-formed whorl and that are broken at the sutures; aperture elongate, loop-shaped, at the junction of the second and third chambers. Length 0.40 to 0.65 mm., diameter 0.30 to 0.50 mm.

The types are from Recent material from Rimini, Italy. The species occurs also in the western Atlantic south of Cape Cod. Le Roy has referred specimens from the Miocene of Sumatra to this species.

This species differs from *Bulimina inflata* Seguenza in having the costae cut off at the sutures and in the presence of a basal spine.

Bulimina striata D'Orbigny var. mexicana Cushman

Plate 28, figure 4

Bulimina inflata Seguenza var. *mexicana* Cushman, U. S. Nat. Mus. Bull. 104, pt. 3, p. 95, pl. 21, fig. 2, 1922.

Bulimina inflata Flint (not Seguenza) (part), U. S. Nat. Mus. Rept., 1897, p. 291, pl. 37, fig. 5, 1899.

Cushman and Jarvis, Jour. Paleontology, vol. 4, p. 362, pl. 33, fig. 5, 1930.

Bulimina striata D'Orbigny var. *mexicana* Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 16, p. 16, pl. 3, fig. 9, 1940.

Cushman and Todd, idem, Special Pub. 15, p. 40, pl. 6, fig. 10, 1945.

Variety differing from the typical form in having the costae terminated by short, sharp spines.

The types are from Recent material, *Albatross* sta. 2377, in 210 fathoms, Lat. 29° 07′ 30″ N., Long. 88° 08′ W. The variety is found in Recent material, from the western Atlantic along the coast of Georgia and south. In the Pacific it is found as far north as Lat. 43°, and in the Philippine region. A somewhat similar form occurs in the Philippine region, near the Fiji Islands, and in the Pliocene of Kar Nicobar (*Bulimina inflata* Schwager (not Seguenza), *Novara*-Exped., Geol. Theil, vol. 2, p. 246, pl. 7, fig. 91, 1866; H. B. Brady, *Challenger* Rept., Zoology, vol. 9, p. 406, pl. 51, figs. 10-13, 1884; Cushman, U. S. Nat. Mus. Bull. 100, vol. 4, p. 160, pl. 31, fig. 6, 1921) but it is distinguished by having somewhat less sharp spines. The variety is found also in the Miocene of Buff Bay, Jamaica.

Bulimina marginata D'Orbigny

Plate 28, figures 5, 6

Bulimina marginata D'Orbigny, Annales sci. nat., vol. 7, p. 269, no. 4, pl. 12, figs. 10-12, 1826.

Parker and Jones (part), Annals and Mag. Nat. History, ser. 2, vol. 19, p. 296, pl. 11, figs. 39, 40 (not figs. 35-38), 1857.

H. B. Brady, *Challenger* Rept., Zoology, vol. 9, p. 405, pl. 51, figs. 3-5, 1884.

H. B. Brady, Parker and Jones, Zool. Soc. London Trans., vol. 12, p. 220, pl. 43, figs. 7, 10, 1888.

Egger, K. bayer. Akad. Wiss. Abh., cl. 2, vol. 18, p. 287, pl. 8, figs. 69, 70, 1893.

Goës, K. svenska vetensk. akad. Handl., vol. 25, no. 9, p. 45, pl. 9, figs. 439-444, 1894.

Jones, Crag Foraminifera, Palaeont. Soc. Pub., pt. 2, p. 165, pl. 3, figs. 5, 6, 1895.

Reade, Geol. Mag., dec. 4, vol. 7, pp. 100, 101 (lists), pl. 5, fig. 4, 1900.

Fornasini, Accad. sci. Ist. Bologna Mem., ser. 5, vol. 9, p. 372, 1901; idem, vol. 10, p. 15, 1902.

Cushman, U. S. Nat. Mus. Bull. 71, pt. 2, p. 83, text figs. 136a, b, 1911.

Applin, Ellisor and Knicker, Am. Assoc. Petroleum Geologists Bull., vol. 9, p. 98, pl. 3, fig. 4, 1925.

Ikari, Suisangaku Zasshi, no. 30, p. 3, pl. 1, fig. 7, 1927.

Cushman and Parker, U. S. Nat. Mus. Proc., vol. 80, art. 3, p. 14, 1931.

Cushman and Ponton, Florida Geol. Survey Bull. 9, p. 77, pl. 11, fig. 12, 1932.

Macfadyen, Geol. Mag., vol. 69, p. 34, fig. 5, 1932.

Cushman, Cushman Lab. Foram. Research Special Pub. 5, pl. 27, figs. 11a, b, 1933.

Cushman and Parker, idem, Contr., vol. 14, p. 91, pl. 16, figs. 5, 6, 1938; idem, vol. 16, p. 9, pl. 2, figs. 8, 9, 1940.

Phleger, Geol. Soc. America Bull., vol. 50, p. 1403, pl. 3, fig. 23, 1939.

Coryell and Rivero, Jour. Paleontology, vol. 14, p. 341, 1940.

Macfadyen, Geol. Mag., vol. 79, p. 135 (list), 1942.

Silvestri and Zangheri, Soc. geol. italiana Boll., vol. 61, p. 88, 1942.

Cushman, Cushman Lab. Foram. Research Special Pub. 12, p. 27, pl. 3, figs. 45, 46, 1944.

Palmer, Bull. Am. Paleontology, vol. 29, no. 115, p. 46, 1945.

Bulimina pulchella D'Orbigny, Voyage dans l'Amérique méridionale, vol. 5, pt. 5, Foraminifères, p. 50, pl. 1, figs. 6, 7, 1839.

Bulimina serrata Bailey, Smithsonian Contr., vol. 2, p. 12, pl., figs. 32-34, 1851.

Bulimina pupoides D'Orbigny var. *marginata* Williamson, Recent Foraminifera of Great Britain, p. 62, pl. 5, figs. 126, 127, 1858.

Bulimina presli Reuss var. *marginata* Parker and Jones, Philos. Trans., vol. 155, p. 372, pl. 15, fig. 10, pl. 17, fig. 70, 1865.

Bulimina elegans D'Orbigny var. *marginata* Fornasini, Accad. sci. Ist. Bologna Mem., ser. 5, vol. 9, p. 376, pl. 0, figs. 7, 14, 33, 39, 1901.

Bulimina fusiformis Williamson var. *marginata* Fornasini, idem, p. 378, pl. 0, figs. 24, 25.

Bulimina gibba Fornasini var. *marginata* Fornasini, idem, p. 379, pl. 0, figs. 15, 19, 22, 26, 35, 42.

Bulimina patagonica Cushman and Wickenden (not D'Orbigny), U. S. Nat. Mus. Proc., vol. 75, art. 9, p. 8, pl. 3, figs. 11a, b, 1929.

Cushman and Kellett, idem, vol. 75, art. 25, p. 7, pl. 3, figs. 4a, b, 1929.

Test medium to large, tapering from the widest point in the last whorl; chambers numerous, angled, somewhat inflated, undercut at the margin; wall, except for the margins of the chambers, smooth, finely perforate, often partially translucent, margins of the chambers ornamented with tooth-like crenulations which are often extended into short, sharp spines; aperture loop-shaped, near the apex of the test, well above the junction of the second and third chambers, with a well-developed lip. Length of figured specimen 0.70 mm., diameter 0.35 mm.

The species was described from Recent material from Rimini, Italy. It appears to be a very variable form and a study of the abundant material from many parts of the world seems to offer no logical method of subdividing it. Some specimens are much more elongate and slender than others. Some develop long spines at the margins of the chambers whereas others have undercut margins with almost no ornamentation. Many of the variations appear at the same locality, and a few are apparently localized. The species has been recorded from the following: Miocene of Louisiana, Florida (*Cancellaria* zone of the Choctawhatchee marl), Haiti, and Jamaica. Pliocene of England. Pleistocene of England and cores from the western Atlantic. Recent deposits of Rimini, Italy; eastern Atlantic Ocean near the British Isles, Norway, and Iceland; western Atlantic Ocean off the coast of North and South America, Falkland Islands; Pacific Ocean off the coast of South America, Japan, Philippine region, Australia, New Zealand.

This group can be differentiated from the *Bulimina denudata* Cushman and Parker group by the larger proportion of the test occupied by the last-formed whorl and the much slighter projection of the chambers, which do not flare outward to the same extent.

Bulimina marginata D'Orbigny var. tessellata Cushman and Todd

Plate 30, figure 18

Bulimina marginata D'Orbigny var. *tessellata* Cushman and Todd, Cushman Lab. Foram. Research Special Pub. 15, p. 39, pl. 6, fig. 9, 1945.

Variety differing from the typical in the somewhat coarser spines and the wall which has rather large, prominent perforations arranged in linear patterns especially noticeable on the smooth, later portion of the chambers.—Cushman and Todd.

The types are from the Miocene, half a mile east of Buff Bay, Jamaica.

Bulimina trilobata D'Orbigny

Plate 28, figure 7

Bulimina trilobata D'Orbigny, Annales sci. nat., vol. 7, p. 269, no. 6, 1826.

Parker, Jones and Brady, Annals and Mag. Nat. History, ser. 4, vol. 8, p. 172, pl. 11, fig. 127, 1871.

Fornasini, Accad. sci. Ist. Bologna Mem., ser. 5, vol. 9, p. 373, text fig. 3, 1901.

Polymorpha pineiformia Soldani (part), Testacea, vol. 1, pt. 2, p. 119, pl. 131, fig. xx, 1791.

The species was described from the Recent material from Rimini, Italy. It is difficult, either from the figure of Soldani designated by D'Orbigny in 1826 or from the later figure published by Fornasini, to refer any of the Rimini material to this species. It is possible that the form represents a variation of the species *Bulimina aculeata* D'Orbigny, in which case the name *B. trilobata* should be given priority. As no definite assertions can be made, however, it would seem best to retain the name *aculeata*, since it has been used so extensively throughout the literature.

Bulimina aculeata D'Orbigny

Plate 28, figures 8-11

Bulimina aculeata D'Orbigny, Annales sci. nat., vol. 7, p. 269, no. 7, 1826.

Parker, Jones and Brady, Annals and Mag. Nat. History, ser. 4, vol. 8, p. 172, pl. 11, fig. 128, 1871.

H. B. Brady, *Challenger* Rept., Zoology, vol. 9, p. 406, pl. 51, figs. 7-9, 1884.

Egger, K. bayer. Akad. Wiss. Abh., cl. 2, vol. 18, p. 287, pl. 8, figs. 72, 78, 1893.

?Jones, Crag Foraminifera, Palaeont. Soc. Pub., pt. 2, p. 163, pl. 3, figs. 1, 2, 1895.

Flint, U. S. Nat. Mus. Rept. for 1897, p. 291, pl. 37, fig. 4, 1899.

Fornasini, Accad. sci. Ist. Bologna Mem., ser. 5, vol. 9, p. 373, text fig. 4, 1901; idem, ser. 5, vol. 10, p. 17, 1902.

Cushman, U. S. Nat. Mus. Bull. 71, pt. 2, p. 86, text fig. 139, 1911; idem, Bull. 100, vol. 4, p. 161, pl. 31, fig. 5, 1921; idem, Bull. 104, pt. 3, p. 96, pl. 22, figs. 1, 2, 1922.

Hada, Tohoku Imp. Univ. Sci. Repts., ser. 4, Biol., vol. 6, p. 127, text fig. 84, 1931.

Cushman, Cushman Lab. Foram. Research Special Pub. 5, pl. 27, fig. 12, 1933.

Cushman and Parker, idem, Contr., vol. 14, p. 92, pl. 16, figs. 8-10, 1938; idem, Contr., vol. 16, p. 11, pl. 2, fig. 16

(in explanation of plate as "*Bulimina pupoides* D'Orbigny var. *spinulosa* Williamson"), 1940.

Phleger, Geol. Soc. America Bull., vol. 50, p. 1403, pl. 3, fig. 24, 1939.

Cushman and Henbest, U. S. Geol. Survey Prof. Paper 196-A, pl. 9, fig. 17, 1940.

Chapman, Royal Soc. South Australia Trans., vol. 65, p. 165, 1941.

ten Dam and Reinhold, Geol. Stichting Mededeelingen, ser. C-V, no. 1, p. 55, 1941.

ten Dam, idem, no. 3, p. 111, 1944.

Cushman, Cushman Lab. Foram. Research Special Pub. 12, p. 28, pl. 3, fig. 47, 1944.

Cushman and Todd, idem, Special Pub. 15, p. 39, pl. 6, fig. 11, 1945.

Valk, in Rutten and Hotz, Geol. Petr. and Pal. Results of Explorations in the island of Ceram, 3rd ser. Geol., no. 1, p. 23, 1945.

Colom, Inst. Invest. Geol., Num. 3 Estudios Geologicos, p. 159, pl. 10, figs. 174, 175, 1946.

Polymorpha pineiformia Soldani (part), Testacea, vol. 1, pt. 2, p. 118, pl. 127, fig. I?; pl. 130, fig. vv, 1791.

Bulimina pupoides D'Orbigny var. *spinulosa* Williamson, Recent Foraminifera of Great Britain, p. 62, pl. 5, fig. 128, 1858.

Bulimina patagonica Heron-Allen and Earland (not D'Orbigny), *Discovery* Repts., vol. 4, p. 350, pl. 8, figs. 33, 34, 1932.

Test large, tapering from the widest portion in the last whorl, initial end subacute, consisting of 4 to 6 whorls; chambers distinct, regularly triserial, increasing rapidly in size as added, rounded, inflated, especially those of last whorl; sutures distinct, depressed; wall of initial portion ornamented by heavy spines, sometimes only at the base but often extending as much as halfway up the test, otherwise smooth, very finely perforate, polished; aperture broadly loop-shaped, in a depression of the apertural face, with a raised lip. Length of specimens from Rimini, Italy, 0.60 to 0.75 mm., diameter 0.40 to 0.50 mm.

The types are from the Recent of Rimini, Italy. The species occurs in the Miocene of Kattowitz, Germany, and Dax, Dept. of Seine-et-Oise, France, and also in the Miocene of Buff Bay, Jamaica. It has been recorded by Jones from the Pliocene Crag of England. In the Recent seas it is found in the Atlantic along the eastern coast of the United States and as far north as Gaspé Bay, and in the Pacific in the Australian, Philippine, Hawaiian and Japanese regions.

D'Orbigny based the species *aculeata* on part of Soldani's species *pineiformia,* but gave no characterization nor figure. It would be difficult to refer anything to Soldani's figure, but the publication of D'Orbigny's figure by Fornasini showed clearly what the species is. D'Orbigny's definite designation for the species gives his name priority over Williamson's name published in 1858.

This species has been confused with *Bulimina gibba* Fornasini. It can be easily differentiated by the globular last-formed chambers, the rounded rather than three-cornered initial end and the more rapidly tapering test. The form is very variable as regards the amount and character of ornamentation. Some specimens have almost no spines whereas others may be spinose halfway up the test. The spines are usually heavy and short but at times may be quite sharp and long.

Bulimina caudigera D'Orbigny

Plate 28, figures 12, 13

Bulimina caudigera D'Orbigny, Annales sci. nat., vol. 7, p. 270, no. 16, Modèles, no. 68, 1826.

Fornasini, Accad. sci. Ist. Bologna Mem., ser. 5, vol. 9, p. 375, 1901.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 14, p. 94, pl. 16, figs. 17, 18, 1938.

Test broadly fusiform, the basal end very broadly rounded, the last-formed whorl forming the greater part of the test; chambers distinct, angled, with almost no inflation; sutures distinct, slightly depressed; wall smooth, very closely perforate, somewhat translucent; aperture loop-shaped, at apex of test, placed well above the suture joining the second and third chambers. Length 0.60 to 0.70 mm., diameter 0.30 to 0.37 mm.

The types are from Recent material from Rimini, Italy. It has not been found elsewhere.

The species differs from *Bulimina affinis* D'Orbigny in the more angled character of the chambers and their almost complete lack of inflation. It is also considerably smaller.

Bulimina squammigera D'Orbigny

Plate 28, figures 14-16

Bulimina squammigera D'Orbigny, in Barker-Webb and Berthelot, Histoire naturelle des îles Canaries, vol. 2, pt. 2, Foraminifères, p. 137, pl. 1, figs. 22-24, 1839.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 16, p. 8, pl. 2, figs. 5-7, 1940.

Test elongate, almost cylindrical, smooth and polished, although marked with small, evenly spaced points, very obtuse at the ends. Spire elongate, turret-like, composed of 5 slightly swollen whorls, without a deep suture. Chambers elongate, oblong, especially in the younger portion, becoming much more swollen in the adult portion; all somewhat pointed at the basal end, giving the appearance altogether of scales placed in regular rows; the last chamber entirely convex right up to the edge of the aperture. Aperture virguline, placed at the upper end of the last chamber. Color white. Total length 0.50 mm.—D'Orbigny (translated).

The species was described from Recent material from Teneriffe in the Canary Islands. We have no typical material.

It is possible that this species belongs in the genus *Buliminella.*

Bulimina patagonica D'Orbigny

Plate 28, figure 17

Bulimina patagonica D'Orbigny, Voyage dans l'Amérique méridionale, vol. 5, pt. 5, Foraminifères, p. 50, pl. 1, figs. 8, 9, 1839.

Cushman and Parker, U. S. Nat. Mus. Proc., vol. 80, art. 3, p. 14, pl. 3, fig. 14, 1931; Cushman Lab. Foram. Research Contr., vol. 16, p. 9, pl. 2, figs. 10-12, 1940.

Test oblong, conical, very polished on the last whorls, rough, covered with small spines on the remainder, these projecting all the more as they are at the base and completely conceal the spire, composed of 5 rounded whorls, separated by somewhat depressed sutures. Chambers broader than high, 3 to a whorl, all somewhat inflated and distinct, the last inflated and larger than the rest. Aperture virguline, placed almost in the center of the width of the chamber. Color white. Length 0.66 mm.—D'Orbigny (translated).

D'Orbigny described the species from Recent material from the Bay of San Blas, Patagonia. We have specimens from off Ilha Govenador, Rio de Janeiro Harbor, Brazil, and from the Falklands that are very close to this form. They are very much smaller, however, and apparently represent immature specimens.

D'Orbigny differentiates this species from *Bulimina echinata* D'Orbigny by its conical shape, and from *B. aculeata* D'Orbigny by its more elongate whorls, less globular chambers, and its much finer spines. The last whorl is more inflated than in *B. elongata* D'Orbigny var. *subulata* Cushman and Parker, and the test is not so elongate.

Bulimina patagonica D'Orbigny var. glabra Cushman and Wickenden

Plate 28, figures 18, 19

Bulimina patagonica D'Orbigny var. *glabra* Cushman and Wickenden, U. S. Nat. Mus. Proc., vol. 75, art. 9, p. 9, pl. 4, figs. 1a-c, 1929.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 16, p. 17, pl. 3, figs. 13, 14, 1940.

Variety differing from the typical form in the lack of spines on the basal portion of the test.

The types are from Recent material from Cumberland Bay, Juan Fernandez Island, Chile. The variety is not known elsewhere.

This form is very close to *Bulimina elongata* D'Orbigny, differing from it in the marked inflation of the last whorl. It is very possible that this variety and the typical form are more closely related to *B. elongata,* but until more material of *B. patagonica* can be obtained for study the relationships of the three cannot be definitely established.

Bulimina ovula D'Orbigny

Plate 28, figures 20-22

Bulimina ovula D'Orbigny, Voyage dans l'Amérique méridionale, vol. 5, pt. 5, Foraminifères, p. 51, pl. 1, figs. 10, 11, 1839.

Cushman, Scripps Inst. Oceanography Bull., Tech. ser., vol. 1, p. 150, pl. 2, fig. 10, 1927.

Heron-Allen and Earland, *Discovery* Repts., vol. 4, p. 350, pl. 8, fig. 32, 1932.

?Kleinpell, Miocene stratigraphy of California, p. 256, pl. 7, fig. 2, Tulsa, 1938.

Cushman and Parker (part), Cushman Lab. Foram. Research Contr., vol. 16, p. 10, pl. 2, figs. 13, 14 (not fig. 15), 1940.

Bulimina ovata Cushman (not D'Orbigny), U. S. Nat. Mus. Bull. 71, pt. 2, p. 77, text figs. 125a-c, 1911.

Globobulimina pacifica Cushman and Parker (not Cushman), Cushman Lab. Foram. Research Contr., vol. 7, p. 9, pl. 1, fig. 30, 1931.

Test broadly oval, consisting of 2 or 3 whorls, the last-formed whorl composing most of the test, the remaining whorls forming a sharply pointed base in the microspheric form; chambers distinct, those of last whorl very much inflated; sutures distinct, very slightly depressed; wall smooth, translucent, with medium sized perforations; aperture comma-shaped, with a long curved tooth. Length of figured specimens 0.70 mm., diameter 0.50–0.60 mm.

The species was described from Recent material off the coast of Chile and Peru. We have specimens from off the west coast of America, and it has been recorded from the Falkland Islands. In the Miocene it is found in the lower part of the Temblor formation of the San Joaquin Valley, California. The form recorded by Kleinpell is placed here questionably. Specimens from Reliz Canyon, Monterey County, California, sample C. 4, have a much less predominant last-formed whorl and an aperture that is smaller and lacks the typical large tooth. These specimens are in a rather bad state of preservation, however, and the characters do not show as clearly as they do in the Recent specimens.

The species resembles *Bulimina pyrula* D'Orbigny but is larger, with more inflated chambers, and lacks the occasional spines.

Bulimina affinis D'Orbigny

Plate 28, figures 23-25

Bulimina affinis D'Orbigny, in De la Sagra, Historia física, política y natural de la isla de Cuba, Foraminifères, vol. 6, p. 109, pl. 2, figs. 25, 26, 1840.

Flint, U. S. Nat. Mus. Rept., 1897, p. 290, pl. 37, fig. 2, 1899.

Cushman, U. S. Nat. Mus. Bull. 104, pt. 3, p. 103, pl. 20, fig. 6, 1922.

Phleger, Geol. Soc. America Bull., vol. 50, p. 1403, 1939.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 16, p. 7, pl. 2, figs. 1-4, 1940.

Coryell and Rivero, Jour. Paleontology, vol. 14, p. 341, pl. 44, fig. 21, 1940.

Palmer, Soc. cubana hist. nat. Mem., vol. 14, p. 295, pl. 51, fig. 14, 1940.

Macfadyen, Geol. Mag., vol. 79, p. 135 (list), 1942.

Coryell and Mossman, Jour. Paleontology, vol. 16, p. 242, pl. 36, fig. 42, 1942.

Franklin, idem, vol. 18, p. 314, pl. 46, fig. 9, 1944.

Renz, 8th Am. Sci. Congress Proc., p. 548 (list), 1942.

Goudkoff and Porter, Am. Assoc. Petroleum Geologists Bull., vol. 26, p. 1652 (list), 1942.

Colom, Inst. Invest. Geol., Num. 3, Estudios Geologicos, p. 159, 1946.

Bulimina pupoides Cushman (not D'Orbigny), U. S. Nat. Mus. Bull. 71, pt. 2, p. 80, text fig. 132, 1911; idem, Bull. 104, pt. 3, p. 105, pl. 20, fig. 3, 1922.

Bulimina ovata Cushman (not D'Orbigny), idem, Bull. 104, pt. 3, p. 100, pl. 21, fig. 3, 1922.

Bulimina ovula Cushman and Moyer (not D'Orbigny), Cushman Lab. Foram. Research Contr., vol. 6, p. 56, pl. 7, fig. 21, 1930.

Test large, composed of 3 to 4 whorls, the last-formed whorl composing three-fifths or more of the test, broadly ovate in the megalospheric form, tapering to a subacute point in the microspheric; chambers distinct, inflated, especially the last-formed, which bulges out over the suture toward the apertural end; sutures distinct, depressed, especially that of the last chamber; wall transparent, coarsely perforate; aperture loop-shaped, with a slight lip and a plate-like tooth. Length of figured specimens 0.82 to 1.00 mm., diameter 0.50 to 0.60 mm.

The species was described from Recent material near Cuba. It occurs in the western Atlantic and in the vicinity of Ireland, in the Pacific at *Guide* sta. 22(24) Lat. 43° 12′ N., Long. 125° 01′ W. in the Galapagos Islands, and in the vicinity of the Philippine Islands. Many specimens of a somewhat broader, stouter form are found in various parts of the Pacific. In the Pliocene it occurs in Cañada de Aliso, Ventura County, California, 2.1 miles N. 74° E. of La Crosse Junction, in gray siltstone, 280 feet stratigraphically above the base of the first Pico sandstone. There are numerous records from the Oligocene to Recent that do not seem entirely typical.

Our specimens are larger than that described by D'Orbigny. The figured specimen (pl. 14, fig. 25), however, shows the microspheric form of the species and is apparently identical with D'Orbigny's figure. He compares the species to *Bulimina laevigata* D'Orbigny (in synonymy of *B. ovata* D'Orbigny), differentiating it by the slight depression of the last chamber, and by the whorls, which are less widely separated. A comparison of the form with specimens from Rimini, Italy, and the Miocene of the Vienna Basin shows these same differences. *B. affinis,* in addition, is a larger form and less ovate in the megalospheric form. It is much larger than *B. pupoides* D'Orbigny and the last-formed whorl makes up a much greater proportion of the test.

Bulimina oceanica Terquem

Plate 28, figure 26

Bulimina oceanica Terquem, Essai sur le classement des animaux qui vivent sur la plage et dans les environs de Dunkerque, pt. 3, p. 127, pl. 17, figs. 10a, b, 1881.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 16, p. 11, pl. 2, figs. 17a, b, 1940.

Test elongate, narrow, conical, polished, obtuse at the ends; composed of 4 whorls, with triangular chambers, convex, the last rounded; aperture round, lateral, placed at the bottom of an acute, oval depression, with a lip.—Terquem (translated).

Terquem described the species from Recent material from Dunkerque, France. We have no typical material. *Bulimina elongata* D'Orbigny occurs in this same region and this form may be referable to it. From the figures, however, it appears to be a more slender form with a marked spiral suture, which is typical of the genus *Buliminella.*

Bulimina exilis H. B. Brady

Plate 28, figures 27, 28

Bulimina elegans D'Orbigny var. *exilis* H. B. Brady, *Challenger* Rept., Zoology, vol. 9, p. 399, pl. 50, figs. 5, 6, 1884.

Sidebottom, Manchester Lit. Philos. Soc. Mem. and Proc., vol. 54, no. 16, p. 12, pl. 1, fig. 11, 1910.

Cushman, U. S. Nat. Mus. Bull. 71, pt. 2, p. 82, text fig. 135, 1911.

Heron-Allen and Earland, Linnean Soc. London Trans., vol. 11, ser. 2, p. 234, pl. 41, figs. 4-9, 1916.

Cushman, U. S. Nat. Mus. Bull. 104, pt. 3, p. 106, pl. 17, figs. 7-12, pl. 19, figs. 2, 3, 1922.

Buliminella elegans D'Orbigny var. *exilis* Phleger, Geol. Soc. Am. Bull., vol. 50, p. 1405, pl. 3, fig. 17, 1939.

Bulimina elegans Flint (not D'Orbigny), U. S. Nat. Mus. Rept., 1897, p. 290, pl. 36, fig. 3, 1899.

Bulimina exilis Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 16, p. 11, pl. 2, figs. 18-21, 1940.

Test elongate, slender, tapering, the length sometimes as much as 5 times the diameter, with a basal spine that is sometimes absent on the megalospheric form; chambers elongate, sharply angled, oblique, very slightly inflated; sutures distinct, usually formed of clear shell material, slightly depressed; wall smooth, polished, finely perforate; aperture broad, loop-shaped, placed at the apex of the test, pointing directly downward to meet the junction of the second and third chambers. Length of figured specimens 0.65 mm., 0.80 mm.; diameter 0.15 mm., 0.18 mm.

The types are from Recent material from *Porcupine* sta. 20, northwest of Ireland. The species is found in the Pliocene of Castel Arquato, Italy. From the Recent it has been recorded from the Bay of Palermo, Italy; from various localities in the British Isles; from the western Atlantic south of Cape Cod; and from various localities in the north Pacific. We have typical material from all these general areas except the Mediterranean. It also occurs in deep sea cores taken in the western Atlantic.

This form is easily recognized by its slender, tapered test with the basal spine, by its polished surface, and by the elongate, angled chambers.

Bulimina exilis H. B. Brady var. tenuata (Cushman) Cushman and Parker

Plate 28, figure 29

Buliminella subfusiformis Cushman var. *tenuata* Cushman, Scripps Inst. Oceanography Bull., Tech. ser., vol. 1, p. 149, pl. 2, fig. 9, 1927.

Bulimina elegans Cushman (not D'Orbigny), U. S. Nat. Mus. Bull. 71, pt. 2, p. 82, text fig. 134, 1911; Cushman Lab. Foram. Research Special Pub. 4, pl. 22, fig. 7, 1933.

Buliminella subfusiformis Cushman and Moyer (not Cushman), Cushman Lab. Foram. Research Contr., vol. 6, p. 56, pl. 7, fig. 20, 1930.

Variety differing from the typical form in having the initial end rounded and in lacking a basal spine.

The types are from Recent material from *Guide* sta. 13, Lat. 33° 17′ N., Long. 117° 55′ W., in 396 fathoms. The variety occurs at various localities along the west coast of North America.

The form may be easily distinguished by the basal end, which is rounded instead of tapering and has no spine.

Bulimina pyrula D'Orbigny var. spinescens H. B. Brady

Plate 28, figures 30, 31

Bulimina pyrula D'Orbigny var. *spinescens* H. B. Brady, *Challenger* Rept., Zoology, vol. 9, p. 400, pl. 50, figs. 11, 12, 1884.

Cushman, U. S. Nat. Mus. Bull. 71, pt. 2, p. 79, text figs. 128, 129, 1911.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 16, p. 12, pl. 2, figs. 22-25, 1940.

Colom, Inst. Invest. Geol., Num. 3 Estudios Geologicos, p. 158, pl. 10, fig. 150, 1946.

Variety differing from the typical form in having the lower part of the test covered with short, sharp spines, not extending above the lowest part of the last-formed chamber.

The types are from Recent material off the Ki Islands, in 480 fathoms, *Challenger* sta. 191A. The variety is found in the Miocene of San Rufillo, Italy, and in the Recent of the north Pacific.

It differs from *Bulimina barbata* Cushman in being much more involute. Both *B. pyrula* D'Orbigny and this variety have a partially involute test which approaches, in character, the involute genus *Globobulimina*.

Bulimina subornata H. B. Brady

Plate 28, figures 32, 33

Bulimina subornata H. B. Brady, *Challenger* Rept., Zoology, vol. 9, p. 402, pl. 51, figs. 6a, b, 1884.

Egger, K. bayer. Akad. Wiss. Abh., cl. 2, vol. 18, p. 286, pl. 8, fig. 79, 1893.

Millett, Royal Micr. Soc. Jour., 1900, p. 276, pl. 2, fig. 3.

Cushman, U. S. Nat. Mus. Bull. 71, pt. 2, p. 88, text fig. 141, 1911.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 16, p. 12, pl. 2, figs. 26-28, 1940.

Test medium in size, fusiform, pointed at the initial end, more rounded at the apertural end, with a short basal spine; chambers distinct, angled, very slightly inflated; sutures distinct, slightly depressed; wall of the lower half of the test covered with irregular, low costae which give the test a roughened appearance, upper part of wall smooth, coarsely perforate; aperture long, narrow, curved, extending over the apex of the test. Length of figured specimens 0.45 mm., 0.55 mm.; diameter 0.25 mm., 0.27 mm.

The types are from the *Hyalonema*-ground, south of Japan, in 345 fathoms, and off Aru Island, in 800 fathoms. We have material from the Philippine region and the species has been recorded from Australia and the Malay Archipelago.

The species is distinctive and may be easily recognized by the angled chambers and roughened lower part of the test. It differs from *Bulimina semicostata* Nuttall in having much finer costae that do not cover as much of the test.

Bulimina rostrata H. B. Brady

Plate 28, figure 34

Bulimina rostrata H. B. Brady, *Challenger* Rept., Zoology, vol. 9, p. 408, pl. 51, figs. 14, 15, 1884.

Cushman, U. S. Nat. Mus. Bull. 71, pt. 2, p. 87, text figs. 140a, b, 1911; Scripps Inst. Oceanography Bull., Tech. ser., vol. 1, p. 152, pl. 2, fig. 12, 1927.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 16, p. 13, pl. 2, figs. 29-31, 1940.

Cushman and Henbest, U. S. Geol. Survey Prof. Paper 196-A, pl. 9, fig. 19, 1940.

Hanna and Hertlein, State of Calif., Div. of Mines, Bull. 118, p. 180, fig. 67 [plate], fig. 40, 1941.

LeRoy, Jour. Paleontology, vol. 15, p. 623 (list), 1941.

Cushman, U. S. Nat. Mus. Bull. 161, pt. 3, p. 10, pl. 3, fig. 12, 1942.

Bulimina buchiana Cushman (not D'Orbigny), U. S. Nat. Mus. Bull. 104, pt. 3, p. 95, pl. 20, fig. 4, 1922.

Test small, fusiform, often somewhat curved, broadest near the middle, rounded at the apertural end, pointed at the initial end; chambers indistinct; sutures indistinct, occasionally showing slightly between the costae, slightly depressed; wall of last chamber smooth, rather coarsely perforate, remainder of test ornamented by 10 or 11, regular, plate-like costae, continuous throughout; aperture small, loop-shaped, at the apex of the test. Length of figured specimen 0.40 mm., diameter 0.20 mm.

The types are from Recent material from the Ki Islands, in 428 fathoms. The species is found in both the north and south Pacific. A similar, somewhat more slender, form is found at various localities in the western Atlantic both in bottom samples and in deep sea cores. It is also recorded from the Pliocene of California.

Bulimina notovata Chapman

Plate 30, figure 8

Bulimina ovata H. B. Brady (not D'Orbigny, 1846), *Challenger* Rept., Zoology, vol. 9, p. 400, pl. 50, figs. 13a, b, 1884.

Bulimina notovata Chapman, Royal Soc. South Australia Trans., vol. 65, p. 166, 1941.

Brady's figured specimens of *B. "ovata"* were obtained east of New Zealand (*fide* Nuttall). D'Orbigny obtained his fossil type from the Miocene of the Vienna Basin; when the latter is compared with the living form, so familiar in southern waters, the differences are easily seen. *B. ovata*, according to the figured type, is a long ovate form, with the segments slightly inflated and prominent and therefore specifically different from the "Challenger" specimen. Goës (1894, 45) has placed Brady's *ovata* in the synonymy of *Bulimina ellipsoides* Costa, but that form, according to Goës' figures (1894, pl. viii, figs. 31-36), is also distinct from this southern living species.—Chapman.

This species is based on the *Challenger* figures which are reproduced on our plate.

Bulimina ornata Egger

Plate 28, figure 35

Bulimina ornata Egger, K. bayer. Akad. Wiss. Abh., cl. 2, vol. 18, p. 286, pl. 8, fig. 80, 1893.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 16, p. 13, pl. 2, fig. 32. 1940.

Test cone-shaped, with the initial end a rounded point, consisting of 4 or 5 whorls of 3 rounded chambers each, ending at the apertural end with an offset, rounded, upward-projecting last chamber. Sutures not very depressed; the surface of the chambers covered with papillae of equal size, low, rising above the surface where the perforations pierce the wall, arranged to give the appearance of a closely striped pattern. Length 0.15 mm., diameter 0.09 mm.—Egger (translated).

The types are from *Gazelle* sta. 90, off west Australia, in 359 meters. We have no typical material.

The possible connection between this species and *Bulimina fijiensis* Cushman has been discussed under the latter form.

Bulimina consobrina Fornasini

Plate 28, figure 36

Bulimina consobrina Fornasini, Accad. sci. Ist. Bologna Mem., ser. 5, vol. 8, p. 374, text fig. 23, 1900.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 16, p. 14, pl. 2, fig. 33, 1940.

Fornasini describes this form as very elongate, pointed, and graceful in the early portion, composed of numerous, inflated chambers, the early chambers arranged in regular series, the later chambers, which are fewer in number, less regularly arranged.

The types are from Recent material from Porto Corsini, near Ravenna, Italy. We have no specimens referable to the species.

The form shows considerable resemblance to the smoother variations of *Bulimina gibba* Fornasini, especially in the early portion of the test. Lack of topotype material makes it impossible definitely to combine the two species.

Bulimina gibba Fornasini

Plate 28, figures 37, 38; plate 29, figures 1-5

Bulimina gibba Fornasini, Accad. sci. Ist. Bologna Mem., ser. 5, vol. 9, p. 378, pl. 0, figs. 32, 34, 1901.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 16, p. 48, 1940.

Bulimina presli Reuss var. *aculeata* Parker and Jones (not D'Orbigny) (part), Philos. Trans., vol. 155, p. 373, pl. 17, figs. 68, 69 (not pl. 15, fig. 11), 1865.

Bulimina elegans H. B. Brady (not D'Orbigny), *Challenger* Rept., Zoology, vol. 9, p. 398, pl. 50, figs. 1-4, 1884.

Cushman, U. S. Nat. Mus. Bull. 104, pt. 3, p. 105, 1922.

Bulimina elongata D'Orbigny var. *ariminensis* Fornasini (not D'Orbigny), Accad. sci. Ist. Bologna Mem., ser. 5, vol. 9, p. 377, pl. 0, figs. 8, 11, 1901.

Bulimina fusiformis Fornasini (not Williamson) (part), idem, pp. 377, 378, pl. 0, figs. 1, 3, 4, 16, 18, 21, 23, 27, 36, 40 (not figs. 6, 9, 31), 1901.

Bulimina fusiformis Williamson var. *baccata* Fornasini (not Yokoyama), idem, p. 378, pl. 0, figs. 2, 5, 30, 1901.

Bulimina baccata Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 16, p. 14, pl. 3, figs. 1-6, 1940.

Bulimina parkerae Thalmann, Am. Midland Naturalist, vol. 28, p. 464, 1942.

Test of medium size, gradually tapering, initial portion somewhat triangular in transverse section, often with a terminal spine, consisting of 5 or 6 whorls; chambers angled, distinct, regularly triserial, sometimes with the chambers sufficiently offset to give a slight twist to the test, increasing regularly in size, slightly inflated; sutures distinct, slightly depressed; wall smooth, polished, finely perforate, usually ornamented at the base with short spines; aperture loop-shaped, broad, with a slight lip. Length 0.33 to 0.58 mm., diameter 0.20 to 0.23 mm.

The species was described from Recent material from the Adriatic Sea. It is found in the Pliocene of Sicily; the Recent of the Mediterranean, the eastern Atlantic near Ireland, and Juan Fernandez Island, Chile, in the Pacific.

This species is close to *Bulimina acanthia* Costa but differs from it in the almost entire absence of marginal overhang of the chambers, this characteristic appearing only occasionally in the basal part of the test. It differs from *B. elongata* D'Orbigny in the more angled character of the chambers, the angled base, and the typically smaller size.

Bulimina torta Cushman

Plate 29, figure 6

Bulimina torta Cushman, U. S. Nat. Mus. Bull. 71, pt. 2, p. 81, text figs. 133a-c, 1911.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 16, p. 15, pl. 3, fig. 8, 1940.

Test elongate, broadest near the apertural end, tapering to the subacute apical end; apertural end broadly rounded; early portion slightly compressed; later portion circular in cross section; chambers several, somewhat inflated; sutures depressed; wall calcareous, perforate, smooth; aperture very long and narrow, curved, broadest at the upper end; color white. Length 0.65 mm.—Cushman.

The type is from *Albatross* sta. H2902, 1,783 fathoms, northeast of the Hawaiian Islands. The species has not been recorded elsewhere.

This species is rendered unique by the long, slit-like aperture that curves over the top of the test. It is questionable whether it actually belongs in *Bulimina* at all. The number of specimens, however, is so limited that the study of the internal structure must wait until more material is available.

Bulimina subaffinis Cushman

Plate 29, figure 7

Bulimina subaffinis Cushman, U. S. Nat. Mus. Bull. 100, vol. 4, p. 166, text figs. 7a, b, 1921.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 16, p. 15, pl. 3, fig. 7, 1940.

LeRoy, Colorado School of Mines Quart., vol. 39, no. 3, p. 27, pl. 5, fig. 9, 1944.

?Bulimina elongata Cushman (not D'Orbigny), U. S. Nat. Mus. Bull. 71, pt. 2, p. 79, text figs. 131a-d, 1911.

Test large, fusiform, apical end sharply pointed, apertural end rounded, the last whorl composing a large proportion of the test; chambers distinct, angled, very slightly inflated, sutures distinct, slightly depressed; aperture long, comma-shaped, with a well developed lip and tooth. Length (of holotype) 1.00 mm., diameter 0.55 mm.

The types are from *Albatross* sta. D5201, Sogod Bay, southern Leyte, in 554 fathoms. Similar specimens are found in the north Pacific, but they are somewhat more elongate and slender and have more chambers. LeRoy records it from the Miocene of Sumatra.

The species is larger and more pointed at the base than *Bulimina ovata* D'Orbigny, and is more ovate with less inflated chambers than *B. affinis* D'Orbigny.

Bulimina barbata Cushman

Plate 29, figure 8

Bulimina barbata Cushman, Scripps Inst. Oceanography Bull., Tech. ser., vol. 1, no. 10, p. 151, pl. 2, fig. 11, 1927.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 16, p. 16, pl. 3, fig. 10, 1940.

Bulimina pyrula D'Orbigny var. *spinescens* Cushman (not H. B. Brady), U. S. Nat. Mus. Bull. 100, p. 164, text fig. 3, 1921.

Test of medium size, broadly oval, the greatest width at, or below, the middle, the last-formed whorl composing more than half the test; chambers distinct, slightly inflated; sutures distinct, slightly depressed; wall of early portion of the test and the lower margin of the last-formed whorl covered with fine acicular spines, remainder of test smooth, finely perforate, somewhat translucent; aperture narrow, loop-shaped, placed at the apex of the test well above the suture joining the second and third chambers. Length 0.75 mm., diameter 0.40 mm.

The species was described from Recent material from the west coast of North America, *Discoverer* sta. 9D, Lat. 36° 40′ N., Long. 122° 26′ W., at 1,121 fathoms. It has been found at several localities in the same general area and at one locality in the Philippine region.

The species resembles *Bulimina pyrula* D'Orbigny var. *spinescens* H. B. Brady but differs from it in being less involute, having somewhat more inflated chambers, and longer spines.

Bulimina spinifera Cushman

Plate 29, figure 9

Bulimina spinifera Cushman (part), Scripps Inst. Oceanography Bull., Tech. ser., vol. 1, p. 151, pl. 2, fig. 15, 1927.

Test broadly fusiform or ovate, chambers of the last-formed portion strongly overlapping, initial end pointed and the base of the chambers sparsely spinose. Length 0.50 mm.; breadth, 0.30 mm.—Cushman.

The types are from *Lydonia* sta. 31, Lat. 7° N., Long. 81° 35.5′ W., in 478 fathoms. Some of the specimens from the west coast of North America that were originally included in this species are very different. They are completely involute, or almost so, and belong in the genus *Globobulimina*. The species is approaching *Globobulimina* in character and seems very close to *Bulimina pyrula* D'Orbigny var. *spinescens* H. B. Brady. The holotype is larger than the typical form of Brady's variety and shows at least four whorls. In order to learn the true relationship of the two forms, however, more material is needed for study.

Bulimina pagoda Cushman

Plate 29, figures 10, 11

Bulimina pagoda Cushman, Scripps Inst. Oceanography Bull., Tech. ser., vol. 1, p. 152, pl. 2, fig. 16, 1927.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 16, p. 17, pl. 3, figs. 11, 12, 1940.

Coryell and Mossman, Jour. Paleontology, vol. 16, p. 242, pl. 36, fig. 44, 1942.

Test rapidly tapering, broadest near the apertural end, almost as broad as long; consisting of as many as 5 whorls; chambers distinct, deeply cut under at the base, inflated, especially those of the last whorl, increasing rapidly in size as added; sutures of last whorl distinct, depressed, the position of the earlier sutures clearly defined

by the sharp undercutting of the chambers; wall of the periphery of each chamber with a series of large, stout spines projecting outward and curving downward, otherwise smooth, thin, rather coarsely perforate; aperture very slightly comma-shaped, at the apex of the test, well above the junction of the second and third chambers. Length 0.50 mm., diameter 0.40 mm.

The types are from Recent material from *Lydonia* sta. 30, Lat. 7° 0.1′ N., Long. 81° 48.7′ W., south of Panama, in 428 fathoms. It is also found in the Pliocene Charco Azul formation of Panama.

This form differs from *Bulimina marginata* D'Orbigny in the flaring of the chambers, the much shallower last-formed whorl, and in having the projecting spines.

Bulimina fijiensis Cushman

Plate 29, figures 14, 15

Bulimina fijiensis Cushman, Cushman Lab. Foram. Research Contr., vol. 9, p. 79, pl. 8, figs. 7a-c, 1933.

Cushman and Parker, idem, vol. 16, p. 17, pl. 3, figs. 15, 16, 1940.

Cushman, U. S. Nat. Mus. Bull. 161, pt. 3, p. 11, pl. 3, figs. 10, 11, 1942.

Test small, stout, slightly longer than broad, rounded; chambers distinct, inflated, somewhat globular, comparatively few, increasing rapidly in size as added; sutures distinct, depressed; wall coarsely perforate except about the aperture where it is apparently without perforations; aperture loop-shaped, placed well above the junction of the second and third chambers. Length 0.25 mm., diameter 0.15 mm.

The types are from Recent material from Nairai, Fiji, in 12 fathoms. In addition to the Fiji localities we have one specimen from Zanzibar.

This species is close to *Bulimina ornata* Egger and possibly should be identified with it. Cushman's species, however, does not have the papillae that are plainly shown in the figure of the latter.

Bulimina brevitrigona Chapman and Parr

Plate 29, figure 17

Bulimina brevitrigona Chapman and Parr, Australasian Antarctic Exped., ser. C, vol. 1, pt. 2, p. 85, pl. 8, fig. 13, 1937.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 16, p. 18, pl. 3, fig. 18, 1940.

Test conical; short and broadly trigonal; consisting of a trifacial series of moderately inflated chambers, the last of which are comparatively large and well-inflated; sutures well impressed, aperture a curved slit between the sutures of the last three chambers, the edges of which are delicately toothed. Aboral end somewhat acute. Test hyaline, finely tubulate and polished on the surface. Length, 0.7 mm.; width, 0.67 mm.

This species is practically isomorphous with *Verneuilina bradyi* Cushman, which has a finely arenaceous test.—Chapman and Parr.

The types are from sta. XXII of the Mawson Australasian Antarctic Expedition, Lat. 66° 13′ S., Long. 91° 15′ E., in 125 fathoms. We have no typical material. It seems questionable whether the form is a true *Bulimina*, as the aperture is apparently not typical. If the species is isomorphous with *Eggerella bradyi* (Cushman) as described, this thesis is certainly true, since the aperture in the latter genus is not placed in the same position as in *Bulimina*, and is differently shaped. In addition, the arenaceous form has five chambers to the whorl in the early portion of the test. A study of the original specimens would have to be made before a final analysis of the generic characteristics of the species could be made.

Bulimina buchiana D'Orbigny var. gutta Chapman and Parr

Plate 29, figure 16

Bulimina buchiana D'Orbigny var. *gutta* Chapman and Parr, Australasian Antarctic Exped., ser. C, vol. 1, pt. 2, p. 86, pl. 8, fig. 14, 1937.

Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 16, p. 19, pl. 3, fig. 17, 1940.

Test elongate, ovate, slightly curved, wider at oral end, pointed aborally; sides gently convex. Surface ornamented with about ten fine sharp costae persistent to the penultimate chamber; aperture bulimine, situated in a slight concavity. Dimensions: Length, 0.40 mm.; greatest width, 0.19 mm.

This variety has a more slender habit of growth than the specific form. Its narrow and slightly curved test makes it easily distinguishable from typical examples of *Bulimina buchiana*. *Bulimina rostrata*, at first sight suggestive of the above variety, differs in the dominant costae, obliterating the suture lines, as well as in the aciculate aboral end.—Chapman and Parr.

The types are from sta. XLVII of the Mawson Australasian Antarctic Expedition, Lat. 42° 38.5′ S., Long. 148° 41.5′ E., in 1,320 fathoms. We have no material referable to the form.

Bulimina clava Cushman and Parker, n.sp.

Plate 29, figures 12, 13

?*Bulimina aculeata* Brady, Parker and Jones (not D'Orbigny), Zool. Soc. London Trans., vol. 12, p. 220, pl. 43, fig. 8, 1888.

Bulimina inflata Cushman (not Seguenza), U. S. Nat. Mus. Bull. 104, pt. 3, p. 93, pl. 21, fig. 1, 1922.

Test large, tapering, greatest width formed by the last whorl, initial end pointed, typically with a stout spine, three or four whorls in the adult test, the last whorl making up more than half the surface; chambers of the earlier portion obscured by the sculpture of the surface, inflated, those of the last whorl distinct, the basal margin distinctly undercut; sutures of the last whorl distinct, slightly depressed; wall finely but distinctly perforate, in the last chambers nearly smooth on the upper part, becoming costate toward the periphery, each costa extending backward

into a spinose process, the costae of adjacent chambers in the earlier part often fused; aperture broadly comma-shaped. Length up to 0.90 mm., diameter up to 0.50 mm.

Holotype (Cushman Coll. No. 35854) from *Albatross* sta. 2018, Atlantic Ocean, off the mouth of Chesapeake Bay, Lat. 37° 12′ 22″ N., Long. 74° 20′ 04″ W., in 788 fathoms.

The species is found in the western Atlantic north of Cape Hatteras and in the eastern Atlantic in the vicinity of Ireland. A somewhat similar form is found in the Pacific, off the west coast of America, and possibly in the vicinity of Japan (*Bulimina inflata* Cushman (not Seguenza), U. S. Nat. Mus. Bull. 71, pt. 2, p. 84, text fig. 137, 1911; Scripps Inst. Oceanography Bull., Tech. ser., vol. 1, p. 151, pl. 2, fig. 14, 1927).

This species differs from ***Bulimina striata*** **D'Orbigny** var. ***mexicana*** Cushman in being much larger, with less regular chambers that increase much more rapidly in size and do not show a uniform collared effect, and in having, typically, a longer, heavier basal spine. The young specimens of the two forms are sometimes difficult to separate.

Subgenus DESINOBULIMINA Cushman and Parker, 1940

Desinobulimina Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 16, p. 19, 1940.

Subgenoholotype *Bulimina auriculata* Bailey, 1851.

Test with the early chambers like ***Bulimina*** but with the aperture of the last-formed chambers becoming terminal, connected with the earlier apertures by an internal trough, which is joined to one side of the aperture toward the front, and projects above at the back in the form of a tooth.

Many of the smooth species of *Bulimina* show a tendency to develop in this direction. All forms that have an apertural tooth have at least an incipient trough-like connection between the apertures. As a general rule, however, the apertures themselves are also connected, the lower part of the aperture of the last chamber joining the upper end of the aperture of the previous chamber. Only a few species show the aperture becoming terminal, with the trough as the sole means of communication. In these forms the trough extends down from the final aperture and twists around to join the tooth-like protuberance of the previous aperture.

The earliest known form showing these characteristics is ***Bulimina quadrata*** Plummer, from the Paleocene Midway group of Texas. Other known species come from the Miocene and Recent.

Bulimina (Desinobulimina) quadrata Plummer

Plate 29, figures 18, 19

Bulimina (*Ellipsobulimina*) *quadrata* Plummer, Univ. Texas Bull. 2644, p. 72, pl. 4, figs. 4, 5, 1927.

Jennings, Bull. Am. Paleontology, vol. 23, no. 78, p. 30, pl. 3, fig. 19, 1936.

Albritton and Phleger, Jour. Paleontology, vol. 11, p. 352, 1937.

Cushman, Cushman Lab. Foram. Research Contr., vol. 16, p. 67, pl. 11, fig. 21, 1940.

Kline, Mississippi Geol. Survey Bull. 53, p. 48, pl. 4, fig. 20, 1943.

Applin and Jordan, Jour. Paleontology, vol. 19, p. 131 (list), 1945.

Cushman and Todd, Cushman Lab. Foram. Research Contr., vol. 22, p. 60, pl. 10, fig. 19, 1946.

Test medium to large, megalospheric form almost cylindrical, microspheric tapering, consisting of 4 to 5 whorls; chambers sharply angled, very slightly if at all inflated; sutures distinct, very slightly depressed; wall thin, translucent, finely perforate; aperture terminal, with a slight lip and small tooth, in well-preserved specimens the inner connecting trough usually visible. Length of topotype specimens 0.60 to 0.90 mm., diameter 0.26 to 0.34 mm.

The types of the species are from the Paleocene, Midway formation, clay pit of Mexia Brick Works, about 1 mile west of the town of Mexia, Limestone County, Texas. Besides various localities in the Midway formation of Texas we have questionable specimens from the Paleocene, about 2⅘ miles N. 44° E. of Santa Susana, in Poison Oak Canyon, north of Simi Valley, Ventura County, California, from brown shale 2,785 feet stratigraphically above the Cretaceous contact in strata mapped by Kew as Martinez. It has also been recorded from the Paleocene of Alabama and Florida and the Cretaceous of New Jersey.

This species very much resembles *Bulimina kickapooensis* Cole but may be easily differentiated from it by the terminal aperture. It differs from most of the other smooth species in the almost complete lack of inflation of the chambers and their sharply angled character.

Bulimina (Desinobulimina) illingi Cushman and Stainforth

Plate 30, figure 12

Bulimina (*Desinobulimina*) *illingi* Cushman and Stainforth, Cushman Lab. Foram. Research Special Pub. 14, p. 41, pl. 6, figs. 7a, b, 1945.

Test fairly short, less than twice as long as broad, irregularly oval, greatest breadth usually above the middle, initial end rounded in the megalospheric form or subacute in the microspheric; chambers comparatively few, increasing rapidly in size as added, the last whorl making up nearly the whole of the surface of the test; sutures slightly depressed; wall smooth, coarsely perforate; aperture terminal with a slightly projecting lip Length 0.75-0.93 mm.; breadth 0.45-0.52 mm.

This species differs from *B.* (*Desinobulimina*) *auriculata* Bailey in the broader form, more inflated chambers, and typically more rounded base.—Cushman and Stainforth.

The types of this species are from the Oligocene Cipero formation of Trinidad.

Bulimina (Desinobulimina) montereyana Kleinpell

Plate 29, figures 20, 21

Bulimina montereyana Kleinpell, Miocene stratigraphy of California, p. 254, pl. 13, fig. 13, Tulsa, 1938.

Bulimina pseudotorta Barbat and Johnson (not Cushman), Jour. Paleontology, vol. 8, p. 13, pl. 1, fig. 10, 1934.

Test large, fusiform, with the initial end sometimes prolonged, narrow, apertural end somewhat truncated, consisting of about 4 whorls in the adult; chambers distinct, slightly inflated, angled; sutures slightly depressed; wall smooth, finely perforate; aperture terminal, crescent-shaped, with a tooth. Length given by Kleinpell 1.00 to 1.25 mm. or more, diameter 0.65 to 0.70 mm.

The types are from the Miocene of Reliz Canyon, California (Leland Stanford Junior Univ. loc. 691, sample D80). The species has been recorded by Kleinpell from various localities ranging from the upper Luisian to the lower Delmontian in the Miocene of California. We have good material from sta. SPD-4, Tice shale, Contra Costa County, California, a locality at which Kleinpell records the species in abundance.

The species differs from *Bulimina pseudotorta* Cushman in its more fusiform shape, larger size, and the presence of the terminal aperture. It is larger than *Bulimina delmonteensis* Kleinpell, has more inflated chambers, is less tapering, and has the terminal aperture.

Bulimina (Desinobulimina) auriculata Bailey

Plate 29, figures 22-24

Bulimina auriculata Bailey, Smithsonian Contr., vol. 2, p. 12, pl., figs. 25-27, 1851.

Bulimina pyrula Flint (not D'Orbigny), U. S. Nat. Mus. Rept., 1897, p. 290, pl. 36, figs. 4, 5, 1899.

Bulimina (Desinobulimina) auriculata Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 16, p. 20, pl. 3, figs. 19-21, 1940.

Cushman, idem, Special Pub. 12, p. 28, pl. 3, fig. 48, 1944.

Cushman and Todd, idem, Special Pub. 15, p. 40, pl. 6, fig. 14, 1945.

Bulimina (Desinobulimina) cf. auriculata Cushman and Todd, Cushman Lab. Foram. Research Contr., vol. 22, p. 92, 1946.

Test long in the adult form, fusiform, consisting of about 3 whorls; chambers distinct, partially involute so that the last-formed whorl usually forms at least three-fourths of the test; sutures distinct, slightly depressed; wall thin, translucent, smooth, with medium sized perforations; aperture terminal, with a large, curved tooth, the connecting internal trough easily visible through the wall of the test. Length up to 0.52 mm., diameter up to 0.92 mm.

The types are from Recent material collected southeast of Montauk Point, Long Island, Lat. 40° 21′ 54″ N., Long. 70° 55′ 35″ W., in 51 fathoms. The species occurs along the eastern coast of the United States north of Cape Hatteras. Specimens from *Albatross* sta. 2018, Atlantic Ocean, off the mouth of Chesapeake Bay, Lat. 37° 12′ 22″ N., Long. 74° 20′ 04″ W., in 788 fathoms, are very much broader in proportion to their length and probably represent a varietal form of Bailey's species (*Bulimina pyrula* Cushman (not D'Orbigny), U. S. Nat. Mus. Bull. 104, p. 101, pl. 20, fig. 1, 1922). In the Pacific off the west coast of North America a form recorded as *Bulimina ovata* Cushman (not D'Orbigny) (Cushman Lab. Foram. Research Contr., vol. 6, p. 56, pl. 7, fig. 22, 1930) is very similar except that the adults rarely show the terminal aperture. Specimens similar to these occur also in the Pliocene of Timms Point, California.

The species is larger and has less inflated chambers than *Bulimina ovata* D'Orbigny. It differs also in having the terminal aperture with the trough-like connection with the earlier apertures.

Bulimina (Desinobulimina) turgida Bailey

Plate 29, figures 25-27

Bulimina turgida Bailey, Smithsonian Contr., vol. 2, p. 12, pl., figs. 28-31, 1851.

Bulimina marginata Parker and Jones (not D'Orbigny) (part), Annals and Mag. Nat. History, ser. 2, vol. 19, p. 296, pl. 11, figs. 36-38 (not figs. 35, 39, 40), 1857.

Bulimina presli Reuss var. *pyrula* Parker and Jones (not D'Orbigny), Philos. Trans., vol. 155, p. 372, pl. 15, figs 8, 9, 1865.

Bulimina doliolum Terquem and Terquem, Soc. Zool. France Bull., vol. 11, p. 333, pl. 11, figs. 17, 18, 1886.

Bulimina ovoides Terquem and Terquem, idem, p. 334, pl. 11, fig. 20.

Bulimina pyrula D'Orbigny var. *spinescens* Flint (not H. B. Brady), U. S. Nat. Mus. Rept., 1897, p. 290, pl. 37, fig. 1, 1899.

Cushman, U. S. Nat. Mus. Bull. 104, pt. 3, p. 102, pl. 20, fig. 2, 1922.

Bulimina (Desinobulimina) turgida Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 16, p. 20, pl. 3, figs. 22-24, 1940.

Test ovate, broadest near the middle, rounded at both ends but with the apertural end narrower and more pointed; chambers distinct, much inflated, giving the test a very irregular appearance; sutures distinct, depressed; wall smooth except for the base, which is usually ornamented with 2 or 3 short spines, finely perforate; aperture curved, terminal in the adult, with a broad tooth. Length of figured specimens 0.75 mm., 0.95 mm., 1.12 mm.; diameter 0.50 mm., 0.55 mm., 0.55 mm.

The types are from sta. E no. 9, Lat. 40° 21′ 54″ N., Long. 70° 55′ 35″ W., southeast of Montauk Point, Long

Island, in 51 fathoms, and sta. F no. 24, Lat. 39° 52′ 40″ N., Long. 72° 14′ W., southeast of Fire Island Inlet, in 49 fathoms. The species occurs along the eastern coast of the United States and in the vicinity of Norway and the British Isles.

This species is quite variable. The immature specimens are almost completely involute, becoming much more evolute in the adult. The figure of an immature specimen from Dröbach, Norway, is given to show this characteristic and also to show the species *"Bulimina doliolum* Terquem". The swollen, inflated chambers and heavy, short spines make it easy to identify the species.

Species originally referred to BULIMINA but not here included

The following species were originally described as *Bulimina* but are not included in the present discussion of that genus:

Bulimina acicula Costa, Accad. pontaniana Atti, vol. 8, pt. 2, p. 338, pl. 22, fig. 6, 1856 (= *Pyrulina?*).

B. acicula Andreae, Specialkarte Elsass-Lothringen Abh., vol. 2, pt. 3, p. 277, pl. 12, fig. 13, 1884 (See *Turrilina andreaei* Cushman).

B. acuta Costa, Accad. pontaniana Atti, vol. 7, pt. 2, p. 336, pl. 13, fig. 25, 1856 (A homonym of *B. acuta* Reuss 1851. We have no typical material).

B. andreae Rzehak, K. naturh. Hofmuseums Wien, vol. 6, p. 2, (list), 1891 (nomen nudum).

B. andreaei Schubert, Deutscher. Naturwiss.-med. Ver. Böhmen "Lotos" Sitzungsber., p. 59, pl. 2, 1900 (= *Virgulina* (*Virgulinella*) *pertusa* Reuss, Cushman, Cushman Lab. Foram. Research Special Pub. 9, p. 31, pl. 5, figs. 6-9, 1937).

B. arcuata Stache, *Novara*-Exped., Geol. Theil, vol. 1, pt. 2, p. 269, pl. 24, figs. 18a-c, 1865 (homonym of *B. arcuata* D'Orbigny, 1826. = ?).

B. auricula Heron-Allen and Earland, *Discovery* Repts., vol. 4, p. 351, pl. 9, figs. 1, 2, 1932 (= *Buliminella?*).

B. auriculata Terquem, Soc. Géol France Mém., ser. 3, vol. 2, p. 115, pl. 12(20), fig. 14, 1882 (homonym of *B. auriculata* Bailey, 1851. = ?).

B. brevicona Perner, Foram. Ceskeho Cenomanu, p. 54, pl. 3, figs. 1a, b, 1892 (= *Arenobulimina brevicona* (Perner) Cushman).

B. candida Terquem, Soc. Géol. France Mém., ser. 3, vol. 2, p. 111, pl. 11(19), figs. 30, 31, 1882 (= *Valvulina candida* (Terquem)).

B. chapmani Heron-Allen and Earland, British Antarctic Exped., Zoology, vol. 6, p. 130, pl. 4, figs. 18-20, 1922 (see *Pseudobulimina chapmani* (Heron-Allen and Earland)).

B. compressa Bailey, Smithsonian Contr., vol. 2, art. 3, p. 12, pl., figs. 35-37, 1851 (= *Virgulina compressa* (Bailey) Cushman, U. S. Nat. Mus. Bull. 104, pt. 3, p. 116, pl. 24, figs. 2, 3, 1922).

B. compressa Carsey, Texas Univ. Bull. 2612, p. 29, pl. 4, fig. 14, 1926 (see *Buliminella carseyae* Plummer).

B. conoidea Perner, Foram. Ceskeho Cenomanu, p. 55, pl. 3, figs. 5a, b, 1892 (= *Arenobulimina conoidea* (Perner) Cushman, Cushman Lab. Foram. Research Special Pub. 8, p. 38, pl. 4, figs. 1, 2, 1937).

B. contorta Gümbel, Anleit. geol. Beob. Alpenreisen, D. O. Alp. Ver. Zeitschr., Beilage, p. 105, fig. 25 [plate], fig. 22, 1878 (= ?).

B. conulus Terquem, Soc. Géol. France Mém., ser. 3, vol. 2, p. 116, pl. 12(20), fig. 17, 1882 (see *Buliminella conulus* (Terquem)).

B. convoluta Williamson var. *dehiscens* Heron-Allen and Earland, Royal Micr. Soc. Jour., 1924, p. 143, pl. 8, figs. 26-28 (= *Ceratobulimina dehiscens* (Heron-Allen and Earland) Cushman and Harris, Cushman Lab. Foram. Research Contr., vol. 3, p. 176, pl. 29, figs. 7a-c, 1927).

B. convoluta Williamson var. *nitida* Millett, Royal Micr. Soc. Jour., 1900, p. 280, pl. 2, fig. 10 (= *Cushmanella?*).

B. cuneiformis Terquem, Essai sur le classement des animaux qui vivent sur la plage et dans les environs de Dunkerque, pt. 3, p. 127, pl. 16, figs. 11a, b, 1881 (= arenaceous form).

B. cuneiformis Terquem, Soc. Géol. France Mém., ser. 3, vol. 2, p. 112, pl. 12(20), figs. 2a, b, 1882 (homonym of *B. cuneiformis* Terquem, 1881. We have no typical material).

B. cylindracea Costa, Accad. pontaniana Atti, vol. 8, pt. 2, p. 269, pl. 15, fig. 10, 1856 (= *Virgulina*).

B. declivis Reuss, Akad. Wiss. Wien Sitzungsber., vol. 48, pt. 1, p. 55, pl. 6, fig. 70; pl. 7, fig. 71, 1863 (see *Robertina declivis* (Reuss)).

B. depressa Perner, Foram. Ceskeho Cenomanu, p. 55, pl. 3, figs. 3a, b, 1892 (= *Pernerina depressa* (Perner) Cushman, Am. Jour. Sci., vol. 36, p. 19, pl. 1, figs. 5-7, 1933).

B. d'orbignyi Reuss, Verstein. böhm. Kreideformation, pt. 1, p. 38, pl. 13, figs. 74a, b, 1845 (= *Arenobulimina d'orbignyi* (Reuss) Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 10, p. 30, pl. 5, figs. 13, 14, 1934).

B. elegans D'Orbigny, Annales sci. nat., vol. 7, p. 270, no. 10, Modèles, no. 9, 1826 (see *Buliminella elegans* (D'Orbigny)).

B. elegans D'Orbigny var. *gibba* Schubert, K.-k. geol. Reichsanstalt Jahrb., vol. 53, p. 416, pl. 19, figs. 6a-c, 1904 (homonym of *B. gibba* Fornasini, 1901. We have no typical material).

B. elegantissima D'Orbigny, Voyage dans l'Amérique méridionale, vol. 5, Foraminifères, p. 51, pl. 7, figs. 13, 14, 1839 (see *Buliminella elegantissima* (D'Orbigny)).

B. elegantissima D'Orbigny var. *apiculata* Chapman, Linnean Soc. London Jour., Zoology, vol. 30, p. 31, pl. 14, fig. 77, 1908 (see *Buliminella madagascariensis* (D'Orbigny) var. *spicata* Cushman and Parker).

B. elegantissima D'Orbigny var. *compressa* Millett, Royal Micr. Soc. Jour., 1900, p. 277, pl. 2, fig. 5 (see *Buliminella parallela* Cushman and Parker).

B. elegantissima D'Orbigny var. *fusiformis* Sidebottom, Royal Micr. Soc. Jour., 1918, p. 23, pl. 3, figs. 8-10 (see *Buliminella madagascariensis* (D'Orbigny)).

B. elongata D'Orbigny var. *cylindrica* Grzybowski, Akad. Umiej., Wydz. mat.-przr. Rozpr., Krakow, vol. 9, p. 189, pl. 2, fig. 14 (pl. 1 in text), 1894 (homonym of *B. cylindrica* Roemer, 1838. We have no typical material).

B. flexa Terquem, Soc. Géol. France Mém., ser. 3, vol. 2, p. 115, pl. 12(20), fig. 15, 1882 (see *Buliminella flexa* (Terquem)).

B. frons Olszewski, Sprawozd. Kom. Fizyj. Akad. Umiej. Krakowie, vol. 9, p. 121, pl. 2, fig. 1, 1875 (= *Arenobulimina frons* (Olszewski) Cushman, Cushman Lab. Foram. Research Special Pub. 8, p. 44, pl. 4, fig. 28, 1937).

B. galliheri Kleinpell, Miocene stratigraphy of California, p. 253,

pl. 17, figs. 2, 5, Tulsa, 1938 (see *Globobulimina galliheri* (Kleinpell)).

B. gregorii Chapman, Royal Soc. Victoria Proc., vol. 16, p. 187, pl. 22, figs. 3, 3a, 1904 (= ? Described by Chapman as finely arenaceous).

B. imbricata Reuss, Haidinger's Naturwiss. Abh., vol. 4, pt. 1, p. 38, pl. 3, fig. 7, 1851 (see *Buliminella imbricata* (Reuss)).

B. imperatrix Karrer, Akad. Wiss. Wien Sitzungsber., vol. 57, pt. 1, p. 176, pl. 4, fig. 11, 1868 (see *Robertina imperatrix* (Karrer)).

B. incrassata Karrer var. *elongata* Seguenza, R. Accad. Lincei Atti, ser. 3, vol. 6, p. 146, 1880 (homonym of *B. elongata* D'Orbigny, 1846).

B. inflata Perner, Foram. Ceskeho Cenomanu, p. 55, pl. 3, figs. 4a-c, 1892 (= *Arenobulimina brevicona* (Perner) Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 10, pp. 35, 36, pl. 6, figs. 7a, b, 1934).

B. intorta Terquem, Soc. Géol. France Mém., ser. 3, vol. 2, p. 115, pl. 12(20), fig. 16, 1882 (see *Buliminella intorta* (Terquem)).

B. irregularis Terquem, idem, p. 112, pl. 12(20), figs. 1a, b (see *Buliminella irregularis* (Terquem)).

B. jaekeli Franke, Abh. geol.-paleont. Inst. Greifswald, vol. 6, p. 24, pl. 2, figs. 15a-c, 1925 (= *Pernerina depressa* (Perner) Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 10, p. 36, 1934).

B. laevis Beissel, Preuss geol. Landesanstalt Abh., n. ser., vol. 3, p. 66, pl. 12, figs. 39-43, 1891 (see *Buliminella laevis* (Beissel)).

B. madagascariensis D'Orbigny, Annales sci. nat., vol. 7, p. 270, no. 17, 1826 (see *Buliminella madagascariensis* (D'Orbigny)).

B. madrugaensis Bermúdez, Soc. cubana historia nat. Mem., vol. 12, no. 2, p. 89, text figs. 1-3, 1938 (= *Angulogerina*?).

B. mammillata Costa, Accad. pontaniana Atti, vol. 7, pt. 2, p. 335, pl. 18, fig. 16, 1856 (= *Virgulina*?).

B. marginata D'Orbigny var. *biserialis* Millett, Royal Micr. Soc. Jour., 1900, p. 278, pl. 2, fig. 7 (= *Suggrunda*?).

B. minutissima Wright, in Reade, Liverpool Geol. Soc. Proc., vol. 9, p. 190, pl. 13, figs. 9-12, 1902 (= *Ceratobulimina*? Referred by Earland to *Robertina*).

B. normani Goës, K. svenska vetensk. akad. Handl., vol. 25, no. 9, p. 47, pl. 9, figs. 437, 438, 1894 (= *Robertina*?).

B. obesa Reuss, Haidinger's Naturwiss. Abh., vol. 4, p. 40, pl. 3, fig. 12, 1851 (= *Arenobulimina obesa* (Reuss) Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 10, p. 31, pl. 5, fig. 20, 1934).

B. obliqua D'Orbigny, Soc. Géol. France Mém., ser. 1, vol. 4, p. 40, pl. 4, figs. 7, 8, 1840 (= *Arenobulimina obliqua* (D'Orbigny) Cushman, Cushman Lab. Foram. Research Contr., vol. 7, p. 36, pl. 5, figs. 5a-c, 1931).

B. obliqua Terquem, Soc. Géol. France Mém., ser. 3, vol. 2, p. 118, pl. 12(20), fig. 23, 1882 (see *Buliminella semi-nuda* (Terquem)).

B. obtusa D'Orbigny, Soc. Géol. France Mém., ser. 1, vol. 4, p. 39, pl. 4, figs. 5, 6, 1840 (see *Buliminella obtusa* (D'Orbigny)).

B. ovigera Terquem, Soc. Géol. France Mém., ser. 3, vol. 2, p. 108, pl. 11(19), figs. 17-20, 1882 (see *Robertina ovigera* (Terquem)).

B. ovula Terquem, idem, p. 113, pl. 12(20), fig. 5, 1882 (see *Buliminella turbinata* (Terquem)).

B. ovulum Harting, Ver. kon. akad. Wetensch., vol. 10, p. 9, pl. 1, figs. 10a, b, 1864 (homonym of *B. ovula* D'Orbigny, 1839. Figure unrecognizable).

B. parkeri Terquem and Terquem, Soc. Zool. France Bull., vol. 11, p. 334, pl. 11, fig. 9, 1886 (see *Robertina parkeri* (Terquem and Terquem)).

B. (?) petalifera Howe, Louisiana Dept. Cons. Geol. Bull. 14, p. 63, pl. 9, figs. 22, 23, 1939 (= *Discorbis*).

B. polystropha Reuss, Verstein böhm. Kreideformation, pt. 2, p. 100, pl. 24, fig. 53, 1846 (= *Verneuilina polystropha* (Reuss), Cushman, Cushman Lab. Foram. Research Special Pub. 7, p. 11, pl. 1, figs. 14, 15, 1937).

B. preslii Reuss, Verstein böhm. Kreideformation, pt. 1, p. 33, pl. 13, fig. 72, 1845 (= *Arenobulimina preslii* (Reuss) Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 10, p. 29, pl. 5, figs. 12, 13, 1934).

B. preslii Reuss var. *sabulosa* Chapman, Royal Micr. Soc. Jour., 1892, p. 7, pl. 12, fig. 5 (= *Arenobulimina sabulosa* (Chapman), Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 10, p. 32, pl. 6, figs. 6a, b, 1934).

B. pulchra Terquem, Soc. Géol. France Mém., ser. 3, vol. 2, p. 114, pl. 12(20), figs. 8, 9, 11, 12 (not fig. 10), 1882 (= *Buliminella*).

B. punctata D'Orbigny, Annales sci. nat., vol. 7, p. 270, no. 11, 1826 (see *Bulminella punctata* (D'Orbigny)).

B. pupa Terquem, Soc. Géol. France Mém., ser. 3, vol. 2, p. 116, pl. 12(20), figs. 18a, b, 1882 (see *Buliminella pupa* (Terquem)).

B. pupoides D'Orbigny var. *brevis* Seguenza, R. accad. Lincei Atti, ser. 3, vol. 6, p. 146, 1880 (homonym of *B. brevis* D'Orbigny, 1826).

B. pupoides D'Orbigny var. *convoluta* Williamson, Recent Foraminifera of Great Britain, p. 63, pl. 5, figs. 132, 133, 1858 (see *Pseudobulimina convoluta* (Williamson)).

B. pupoides D'Orbigny var. *fusiformis* Williamson, idem, p. 63, pl. 5, figs. 129, 130, 1858 (= *Virgulina*—not *V. fusiformis* Cushman).

B. puschi Reuss, Haidinger's Naturwiss. Abh., vol. 4, p. 37, pl. 3, figs. 6a, b, 1851 (= *Arenobulimina puschi* (Reuss) Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 10, p. 30, pl. 5, figs. 18a, b, 1934).

B. pusilla Brotzen, Sveriges geol. undersökning, ser. C, no. 391, vol. 30, no. 3, p. 127, pl. 8, fig. 4; text fig. 44, 1936 (see *Buliminella pusilla* (Brotzen)).

B. pygmaea Egger, Neues Jahrb., 1857, p. 284, pl. 12, figs. 10, 11 (= ?).

B. pyrula D'Orbigny var. *perversa* Cushman, U. S. Nat. Mus. Bull. 100, vol. 4, p. 163, text figs. 2a-c, 1921 (see *Globobulimina perversa* (Cushman)).

B. pyrula D'Orbigny var. *spinosa* Seguenza, R. accad. Lincei Atti, ser. 3, vol. 6, p. 147, 1880 (homonym of *B. spinosa* Seguenza, 1862).

B. rhomboidalis Costa, Accad. pontaniana Atti, vol. 8, pt. 2, pl. 13, fig. 24, 1856 (= *Uvigerina*?).

B. rimosa Marsson, Naturw. Ver. Neu-Vorpommern u. Rügen Mitth., vol. 10, p. 153, pl. 3, figs. 2a, b, 1878 (= *Ataxophragmium rimosum* (Marsson) Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 10, p. 32, pl. 6, figs. 3-5, 1934).

B. robertsi Howe and Ellis, in Howe, Louisiana Dept. Cons. Geol. Bull. 14, p. 63, pl. 8, figs. 32, 33, 1939 (see *Buliminella robertsi* (Howe and Ellis)).

B. scabra Williamson, Recent Foraminifera of Great Britain, p.

65, pl. 5, figs. 136, 137, 1858 (*B. arenacea* on expl. of plate) (= *Eggerella scabra* (Williamson) Cushman, Cushman Lab. Foram. Research Special Pub. 8, p. 50, pl. 5, figs. 10, 11, 1937).

B. scalariformis Terquem, Soc. Géol. France Mém., ser. 3, vol. 2, p. 114, pl. 12(20), fig. 13, 1882 (see *Buliminella irregularis* (Terquem)).

B. sellini Brotzen, Deutschen Palästina-Ver. Zeitschr., Jahrg. 1934, p. 59, pl. 4, fig. 2 (= *Discorbis*?).

B. semi-nuda Terquem, Soc. Géol. France Mém., ser. 3, vol. 2, p. 117, pl. 12(20), fig. 21, 1882 (see *Buliminella semi-nuda* (Terquem)).

B. striato-punctata Terquem, idem, p. 116, pl. 12(20), fig. 19 (see *Buliminella pupa* (Terquem)).

B. subbulbiformis Rzehak, K. naturh. Hofmuseums Wien, vol. 6, pp. 2, 9, (list), 1891 (nomen nudum).

B. subcylindrica H. B. Brady, Quart. Jour. Micr. Sci., vol. 21, p. 56, 1881 (see *Robertina subcylindrica* (H. B. Brady)).

B. subdeclivis Rzehak (no reference or information concerning this species).

B. subsphaerica Reuss, Verstein. Böhm. Kreideformation, pt. 2, p. 109, pl. 24, fig. 53, 1846 (= *Arenobulimina subsphaerica* (Reuss) Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 10, p. 30, pl. 5, fig. 16, 1934).

B. subteres H. B. Brady, in Wright, Belfast Nat. Field Club, App. 1880, p. 180, pl. 8, figs. 2, 2a, 1881 (see *Robertina subteres* (H. B. Brady)).

B. sulcata D'Orbigny, Annales sci. nat., vol. 7, p. 269, no. 3, 1826 (=*Uvigerina*?).

B. terquemiana Heron-Allen and Earland, Royal Micr. Soc. Jour., 1911, p. 314, pl. 9, figs. 13, 14 (see *Buliminella semi-nuda* (Terquem)).

B. textilariformis Stache, *Novara*-Exped., Geol. Theil, vol. 1, pt. 2, p. 268, pl. 24, figs. 17a-c, 1865 (=?).

B. trigona Chapman, Geol. Soc. London Quart. Jour., vol. 48, p. 514, pl. 15, fig. 8, 1892 (= *Arenobulimina? trigonula* (Chapman) var. *inornata* (Chapman) Cushman, Cushman Lab. Foram. Research Special Pub. 8, p. 44, 1937).

B. trigonula Chapman var. *inornata* Chapman, South African Mus. Ann., vol. 4, no. 10, p. 224, pl. 29, fig. 3, 1904 (= *Arenobulimina? trigonula* (Chapman) var. *inornata* (Chapman) Cushman, Cushman Lab. Foram. Research Special Pub. 8, p. 44, 1937).

B. trilobata Franke, Preuss. Geol. Landes. Abh., n. ser., vol. 3, p. 161, pl. 14, fig. 26, 1928 (= *Ataxophragmium*? Homonym of *B. trilobata* D'Orbigny, 1826).

B. trocheata Terquem, Soc. Géol. France Mém., ser. 3, vol. 2, p. 111, pl. 11(19), fig. 33, 1882 (= *Arenobulimina*?).

B. truncata Reuss, Verstein. Böhm. Kreideformation, pt. 1, p. 37, pl. 8, fig. 73, 1845 (= *Arenobulimina truncata* (Reuss) Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 10, p. 29, pl. 5, figs, 8, 9, 1934).

B. turbinata Terquem, Soc. Géol. France Mém., ser. 3, vol. 2, p. 113, pl. 12(20), figs. 6, 7, 1882 (see *Buliminella turbinata* (Terquem)).

B. uviformis Terquem, idem, p. 110, pl. 11(19), figs. 27a, b, 1882 (= *Valvulina*).

B. variabilis D'Orbigny, Soc. Géol. France Mém., ser. 1, vol. 4, p. 40, pl. 4, figs. 9-12, 1840 (= *Ataxophragmium variabile* (D'Orbigny) Reuss, Models nos. 6 and 7, 1865).

B. williamsoniana H. B. Brady, Quart. Jour. Micr. Sci., vol. 21, p. 56, 1881 (see *Buliminoides williamsoniana* (H. B. Brady)).

Genus NEOBULIMINA Cushman and Wickenden, 1928

Neobulimina Cushman and Wickenden, Cushman Lab. Foram. Research Contr., vol. 4, p. 12, 1928.

Cushman, idem, Special Pub. 1, p. 247, 1928; idem, Special Pub. 4, p. 220, 1933.

Genotype *Neobulimina canadensis* Cushman and Wickenden, 1928.

Test in the early stages triserial, as in *Bulimina;* adult biserial, not compressed; chambers inflated, simple; wall calcareous, perforate, aperture in the triserial stage as in *Bulimina,* in the adult broader, tending to become subterminal. Cretaceous.

So far as known the species of *Neobulimina* are all confined to the Cretaceous.

Neobulimina minima Tappan

Plate 29, figures 28, 29

Neobulimina minima Tappan, Jour. Paleontology, vol. 14, p. 117, pl. 19, figs. 5a-c, 6, 1940; idem, vol. 17, p. 597, pl. 81, fig. 16, 1943.

Test minute, early stage triserial, later stage biserial, final pair of chambers forming approximately one-third of the test, slightly twisted, nearly circular in cross-section; chambers inflated, slightly elongate, wall calcareous, surface smooth, aperture broad, loop-shaped at the base of the last-formed chamber. Length of holotype, 0.26 mm.; breadth, 0.10 mm.; width, 0.08 mm.; length of paratype, 0.21 mm.; breadth, 0.09 mm.—Tappan.

The types are from the Lower Cretaceous Grayson formation, middle and top of zone 1, Grayson Bluff, Denton Creek, 3½ miles northeast of Roanoke, 2 miles by road east of the Fort Worth-Denton highway, Denton County, Texas. The species has also been recorded from the Duck Creek formation of Texas and Oklahoma.

It is somewhat smaller, more slender, and with more gradually increasing chambers than typical specimens of *Neobulimina canadensis* Cushman and Wickenden. The two forms are undoubtedly closely related, and it is possible that some Upper Cretaceous forms referred to *N. canadensis* are more closely related to *N. minima.*

Neobulimina canadensis Cushman and Wickenden

Plate 29, figures 32, 33

Neobulimina canadensis Cushman and Wickenden, Cushman Lab. Foram. Research Contr., vol. 4, p. 13, pl. 1, figs. 1, 2, 1928.

Cushman, Tennessee Div. Geol. Bull. 41, p. 48, pl. 8, figs. 1a-c, 1931; Cushman Lab. Foram. Research Special Pub. 4, pl. 22, figs. 24a, b, 1933; idem, Special Pub. 5, pl. 27, figs. 15a-c, 1933.

Cushman and Parker, idem, Contr., vol. 12, p. 9, pl. 2, figs. 9, 10a, b, 1936.

Jennings, Bull. Am. Paleontology, vol. 23, no. 78, p. 31, pl. 3, fig. 22, 1936.

Albritton and Phleger, Jour. Paleontology, vol. 11, p. 352, 1937.

Frizzell, idem, vol. 17, p. 350, pl. 57, fig. 3, 1943.

Cushman and Todd, Cushman Lab. Foram. Research Contr., vol. 19, p. 66, 1943.

Cushman, idem, Contr., vol. 20, p. 93, pl. 14, figs. 12, 13, 1944.

Cushman and Deaderick, Jour. Paleontology, vol. 18, p. 337, pl. 53, figs. 9, 10, 1944.

Cushman, U. S. Geol. Survey Prof. Paper 206, p. 125, pl. 52, figs. 11, 12, 1946.

Test small, elongate, fusiform, greatest width near the middle, tapering slightly toward either end, about 2½ times as long as broad in adult specimens, early triserial stage of 12 to 18 chambers, the biserial adult stage of 4 to 6 chambers, each part making about one-half the mass of the test; chambers distinct, subglobular, inflated; sutures very distinct, depressed; wall calcareous, coarsely perforate, in some of the thicker-walled specimens appearing almost reticulate; aperture in the early triserial portion oblique and comma-shaped, in the adult biserial stage broader, the portion at the basal edge of the chamber broad and the elongate axis nearly at right angles to the margin of the chamber, the whole aperture in the adult at the base of a distinct depression. Length 0.30 mm., breadth 0.13 mm., breadth of biserial portion 0.13 mm., thickness 0.09 mm.

The types of the species are from the Upper Cretaceous of Alberta, from Imperial Ribstone Well at a depth of 360-370 feet, Land Subdivision 6, Sec. 6, T. 45, R. 1 W, 4th meridian. The species occurs in the Upper Cretaceous of the United States in formations of Navarro, Taylor and Austin ages of the Gulf Coast area and in the Navesink marl of New Jersey. It is found also in the Bearpaw shale of Alberta, Canada, and is recorded from the Upper Cretaceous of Peru.

The microspheric form is more irregular and twisted than the megalospheric and is usually much less common. The young forms, which occur most commonly, do not show the biserial stage and appear like perfectly normal *Bulimina*. It differs from *Neobulimina irregularis* Cushman and Parker in being smaller, with more regular chambers that are less inflated and less globular in character.

Neobulimina spinosa Cushman and Parker

Plate 29, figure 31

Neobulimina spinosa Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 12, p. 9, pl. 2, figs. 11a, b, 1936.

Cushman, idem, Contr., vol. 20, p. 12, 1944; U. S. Geol. Survey Prof. Paper 206, p. 126, pl. 52, fig. 14, 1946.

Test small, about 1½ times as long as broad, widest portion of the test at a point about two-thirds of the distance from the initial end, the initial end covered with short spines sometimes as much as one-third of the way up the test; chambers inflated, about 9 in the triserial portion, 2 in the biserial; sutures distinct, depressed; wall transparent or partially so, coarsely perforate; aperture loop-shaped, with a distinct, slightly flaring lip, nearly terminal. Length 0.16 to 0.25 mm., diameter 0.10 to 0.17 mm.

The types are from the Upper Cretaceous Selma chalk, 1½ miles west of Sardis, on the Sardis-Henderson road, Henderson County, Tenn. The species occurs in the Upper Cretaceous of the United States in formations of lower Navarro age (below the Nacatoch sand) and of Taylor age in the Gulf Coast Region.

Neobulimina irregularis Cushman and Parker

Plate 29, figure 30

Neobulimina irregularis Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 12, p. 9, pl. 2, figs. 8a, b, 1936.

Loetterle, Nebraska Geol. Survey, ser. 2, Bull. 12, p. 38, pl. 5, fig. 12, 1937.

Cushman, U. S. Geol. Survey Prof. Paper 206, p. 125, pl. 52, fig. 13, 1946.

Test elongate, practically the same width throughout, except for the initial end which is tapering, about 5 times as long as broad in the microspheric form, shorter in the megalospheric, about 5 whorls in the triserial stage and 4 in the biserial stage of the adult form; chambers distinct, globular, irregular; sutures distinct, depressed; wall coarsely perforate; aperture broadly loop-shaped, extending from the base of the last-formed chamber. Length 0.20 to 0.43 mm., diameter 0.08 to 0.20 mm.

The types are from the Upper Cretaceous, Ector tongue of the Austin chalk, about 2.3 miles south of Sherman, Grayson County, Texas. This species occurs in the Upper Cretaceous of the United States in the Austin and Eagle Ford formations of Texas and the Niobrara formation of Kansas, Nebraska and South Dakota. It occurs also in the Boyne Beds of Manitoba, Canada.

The species bears considerable resemblance, in form, to *Verneuilina schizea* Cushman and Alexander but is definitely calcareous, with a *Bulimina* type of aperture and has the later chambers biserial. It has more globular, less regularly arranged chambers than *Neobulimina canadensis* Cushman and Wickenden and a larger biserial portion of the test.

Genus GLOBOBULIMINA Cushman, 1927

Globobulimina Cushman, Cushman Lab. Foram. Research Contr., vol. 3, p. 67, 1927.

Galloway and Wissler, Jour. Paleontology, vol. 1, p. 73, 1927.

Cushman, Cushman Lab. Foram. Research Special Pub. 1, p. 248, 1928; idem, Special Pub. 4, p. 220, 1933.

Bulimina (part) of authors.

Genotype *Globobulimina pacifica* Cushman, 1927.

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Test spiral, triserial, early chambers tending to elongate, later chambers extending backwards, and in the adult becoming involute or nearly so, the last 3 chambers often making up the whole exterior; wall calcareous, finely perforate; aperture loop-shaped, with a tooth or plate and internal tube or trough. Cretaceous (?), Tertiary, Recent.

The early stages of this genus are similar to *Bulimina*, after which stages the chambers extend backward and, in the megalospheric specimens particularly, enclose the earlier ones. The microspheric specimens alone are often difficult to place.

Globobulimina galliheri (Kleinpell) Cushman and Parker

Plate 29, figure 38

Bulimina galliheri Kleinpell, Miocene stratigraphy of California, p. 253, pl. 17, figs. 2, 5, Tulsa, 1938.

Weaver, Washington Univ. [Seattle] Pub. in Geology, vol. 6, p. 23 (list), 1944.

Globobulimina cf. *G. pacifica* Cushman and Hobson, Cushman Lab. Foram. Research Contr., vol. 11, p. 62, pl. 9, figs. 3a, b, 1935.

Test large, inflated, pyriform, triserial, the last whorl making up almost the entire test; chambers distinct, inflated; sutures distinct, depressed; wall smooth, finely perforate; aperture terminal, comma-shaped, almost round with surrounding edge slightly raised. Length, up to 0.9 mm.; breadth, 0.64 mm.—Kleinpell.

The species was described from the Miocene Monterey shale of California at the type locality. Kleinpell also records it from the lower Modelo shale near Girard, California. We have some poorly preserved specimens from the latter locality that are adequate for general study. The species occurs also in the San Lorenzo and Gallaway formations of California.

Our specimens, though poor, show very plainly that the species should be placed in the genus *Globobulimina*. As Kleinpell says, a few early chambers are sometimes seen at the base of the test but with a few exceptions this is not true of the adult specimens. The form differs from *G. pacifica* Cushman in being broader at the base, with somewhat more inflated chambers, and with the first chamber of the last whorl broader and more rounded.

Globobulimina globosa LeRoy

Globobulimina globosa LeRoy, Colorado School of Mines Quart., vol. 39, no. 3, p. 27, pl. 1, fig. 3; pl. 5, fig. 13, 1944.

Test ovate globular, nearly as thick as high, initial end broadly rounded, apertural end somewhat pointed; chambers distinct, last three comprise seven-eighths of the test; aperture comma-shaped. Length 0.76 mm., diameter 0.62 mm.

As a general rule this species occurs in small numbers within the Telisa. In the Lower Palembang it is occasionally present.

It differs from *Globobulimina pacifica* Cushman by being less elongate and by showing a broader base.—LeRoy.

This species was described from Miocene beds of Central Sumatra.

Globobulimina bulbosa LeRoy

Globobulimina bulbosa LeRoy, Colorado School of Mines Quart., vol. 39, no. 3, p. 85, pl. 2, fig. 1, 1944.

Test medium, bulbous, maximum diameter in lower third, base rather flat; chambers distinct, somewhat inflated, strongly overlapping; sutures distinct, slightly depressed; wall smooth; aperture elliptical with distinct lip. Length 0.71 mm., diameter (max.) 0.58 mm.

This species differs from *Globobulimina pacifica* Cushman by being more bulbous and less elongate. The species tends to be rather constant in character.—LeRoy.

This species was described from Miocene beds of West Java.

Globobulimina glabra Cushman and Parker, n.sp.

Plate 29, figures 35, 36

?Bulimina pyrula H. B. Brady (not D'Orbigny), *Challenger* Rept., Zoology, vol. 9, p. 399, pl. 50, figs. 7-10, 1884.

Test of medium size, ovate, the megalospheric form being broader at the base than the microspheric, the earlier whorls often visible in the young forms; chambers distinct, the first-formed chamber of the last whorl not completely enclosed in front view so that it is visible on both sides of the test, somewhat inflated; sutures distinct, slightly depressed; wall thin, smooth, with medium sized perforations; aperture comma-shaped, with a lip and high curved tooth. Length 0.45 to 0.55 mm., diameter 0.30 to 0.40 mm.

Holotype (Cushman Coll. No. 35851) from the Pliocene Vatican clay, clay pit behind the Vatican, Rome, Italy.

The species figured by Brady from New Zealand, the Ki Islands, and the Azores seems to resemble this form. It is probable that the distribution given by Brady includes more than one species. We have not found any specimens outside of the type locality.

The species may be differentiated from *Globobulimina pacifica* Cushman by the fact that the last two chambers do not enclose the third at the base of the test, hence it is visible from both sides. In many specimens the suture of the last chamber makes a wide angle with the vertical axis instead of curving downward as in *G. pacifica*.

Globobulimina pacifica Cushman

Plate 29, figure 37

Globobulimina pacifica Cushman, Cushman Lab. Foram. Research Contr., vol. 3, p. 67, pl. 14, fig. 12, 1927; Scripps Inst. Oceanography Bull., Tech. ser., vol. 1, p. 153, pl. 3, fig. 1, 1927.

Galloway and Wissler, Jour. Paleontology, vol. 1, p. 74, pl. 11, fig. 18, 1927.

Cushman and Moyer, Cushman Lab. Foram. Research Contr., vol. 6, p. 57, 1930.

?Cushman, Stewart and Stewart, San Diego Soc. Nat. History Trans., vol. 6, p. 66, pl. 5, fig. 4, 1930.

Cushman and Ponton, Florida Geol. Survey Bull. 9, p. 79, pl. 12, fig. 2, 1932.

Cushman, Cushman Lab. Foram. Research Special Pub. 4, pl. 22, figs. 22a, b, 1933; idem, Special Pub. 5, pl. 27, figs. 16a, b, 1933; ?Bernice P. Bishop Mus. Bull. 119, p. 123, pl. 15, fig. 1, 1934.

Campbell, Jour. Entom. and Zool., vol. 27, no. 3, p. 41, text fig. 1, 1935.

Palmer, Soc. cubana hist. nat. Mem., vol. 14, p. 296, 1940.

LeRoy, Colorado School of Mines Quart., vol. 36, no. 1, p. 33, pl. 3, figs. 70, 71, 1941

Schenck and Childs, Stanford Univ. Pub., Univ. Ser., Geol. Sci., vol. 3, no. 2, p. 27 (list), 1942.

Beck, Jour. Paleontology, vol. 17, p. 606, pl. 107, fig. 16, 1943.

Franklin, idem, vol. 18, p. 314, pl. 46, fig. 19, 1944.

LeRoy, Colorado School of Mines Quart., vol. 39, no. 3, p. 27, pl. 5, fig. 12, 1944

Weaver, Washington Univ. [Seattle] Pub. in Geology, vol. 6, no. 1, p. 24 (list), 1944.

Test oval, broadest near the bottom and gradually narrowing toward the apertural end; chambers distinct, the first-formed chamber of the last whorl narrow, usually surrounded on both sides by the last 2 chambers in front view, with only 2 chambers showing in rear view, very slightly inflated; sutures distinct, slightly depressed; wall thin, finely perforate, smooth; aperture loop-shaped, with a slight border and a broad apertural tooth. Length up to 1.50 mm., diameter 1.00 mm.

The types are from the eastern Pacific, Lat. 17° 18′ N., Long. 102° 22′ W., at 1,197 fathoms. The species is common along the west coast of North America. It has been recorded from the Miocene of Florida and California and questionably from the Pliocene of Humboldt County, California, and Vitilevu, Fiji. We have a single specimen from the Pliocene in Cañada de Aliso, Ventura County, California, 2.1 miles N. 74° E. of La Crosse Junction, in gray siltstone, 280 feet stratigraphically above the base of the first Pico sandstone. The specimen figured by Kleinpell from the Miocene of Reliz Canyon, Monterey County, California (Miocene stratigraphy of California, p. 260, pl. 8, fig. 7, Tulsa, 1938), does not seem to represent this species and we have no material to verify it. The species has been recorded from Eocene age to Recent from widely separated areas and these records need further study.

Globobulimina pacifica Cushman var. scalprata Cushman and Todd

Plate 30, figure 17

Globobulimina pacifica Cushman and Jarvis (not Cushman), Jour. Paleontology, vol. 4, p. 362, pl. 33, fig. 6, 1930.

Globobulimina pacifica Cushman var. *scalprata* Cushman and Todd, Cushman Lab. Foram. Research Special Pub. 15, p. 40, pl. 6, fig. 15, 1945.

Variety differing from the typical in the ornamentation of the test consisting of very fine, numerous, linear costae.

This variety is fairly common and varies somewhat in the relative prominence of the ornamentation.—Cushman and Todd.

The types are from the Miocene, half a mile east of Buff Bay, Jamaica.

Globobulimina perversa (Cushman) Cushman and Parker

Plate 29, figure 34

Bulimina pyrula D'Orbigny var. *perversa* Cushman, U. S. Nat. Mus. Bull. 100, vol. 4, p. 163, text figs. 2a-c, 1921.

Bulimina pyrula Cushman (not D'Orbigny), idem, p. 162, text figs. 1a-c, 1921.

Macfadyen, Egypt Geol. Survey, 1930, p. 54, pl. 1, figs. 16a, b, 1931.

Test large, pyriform, initial chambers sometimes showing very slightly at the base; chambers distinct, somewhat inflated, first-formed chamber of last whorl broad at the base; sutures distinct, the suture of the last-formed chamber in the portion that extends from the base up to the aperture very much depressed, so the chamber forms a very decided fold above it; aperture slightly curving, in a deep depression caused by the upward bulge of the chamber, with a thick, curving tooth. Length of figured specimen 1.25 mm., diameter 0.95 mm.

The types are from Recent material from *Albatross* sta. D5591, in 260 fathoms, Sibuko Bay, Borneo. The species occurs in the Miocene of Baden, Vienna Basin, Austria, the Pliocene of Castel Arquato, Italy, and the Recent deposits of the Philippine region.

This is one of the largest known species of *Globobulimina* and may be easily differentiated by the deeply depressed suture of the last chamber.

Globobulimina caribbea Cushman and Bermúdez

Globobulimina caribbea Cushman and Bermúdez, Cushman Lab. Foram. Research Contr., vol. 21, p. 73, pl. 12, figs. 1-3, 1945.

Test very large for the genus, slightly pyriform, early chambers slightly visible at the base, sides convex and tapering gradually toward the apertural end; chambers distinct, somewhat inflated, the last two making up a large portion of the surface of the test; sutures distinct, depressed, especially in the last-formed whorl; wall smooth except at the base where in some specimens there is a slight tendency to become spinose; aperture elongate, with a slight lip at one side and a somewhat thickened, curving tooth projecting distinctly above the general outline of the test. Length of adult specimens 1.90-2.45 mm.; diameter 1.13-1.57 mm. —Cushman and Bermúdez.

This species was described from off southern Cuba, *Atlantis* station 3345, lat. 21° 08′ N., long. 79° 56′ 30″ W., 690-700 fathoms.

This species, the largest of the genus so far known, can be distinguished from *Globobulimina perversa* (Cush-

man) by its larger size, slightly more elongate form, and the tendency to spinosity at the base.

Globobulimina sobrina Galloway and Morrey

Globobulimina sobrina Galloway and Morrey, Jour. Paleontology, vol. 5, p. 352, pl. 40, figs. 12a, b, 1931.

Test robust, ovate, broadest near the base, oval in cross section; apical end broadly rounded; chambers embracing, only three visible; sutures distinct, slightly depressed; wall smooth, very finely perforate; aperture virguline, with vertical tooth, near the periphery. Length 0.45 mm.

The Tabasco specimens are megaspheric and have a more rounded initial end than *B. pyrula* (D'Orbigny), the apertural end is less pointed, and it is not subtriangular in cross section. The form is shorter than *G. pacifica* Cushman.—Galloway and Morrey.

The types are from the "Cretaceous", near Puenta Piedra, on the Rio Puscatan, 19 kilometers south of Macuspana, Tabasco, Mexico. We have no material referable to the species.

SUPPLEMENT

The following species and varieties have become available since this work was completed:

Bulimina abatissae Selli, Annali Mus. Geol. Bologna, 2d ser., vol. 17, 1943-44, p. 58, pl. 1, fig. 15, 1944. Eocene, Italy.

B. bortonica Finlay, Royal Soc. New Zealand Trans., vol. 69, p. 100, pl. 12, figs. 25, 26, 1939. Middle Eocene, New Zealand.

B. bremneri Finlay, idem, vol. 69, p. 455, pl. 64, figs. 84-86, 1940. Lower to middle Miocene, New Zealand.

B. byramensis Cushman and Todd, Cushman Lab. Foram. Research Contr., vol. 22, p. 91, pl. 15, figs. 25, 26, 1946. Oligocene, Byram marl, Mississippi.

B. forticosta Finlay, Royal Soc. New Zealand Trans., vol. 69, p. 455, pl. 64, figs. 77-81, 1940. Upper middle Eocene to middle Oligocene, New Zealand.

B. mapiria Finlay, idem, vol. 69, p. 454, pl. 64, fig. 72, 1940. Uppermost Miocene, New Zealand.

B. miolaevis Finlay, idem, vol. 69, p. 454, pl. 64, figs. 70, 71, 1940. Lower Miocene, New Zealand.

B. pahiensis Finlay, idem, vol. 69, p. 455, pl. 64, figs. 87, 88, 1940. Upper middle Eocene, New Zealand.

B. petroleana Cushman and Hedberg var. *spinea* Cushman and Renz, Cushman Lab. Foram. Research Special Pub. 18, p. 37, pl. 6, fig. 13, 1946. Upper Cretaceous, Trinidad.

B. rakauroana Finlay, Royal Soc. New Zealand Trans., vol. 69, p. 454, pl. 64, figs. 75, 76, 1940. Upper Cretaceous (Santonian), New Zealand.

B. scobinata Finlay, idem, vol. 69, p. 455, pl. 64, figs. 82, 83, 1940. Middle to upper Oligocene, New Zealand.

B. sculptilis Cushman var. *paucicostata* Cushman and Ellisor, Jour. Paleontology, vol. 19, p. 562, pl. 75, fig. 15, 1945. Middle Oligocene, Anahuac formation, Texas.

B. senta Finlay, Royal Soc. New Zealand Trans., vol. 69, p. 454, pl. 64, figs. 73, 74, 1940. Lower to upper Miocene, New Zealand.

B. simaensis Makiyama and Nakagawa, Geol. Soc. Japan Jour., vol. 48, no. 572, p. 241, 1941. Pleistocene, Japan.

B. stokesi Cushman and Renz, Cushman Lab. Foram. Research Special Pub. 18, p. 37, pl. 6, fig. 14, 1946. Upper Cretaceous, Trinidad.

B. trigonalis ten Dam, Geol. Stichting Mededeelingen, ser. C-V, no. 3, p. 112, pl. 3, figs. 16, 17, 1944. Paleocene, Netherlands.

B. truncana Gümbel var. *aksuatica* Morozova, Soc. naturalistes Moscou, Bull., new ser., vol. 47, sect. geol., vol. 17, p. 74, pl. 3, fig. 3, 1939. Eocene, Russia.

B. truncanella Finlay, Royal Soc. New Zealand Trans., vol. 69, p. 455, pl. 64, figs. 89-91, 1940. Middle Eocene to upper Miocene, New Zealand.

B. (Desinobulimina) suteri Cushman and Renz, Cushman Lab. Foram. Research Special Pub. 18, p. 38, pl. 6, fig. 15, 1946. Upper Cretaceous, Trinidad.

Buliminella beaumonti Cushman and Renz, idem, Special Pub. 18, p. 36, pl. 6, fig. 7, 1946. Upper Cretaceous, Trinidad.

B. browni Finlay, Royal Soc. New Zealand Trans., vol. 69, p. 321, pl. 27, figs. 85, 86, 1939. Lower middle Eocene, New Zealand.

B. sauria Finlay, idem, vol. 69, p. 321, pl. 27, figs. 87, 97, 98, 1939. Upper Cretaceous (Santonian), New Zealand.

Globobulimina hannai Cushman and Ellisor, Jour. Paleontology, vol. 19, p. 562, pl. 76, fig. 1, 1945. Middle Oligocene, Anahuac formation, Texas.

Robertina lornensis Finlay, Royal Soc. New Zealand Trans., vol. 69, p. 114, pl. 12, figs. 27, 28, 1939. Lower Oligocene, New Zealand.

R. moodysensis Cushman and Todd, Cushman Lab. Foram. Research Contr., vol. 21, p. 94, pl. 15, figs. 10, 11, 1945. Eocene, Moodys marl member of Jackson formation, Mississippi.

Turrilina brevispira ten Dam, Geol. Stichting Mededeelingen, ser. C-V, no. 3, p. 110, pl. 3, fig. 14, 1944. Eocene (Ypresian), Netherlands.

PLATES 15–30

PLATE 15

FIGURE 1. *Terebralina regularis* Terquem. (After Terquem.) Jurassic, France. × 50.

FIGURE 2. *Turrilina andreaei* Cushman. (After Andreae.) Oligocene, France. × 70. *a,* Front view; *b,* rear view.

FIGURE 3. *T. alsatica* Andreae. (After Andreae.) Oligocene, France. × 70. *a,* Front view; *b,* rear view; *c,* apertural view.

FIGURE 4. *Buliminella obtusa* (D'Orbigny) Cushman and Parker. Cretaceous, Bougival, France. × 50. *a,* Front view; *b,* rear view; *c,* apertural view.

FIGURE 5. *B. imbricata* (Reuss) Cushman and Parker. Cretaceous, Lemberg, Galicia. × 115. *a,* Front view; *b,* rear view; *c,* apertural view.

FIGURE 6. *B. laevis* (Beissel) Cushman and Parker. Cretaceous, Friedrichsberg, near Aachen, Germany. × 50. *a,* Front view; *b,* rear view; *c,* apertural view.

FIGURE 7. *B. pusilla* (Brotzen) Cushman and Parker. (After Brotzen.) Cretaceous, Sweden. × 70.

FIGURE 8. *B. carseyae* Plummer. Cretaceous, Taylor marl, southeast of Del Valle, Texas. × 75, *a,* Front view; *b,* rear view; *c,* apertural view.

FIGURE 9. *B. carseyae* Plummer var. *plana* Cushman and Parker. Cretaceous, Navarro group, 6 miles east of Castroville, Texas. × 75. *a,* Front view; *b,* rear view; *c,* apertural view.

FIGURES 10, 11. *B. cushmani* Sandidge. Cretaceous. 10, Kemp clay, 1 mile west-southwest of Noack, Texas. 11, Gotzreuther Graben, near Siegsdorf, Bavaria. × 85.

FIGURE 12. *B. vitrea* Cushman and Parker. Cretaceous, Selma chalk, 2 miles west of Guntown, Mississippi. × 75. *a,* Front view; *b,* rear view; *c;* apertural view.

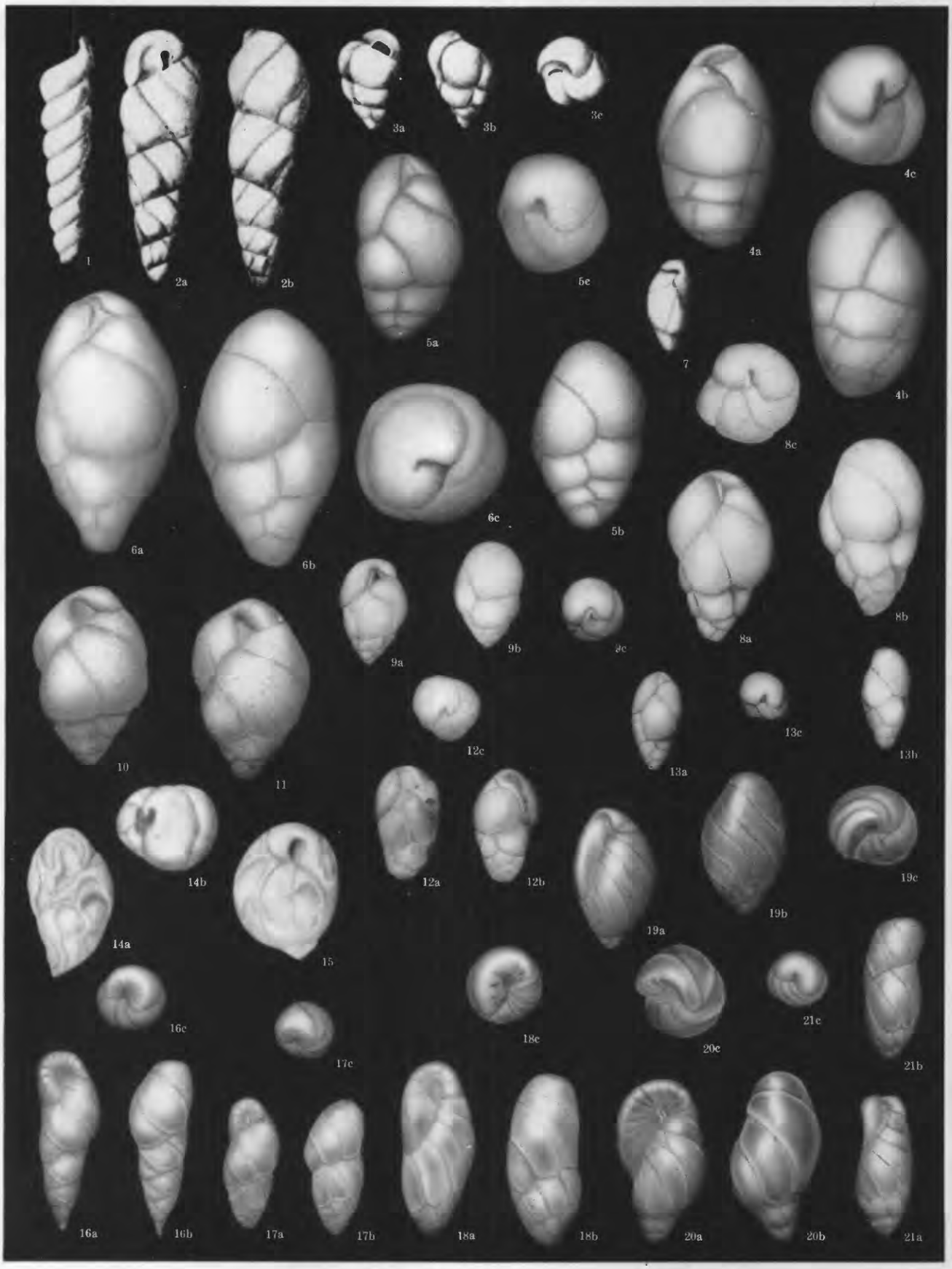
FIGURE 13. *B. fabilis* Cushman and Parker. Cretaceous, Taylor marl, 14.2 miles east of Hillsboro, Texas. × 85. *a,* Front view; *b,* rear view; *c,* apertural view.

FIGURES 14, 15. *B. colonensis* Cushman and Hedberg. (After Cushman and Hedberg.) Cretaceous, Venezuela. × 75. 14*a,* Front view; *b,* apertural view.

FIGURE 16. *B. irregularis* (Terquem) Cushman and Parker. Eocene, France. × 90. *a,* Front view; *b,* rear view; *c,* apertural view.

FIGURE 17. *B. intorta* (Terquem) Cushman and Parker. Eocene, France. × 90. *a,* Front view; *b,* rear view; *c.* apertural view.

FIGURES 18–21. *B. turbinata* (Terquem) Cushman and Parker. Eocene, France. *a,* Front view; *b,* rear view; *c,* apertural view. 18, 19, × 100. 20, 21, × 95, abnormal specimens.



TEREBRALINA, TURRILINA, AND BULIMINELLA

PLATE 16

FIGURE 1. *Buliminella flexa* (Terquem) Cushman and Parker. Eocene, France. × 95.

FIGURE 2. *B. conulus* (Terquem) Cushman and Parker. (After Terquem.) Eocene, France. × 30.

FIGURE 3. *B. pupa* (Terquem) Cushman and Parker. Eocene, France. × 95. *a*, Front view; *b*, rear view; *c*, apertural view.

FIGURES 4, 9. *B. semi-nuda* (Terquem) Cushman and Parker. Eocene, France. × 95. *a*, Front view; *b*, rear view; *c*, apertural view.

FIGURES 5, 6. *B. pulchra* (Terquem) Cushman and Parker. Eocene, France. × 70. *a*, Front view; *b*, rear view; *c*, apertural view.

FIGURE 7. *B. alabamensis* Cushman. (After Cushman.) Eocene, Water Valley, Alabama. × 70. *a*, Front view; *b*, side view.

FIGURE 8. *B. robertsi* (Howe and Ellis) Martin. Eocene, 3 miles north of Branson, Texas. × 110.

FIGURE 10. *B. basistriata* Cushman and Jarvis. Eocene, Trinidad. × 85.

FIGURE 11. *B. basistriata* Cushman and Jarvis var. *nuda* Howe and Wallace. Eocene, Danville Landing, Louisiana. × 85.

FIGURE 12. *B. grata* Parker and Bermúdez. (After Parker and Bermúdez.) Eocene, Cuba. × 65. *a*, Front view; *b*, rear view; *c*, apertural view.

FIGURE 13. *B. grata* Parker and Bermúdez var. *spinosa* Parker and Bermúdez. (After Parker and Bermúdez.) Eocene, Cuba. × 55. *a*, Front view; *b*, rear view; *c*, apertural view.

FIGURES 14, 15. *B. westraliensis* Parr. (After Parr.) Eocene, Australia. × 60.

FIGURES 16, 17. *B. obtusata* Cushman. Oligocene, Byram, Mississippi. × 95. 17*a*, Front view; *b*, rear view.

FIGURES 18, 19. *B. choctawensis* Cushman and McGlamery. (After Cushman and McGlamery.) Oligocene, Alabama. × 85.

FIGURE 20. *B. madagascariensis* (D'Orbigny) var. *spicata* Cushman and Parker. Oligocene, Australia. × 65. *a*, Front view; *b*, rear view.

FIGURE 21. *B. subfusiformis* Cushman. Miocene, California. × 85.

FIGURE 22. *B. curta* Cushman. Miocene, California. × 85.

FIGURE 23. *B. curta* Cushman var. *basispinata* R. E. and K. C. Stewart. (After R. E. and K. C. Stewart.) Pliocene, California. × 65.

FIGURE 24. *B. brevior* Cushman. Miocene, California. × 65.

BULIMINELLA

PLATE 17

FIGURE 1. *Buliminella californica* Cushman. Miocene, California. × 85.

FIGURE 2. *B. glomerata* Cushman and Parker, n. name (After Tolmachoff.) Miocene, Colombia. × 35.

FIGURES 3, 4. *B. dubia* Barbat and Johnson. (After Barbat and Johnson.) Miocene, California. × 55.

FIGURE 5. *B. henryana* Cushman and Kleinpell. (After Cushman and Kleinpell.) Miocene, California. × 65. *a*, Front view; *b*, apertural view.

FIGURE 6. *B. bassendorfensis* Cushman and Parker. Miocene, Oregon. × 65. *a*, Front view; *b*, rear view.

FIGURE 7. *B. semihispida* Kleinpell. (After Kleinpell.) Miocene, California. × 35. *a*, Front view; *b*, rear view; *c*, apertural view.

FIGURES 8, 9. *B. multicamera* Cushman and Parker. Pliocene, Italy. × 70. *a*, Front view; *b*, rear view.

FIGURES 10–12. *B. elegantissima* (D'Orbigny) Cushman. Recent. × 100. 10, Off Peru. 11, 12, Off Brazil.

FIGURE 13. *B. elegantissima* (D'Orbigny) Cushman var. *cochlea* Wiesner. (After Wiesner.) Recent, Antarctic. × 25.

FIGURE 14. *B. elegans* (D'Orbigny) Cushman and Parker. Drawn from D'Orbigny's model.

FIGURES 15–17. *B. madagascariensis* (D'Orbigny) Cushman and Parker. 15, 16, Oligocene, Australia. × 65. *a*, Front view; *b*, rear view. 17, Recent, New Zealand. × 85.

FIGURES 18, 19. *B. spinigera* Cushman. Recent, Atlantic. × 50.

FIGURES 20, 21. *B. milletti* Cushman. (After Cushman.) Recent, Fiji. × 65. *a*, Front view; *b*, apertural view.

FIGURE 22. *B. parallela* Cushman and Parker. Recent, off Brazil. × 135. *a*, Front view; *b*, rear view; *c*, apertural view.

FIGURES 23, 24. *Buliminoides williamsoniana* (H. B. Brady) Cushman. (After H. B. Brady.) Recent, Pacific. × 50. 23*a*, Front view; 23*b*, side view. 24*a*, Front view; 24*b*, apertural view.

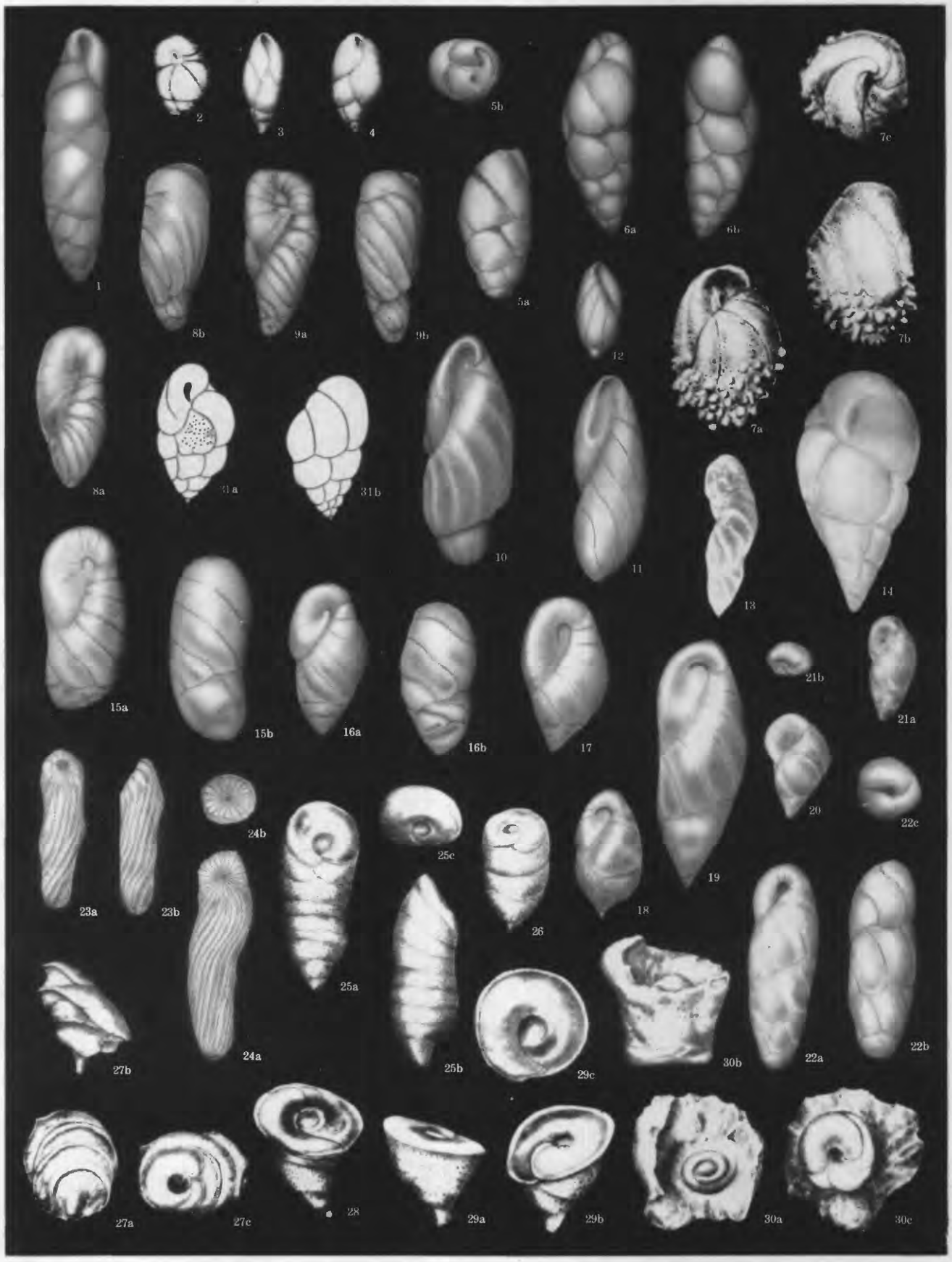
FIGURES 25, 26. *Ungulatella pacifica* Cushman. (After Cushman.) Recent, Pacific. × 40. *a*, Front view; *b*, side view; *c*, apertural view.

FIGURE 27. *U. peregrina* Cushman. (After Cushman.) Recent, Pacific. × 105. *a*, Front view; *b*, side view; *c*, apertural view.

FIGURES 28, 29. *U. conoides* Cushman. (After Cushman.) Recent, Pacific. × 105. *a*, Front view; *b*, side view, *c*, apertural view.

FIGURE 30. *U. capistra* Cushman. (After Cushman.) Recent, Pacific. × 80. *a*, Front view; *b*, side view, *c*, apertural view.

FIGURE 31. *Buliminella punctata* (D'Orbigny) Cushman and Parker. (After Fornasini.) Recent, Mediterranean. *a*, Front view; *b*, rear view.



BULIMINELLA, BULIMINOIDES, UNGULATELLA, AND BULIMINA

PLATE 18

FIGURE 1. *Robertina wilcoxensis* Cushman and Ponton. Eocene, Wilcox, 1 mile north of Ozark, Alabama. × 100. *a*, Front view; *b*, rear view.

FIGURE 2. *R. mcguirti* Howe. (After Howe.) Eocene, Cook Mountain, St. Maurice, Louisiana. *a*, Front view; *b*, rear view. × 80.

FIGURE 3. *R. plummerae* Cushman and Parker. Eocene, Claiborne, Bastrop Co., Texas. × 70. *a*, Front view; *b*, rear view.

FIGURE 4. *R. ovigera* (Terquem) Cushman and Parker. Eocene, France. × 85. *a*, Front view; *b*, rear view.

FIGURE 5. *R. germanica* Cushman and Parker. Oligocene, Germany. × 40. *a*, Front view; *b*, rear view.

FIGURE 6. *R. angusta* (Cushman) Cushman and Parker. Oligocene, Mississippi. × 55. *a*, Front view; *b*, rear view.

FIGURE 7. *R. declivis* (Reuss) Cushman and Parker. Oligocene, Germany. × 85. *a*, Front view; *b*, rear view.

FIGURES 8, 22. *R. austriaca* Reuss. Miocene, Austria. × 65. *a*, Front view; *b*, rear view;

FIGURES 9, 10. *R. imperatrix* (Karrer) Cushman and Parker. Miocene, Hungary. × 65. *a*, Front view; *b*, rear view.

FIGURE 11. *R. californica* Cushman and Parker. Pliocene, California. × 55. *a*, Front view; *b*, rear view.

FIGURE 12. *R. arctica* D'Orbigny. Recent, off Greenland. × 65. *a*, Front view; *b*, rear view.

FIGURE 13. *R. subcylindrica* (H. B. Brady) Cushman and Parker. Recent, off Brazil. × 65. *a*, Front view; *b*, rear view.

FIGURE 14. *R. charlottensis* (Cushman) Cushman, Recent, Queen Charlotte Sound. × 55. *a*, Front view; *b*, rear view.

FIGURE 15. *R. translucens* Cushman and Parker. Recent, off Ireland. × 85. *a*, Front view; *b*, rear view.

FIGURE 16. *R. bradyi* Cushman and Parker. Recent, Caribbean Sea. × 85. *a*, Front view; *b*, rear view.

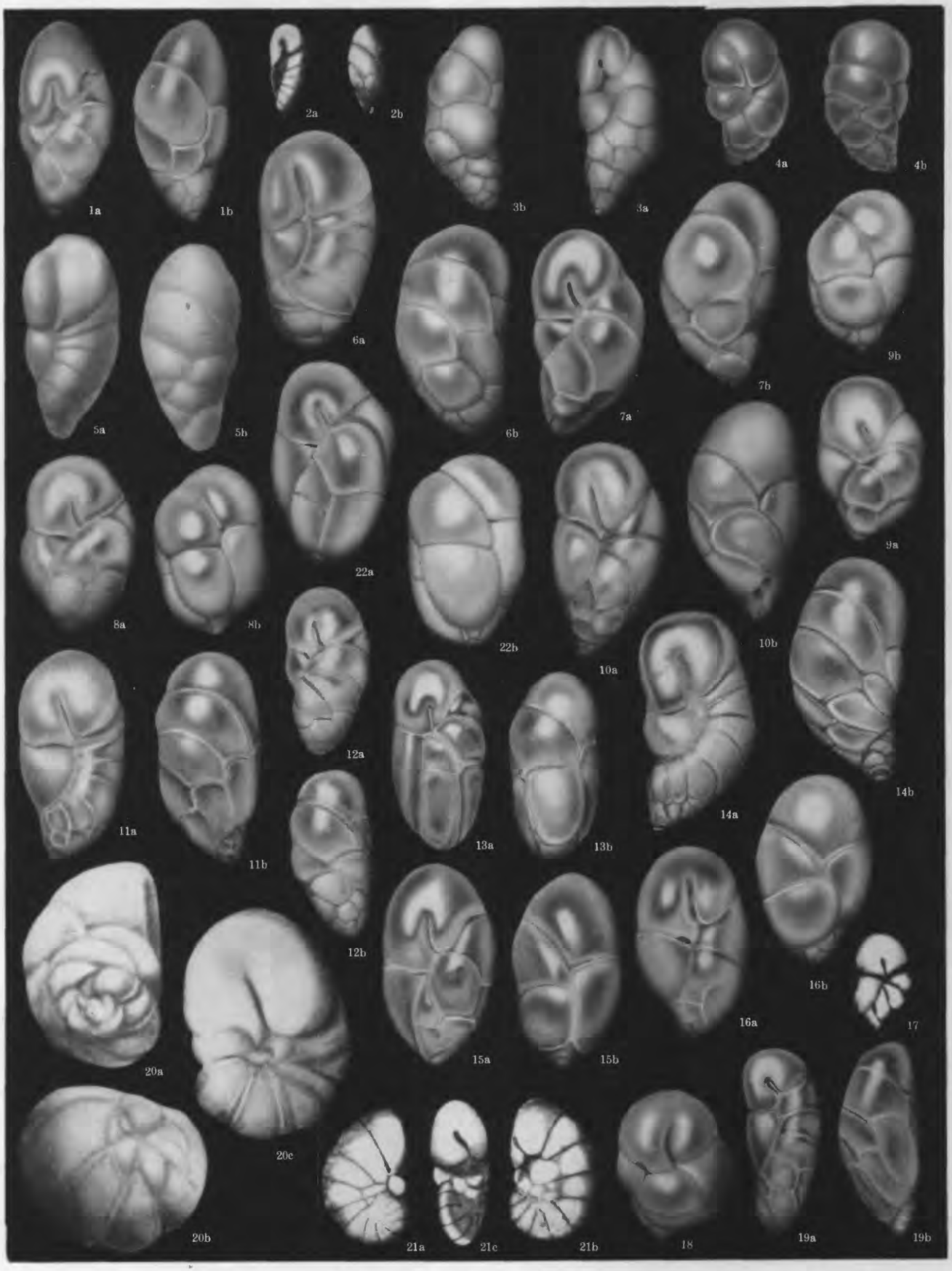
FIGURE 17. *R. parkeri* (Terquem and Terquem) Cushman and Parker. (After Terquem and Terquem.) Recent, off Norway.

FIGURE 18. *R. oceanica* Cushman and Parker, n. sp. Recent, off New Zealand. Holotype. × 35.

FIGURE 19. *R. subteres* (H. B. Brady) Cushman and Parker. Recent, off Ireland. × 85. *a*, Front view; *b*, rear view.

FIGURE 20. *Pseudobulimina chapmani* (Heron-Allen and Earland) Earland. (After Heron-Allen and Earland.) Recent, Antarctic. × 50. *a*, Dorsal view; *b*, ventral view; *c*, apertural view.

FIGURE 21. *P. glaessneri* Howe and Roberts. (After Howe.) Eocene, Cook Mountain, St. Maurice, Louisiana. × 55. *a*, Dorsal view; *b*, ventral view; *c*, apertural view.



ROBERTINA AND PSEUDOBULIMINA

PLATE 19

FIGURE 1. *Bulimina antiqua* Terquem and Berthelin. (After Terquem and Berthelin.) Jurassic, France. × 80.

FIGURES 2, 3. *B. incurva* Terquem. (After Terquem.) Jurassic, France. × 50.

FIGURE 4. *B. intricata* Terquem. (After Terquem.) Jurassic, France. × 50.

FIGURES 5, 6. *B. muricata* Terquem. (After Terquem.) Jurassic, France. × 55.

FIGURES 7–9. *B. prima* Terquem. (After Terquem.) Jurassic, France. Fig. 7, × 50. Figs. 8, 9, × 40.

FIGURE 10. *B. nannina* Tappan. (After Tappan.) Lower Cretaceous, Texas. × 60. *a*, Front view; *b*, rear view.

FIGURE 11. *B. murchisoniana* D'Orbigny. Cretaceous, Gravesend, England. × 35. *a*, Front view; *b*, apertural view.

FIGURES 12–15. *B. intermedia* Reuss. 12, 13, Cretaceous, Kosstitz, Bohemia. 14, 15, Cretaceous, Luschitz, Bohemia. Autotypes in Reuss collection at Vienna. × 35. *a* Front view; *b*, apertural view.

FIGURE 16. *B. acuta* Reuss. (After Reuss.) Cretaceous, Lemberg, Galicia.

FIGURE 17. *B. parva* Franke. Cretaceous, Mersch, near Hamm, Germany. × 100.

FIGURE 18. *B. exigua* Cushman and Parker. Cretaceous, Brownstown marl, Texas. × 65. *a*, Front view; *b*, apertural view.

FIGURES 19, 20. *B. kickapooensis* Cole. Cretaceous. 19, Upper part of Taylor marl, Red River Co., Texas. Holotype, megalospheric. × 55. *a*, Front view; *b*, apertural view. 20, Upper part of Taylor marl, Navarro Co., Texas. Paratype, microspheric. × 55.

FIGURES 21, 22. *B. kickapooensis* Cole var. *pingua* Cushman and Parker, Cretaceous, Corsicana marl, Limestone Co., Texas. 21, Holotype. 22, Paratype. × 40. *a*, Front view; *b*, apertural view.

FIGURES 23, 24. *B. taylorensis* Cushman and Parker. Cretaceous. 23, Upper part of Taylor marl, Red River Co., Texas. *a*, Front view; *b*, apertural view. × 60. 24, Upper part of Taylor marl, Bexar Co., Texas. × 70.

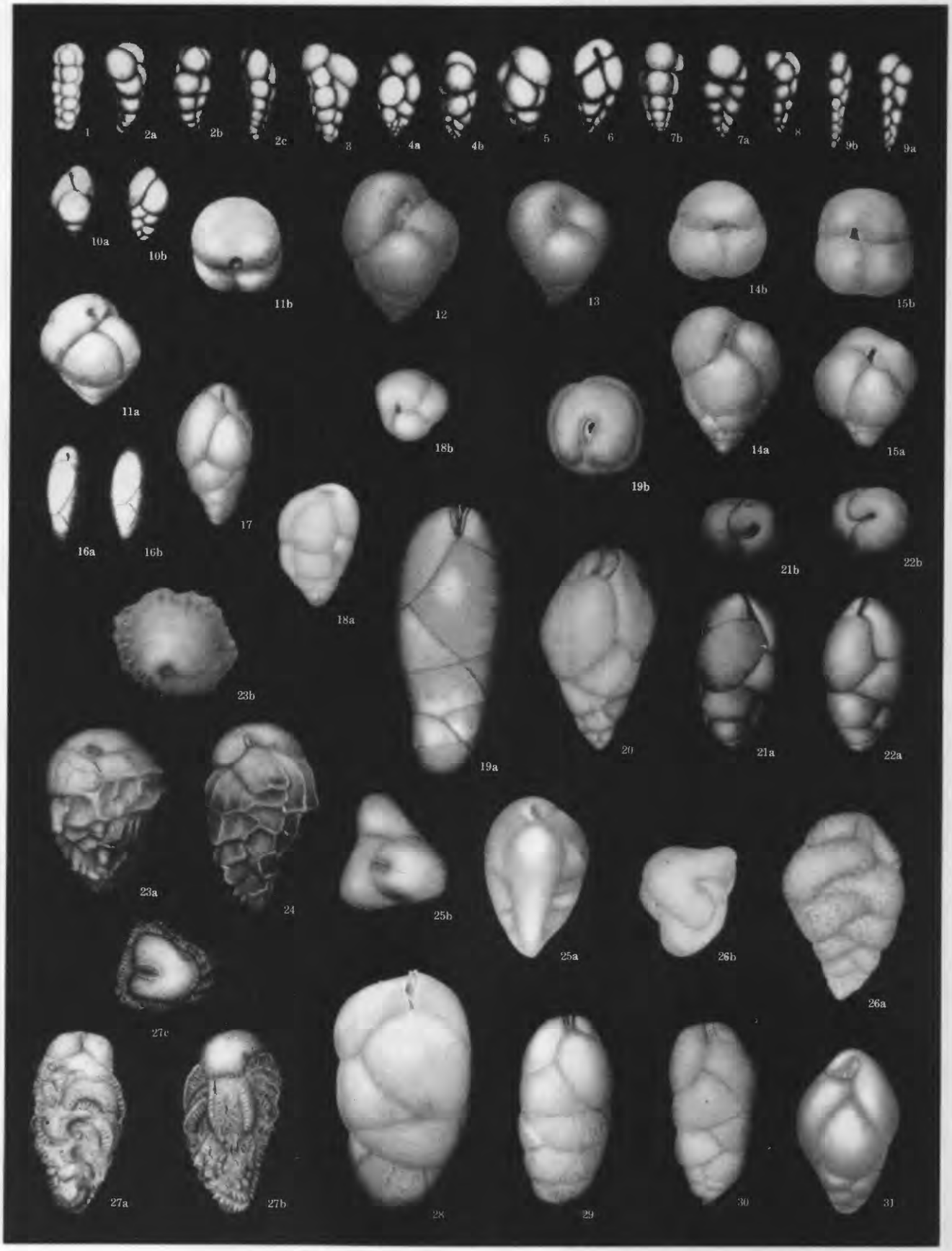
FIGURE 25. *B. triangularis* Cushman and Parker. Cretaceous, upper part of Taylor marl, Collin Co., Texas. × 60. *a*, Front view; *b*, apertural view.

FIGURE 26. *B. rudita* Cushman and Parker. Cretaceous, upper part of Taylor marl, Red River Co., Texas. × 70. *a*, Front view; *b*, apertural view.

FIGURE 27. *B. pectinata* Cushman and Parker. Cretaceous, lower part of Taylor marl, Delta Co., Texas. × 75. *a*, Front view; *b*, rear view; *c*, apertural view.

FIGURES 28–30. *B. aspera* Cushman and Parker. Cretaceous. 28, 29. Corsicana marl, Navarro Co., Texas. × 40. 30, Upper part of Taylor marl, Kaufman Co., Texas.

FIGURE 31. *B. reussi* Morrow. Cretaceous, Lemberg, Galicia. × 90.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BULIMINA

PLATE 20

FIGURES 1–5. *Bulimina reussi* Morrow. Cretaceous. 1, Wolfe City sand member of Taylor marl, Collin Co., Texas. 2, Austin chalk, Collin Co., Texas. 3, 4, White Chalk, Antigua, B. W. I. 5, Saratoga chalk, Howard Co., Arkansas. 1, 2, × 90. 3–5, × 55. *a*, Front view; *b*, apertural view.

FIGURE 6. *B. reussi* Morrow var. *navarroensis* Cushman and Parker. Cretaceous, Corsicana marl, Caldwell Co., Texas. × 90. *a*, Front view; *b*, apertural view.

FIGURES 7, 8. *B. prolixa* Cushman and Parker. Cretaceous, Ripley, McNairy Co., Tennessee. 7*a*, Front view; *b*, apertural view. × 90. 8*a*, Front view; *b*, side view. × 55.

FIGURES 9, 10. *B. arkadelphiana* Cushman and Parker. Cretaceous, Arkadelphia marl, Hempstead Co., Arkansas. × 65. *a*, Front view; *b*, apertural view.

FIGURE 11. *B. velascoensis* (Cushman) White. Cretaceous. Mexico. × 65.

FIGURES 12, 13. *B. incisa* Cushman. Cretaceous, Mexico. 12, × 55. 13, × 80.

FIGURE 14. *B. tortilis* Reuss. (After Reuss.) Cretaceous, New Jersey. *a*, Front view; *b*, rear view.

FIGURE 15. *B. trihedra* Cushman. Cretaceous, Mexico. × 55. *a*, Front view; *b*, rear view.

FIGURES 16, 17. *B. trinitatensis* Cushman and Jarvis. Cretaceous. Trinidad. × 50. *a*, Front view; *b*, apertural view.

FIGURE 18. *B. globocapitata* Chapman. (After Chapman.) Eocene, New Zealand. × 25. *a*, Front view; *b*, rear view.

FIGURE 19. *B. limbata* White. Cretaceous, Mexico. × 55. *a*, Front view; *b*, apertural view.

FIGURE 20. *B. mendezensis* White. Cretaceous, Mexico. × 90. *a*, Front view; *b*, rear view.

FIGURE 21. *B. spinata* Cushman and Campbell. Cretaceous, California. × 65.

FIGURES 22, 23. *B. callahani* Galloway and Morrey. Cretaceous, Mexico. 22, (After Galloway and Morrey) × 45. 23, × 50.

FIGURE 24. *B. tabascoensis* Galloway and Morrey. (After Galloway and Morrey.) Cretaceous, Mexico. × 45.

FIGURE 25. *B. ezoensis* Yokoyama. (After Yokoyama.) Cretaceous(?), Japan. × 20. *a*, Front view; *b*, rear view; *c*, apertural view.

FIGURES 26–28. *B. schwageri* Yokoyama. (After Yokoyama.) Cretaceous(?), Japan. × 70. *a*, Front view; *b*, rear view.

FIGURE 29. *B. baccata* Yokoyama. (After Yokoyama.) Cretaceous(?), Japan. × 70. *a*, Front view; *b*, rear view; *c*, apertural view.

FIGURE 30. *B. capitata* Yokoyama. (After Yokoyama.) Cretaceous(?), Japan. × 70. *a*, Front view; *b*, rear view; *c*, apertural view.

FIGURE 31. *B. polymorphinoides* Yokoyama. (After Yokoyama.) Cretaceous(?), Japan. × 70. *a*, Front view; *b*, rear view; *c*, side view.


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BULIMINA

PLATE 21

FIGURES 1, 2. *Bulimina aspera* Cushman and Parker. Cretaceous, Taylor marl, Caldwell Co., Texas. × 80.

FIGURE 3. *B. brevis* D'Orbigny. Cretaceous, Gravesend, England. × 35.

FIGURE 4. *B. minuta* (Marsson) Cushman. Cretaceous, Rügen, Germany. × 50.

FIGURE 5. *Buliminella pusilla* (Brotzen) Cushman and Parker. Cretaceous, Eriksdal, Sweden. × 125.

FIGURE 6. *Bulimina tabascoensis* Galloway and Morrey. Cretaceous, Mexico. × 65.

FIGURES 7, 8. *B. truncana* Gümbel. Eocene, Budapest, Hungary. × 85. *a,* Front view; *b,* rear view; *c,* apertural view.

FIGURE 9. *B. simplex* Terquem. Eocene, France. × 65. *a,* Front view; *b,* rear view; *c,* apertural view.

FIGURES 10, 11. *B. longiscata* Terquem. (After Terquem.) Eocene, France. 10, × 12. 11, × 28.

FIGURE 12. *B. obscura* Terquem. (After Terquem.) Eocene, France. × 25. *a,* Front view; *b,* apertural view.

FIGURE 13. *B. oviformis* Terquem. (After Terquem.) Eocene, France. × 25.

FIGURE 14. *B. splendens* Terquem. (After Terquem.) Eocene, France. × 35.

FIGURE 15. *B. glanduliformis* Terquem. (After Terquem.) Eocene, France. × 28.

FIGURE 16. *B. decorata* Terquem. (After Terquem.) Eocene, France. × 28.

FIGURE 17. *B. tenuistriata* Terquem. Eocene, France. × 90. *a,* Front view; *b,* rear view; *c,* apertural view.

FIGURE 18. *B. trigona* Terquem. Eocene, France. × 50. *a,* Front view; *b,* rear view; *c,* apertural view.

FIGURES 19, 20. *B. selseyensis* Heron-Allen and Earland. (After Heron-Allen and Earland.) Eocene, Selsey, England. × 70.

FIGURES 21, 22. *B. versa* Cushman and Parker. Eocene, France. × 75. *a,* Front view; *b,* rear view; *c,* apertural view.

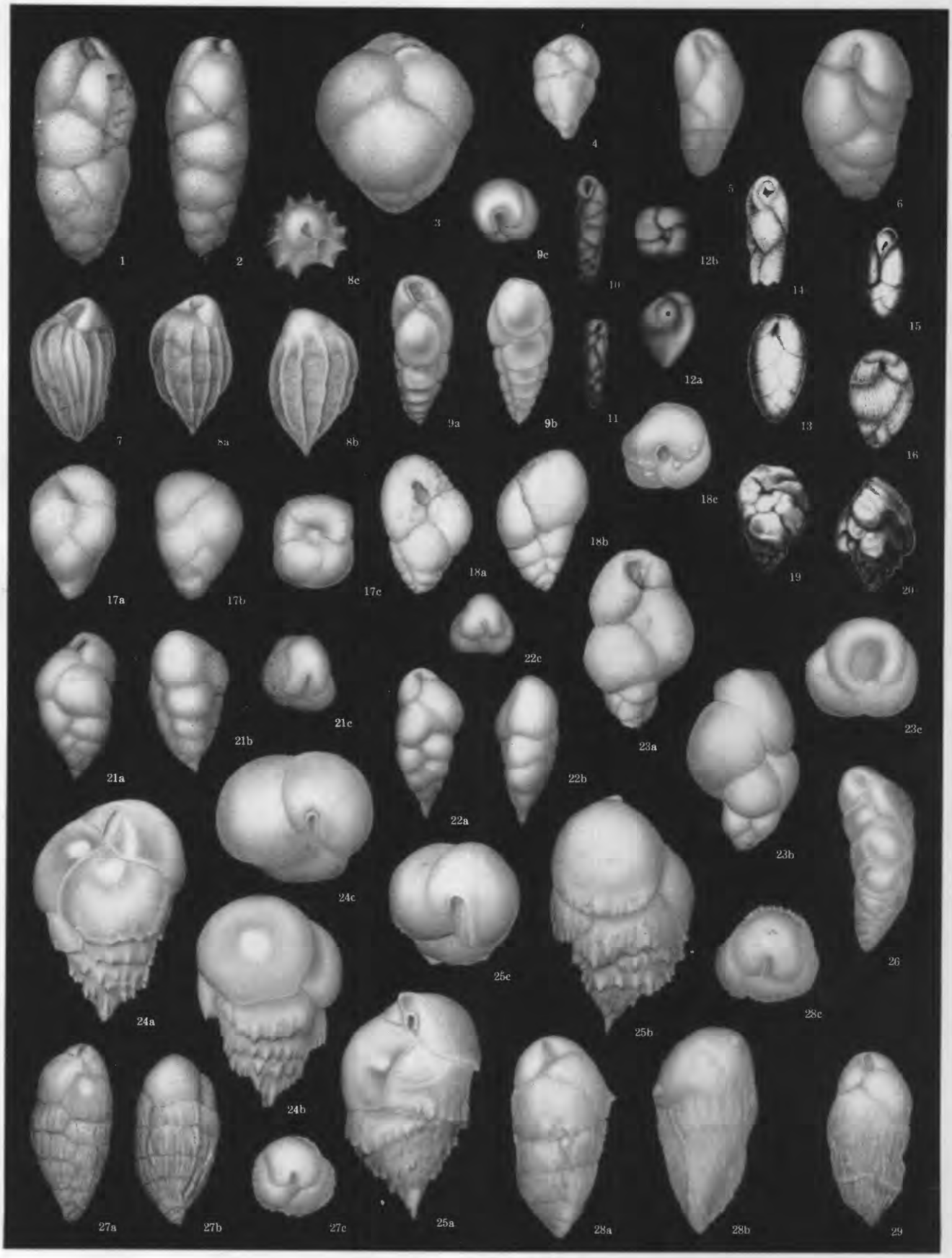
FIGURE 23. *B. eccentrica* Cushman and Parker. Eocene, France. × 45. *a,* Front view; *b,* rear view; *c,* apertural view.

FIGURES 24, 25. *B. arkadelphiana* Cushman and Parker var. *midwayensis* Cushman and Parker. Paleocene, Midway, Texas. × 105. *a,* Front view; *b,* rear view; *c,* apertural view.

FIGURE 26. *B. thanetensis* Cushman and Parker, n. sp. Eocene, Thanet Beds, Pegwell Bay, England. Holotype. × 85.

FIGURE 27. *B. cacumenata* Cushman and Parker. Paleocene, Midway, Bastrop Co., Texas. × 125. *a,* Front view; *b,* rear view; *c,* apertural view.

FIGURES 28, 29. *B. semicostata* Nuttall. Eocene. 28, Cuba. (After Parker and Bermúdez.) × 65. *a,* Front view; *b,* rear view; *c,* apertural view. 29, Mexico. × 50. Paratype.



BULIMINA AND BULIMINELLA

PLATE 22

FIGURE 1. *Bulimina semicostata* Nuttall var. *crassicosta* Parker and Bermúdez. (After Parker and Bermúdez.) Eocene, Cuba. × 85. *a*, Front view; *b*, rear view; *c*, apertural view.

FIGURE 2. *B. corrugata* Cushman and Siegfus. (After Cushman and Siegfus.) Eocene, California. × 85. *a*, Front view; *b*, apertural view.

FIGURE 3. *B. bradyi* Wienzierl and Applin. Eocene, Claiborne, South Liberty, Texas. Holotype refigured. × 65.

FIGURE 4. *B. mauricensis* Howe. (After Howe.) Eocene, Claiborne, St. Maurice, Louisiana. × 65. *a*, Front view; *b*, apertural view.

FIGURE 5. *B. winniana* Howe. (After Howe.) Eocene, Claiborne, St. Maurice, Louisiana. × 70

FIGURE 6. *B. curtissima* Cushman and Siegfus. (After Cushman and Siegfus.) Eocene, California. × 90. *a*, Front view; *b*, apertural view.

FIGURE 7. *B. garzaensis* Cushman and Siegfus. (After Cushman and Siegfus.) Eocene, California. × 85. *a*, Front view; *b*, apertural view.

FIGURE 8. *B. adamsi* Cushman and Parker. Eocene, California. × 85. *a*, Front view; *b*, rear view; *c*, apertural view.

FIGURE 9. *B. microcostata* Cushman and Parker. Eocene, California. × 85. *a*, Front view; *b*, rear view; *c*, apertural view.

FIGURE 10. *B. lirata* Cushman and Parker. Eocene, California. × 65. *a*, Front view; *b*, rear view; *c*, apertural view.

FIGURE 11. *B. excavata* Cushman and Parker. Eocene, California. × 85. *a*, Front view; *b*, rear view; *c*, apertural view.

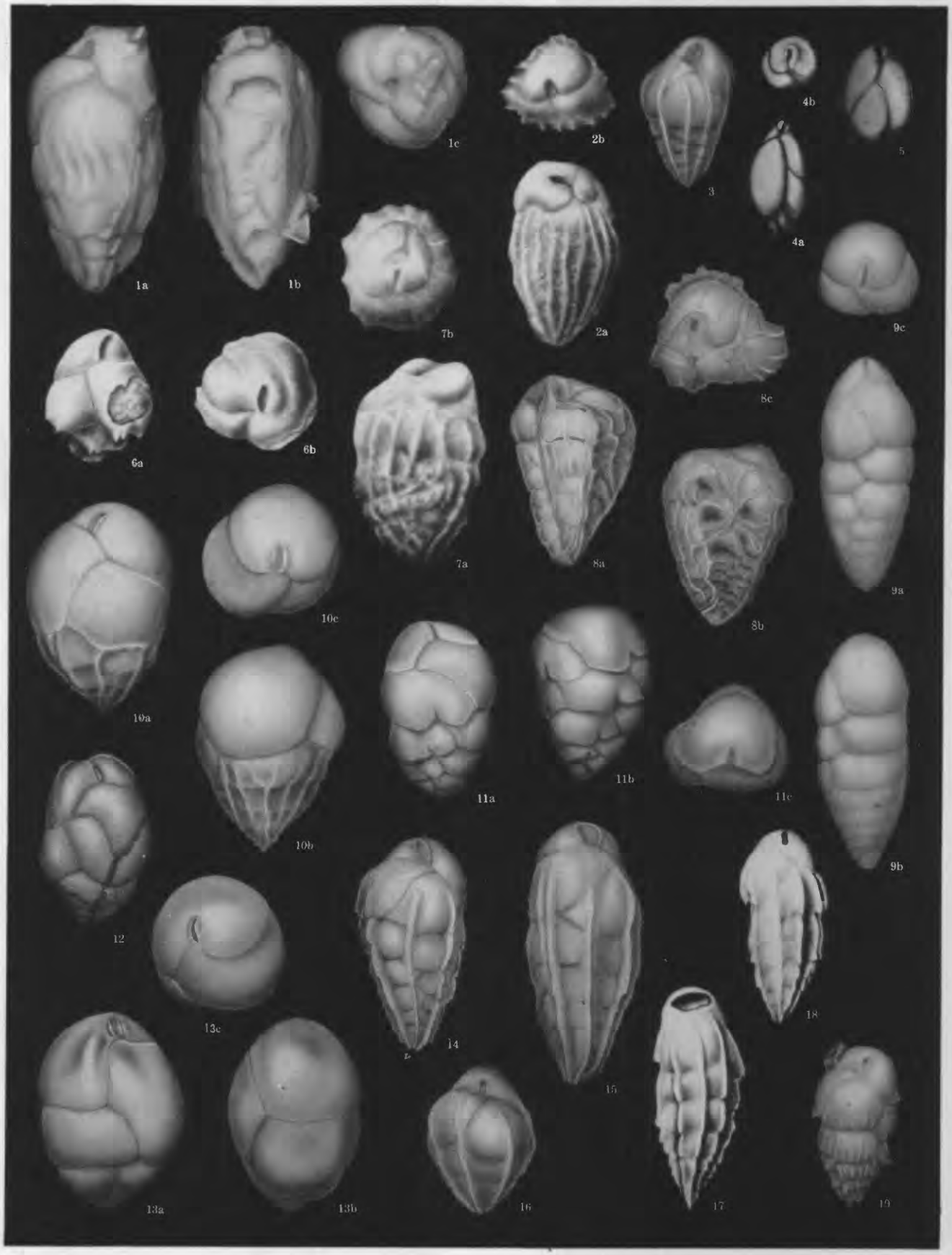
FIGURE 12. *B. guayabalensis* Cole. Eocene, Guayabal, Mexico Topotype. × 65.

FIGURE 13. *B. guayabalensis* Cole var. *ampla* Cushman and Parker. Eocene, California. × 60. *a*, Front view; *b*, rear view, *c*, apertural view.

FIGURES 14–16. *B. jacksonensis* Cushman. 14, 15, Eocene, Jackson, Cocoa Post Office, Alabama. × 45. 16 (After Cushman). Holotype refigured. × 65. Eocene, Mexico.

FIGURES 17, 18. *B. jacksonensis* Cushman var. *cuneata* Cushman. (After Cushman.) Eocene, Jackson, southeast of Melvin, Alabama. × 45.

FIGURE 19. *B. cooperensis* Cushman. Eocene, Cooper marl, South Carolina. × 65.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BULIMINA

PLATE 23

FIGURE 1. *Bulimina instabilis* Cushman and Parker. Eocene, California. × 60. *a*, Front view; *b*, rear view; *c*, apertural view.

FIGURES 2, 3. *B. macilenta* Cushman and Parker. Eocene, California. × 85. *a*, Front view; *b*, rear view; *c*, apertural view.

FIGURE 4. *B. stalacta* Cushman and Parker. Eocene, California. × 105. *a*, Front view; *b*, rear view; *c*, apertural view.

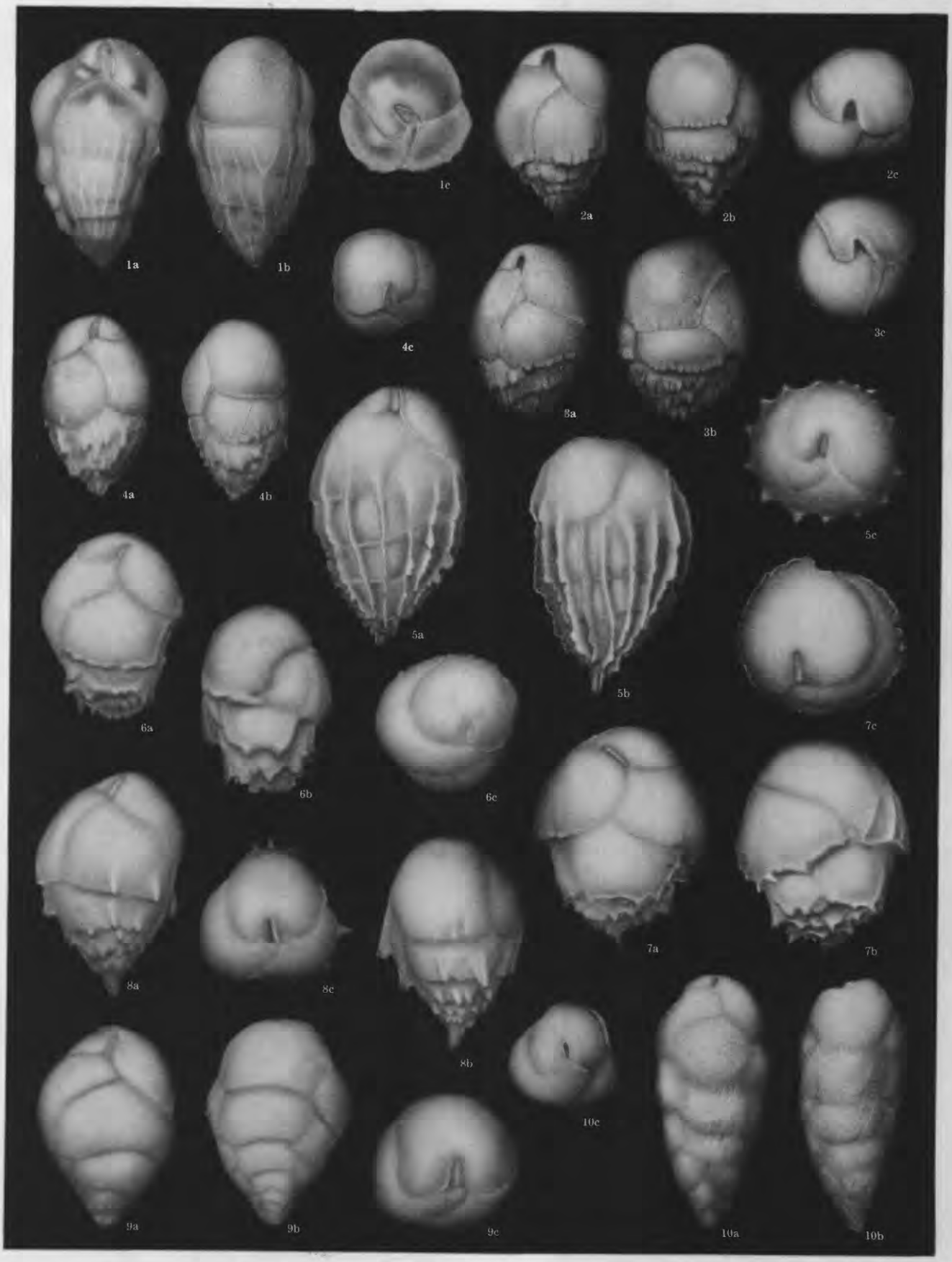
FIGURE 5. *B. consanguinea* Parker and Bermúdez. (After Parker and Bermúdez.) Eocene, Cuba. × 55. *a*, Front view; *b*, rear view; *c*, apertural view.

FIGURES 6, 7. *B. impendens* Parker and Bermúdez. (After Parker and Bermúdez.) Eocene, Cuba. × 85. *a*, Front view; *b*, rear view; *c*, apertural view.

FIGURE 8. *B. palmerae* Parker and Bermúdez. (After Parker and Bermúdez.) Eocene, Cuba. × 55. *a*, Front view; *b*, rear view; *c*, apertural view.

FIGURE 9. *B. tarda* Parker and Bermúdez. (After Parker and Bermúdez.) Eocene, Cuba. × 100. *a*, Front view; *b*, rear view; *c*, apertural view.

FIGURE 10. *B. jarvisi* Cushman and Parker. Eocene, Trinidad. × 80. *a*, Front view; *b*, rear view; *c*, apertural view.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BULIMINA

PLATE 24

FIGURE 1. *Bulimina jarvisi* Cushman and Parker. (After Parker and Bermúdez.) Eocene, Cuba. × 50. *a*, Front view; *b*, rear view; *c*, apertural view.

FIGURE 2. *B. heathensis* W. Berry. (After W. Berry.) Oligocene, Peru. × 20, *a*, *b*, Opposite sides.

FIGURE 3. *B. socialis* Bornemann. Oligocene, Germany. × 65. *a*, Front view; *b*, rear view; *c*, apertural view.

FIGURE 4. *B. cylindrica* Roemer. (After Roemer.) Oligocene, Germany. *a*, Front view; *b*, apertural view.

FIGURE 5. *B. uva* Roemer. (After Roemer.) Oligocene, Germany. *a*, Front view; *b*, apertural view.

FIGURE 6. *B. tuxpamensis* Cole. (After Parker and Bermúdez.) Eocene, Cuba. × 55, *a*, Front view; *b*, rear view; *c*, apertural view.

FIGURES 7, 8. *B. pupula* Stache. Eocene, New Zealand. × 28. *a*, Front view; *b*, rear view; *c*, apertural view.

FIGURE 9. *B. coprolithoides* Andreae. Oligocene, France. × 125. *a*, Front view; *b*, rear view; *c*, apertural view.

FIGURES 10, 11. *B. alsatica* Cushman and Parker. Oligocene, France. × 85. *a*, Front view; *b*, rear view; *c*, apertural view.

FIGURE 12. *B. sculptilis* Cushman. Oligocene, Red Bluff, Mississippi. × 50. *a*, Front view; *b*, rear view; *c*, apertural view.

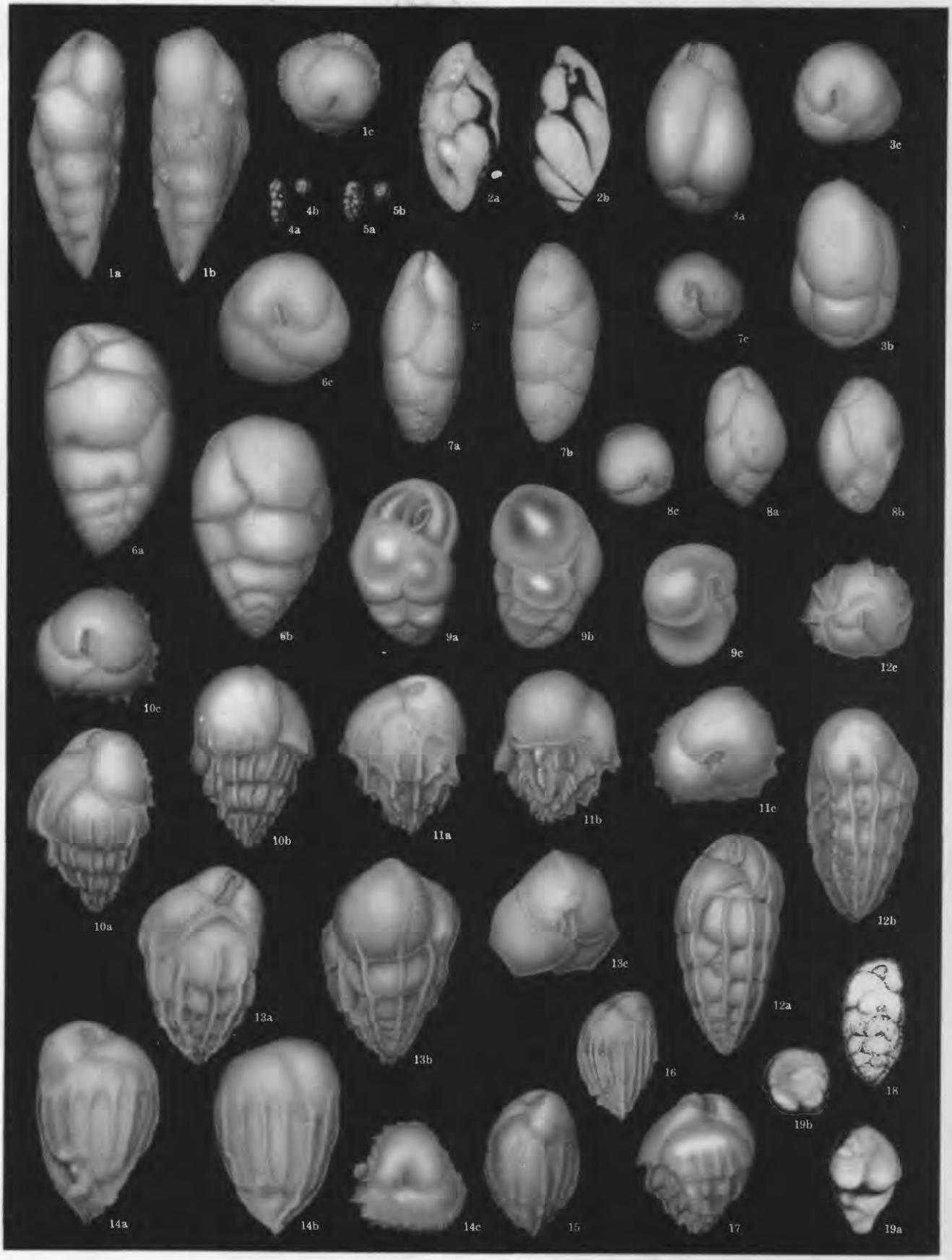
FIGURE 13. *B. sculptilis* Cushman var. *laciniata* Cushman and Parker. Oligocene, Oregon. × 50. *a*, Front view; *b*, rear view; *c*, apertural view.

FIGURES 14–16. *B. alazanensis* Cushman. × 85. 14, (After Parker and Bermúdez.) Eocene, Cuba. *a*, Front view; *b*, rear view; *c*, apertural view. 15, Alazan clay, Mexico. 16, Recent, West Indies.

FIGURE 17. *B. bleeckeri* Hedberg. Oligocene, Venezuela. × 65.

FIGURE 18. *B. rugifera* Glaessner. (After Glaessner.) Oligocene, Russia. × 55.

FIGURE 19. *B. bicona* W. Berry. (After W. Berry.) Oligocene, Peru. × 20. *a*, Front view; *b*, apertural view.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BULIMINA

PLATE 25

FIGURE 1. *Bulimina jugosa* Cushman and Parker. Oligocene(?), Ecuador. × 90. *a*, Front view; *b*, rear view; *c*, apertural view.

FIGURE 2. *B. pyrula* D'Orbigny. Miocene, Austria. × 35. *a*, Front view; *b*, rear view; *c*, apertural view.

FIGURES 3–7. *B. pupoides* D'Orbigny. 3, 4, Miocene, Austria. × 35. 5–7, (After Parker and Bermúdez.) Eocene, Cuba. × 50. *a*, Front view; *b*, rear view; *c*, apertural view.

FIGURES 8, 9. *B. ovata* D'Orbigny. Miocene, Austria. 8, × 35. 9, × 50. *a*, Front view; *b*, rear view; *c*, apertural view.

FIGURE 10. *B. arcuata* D'Orbigny. (After Fornasini.) Miocene, France. *a*, Front view; *b*, rear view.

FIGURES 11, 12. *B. buchiana* D'Orbigny. Miocene, Austria. × 35. *a*, Front view; *b*, rear view; *c*, apertural view.

FIGURE 13. *B. buchiana* D'Orbigny var. *calabra* Seguenza. Miocene, Hungary. × 50. *a*, Front view; *b*, rear view; *c*, apertural view.

FIGURES 14–17. *B. elongata* D'Orbigny. 14, (After Fornasini) Recent, Rimini, Italy. *a*, Side view; *b*, front view. 15–17, Miocene, Austria. × 50. 15*a*, Front view; *b*, apertural view. 16*a*, Front view; *b*, rear view; *c*, apertural view. 17*a*, Front view; *b*, apertural view.

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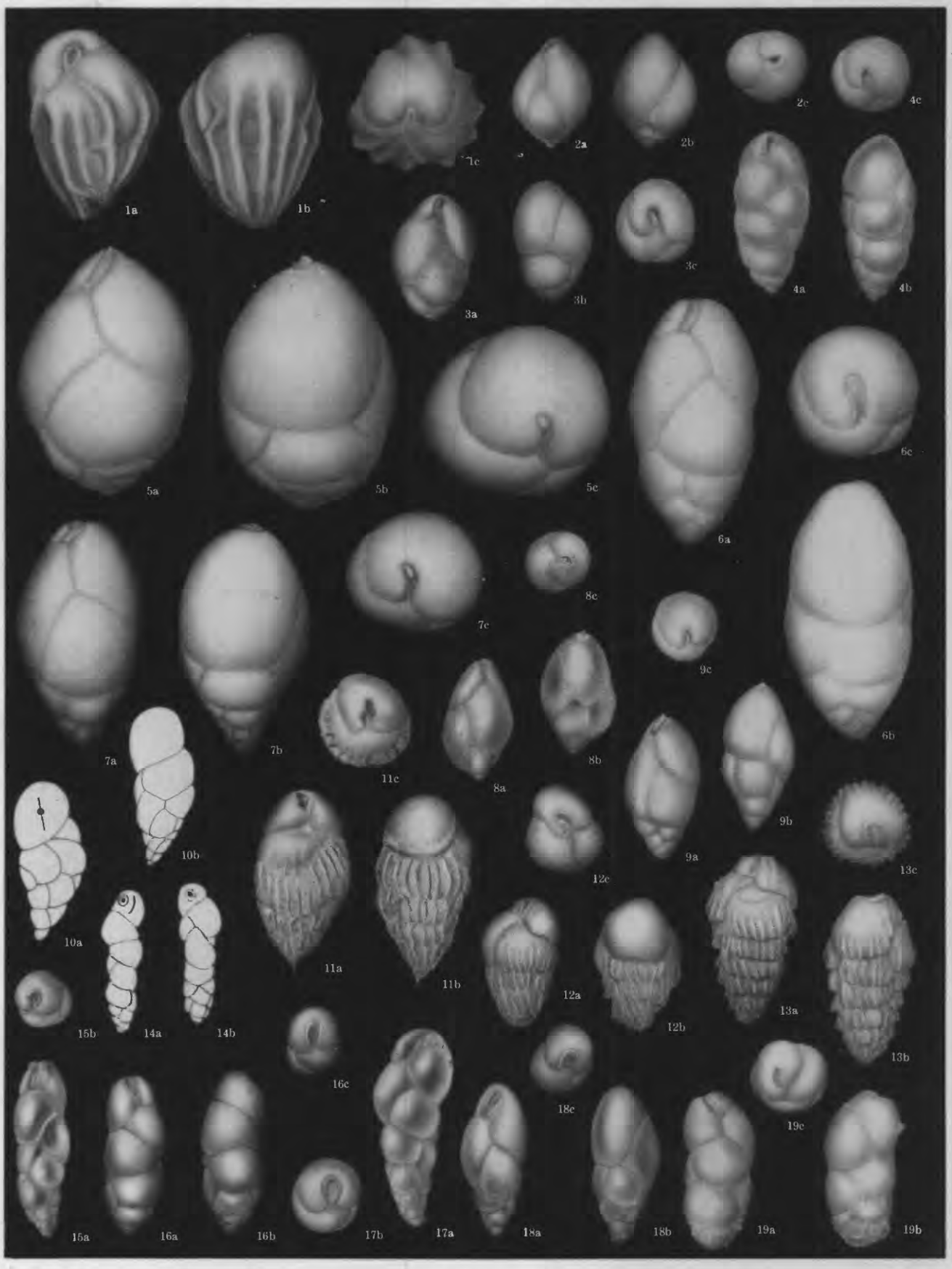
FIGURE 19. *B. elongata* D'Orbigny var. *lappa* Cushman and Parker. Miocene, Austria. × 50. *a*, Front view; *b*, rear view; *c*, apertural view.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BULIMINA

PLATE 26

FIGURES 1, 2. *Bulimina elongata* D'Orbigny var. *subulata* Cushman and Parker. Miocene, Austria. × 50. *a*, Front view; *b*, rear view; *c*, apertural view.

FIGURE 3. *B. buccinoides* Egger. (After Egger.) Miocene, Germany. *a*, Front view; *b*, rear view; *c*, apertural view.

FIGURES 4, 5. *B. tuberculata* Egger. Miocene, Ortenburg, Germany. 4, × 85. 5, × 65. *a*, Front view; *b*, rear view; *c*, apertural view.

FIGURE 6. *B. bulbiformis* Seguenza. (After Seguenza.) Miocene, Italy. × 35.

FIGURES 7–9. *B. calcarata* Seguenza. 7, (After Seguenza.) Miocene, Italy. × 35. 8, Pliocene, Castel Arquato, Italy. × 40. *a*, Front view; *b*, rear view; *c*, apertural view. 9, Miocene, Loos, Austria. × 50.

FIGURES 10, 11. *B. affinis* D'Orbigny var. *tenuissimestriata* Schubert. (After Schubert.) Miocene, Austria. *a*, Front view; *b*, rear view.

FIGURE 12. *B. rotula* Schubert. (After Schubert.) Miocene, Austria. *a*, Front view; *b*, rear view.

FIGURE 13. *B. pseudotorta* Cushman. Miocene, California. × 35.

FIGURE 14. *B. alligata* Cushman and Laiming. Miocene, California. × 50.

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FIGURE 16. *B. delreyensis* Cushman and Galliher. (After Cushman and Galliher.) Miocene, California. × 35. *a*, Front view; *b*, apertural view.

FIGURE 17. *B. carnerosensis* Cushman and Kleinpell. (After Cushman and Kleinpell.) Miocene, California. × 65. *a*, Front view; *b*, apertural view.

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FIGURE 20. *B. pseudoaffinis* Kleinpell. Miocene, California. × 50.

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BULIMINA

PLATE 27

FIGURE 1. *Bulimina acanthia* Costa. Pliocene, Sicily. × 70. *a*, Front view; *b*, rear view; *c*, apertural view.

FIGURES 2, 3. *B. costata* D'Orbigny. Pliocene, Castel Arquato, Italy. × 85. *a*, Front view; *b*, rear view; *c*, apertural view.

FIGURE 4. *B. peucetia* Costa. (After Costa.) Pliocene, Italy. *a*, Front view; *b*, rear view.

FIGURE 5. *B. pustulosa* Costa. (After Costa.) Pliocene, Italy.

FIGURE 6. *B. pedunculata* Costa. (After Costa.) Pliocene, Italy.

FIGURE 7. *B. subcalva* Cushman and K. C. Stewart. Pliocene, California. × 50. *a*, Front view; *b*, rear view; *c*, apertural view.

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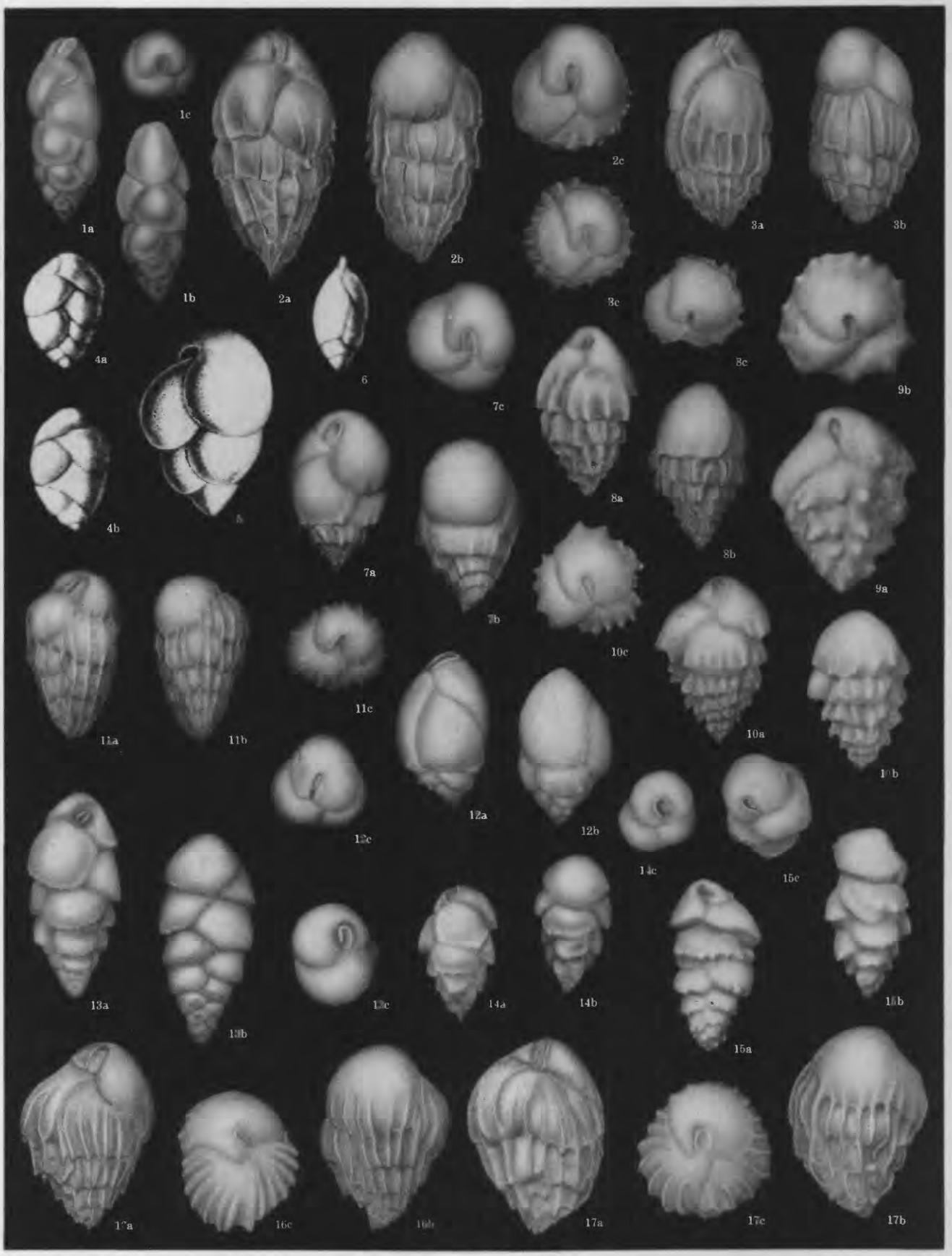
FIGURE 11. *B. fossa* Cushman and Parker. Pliocene, California. × 85. *a*, Front view; *b*, rear view; *c*, apertural view.

FIGURE 12. *B. marginospinata* Cushman and Parker. Pliocene, California. × 65. *a*, Front view; *b*, rear view; *c*, apertural view.

FIGURES 13, 14. *B. denudata* Cushman and Parker. Pliocene, California. × 65. *a*, Front view; *b*, rear view; *c*, apertural view.

FIGURE 15. *B. denudata* Cushman and Parker, var. *deformata* Cushman and Parker. Pliocene, California. × 70. *a*, Front view; *b*, rear view; *c*, apertural view.

FIGURES 16, 17. *B. inflata* Seguenza. × 70. 16, Pliocene, Southern Spain. 17, Pliocene, Messina, Italy. *a*, Front view; *b*, rear view; *c*, apertural view.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BULIMINA

PLATE 28

FIGURES 1–3. *Bulimina striata* D'Orbigny. 1, (After Fornasini). *a,* Front view; *b,* rear view. 2, 3, Recent, Rimini, Italy. × 42.

FIGURE 4. *B. striata* D'Orbigny var. *mexicana* Cushman. Recent, Gulf of Mexico. × 35.

FIGURES 5, 6. *B. marginata* D'Orbigny. 5, (After D'Orbigny). *a,* Front view; *b,* rear view. 6, Recent, Rimini, Italy. × 45. *a,* Front view; *b,* apertural view.

FIGURE 7. *B. trilobata* D'Orbigny. (After Fornasini.) *a,* Front view; *b,* rear view.

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FIGURES 27, 28. *B. exilis* H. B. Brady. Recent, off British Isles. × 50.

FIGURE 29. *B. exilis* H. B. Brady var. *tenuata* (Cushman) Cushman and Parker. Recent, Eastern Pacific. × 42.

FIGURES 30, 31. *B. pyrula* D'Orbigny var. *spinescens* H. B. Brady. Recent, Philippines. × 50.

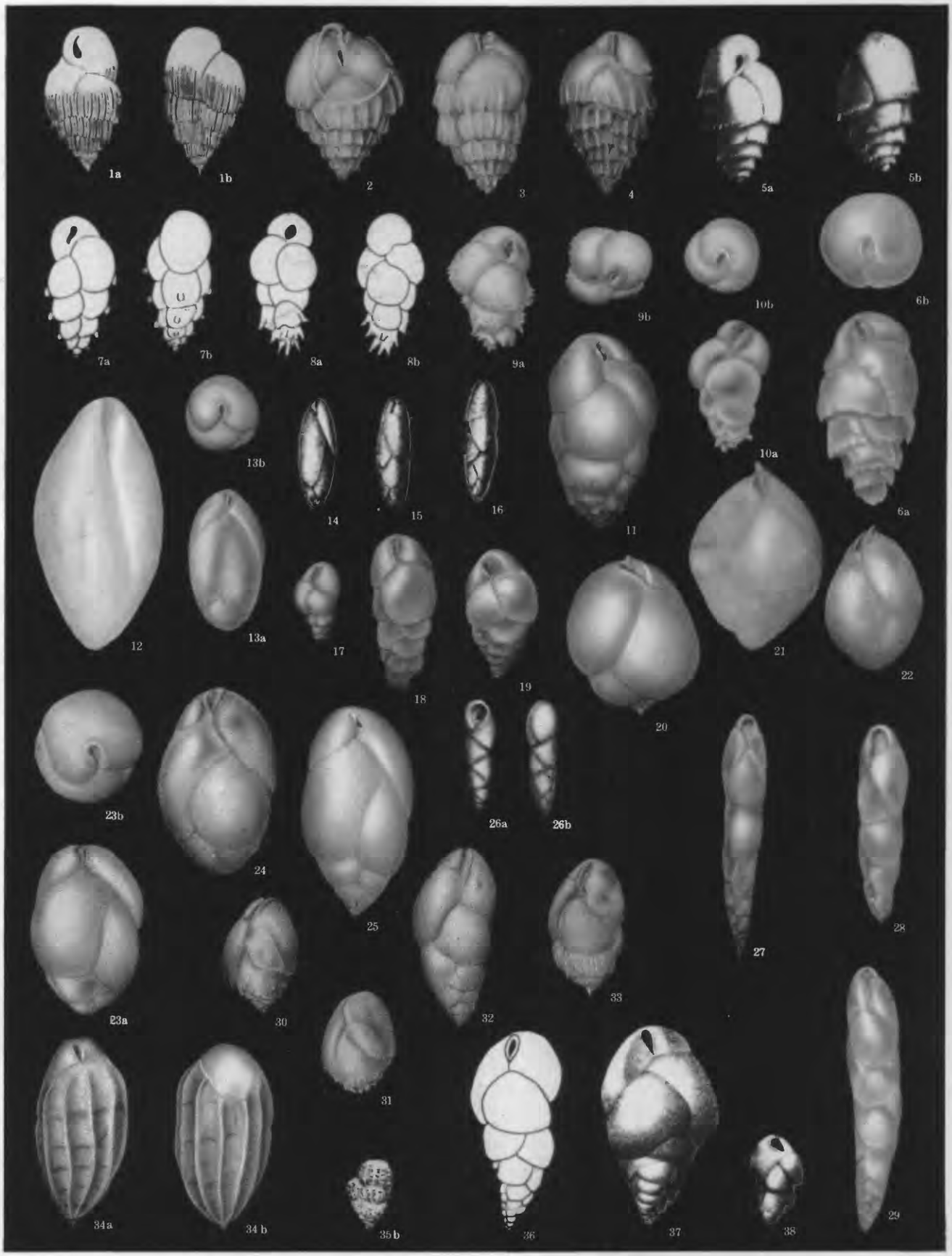
FIGURES 32, 33. *B. subornata* H. B. Brady. Recent, Philippines. × 50

FIGURE 34. *B. rostrata* H. B. Brady. Recent, Eastern Pacific. × 85. *a,* Front view; *b,* rear view.

FIGURE 35. *B. ornata* Egger. (After Egger.) Recent, off West Australia.

FIGURE 36. *B. consobrina* Fornasini. (After Fornasini.) Recent, Italy. × 40.

FIGURES 37, 38. *B. gibba* Fornasini. (After Fornasini.) Recent, Italy. × 40.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BULIMINA

PLATE 29

FIGURES 1–5. *Bulimina gibba* Fornasini. Recent, off Villefranche, France. × 50.

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FIGURE 9. *B. spinifera* Cushman. Recent, Pacific. × 50.

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FIGURES 12, 13. *B. clava* Cushman and Parker, n. sp. Recent, Western Atlantic. × 35. 12, Holotype. 13, Paratype.

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FIGURE 34. *Globobulimina perversa* (Cushman) Cushman and Parker. Recent, Philippines. × 23.

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FIGURE 37. *G. pacifica* Cushman. Recent, off California. × 28.

FIGURE 38. *G. galliheri* (Kleinpell) Cushman and Parker. (After Kleinpell.) Miocene, California. × 35. *a*, Front view; *b*, apertural view.

BULIMINA, BULIMINA (DESINOBULIMINA), NEOBULIMINA, GLOBOBULIMINA

PLATE 30

FIGURE 1. *Buliminella barbati* Cushman and Simonson. (After Cushman and Simonson.) Oligocene, California. × 90. *a*, Front view; *b*, rear view; *c*, apertural view.

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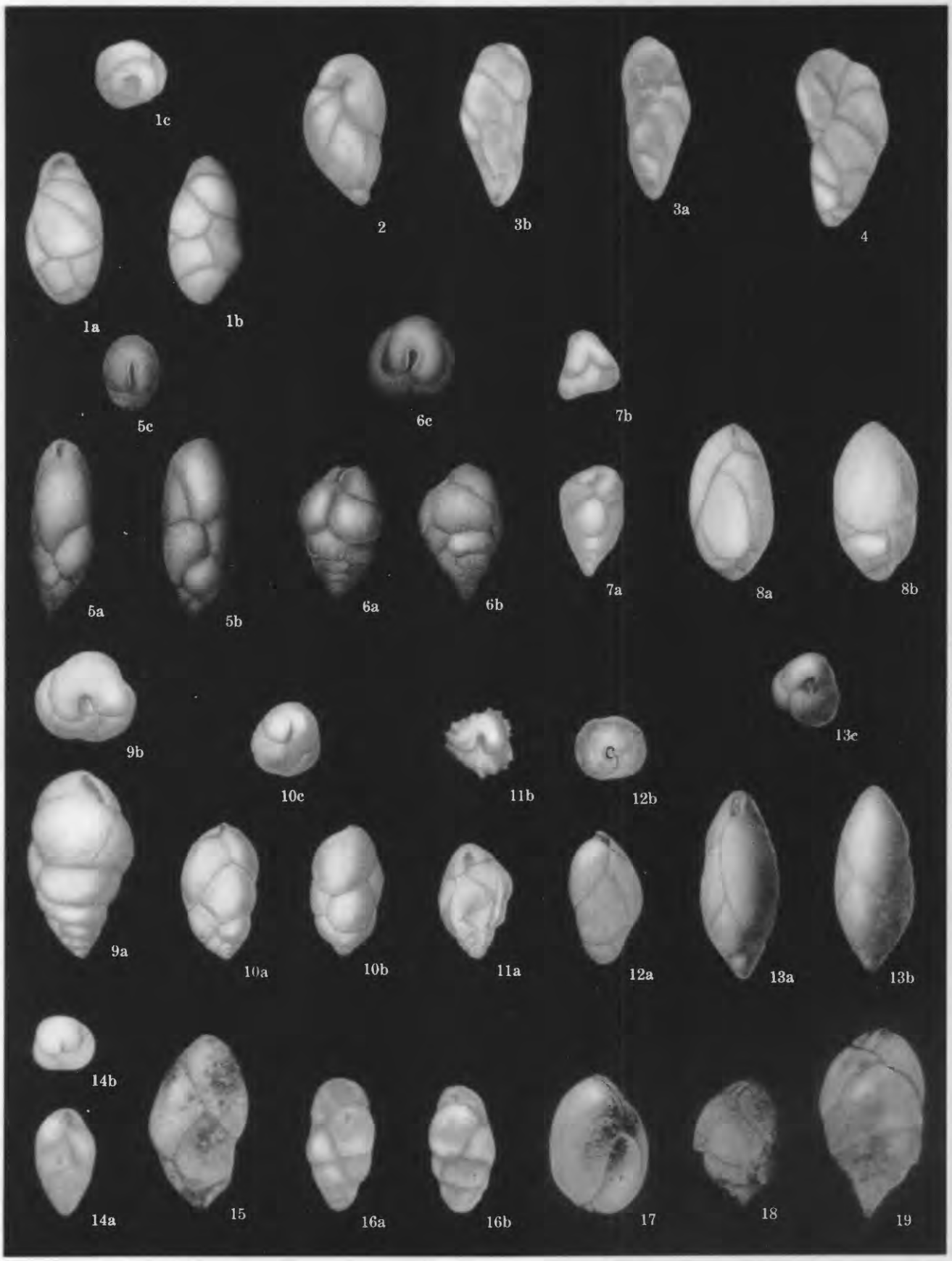
FIGURE 19. *B. alazanensis* Cushman var. *spatiosa* Cushman and Todd. (After Cushman and Todd.) Miocene, Jamaica. × 42.



BULIMINELLA, BULIMINA, AND GLOBOBULIMINA

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Professional Paper 210–E

NEW UPPER CRETACEOUS FOSSILS FROM MISSISSIPPI AND TEXAS

PART 1. FOSSILS FROM TWO DEEP WELLS IN MISSISSIPPI

PART 2. A VENERICARDIA FROM UVALDE COUNTY, TEXAS

BY
LLOYD WILLIAM STEPHENSON

Shorter contributions to general geology, 1946
(Pages 161–198)

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ILLUSTRATIONS

NEW UPPER CRETACEOUS FOSSILS FROM MISSISSIPPI AND TEXAS

By LLOYD WILLIAM STEPHENSON

ABSTRACT

In Part 1 macrofossils of Upper Cretaceous age found in core samples from two deep wells in Mississippi, one in Hinds County and the other in Grenada County, are described. Two cores taken from depths of 3,931 to 3,937 feet and 3,970 to 3,980 feet in McRae No. 1 well in Hinds County yielded previously undescribed molluscan species as follows: *Vetoarca hindsana* (n. gen. and n. sp.), *Postligata monroei, Anomia microlirae, Venericardia subterrea*, and *Odostomia mcraei*. One core from depths of 2,730 to 2,750 feet in Avent No. 1 well in Grenada County yielded the following new molluscan species: *Nucula nulla, Postligata aventi, Trigonarca munda, Anomia acutilinearis, Crassatella subterrestris, Cardium (Trachycardium) grenadense, Fulpia? subtrigona, Tellina harrelli, Spisula brevis, Caryocorbula mississippiana, Caryocorbula morsei, Nerita nodosa, Nerita denticulata, Melanella (Eulima?) parva, Turritella toleri, Turritella magnoliana, "Cerithium" imlayi, Pugnellus calcaris*, and *Paladmete caveola*. One previously described species, *Hamulus onyx* Morton (a worm tube), was identified in this well. In the cores from both wells poorly preserved specimens of several genera, which are specifically unidentified, were obtained. The paleontologic evidence is interpreted to indicate the early Taylor (=early Demopolis) age of the two cores from the McRae well in Hinds County, and the late Austin (=Eutaw) age of the core from the Avent well in Grenada County.

In Part 2 a new bivalve species, *Venericardia uvaldana*, from the lower part of the Anacacho limestone of Uvalde County, Tex., is described. It is closely related to the species, *V. subterrea* Stephenson, from core samples at depths of 3,931 to 3,937 feet and 3,970 to 3,980 feet in the oil-prospecting well, McRae No. 1, in Hinds County, Miss. Because of the close biologic relationship of the two species and considering the rarity of the genus *Venericardia* in the American Cretaceous, the evidence is believed to favor the approximate synchroneity of the bed containing *V. uvaldana* in Uvalde County with the beds containing *V. subterrea* in Hinds County.

PART 1. FOSSILS FROM TWO DEEP WELLS IN MISSISSIPPI

INTRODUCTION

Upper Cretaceous fossils from two deep wells in Hinds and Grenada Counties, Miss., have been submitted to me for identification and study. They are chiefly mollusks and are in part well-preserved. Preliminary lists of the recognizable forms have been prepared and submitted, through the Geological Survey, to the persons who furnished the materials. The fossils are from core samples and are of particular interest because most of them belong to undescribed species; all but one of the species are referred to previously described genera, some of them, however, provisionally or questionably. One new genus is described. The assemblage from each well appears to be a heretofore unrecorded facies fauna. Most geologists interested in the subsurface geology of Mississippi have regarded the fossil-bearing cores from the well in Grenada County as of the age of the upper part of the Eutaw formation of the eastern Gulf region and the upper part of the Austin chalk of Texas, and the paleontologic evidence here presented tends to confirm that correlation. There has been less certainty about the age of the fossil-bearing cores from the well in Hinds County, but paleontologic evidence is now available which suggests that they correspond in age to the lower part of the Taylor marl of central Texas and to the lower part of the Anacacho limestone of Uvalde County, Tex.

The cores from these two wells demonstrate the possibilities afforded by core samples for obtaining identifiable macrofossils and suggest that a great amount of valuable stratigraphic data has been and is being overlooked and lost because of failure to have core samples studied by qualified paleontologists. Many micropaleontologists are on the company pay rolls, but only rarely have the services of specialists in macrofossils been used by the companies in subsurface investigations.

McRAE NO. 1 WELL IN HINDS COUNTY

LOCATION AND OTHER PERTINENT DATA

The well in Hinds County is known as Baker, Ridgway, et al., McRae No. 1 and is located in SE¼SW¼-NW¼ sec. 24, T. 7 N., R. 1 W., about 10 miles north-northwest of the center of Jackson. The elevation above sea level at the mouth of the well is recorded as 319 feet (plane-table determination). Drilling was begun on November 9, 1933, and the well was completed December 28, 1933, at a total depth of 3,981 feet. It has been abandoned as a nonproducer. Sedimentary rocks of Tertiary age were penetrated to a depth of 3,456 feet, where the first rock of Cretaceous age was encountered. The latter, generally known as the gas rock,

is considered by the company geologists to be of the age of the Navarro group of Texas.

Core samples were taken in the lower part of the hole as follows: 3,360–3,364 feet; 3,441–3,446 feet; 3,484 feet (four cores, presumably meaning that four core samples were taken between depths of 3,484 and 3,884 feet); 3,884–3,892 feet; and 3,909–3,981 feet. The fossiliferous core samples submitted for study were labeled as coming from depths of 3,931 to 3,937 feet and 3,970 to 3,980 feet; the diameter of each of these samples was about 1⅝ inches.

The core taken at a depth of 3,884 to 3,892 feet was logged by the driller as chalk; presumably this is the basal bed of the Selma chalk, as that unit is generally interpreted in this part of the Gulf region by the company geologists and the drillers. The cores taken between depths of 3,909 feet and the bottom of the hole at 3,981 feet were logged as "packed sand," and the two fossiliferous cores fall within the limits of this so-called packed sand. The fossiliferous materials were submitted to the United States Geological Survey by Mr. George C. Swearingen, State Oil and Gas Supervisor, of Jackson, Miss., in January 1934, through Mr. Watson H. Monroe, of the Federal Survey.

FOSSILIFEROUS CORES

The fossiliferous core taken between depths of 3,931 and 3,937 feet is a water-laid, tuffaceous, calcareous rock of only moderate hardness and is essentially similar in its lithology to the more richly fossiliferous core at the lower depth. It yielded the following bivalve fossils (U. S. G. S. 18883): *Vetoarca hindsana*, *Postligata monroei*, *Venericardia subterrea*, and *Tenea?* sp. All these species are present also in the core from the lower depth (3,970–3,980 feet).

The core that yielded the greater number of the fossils was taken between depths of 3,970 and 3,980 feet. This rock is a heterogeneous aggregate of volcanic rock grains, some sharply angular, some rounded in greater or less degree. Scattered through the rock are occasional well-rounded pebbles of altered igneous rock, the largest one measured being 13 mm. long. The rock is calcareous, as evidenced by its active effervescence in cold hydrochloric acid. A piece of the core was examined by Dr. C. S. Ross, of the Geological Survey, who describes it as follows:

> Composed largely of igneous rock and mineral grains. The rock grains are in part andesitic in character, but in general they are characterized by a very fine-grained or glassy groundmass, now completely replaced by secondary minerals. Many of them are markedly vesicular, being characterized by abundant rounded gas bubbles. The rock is marked by a larger proportion of ferromagnesian minerals than the Grenada specimen. The indeterminable character of the groundmass and the thorough alteration make the original character of the rock somewhat doubtful, but it seems to have been andesitic and phonolitic materials. The volcanic mineral grains are especially abundant and comprise sodic amphiboles, brown hornblende, biotite, sphene, and potassic feldspar. Amphiboles have been partly or completely replaced by calcite, and brown hornblende has been partly replaced. All mineral grains are surrounded by rims of a clay mineral, probably a high iron saponite. A little glauconite is present, but quartz and others of the common detrital minerals are almost absent.

LIST OF FOSSILS

Fossils were obtained from the lower core as listed below (U. S. G. S. 18884):

Fossils from core sample from depth 3,970–3,980 feet, McRae No. 1 well

Animalia:
- Coelenterata:
  - Fragment of madreporarian coral, indeterminate.
- Echinodermata:
  - Fragments of small unidentified crinoid stems.
- Molluscoidea:
  - Two fragments of a bryozoan of the order Cheilostomata (identified by Dr. R. S. Bassler).
- Mollusca:
  - Pelecypoda:
    - Barbatia? sp.
    - Vetoarca hindsana n. sp.
    - Postligata monroei n. sp.
    - Inoceramus sp.
    - Anomia microlirae n. sp.
    - Venericardia subterrea n. sp.
    - Tenea? sp.
  - Gastropoda:
    - Turritella sp.
    - "Cerithium" sp.
    - Odostomia mcraei n. sp.

Plantae:
- Hollow stems believed to belong to a species of marine algae.

CORRELATION

The fact that the identifiable species in the cores from the two depths, as just recorded, are all new detracts from their value in determining the age of the cores with respect to better-known sections elsewhere. However, two of the forms listed appear to possess some correlative value. *Inoceramus* sp. belongs to a form of the genus that is not found in beds older than the upper part of the Austin chalk but ranges into higher beds as, for example, the Taylor marl and its age equivalents. *Venericardia subterrea* is a close analog of *V. uvaldana* Stephenson, a new species from Uvalde County, Tex., described in Part 2 of this report (p. 185). These two forms, though closely related, appear to differ from each other sufficiently to justify their specific separation. *V. uvaldana* is from the Anacacho limestone, probably a basal bed of that formation.

The Anacacho limestone is of Taylor age but has not been determined to represent all the Taylor of central Texas. So far as it goes the paleontologic evidence seems to favor the early Taylor age (=early Demopolis age) of the two fossil-bearing cores in the McRae well, but the evidence is admittedly meager, since the stratigraphic range of *Venericardia subterrea* is not known.

If the differences noted between *V. subterrea* and *V. uvaldana* (p. 187) represent evolutionary changes in time rather than provincial differences, then the two species would differ somewhat, although probably not greatly, in age.

Although the fossiliferous core samples from the McRae well resemble those from the Avent well in Grenada County both in lithologic character and in origin, no fossil species are common to the two wells. The paleontologic evidence would seem to indicate that they are not of exactly the same age. Water-laid volcanic rocks resembling one another but differing in age are well-known in the western Gulf region.

In addition to the fossils from the McRae No. 1 well described in this paper, one species of Foraminifera, *Pseudorbitoides israelski* Vaughan and Cole, represented by numerous individuals, has been recorded by Vaughan and Cole (1943, p. 98) from a slightly shallower position, depth 3,909–3,922 feet in the same well. The material was submitted for identification by Mr. W. H. Monroe in 1942. Apparently this material also came from the so-called packed sand of the drillers. Data on the occurrence of the same species in the lower part of the Taylor marl in a well in Louisiana, in the lower part of the Anacacho limestone in wells in Zavalla and Uvalde Counties, Tex., at the surface in Kinney County, Tex., and at an equivalent stratigraphic position at the surface in southern Petén, Guatamala, are given by Vaughan and Cole in an earlier paper (1932, pp. 615, 616).

AVENT NO. 1 WELL IN GRENADA COUNTY

LOCATION AND OTHER PERTINENT DATA

The well in Grenada County was drilled by the Adams Oil & Gas Co. and is known as Avent No. 1. It is located in the center of NE¼NE¼NW¼ sec. 26, T. 22 N., R. 4 E., about 2 miles southwest of Grenada. The elevation at the mouth of the well is reported to be 304 feet above sea level. The well was completed and abandoned as a nonproducer December 7, 1942, at a total depth of 4,031 feet. No complete log of the well is available, but the geologists of several of the oil companies agree in placing the Cretaceous-Tertiary contact at a depth of 1,840 feet. The companies do not agree as to the exact depth at which the top of the Eutaw formation was encountered, but most of them agree within a range of 5 feet, placing the Eutaw-Selma contact between depths of 2,725 and 2,730 feet, and at least one company places this contact as deep as 2,740 feet.

FOSSILIFEROUS CORES

The core samples that yielded the fossils listed and described in this paper were 2¾ inches in diameter and were labeled as coming from between depths of 2,730 and 2,750 feet, but their exact position within this range of 20 feet was not indicated. The piece of core (No. 5) from which more than half of the fossils were obtained (U. S. G. S. 18894) was presented to the United States Geological Survey by Mr. David Harrell, district geologist of the Carter Oil Co. through Dr. Ralph W. Imlay, geologist of the Federal Survey. This core sample was 8 or 9 inches long and consisted of water-laid and more or less water-worn fragments of volcanic rock, including scattered smoothly worn igneous pebbles up to half an inch or more in diameter, considerable glauconite, and many shells and fragments of shells. Most of the shells and fragments are water-worn in greater or less degree, though a goodly number were not seriously damaged, and a few are nearly perfect. A small sample of this rock was examined by Dr. C. S. Ross, who describes it as follows:

> Composed dominantly of well-rounded volcanic rock fragments up to 5 millimeters in diameter. These are in general andesitic in character, but others are probably phonolites. The feldspar is nearly fresh, but sparse ferromagnesian minerals are altered to calcite. A few feldspar grains which represent volcanic rock phenocrysts are present, but ferromagnesian mineral grains are sparse or absent. Glauconite is abundant.

Irregularly distributed through the rock and often closely associated with the shells are stringers, sheets, and patches of secondary calcite, which in certain spots has been replaced by silica to form a pale bluish-gray variety of chalcedony; the calcite may commonly be seen coating the exterior or filling the interior cavities of the shells.

A second piece of this core (depth 2,730–2,750 feet) 4 or 5 inches long was presented by Mr. Frederic F. Mellen through Mr. W. H. Monroe, geologist of the Federal Survey (U. S. G. S. 18930). Though not so prolific as the preceding samples, it nevertheless yielded a goodly number of fossils. Lithologically it is essentially like the first sample; one smoothly rounded igneous pebble, which was cut away at one end by the core barrel, was originally more than an inch in length.

LIST OF FOSSILS

The list of fossils given below includes those obtained from both the core samples just described (U. S. G. S. 18894, 18930).

Fossils from core samples from depth 2,730–2,750 feet, Avent well No. 1

Annelida:
- Serpula sp.
- Hamulus onyx Morton.

Molluscoidea:
- Membranipora sp.

Mollusca:
- Pelecypoda:
  - Nucula nulla n. sp.
  - Barbatia? sp.
  - Breviarca sp.
  - Postligata aventi n. sp.
  - Trigonarca munda n. sp

Fossils from core samples from depth 2,730–2,750 feet, Avent well No. 1—Continued

Mollusca—Continued.
Pelecypoda—Continued.
Pteria? sp.
Inoceramus sp.
Ostrea sp.
Exogyra? sp.
Pecten (Camptonectes) sp.
Anomia acutilinearis n. sp.
Volsella sp.
Etea? sp.
Crassatella subterrestris n. sp.
Cardium (Trachycardium) grenadense n. sp.
Fulpia? subtrigona n. sp.
Aphrodina sp.
Tellina harrelli n. sp.
Tellina? sp. *a*.
Tellina? sp. *b*.
Tellina? sp. *c*.
Linearia sp.
Protodonax sp.
Spisula brevis n. sp.
Caryocorbula mississippiana n. sp.
Caryocorbula morsei n. sp.
Caryocorbula sp. *a*.
Caryocorbula sp. *b*.
Caryocorbula sp. *c*.
Coryocorbula sp. *d*.
Scaphopoda:
Dentalium sp.
Gastropoda:
Nerita nodosa n. sp.
Nerita denticulata n. sp.
Melanella (Eulima?) parva n. sp.
Natica sp.
Natica? sp.
Turritella toleri n. sp.
Turritella magnoliana n. sp.
"Cerithium" imlayi n. sp.
"Cerithium" sp. *a*.
"Cerithium" sp. *b*.
Pugnellus calcaris n. sp.
Hercorhyncus? sp.
Paladmete caveola n. sp.
Paladmete? sp.
"Fusinus" sp.

CORRELATION

Only one of the species obtained from the Avent cores, the marine worm *Hamulus onyx* Morton, is referred to a previously described species. It has a long range in the Upper Cretaceous series but has not been recorded from beds older than the upper part of the Austin chalk of that series. Nineteen new species of mollusks are described, including 11 pelecypods and 8 gastropods. About 25 genera of mollusks are too poorly preserved to justify giving them specific names. Most of them probably belong to undescribed species.

Certain of the forms listed suggest a close age relationship of the Avent cores to fossiliferous water-laid volcanic rock appearing at the surface in a small outcrop on the west flank of Prothro salt dome in NE¼ sec. 18 and SE¼ sec. 7, T. 14 N., R. 6 W., 4 miles northwest of Saline, Bienville Parish, La. (See Spooner, 1926, pp. 245–252.) The fossils from this locality have had their shell substance replaced by crystalline calcite, which causes them to break and crumble readily along cleavage planes. It is therefore difficult to compare them critically with fossils from the Avent well. One of the forms from the Avent well is *Inoceramus* sp. (pl. 32, fig. 37), which is closely analogous to several specimens from the Prothro dome locality; another is *Cardium* (*Trachycardium*) *grenadense* (pl. 32, figs. 34–36), also closely analogous to a species there; and several poorly preserved specimens of *Pugnellus* from Prothro dome, though perhaps not specifically identical, certainly represent a species that is a close analog of *Pugnellus calcaris* (pl. 33, figs. 25–32).

The specimen of *Inoceramus* to which reference was made above is a close analog also of a form of the genus found in a hard calcareous, concretionary sandstone at the top of the Tokio formation a mile north of Ben Lomond, Sevier County, Ark. (Dane, 1929, p. 41, pl. 8, fig. 1). Both the fossiliferous rock at this locality and that at the Prothro dome locality have been correlated with the Blossom sand of northeastern Texas, which in turn is correlated with the upper part of the Austin chalk (Dane, 1929, p. 42; Russell, 1941, pp. 32–34).

It would appear, therefore, from the paleontologic evidence that the fossiliferous cores from the Avent well are of the age of the upper part of the Austin chalk. There has been general agreement among the company geologists that the Avent cores are of Eutaw age. The larger fossils do not at present afford a direct paleontologic tie with the Eutaw formation in outcrops, but the upper part of the Eutaw (Tombigbee sand member) has been shown to be of upper Austin age on satisfactory paleontologic grounds (Stephenson and Monroe, 1940, pp. 69, 242).

SYSTEMATIC DESCRIPTIONS

FOSSILS FROM THE McRAE WELL

Kingdom ANIMALIA

Phylum COELENTERATA

Subphylum CNIDARIA

Class ANTHOZOA

Subclass HEXACORALLA

Order MADREPORARIA

The Coelenterata are represented in the McRae No. 1 well by one small water-worn fragment of a proportionately rather tall madreporarian coral. Prior to fossilization it was first subjected to wear on a beach, which destroyed the external features, and it was subsequently broken, revealing the irregular features of the narrow columella and the arrangement of the tuber-

cles on the side of one septum (pl. 31, fig. 17). The specimen is too incomplete for generic or specific assignment. The height of the fragment is 6.5 mm.

Occurrence: McRae No. 1 well, Hinds County, depth 3,970–3,980 feet. U. S. N. M. 103984 (U. S. G. S. 18884).

Phylum ECHINODERMATA

Subphylum PELMATOZOA

Class CRINOIDEA

The core sample yielded several fragments of the columns of an unclassified crinoid (pl. 31, figs. 18, 19), concerning which Dr. Edwin Kirk, of the Geological Survey, says:

> These fragments of columns are not referable to any known genus. They are circular in section, with a circular lumen. The diameter of an average columnal is 1 mm. and its height, 0.17 mm. The side faces are somewhat convex. The joint face is plane and is traversed by strong radiating ridges, some of which increase by dichotomy toward the periphery. There seem to be about 20 primary ridges. Externally tre suture line is somewhat depressed and is marked by a series of sharply incised pits, separated by short vertical ridges. This gives the column a very unusual and characteristic ornamentation.

Occurrence: McRae No. 1 well, Hinds County, depth 3,970–3,980 feet. U. S. N. M. 103985 and 103986 (U. S. G. S. 18884).

Phylum MOLLUSCOIDEA

Class BRYOZOA

Order CHEILOSTOMATA

The core yielded two fragments of a hollow cylindrical bryozoan (pl. 31, figs. 20, 21), which, according to Dr. R. S. Bassler, belongs to the order Cheilostomata, but of a type unknown to him. One of the fragments has a diameter of 3.2 mm. and a length of 5 mm. The wall as seen at the broken end is about 0.5 mm. thick and encloses a matrix of crystalline calcite; at the other end of the fragment the walls dome over and seal the interior space. The other fragment, which affords a view of the inner surface of the wall, reveals some of the structural details of the organism.

Occurrence: McRae No. 1 well, Hinds County, depth 3,970–3,980 feet. U. S. N. M. 103987 (U. S. G. S. 18884).

Phylum MOLLUSCA

Class PELECYPODA

Family ARCIDAE

Genus BARBATIA Gray, 1840

Barbatia? sp.

Plate 31, figure 22

One juvenile *Barbatia*-like shell, a left valve, is elongated in outline, moderately inflated, has a well-developed, round-crested umbonal ridge, and is ornamented all over with rather subdued radial costae, coarsest on the dorsal slopes. A broad, shallow depression extends from the beak to the ventral margin. The dentition is like that of *Barbatia* with the subumbonal teeth small and vertical, and the teeth away from the umbo becoming successively more oblique to nearly horizontal at the ends. The shell measures: Length 4 mm., height 2 mm., convexity about 0.8 mm.

Occurrence: McRae No. 1 well, Hinds County, depth 3,970–3,980 feet. U. S. N. M. 103988 (U. S. G. S. 18884).

Genus VETOARCA Stephenson, n. gen.

Type species: *Vetoarca hindsana* Stephenson.

Etymology: Latin *vetus*, ancient; *Arca*, a bivalve molluscan genus.

This new genus is characterized by its small size, its small trigonal ligamental pit, which appears to be alivincular, the subcentral position of the beaks with respect to the hinge, the slightly raised platforms supporting the adductor muscles, and the strongly ribbed inner surface. The genus appears to be related to *Trigonarca* Conrad, the adductor scars of which occupy similar but more pronounced raised platforms, the inner surface of which is marked by short radial ribs in a band near the pallial line, and the beak of which is opisthogyrate. The type species of *Trigonarca*, *T. maconensis* Conrad, is very large, has a very large multivincular ligamental area, and has its beak situated well back of the center of the area and hinge.

Vetoarca hindsana Stephenson, n. sp.

Plate 31, figures 23–26

Shell small, subtrigonal in outline, strongly convex, slightly inequilateral, equivalve. Beaks prominent, incurved, slightly opisthogyrate, not closely approximate, situated about 0.45 the length of the shell from the anterior extremity. Greatest inflation near the midlength, well above the midheight. Umbonal ridge prominent but well-rounded on the crest. Antero- and posterodorsal slopes steep. The posterior slope of each valve is divided by a radial swell which reaches the posterior margin near its midlength, producing a marginal, wide-obtuse, subangulation. Between this swell and the umbonal ridge is a shallow radial depression. Surface smooth with the exception of fine growth lines. Anterodorsal margin broadly arched; anterior margin rather sharply rounded; ventral margin broadly rounded; posterior margin sharply rounded below, subtruncated and inclined forward above, rounding into the dorsal margin.

Dimensions of the holotype, a left valve: Length 10.8 mm., height 8.4 mm., convexity 3.5 mm. The largest paratype, also a left valve, is 11.4 mm. long.

The ligament is set in a small sunken triangular pit below the beak; it appears to be alivincular but is a little

longer posteriorly than anteriorly; the base of the triangle next to the hinge is a little longer than either of the other two sides. The hinge is narrow, of nearly uniform width from end to end, and somewhat arched in trend. The short, transverse, somewhat irregular teeth may form a continuous row, as in the holotype, or the continuity may be broken by a short toothless gap at the center; away from the center the teeth become a little oblique, and some of them may be angulated in trend. The adductor scars are subequal in size and occupy a high position in the shell; each scar occupies a slightly raised platform which extends from the scar radially back toward the umbonal region. Pallial line simple. The inner surface of the shell between the adductor scars is covered with about 16 pairs of narrow, sharply defined, radial ribs which extend from the inner umbonal region to the pallial line, where each pair ends in a sort of "tack-puller" fork; on the holotype and on some of the paratypes these ribs are somewhat obscured in part by a coating of secondary calcite and in part by corrosion; they are best seen in the paratype shown in plate 31, figure 24. The inner margin is smooth.

The shells of this species are present in great numbers in the core sample from a depth of 3,970 to 3,980 feet, many of the specimens being young individuals. The holotype is larger than average but is exceeded in length by the specimen shown in plate 31, figure 23.

Types: Holotype, a left valve, U. S. N. M. 103989; 2 figured paratypes, left valves, U. S. N. M. 103990; 71 selected unfigured paratypes, left valves, and 55 selected unfigured paratypes, right valves, U. S. N. M. 103991.

Occurrence: McRae No. 1 well, depths 3,931–3,937 feet (U. S. N. M. 103993; U. S. G. S. 18883) and 3,970–3,980 feet (U. S. G. S. 18884, type lot).

Genus POSTLIGATA Gardner, 1916

Postligata monroei Stephenson, n. sp.

Plate 31, figures 27–29

Shell small, subovate in outline, slightly inflated, a little compressed anteriorly, slightly inequilateral, equivalve. Beaks of moderate prominence, incurved, prosogyrate, separated slightly, situated a little in advance of the midlength. Greatest inflation near the midlength, well above the midheight. Surface smooth. Anterodorsal margin nearly straight, descending; posterodorsal margin broadly arched, descending; anterior and posterior margins rather sharply rounded; ventral margin broadly and regularly rounded. Lunule and escutcheon wanting.

Dimensions of the holotype, a complete shell: Length 6.8 mm., height 5.9 mm., thickness 3.1 mm.

Ligament opisthodetic, rather long, set in at least 2 grooves, which are oblique to the dorsal margin backward and slightly downward. Hinge taxodont, relatively thick, with teeth in 2 series scarcely separated; the anterior series is the shorter, with 5 or 6 relatively strong transverse teeth, and is gently concave upward in trend; the posterior series is long and gently arched upward in trend with 15 or 16 teeth, which are small, short, and closely spaced in the anterior half of the series and stronger, longer, and more widely spaced in the posterior half. The inner surface of the shell is only partly uncovered in one of the paratypes; it appears to be smooth, and the pallial line is obscure. The inner margin is smooth.

Compared with the nearly circular genotype, *Postligata wordeni* Gardner (1916, pp. 543, 544, pl. 21, figs. 7–9) from the Monmouth formation of Maryland, the outline of *monroei* is more elongated, and the beaks are more prominent and a little farther forward. *Postligata greenensis* (Stephenson), from the Snow Hill marl member of the Black Creek formation of the Carolinas (Stephenson, 1923, p. 107, pl. 18, figs. 9, 10) is more broadly subovate, more oblique in outline, has nonprominent beaks, and is more compressed. *Postligata schalki* Stephenson from Georges Bank, Atlantic Ocean (1936, p. 374, pl. 1, fig. 8), is more compressed and is more oblique in the posteroventral direction. *Postligata crenata* Wade, from the Coon Creek tongue of the Ripley formation, McNairy County, Tenn. (1926, p. 48, pl. 11, figs. 3, 6), is more compressed, is more nearly circular in outline, has less prominent beaks, and is crenulated on the inner margin.

The species is named in honor of Mr. W. H. Monroe, geologist, U. S. Geological Survey, Washington, D. C.

Types: Holotype, U. S. N. M. 103992; one paratype, a right valve, figured, U. S. N. M. 103994; five unfigured paratypes, including one adult left valve and four juvenile shells; of the latter, one is a complete shell and three are left valves, U. S. N. M. 103995.

Occurrence: McRae well No. 1, Hinds County, depths 3,931–3,937 feet (U. S. G. S. 18883; U. S. N. M. 103996) and 3,970–3,980 feet (U. S. G. S. 18884, type lot).

Family PEDALIONIDAE

Genus INOCERAMUS J. Sowerby, 1814

Inoceramus sp.

Plate 31, figure 30

The genus *Inoceramus* Sowerby is represented by one small, incomplete right valve, consisting of the internal mold partly covered with shell. The specimen happened to lie in a position such that the descending core barrel cut off the posterior and ventral parts of the shell in a strip several millimeters wide. The shell is of moderate convexity, fullest in front, and is broadly subovate in outline with the long axis lying parallel to the hinge line. The beak is small and nonprominent and is situated a few millimeters back of the anterior end. The surface is covered with low, narrow, broadly

round-crested, concentric ridges separated by shallow, slightly broader interspaces. The anterior margin is subtruncated, the ventral margin broadly rounded, the posterior margin shorter and more evenly rounded than the anterior margin, and the dorsal margin nearly straight.

Dimensions: Length 19+ mm., height 18+ mm., convexity about 8 mm.

Although this shell is specifically indeterminate in our present somewhat confused state of knowledge of this generic group, its form is that of shells not older than the Austin chalk of Texas and probably not older than the Taylor marl.

Occurrence: McRae No. 1 well, Hinds County, depth 3,970–3,980 feet. U. S. N. M. 103997 (U. S. G. S. 18884).

Family ANOMIIDAE

Genus ANOMIA (Linné) Müller, 1758, 1776

Anomia microlirae Stephenson, n. sp.

Plate 31, figures 31–33

Shell small, thin, inequivalve, irregular in outline and form, but in general subcircular to broadly subovate in outline; the individuals vary in form from flattish to strongly convex depending on the form of the object to which the right valve was attached. Beak of left valve small, direct, node-like, situated centrally with respect to length of shell and about half a millimeter back from the dorsal margin. Surface covered with closely spaced radiating, almost microscopic lirae, which are delicately wavy in trend. Growth lines fine with an occasional stronger lamina. Resilifer a narrow, elongated, internal amphidetic pit situated well below the dorsal margin.

Dimensions of the holotype: Length 5.6 mm., height 4.6 mm., convexity 2.3 mm.

This species differs from *Anomia acutilinearis* (p. 174) in having fine radiating lirae and weaker, finer-developed concentric markings.

Types: Holotype, U. S. N. M. 103998; six unfigured paratypes, U. S. N. M. 103999.

Occurrence: McRae well No. 1, Hinds County, depth 3,970–3,980 feet (U. S. G. S. 18884).

Order TELEODESMACEA

Family CARDITIDAE

Genus VENERICARDIA Lamarck, 1801

Type species: *Venericardia imbricata* (Gmelin) (=*Venus imbricata* Gmelin), from the Eocene of the Paris Basin, France.

In its relatively small size, rounded outline, numerous noded ribs, and small subumbonal lunule, the species *Venericardia subterrea* (described on this page), closely resembles the genotype, *Venericardia imbricata* (Gmelin), from the Eocene of the Paris Basin. As is to be expected there are differences between the two species, among which may be mentioned the narrower hinge plate and more oblique cardinal teeth, the smaller lunule, and the sharper and more pronounced ribs and nodes of *V. imbricata*. However, the features that characterize the genotype, though differing in strength of development, seem all to be present in *V. subterrea*, and the close genetic relationship between the two species seems indisputable.

Venericardia subterrea Stephenson, n. sp.

Plate 31, figures 34–37

Shell of medium size and submedium convexity, subcircular in outline, slightly inequilateral, equivalve. Beaks prominent, incurved, prosogyrate, approximate, situated slightly forward of the midlength. Greatest convexity about midway of the length, well above the midheight, from which place the surface rounds broadly down to the front, rear, and ventral margins, and steeply down to the dorsal margin. Lunule short, deeply impressed, vertically descending, delimited by a deeply incised groove, V-shaped in cross section. Escutcheon wanting. Surface ornamented all over with about 31 radiating ribs of medium strength, broadly curved in trend; these ribs appear to have been worn somewhat before fossilization, are coarsest on the anterior slope, and become progressively narrower and weaker toward the rear; the interspaces are narrower than the ribs. The crests of the ribs are broken into squarish and rectangular nodes by concentric grooves which are less deeply incised than the spaces between the ribs.

Dimensions of the holotype, a left valve: Length 20 mm., height 20.4 mm., convexity 6.3 mm.

Ligamental groove long, narrow, deeply incised, broadly arched in trend. Nymph narrow and deeply submerged. Hinge heavy. Two cardinal teeth in left valve, the anterior one of medium thickness, trending downward and a little backward, the posterior one prominent, long, narrow, broadly arched in trend; a deep, oblique, elongate, trigonal socket of medium width separates the two cardinals; a very narrow, shallow socket lies in front of the anterior tooth. The sides of the cardinals are finely striated in the direction of movement. A small protuberance lies on the hinge plate just in front of the distal end of the groove delimiting the lunule. The right hinge as seen in a fragment of one young shell presents a thick, long, oblique, slightly arched, trigonal cardinal, bordered behind by a long, narrow, broadly arched socket and in front by a short, trigonal socket; in front of the latter is a feeble, almost obsolete anterior cardinal; back of the posterior socket and closely bordering the nymph is a narrow, relatively weak, oblique, slightly arched posterior cardinal. A small depression on the hinge plate just below the distal end of the groove delimiting the lunule receives the corresponding protuberance on the left valve. Adductor scars subequal, the anterior scar subovate, the

posterior one subtrigonal. Pallial line simple. Inner margin crenate, each indentation lying immediately below the end of a rib.

In general form, outline, and pattern of ornamentation this species is similar to *Venericardia uvaldana* (p. 186), but the shell is not so strongly convex, the ribs are much less sharp and prominent, the lunule is markedly more deeply impressed, and the anterior cardinal tooth is proportionately smaller and thinner. The number of ribs is essentially the same in the two species.

Types: Holotype, a left valve, U. S. N. M. 104001; 18 mostly incomplete, in part fragmentary, paratypes, ranging in size from adult to very small, and including 11 left valves (2 internal molds), 5 right valves (1 hinge figured), and 2 very small, complete individuals with both valves intact. The figured paratype bears the catalog number U. S. N. M. 104000, and the other 17 paratypes U. S. N. M. 104002.

Occurrence: McRae No. 1 well, Hinds County; two examples from depth 3,931 to 3,937 feet (U. S. N. M. 104003; U. S. G. S. 18883); type specimens from depth 3,970 to 3,980 feet (U. S. G. S. 18884).

Family VENERIDAE

Genus TENEA Conrad, 1870

Tenea? sp.

Plate 31, figure 38

Two small specimens of a smooth pelecypod, one a left and the other a right valve, have a form suggestive of that of the genus *Tenea* Conrad, but on both a closely adhering matrix of secondary calcite conceals the features of the hinge. The shell is smooth, subcircular in outline, of medium convexity, and the beak is of medium prominence.

Dimensions of the right valve: Length 2.3 mm., height 2.4 mm., convexity about 0.4 mm.

Occurrence: McRae well No. 1, Hinds County, left valve, depth 3,931–3,937 feet (U. S. N. M. 104004; U. S. G. S. 18883); right valve depth 3,970–3,980 feet (U. S. N. M. 104005; U. S. G. S. 18884).

Class GASTROPODA

Family TURRITELLIDAE

Genus TURRITELLA Lamarck, 1799

Turritella sp.

Plate 31, figure 39

Two fragments of a small turreted gastropod, both incomplete at both ends, appear to be young shells of an unidentified species of *Turritella* Lamarck. The larger specimen includes four whorls and part of a fifth whorl and measures: Height 5.7 mm., diameter at large end 2.4 mm. Spiral angle about 18°. Suture closely appressed and sharply but not deeply impressed. Sides of whorls flattish to very gently convex. The body whorl bears about six obscure, narrow primary spirals, with very obscure secondaries in the interspaces. The upper edge of the growing whorl abuts against the lower side of the lowermost primary spiral, leaving it partly exposed just above the suture. The lowermost primary marks the periphery of the body whorl, below which the base is sharpy constricted, flattish, and bears numerous very fine, obscure spiral lirae. The spiral ornamentation becomes progressively more obscure on the sides of the younger whorls in the direction of the apex. Aperture apparently subtriangular. Outer lip partly broken away but apparently thin. Inner lip forming a thin callus over the parietal wall.

This shell probably belongs to the subgroup of *Turritella* to which *T. vertebroides* Morton belongs.

Occurrence: McRae well No. 1, Hinds County, depth 3,970–3,980 feet, figured specimen (U. S. N. M. 104006; U. S. G. S. 18884); one example (U. S. N. M. 104007; U. S. G. S. 18884).

Family CERITHIIDAE

Genus CERITHIUM Bruguière, 1788

"Cerithium" sp.

Plate 31, figure 40

Two whorls of a small turreted gastropod possess external ornamentation that suggests membership in the family Cerithiidae. In profile the side of each whorl is rather strongly constricted in a band below the upper suture and inflated below toward the lower suture. Four nodose spiral ribs are present, the lowermost one, which follows the crest of the inflation, being the strongest; the second strongest rib closely parallels the upper suture, and intermediate between the two strong ribs are two weaker ribs, the upper one of which is the smaller. The periphery of the body whorl is obtusely subangular, the base is constricted and bears only obscure traces of spiral lirae. The anterior end of the aperture bears a short, twisted siphonal channel, which was broken away and lost during preparation.

Dimensions of the fragment: Height 3+mm., diameter 2.5 mm.

Occurrence: McRae well No. 1, Hinds County, depth 3,970–3,980 feet. U. S. N. M. 104008 (U. S. G. S. 18884).

Family PYRAMIDELLIDAE

Genus ODOSTOMIA Jeffreys, 1839

Odostomia mcraei Stephenson, n. sp.

Plate 31, figures 41, 42

Shell small, smooth, with spire about twice as high as the aperture is long; spiral angle about 40°. Proto-

conch somewhat worn but apparently a low, smooth, trochoid shell. Whorls 3½ or 4, moderately and evenly convex on the side. Suture closely appressed, moderately impressed. Body whorl broadly rounded in profile from suture above to base. Through the semiopaque shell of the body whorl may be obscurely seen seven or eight spiral lirae, which apparently traverse the inner surface; closely adhering matrix prevents the observation of these lirae on the inner surface near the aperture. Aperture subovate, angular at the rear, sharply rounded at the front. Outer lip thin, broadly and regularly arched. The upper part of the inner lip forms a thin callus on the parietal wall; below, it forms a ridge of callus bordering a weak umbilical fissure.

Dimensions of the holotype: Height 3.2 mm., diameter 1.8 mm.

The name of the species is derived from the family name McRae.

Type: Holotype, U. S. N. M. 104009.

Occurrence: McRae well No. 1, Hinds County, depth 3,970–3,980 feet (U. S. G. S. 18884). A smaller, less perfect shell in the same collection is regarded as a questionable example of the species.

Kingdom PLANTAE

Plate 31, figures 43–46

The plant kingdom is believed to be represented in one of the cores from the McRae well by 20 fragments of stems interpreted to belong to a species of marine algae. The stems are hollow cylinders and range in diameter from 0.9 mm. to 1.2 mm. The walls are a quarter of a millimeter or less in thickness, and the hollow interior is filled with a matrix mainly of crystalline calcite. The outer surface is densely stippled with tiny tubercles, each of which is perforated in the center. The inner surface also presents a stippled appearance. That the stems are in sections is indicated by the constrictions at the ends of several fragments, and joints connecting the end portions of sections appear on 2 short fragments. Some of the fragments are slightly constricted at both ends, and the terminal edges of their walls are rounded; these may be complete, short sections; one such section is 2.5 mm. long and 1.2 mm. in diameter. A freshly broken end of a tube shows transverse structural markings in the wall which seem to be connected with the stippling on the inner and outer surfaces of the tube; these may be filled pores.

Occurrence: McRae well No. 1, Hinds County, three figured specimens (U. S. N. M. 104010; U. S. G. S. 18884); several unfigured fragments (U. S. N. M. 104011; U. S. G. S. 18884).

FOSSILS FROM THE AVENT WELL

Kingdom ANIMALIA

Phylum ANNELIDA

Family SERPULIDAE

Genus SERPULA Linné, 1758

Serpula sp.

Plate 31, figures 1, 2

Marine worms are represented in the fauna from the Avent core (depth 2,730–2,750 feet) by three fragments of irregular calcareous tubes that appear to belong to the genus *Serpula*, using that name in a broad sense. The smaller of the two better preserved fragments is 9 mm. in length, 1.7 mm. in diameter at the small end, and 2 mm. in diameter at the large end (U. S. G. S. 18930, U. S. N. M. 104012); in addition to the growth lines, which extend directly around the tube, this specimen bears three narrow longitudinal ribs grouped on one side, the middle one of which is irregular in height but in part prominent, and the other two of which are nonprominent; obscure traces of several other longitudinal markings are present. The larger of these two fragments is 9.5 mm. in length, 3.1 mm. in diameter at the small end, and 3.8 mm. in diameter at the large end (U. S. G. S. 18930, U. S. N. M. 104012); it bears four narrow longitudinal ribs, also grouped on one side, two of which are in part prominent and flangelike, and two nonprominent and alternating in position with the other two; several obscure longitudinal markings are present. The tube wall is less than half a millimeter thick, and at the large end bevels from the inside outward to a thin edge, apparently indicating that this was the terminus of the tube at the time of the animal's death. The third fragment (U. S. G. S. 18894, U. S. N. M. 104013) is smaller and much less complete than the other two; it is 6.2 mm. long and bears a pair of narrow, fairly regular nonprominent longitudinal ribs on one side.

Genus HAMULUS Morton, 1834

Hamulus onyx Morton

Plate 31, figures 3, 4

1834. *Hamulus onyx* Morton, Synopsis of the organic remains of the Cretaceous group of the United States, p. 73, pl. 2, fig. 8; pl. 16, fig. 5.

1905. *Hamulus onyx* Morton. Johnson, Acad. Nat. Sci. Philadelphia Proc., vol. 57, p. 4.

1916. *Hamulus onyx* Morton. Gardner, Maryland Geol. Survey, Upper Cretaceous (2 vols.), p. 747.

1921. *Hamulus onyx* Morton. Wade, U. S. Nat. Mus. Proc., vol. 59, p. 43, pl. 9, figs. 1–3, 5, 6.

1923. *Hamulus onyx* Morton. Stephenson, North Carolina Geol. and Econ. Survey, vol. 5, p. 76, pl. 10, fig. 11.
1926. *Hamulus onyx* Morton. Stephenson, Alabama Geol. Survey, Special Rept. 14, p. 250, pl. 92, fig. 2.
1926. *Hamulus onyx* Morton. Wade, U. S. Geol. Survey Prof. Paper 137, p. 30, pl. 2, figs. 4–7, 12.
1929. *Hamulus onyx* Morton. Dane, Arkansas Geol. Survey Bull. 1, p. 150, pl. 27, fig. 2.
1941. *Hamulus onyx* Morton. Stephenson, Texas Univ. Pub. 4101, p. 58, pl. 4, figs. 8, 9.
1943. *Hamulus onyx* Morton. Howell, Acad. Nat. Sci. Philadelphia Proc., vol. 95, p. 150, pl. 19, figs. 1–12.

Several fragmentary tubes seem to be essentially like those of the species *Hamulus onyx* Morton. One fragment, the large end of a medium-sized tube (pl. 31, fig. 3), is attached at its smaller end to a small shell fragment; in large suites of tubes of this species from the Upper Cretaceous of the Gulf region only a few have been found attached to extraneous objects. The fragments in the present fauna indicate curved tubes of about the average size, and the same degree of taper, as seen in typical tubes of *onyx*. Each tube is ornamented with six subangular to rounded, rather rugged longitudinal ribs of subequal size. The first fragment mentioned above is 10 mm. in length, 2 mm. in diameter at its incomplete small end, and 4.4 mm. in diameter at its large end measured on the outside of the ribs. A fragment of another tube, the large end of which is broken away, is 8.4 mm. in length, 1.3 mm. in diameter at the small end, and 3 mm. in diameter at the large end.

Types: Morton (1834, pp. 73, 74, pl. 2, fig. 8; pl. 16, fig. 5) in his original description figured two specimens (cotypes), one from Lynchs Creek, S. C., and one from Erie Bluff, Warrior River, Hale County, Ala. The former is lost, and the latter is presumed to be one of four specimens in the collection of the Academy of Natural Sciences of Philadelphia (Acad. Nat. Sci. Philadelphia, Nos. 2303, 14996, 14997, 14998). The one of the four nearest in appearance to Morton's figured specimen from Erie Bluff was figured by Stephenson (1923, pp. 76–79, pl. 10, fig. 11), and all four of them were figured by Howell (1943, pp. 150–152, pl. 19, figs. 1–8). Howell designates the specimen shown in his figure 1 as holotype (meaning lectotype) and called the other three paratypes. As Morton did not designate a holotype, Howell is mistaken in referring to the Lynchs Creek specimen (his p. 140) as "Morton's holotype," and to the other three specimens as paratypes. In order to clear up the matter, I herewith designate as the lectotype of *Hamulus onyx* Morton the specimen from Erie figured by Howell as "holotype" (his pl. 19, fig. 1). This specimen appears to be the same as the one figured by Stephenson. (See reference in the synonymy.) Two plesiotypes, one, U. S. G. S. 18894 (U. S. N. M. 104014); the other, U. S. N. M. 104014a. Two unfigured fragments, U. S. N. M. 104015 (U. S. G. S. 18930).

Occurrence: Avent No. 1 well, Grenada County, depth 2,730–2,750 feet. U. S. N. M. 104014, 104015 (U. S. G. S. 18894, 18930).

Hamulus? sp.

Plate 31, figures 5–7

A detached serpuloid operculum from one of the core samples (U. S. G. S. 18894; U. S. N. M. 104016) may have come from a tube of *Hamulus*. It does not agree in detail with the operculum of *H. onyx* Morton, as described and figured by Wade (1926, pp. 30, 31, pl. 2, figs. 6, 12). It has a diameter of 2.3 mm. and a height of 2.7 mm.

No tubes of *H. onyx* with the operculum attached are available in the material from Erie Bluff, Tombigbee River, Hale County, Ala., one of Morton's localities.

Phylum MOLLUSCOIDEA

Class BRYOZOA

Order CHEILOSTOMATA

Family MEMBRANIPORIDAE

Genus MEMBRANIPORA Blainville, 1830

Membranipora sp.

Plate 31, figure 8

The Bryozoa are represented by one poorly preserved specimen, which Dr. R. S. Bassler refers to the genus *Membranipora* Blainville. The zooecia have a thick clublike, probably branching, habit of growth.

Occurrence: Avent No. 1 well, Grenada County, depth 2,730–2,750 feet. U. S. N. M. 104017 (U. S. G. S. 18930).

Phylum MOLLUSCA

Class PELECYPODA

Family NUCULIDAE

Genus NUCULA Lamarck, 1799

Nucula nulla Stephenson, n. sp.

Plate 31, figures 9, 10

The species is represented in the Avent core samples by 11 individuals, which range in length from 1.4 mm. to 4.3 mm. In view of the number of specimens it is assumed that the larger ones are adults, an assumption that may not be justified.

Shell small, subelliptical-elongate in outline, strongly inequilateral, equivalve, of medium convexity, the greatest inflation being a little back of the midlength and a little above the midheight. Beaks moderately prominent, incurved, approximate, opistl ogyrate, situated about three-tenths the length of the shell from the posterior extremity. The surface rounds down broadly to the anterior and ventral margins and steeply to the

anterodorsal and posterior margins. A shallow sulcus extends radially in a curve from the beak to the lower posterior margin on each valve, and between these two sulci the posterodorsal margins of the two valves rise to form a well-defined rostrum. Anterodorsal margin long and broadly arched; anterior margin sharply rounded; ventral margin long and broadly rounded, rising a little more steeply at each end; posterior margin with a short subtruncation inclined forward; posterodorsal margin short, steep, nearly straight. Surface of shell marked only by very fine, obscure growth lines. The internal features are not clearly uncovered, but the numerous taxodont teeth, numbering six or more to the millimeter, can be obscurely seen through the semitransparent shell of the holotype and of several of the paratypes. Radiating internal shell structure such as is characteristic of the nuculid group can be faintly discerned on one of the paratypes.

Dimensions of the holotype, a shell chosen for its completeness: Length 4.3 mm., height 3.1 mm., thickness 2 mm.

Types: Holotype, U. S. N. M. 104018 (U. S. G. S. 18894); four unfigured paratypes, U. S. N. M. 104020 (U. S. G. S. 18894); seven unfigured paratypes, U. S. N. M. 104019 (U. S. G. S. 18930).

Occurrence: Avent No. 1 well, Grenada County, depth 2,730–2,750 feet (U. S. G. S. 18894, 18930).

Family ARCIDAE, sensu lato

Genus BARBATIA Gray, 1842

Barbatia? sp.

Plate 31, figure 11

Three shells in the Avent core are questionably referred to *Barbatia* Gray. None are completely preserved, and none show the hinge; one appears to be adult, and the other two appear to be juvenile, probably all of the same species. The adult, a right valve, is about 17 mm. long and 9 mm. high and bears 25 or more tuberculated, moderately strong ribs, of which a centrally located group are smaller and more closely spaced than those either anterior or posterior to them. The juvenile shells, one a left and the other a right valve, are each about 3+ mm. long and about 2 mm. high and are similarly ribbed. Figured specimen, U. S. N. M. 104021; unfigured, U. S. N. M. 104022.

Occurrence: Avent No. 1 well, Grenada County, depth 2,730–2,750 feet (U. S. G. S. 18894, 18930).

Genus BREVIARCA Conrad, 1872

Breviarca sp.

Plate 31, figures 12, 13

One shell, a left valve, in the Avent core is referable to the genus *Breviarca* Conrad. It is considerably water-worn and cannot be referred safely to a species. However, it has the outline and form of *Breviarca congesta* Conrad and is closely allied to that species. Conrad's species came from the Snow Hill calcareous member of the Black Creek formation at Snow Hill, N. C. (Stephenson, 1923, pp. 112–114, pl. 20, figs. 9–13), and is considered to be of upper Taylor age. The shell measures: Length 8.3 mm., height 7.9 mm., convexity 2.5 mm. In outline the shell is broadly subovate, and the surface is smooth as preserved. The hinge and ligamental area are worn, but the dentition appears to be typical, and ligamental striations transverse to the hinge line are present. Other internal features are concealed by hard matrix.

Occurrence: Avent No. 1 well, Grenada County, depth 2,730–2,750 feet. U. S. N. M. 104023 (U. S. G. S. 18894).

Genus TRIGONARCA Conrad, 1862

Trigonarca munda Stephenson, n. sp.

Plate 31, figures 14–16

This species is represented in the Avent core by one nearly complete left valve, which possesses all the characteristic features of the genus *Trigonarca* Conrad; it is probably a young individual.

Shell small for the genus, moderately inflated, roughly subquadrate in outline, inequilateral. Beak of medium prominence, rather narrow, strongly incurved, approximate, opisthogyrate, situated back of the midlength, about three-fifths the length of the hinge from its anterior end. Umbonal ridge well developed, rounded on the crest. Greatest inflation a little back of the midlength, well above the midheight, from which point the surface rounds down regularly to the anterior and ventral margins; posterior slope steep and broadly excavated radially from the beak to the posterior margin. Anterodorsal margin short and nearly straight; anterior margin regularly rounded; ventral margin broadly and regularly rounded; posterior margin strongly truncated, inclined forward, rounded at upper and lower ends. The surface bears sharp growth lines of irregular strength; a closely spaced group of 9 or 10 weak radial lines diverges outward from the beak on the anterodorsal slope, fading out before reaching the anterior margin; a similar but much shorter and weaker group of lines passes rearward from the beak on the posterodorsal slope. The most prominent part of the umbo is faintly divided by a radial depression, in which several very faint radial lines may be detected. Lunule and escutcheon wanting.

Dimensions: Length 24 mm., height 21.2 mm., convexity 7.1 mm.

The ligament is amphidetic, but the posterior part is short and covers only a small part of the area; it is sharply defined by impressed grooves. The area of attachment of the ligament is triangular with its

longest side coinciding with the upper edge of the hinge plate; the markings on the area appear to be the beginnings of rather coarse chevron-shaped grooves, suggesting that this specimen is the young stage of an individual that in its adult stage might be several times larger. The numerous taxodont teeth form a broad asymmetric arch on a narrow hinge plate, curving down more sharply at the rear; centrally the teeth are short, irregular, and vertical; away from the center in each direction they become first longer and successively more oblique, then shorter, continuing to increase their obliquity until the short terminal teeth become horizontal; some of the teeth anterior and posterior to the umbo are obtusely and asymmetrically angulated in trend. Adductor scars large, elongated, the posterior one a little larger; a narrow sharp ridge extends from under the beak radially past the anterior scar; the posterior scar occupies a raised platform, which is bordered on the inner side by a prominent, curved, sharp-edged carina, the posterior part of which extends radially with diminishing strength toward the umbo. Pallial line entire. Inner surface bearing numerous weak radial lines which end distally at the pallial line. Inner margin smooth. Brownish, rather dim spots and zigzag bands, mainly on the posterior half of the surface, appear to be original color patterns.

A small outcrop of water-laid volcanic sandstone exposed on the west flank of Prothro salt dome, Bienville Parish, La., has yielded eight poorly preserved specimens of *Trigonarca* ranging in size from that of *T. munda* up to a length of 72 mm. The two smaller specimens in the lot agree rather closely in form with *T. munda* and may be specifically identical with it; they appear to be the young stage of a species, of which the larger specimens are the adults. These shells were mistakenly referred to *Cucullaea* by me in a paper by W. C. Spooner (1926, p. 248).

Type: Holotype, U. S. N. M. 104024.

Occurrence: Avent No. 1 well, Grenada County, depth 2,730–2,750 feet (U. S. G. S. 18894).

Louisiana, questionably on the west flank of the Prothro salt dome (secs. 7 and 18, T. 14 N., R. 6 W.), Bienville Parish (U. S. G. S. 12950).

Genus POSTLIGATA Gardner, 1916

Postligata aventi Stephenson, n. sp.

Plate 32, figures 31–33

Shell small, compressed, broadly subovate in outline, slightly extended in the posteroventral direction, slightly inequilateral, equivalve. Beaks small, nonprominent, prosogyrate, situated a little in advance of the midlength; in nearly all specimens the beak and hinge are more or less water-worn. Surface marked only by fine growth lines and an occasional concentric groove marking a resting stage. With the exception of a faint subtruncation on the lower anterior margin and the interruption caused by the beak, the margins are evenly curved all the way around. Lunule and escutcheon wanting.

Dimensions of the holotype, a right valve: Length 10.4 mm., height 9.8 mm., convexity 2 mm.

Ligament opisthodetic, multivincular, set in 3 or 4 grooves oblique to the hinge line backward and downward. Taxodont teeth in two series scarcely separated from each other; the anterior series numbers 8 or 9 teeth alined in a nearly straight row; the posterior series numbers 13 or 14 alined in a slightly uparching curve. Inner surface smooth with the exception of 2 narrow, weak ridges extending from under the beak, 1 radially past the inner side of each adductor scar. Adductor scars slightly impressed, subequal, the anterior one roundish, the posterior one a little elongated in the posteroventral direction. Pallial line entire. Inner margin smooth.

Compared with *Postligata monroei* (p. 166) from the McRae No. 1 well in Hinds County, this species is more compressed laterally, is less elongated in the direction of the length, and is a little more extended in the posteroventral direction.

The species is named in honor of Dr. J. K. Avent, on whose land the Avent well was drilled.

Types: Holotype, a right valve, U. S. N. M. 104025 (U. S. G. S. 18930); 1 figured paratype, a left valve, U. S. N. M. 104026 (U. S. G. S. 18894); 16 unfigured paratypes, U S. N. M. 104027 (U. S. G. S. 18930); 25 unfigured paratypes, U. S. N. M. 104028 (U. S. G. S. 18894).

Occurrence: Avent No. 1 well, Grenada County, depth 2,730–2,750 feet (U. S. G. S. 18894, 18930).

Family PTERIIDAE

Genus PTERIA Scopoli, 1777

Pteria? sp.

A fragment of a small left valve, which includes the umbonal region and the anterior wing, is too incomplete for specific identification. The surface is smooth, and the wing trigonal and strongly compressed. Part of the hinge is present but is badly worn; it shows a ligamental depression below the beak in front of which a toothlike protrusion bulges slightly inward from the straight hinge line.

Occurrence: Avent No. 1 well, Grenada County, depth 2,730–2,750 feet. U. S. N. M. 104029 (U. S. G. S. 18894).

Family PEDALIONIDAE

Genus INOCERAMUS Sowerby, 1814

The status of our present knowledge of the group of American Upper Cretaceous bivalve molluscan fossils to which the name *Inoceramus* Sowerby is commonly

applied is discussed by me in two papers (Stephenson, 1923, pp. 127–131; 1941, pp. 98, 99). Supplemental to those discussions it now appears that Sowerby's name, *Inoceramus cuvierii*, appeared in print as early as December 1814. The following is quoted from the proceedings of the Linnaean Society published in the Annals of Philosophy, vol. 4, p. 448, 1814:

> A paper by Mr. [J.] Sowerby was read on a fossil shell which occurs in chalk, very frequently in the flint nodules. Fragments of it had been observed by Cuvier and Brongniart in the chalk near Paris, and from their fibrous texture they were led to consider them as fragments of pinnæ; but from their thickness (near half an inch) they concluded that the shell must have been of enormous size. Mr. Sowerby got specimens of the fossil from various quarters of the chalk country in the south of England. He ascertained, by comparing these specimens with each other, that it was a bivalve shell, having a hinge of a peculiar structure, and constituting a genus apart. To this genus he has given the name *inoceramus;* and the most common species he calls inoceramus Cuvierii.

What was said about the difficulty of classifying and naming many of the American specimens of *Inoceramus*, in my two papers cited above, still remains true, for which reason I refrain from giving a specific name to the comparatively well preserved shell shown in plate 32, figure 37.

Inoceramus sp.

Plate 32, figure 37

The material referable to *Inoceramus* Sowerby in the Avent core includes one fairly well preserved right valve, an incomplete juvenile left valve, and several fragments. The right valve (U. S. G. S. 18894) is subovate in outline, of medium convexity with the greatest inflation above the midheight and well toward the front, strongly inequilateral. Beak slightly prominent, strongly incurved, prosogyrate, situated only a little back of the anterior extremity. Surface rounding down steeply to the anterior margin and broadly to the ventral margin; there is a suggestion of a weak umbonal ridge, back of which the surface becomes slightly compressed in the posterior and posterodorsal regions. The concentric undulations range in distance apart from less than 1 mm. near the beak to a maximum of about 6 mm. in the posteroventral region; the undulations are rather sharply curved in trend on the anterior slope, broadly curved on the ventral-facing slope as far as the umbonal ridge, where they bend sharply up and pass first in a very gentle curve to the posterodorsal slope, thence in a regular curve forward to the dorsal margin. The anterior, ventral, and posterior margins are not complete but if present would conform to the trend of the concentric ridges. A rather marked subtruncation of the posterior margin is indicated. The dorsal margin is straight.

Dimensions of the large right valve: Length 48+mm., height 43 mm., convexity about 11 mm.

This shell belongs to the subgroup of *Inoceramus*, the valves of which are elongate parallel to the hinge line. The subgroup makes its first appearance in late Austin (= Eutaw) time and is common in marine sediments throughout the remainder of Upper Cretaceous time. Although not specifically identical with *Inoceramus barabini* Morton, from "Greene County, Ala.," the Avent specimens are closely allied to it. They appear to match closely specimens of *Inoceramus* from water-laid volcanic rock exposed on the west flank of Prothro salt dome near the north line of NE¼ sec. 18, T. 14 N., R. 6 E., Bienville Parish, La. It is also closely similar in outline and form to a representative of the genus found in the upper part of the Tokio formation near Ben Lomond, Sevier County, Ark. (Dane, 1929, p. 41, pl. 8, fig. 1). Figured, U. S. N. M. 104030; unfigured, U. S. N. M. 104031.

Occurrence: Avent No. 1 well, Grenada County, depth 2,730–2,750 feet (U. S. G. S. 18894); fragments, U. S. N. M. 104032 (U. S. G. S. 18930).

Family OSTREIDAE

Genus OSTREA Linné, 1758

Ostrea sp.

Juvenile shells of *Ostrea* of a rather nondescript character, some of them water-worn, are scattered through the Avent core. Some of the fragments are irregularly costate. None of the material is specifically determinate.

Occurrence: Avent No. 1 well, Grenada County, depth 2,730–2,750 feet. U. S. N. M. 104033 (U. S. G. S. 18894, 18930).

Genus EXOGYRA Say, 1820

Exogyra? sp.

One incomplete juvenile shell having a maximum dimension of 8.3 mm. is questionably referred to *Exogyra* Say. It is irregular in form and finely and irregularly costate. The beak and hinge are strongly twisted as in *Exogyra*.

Occurrence: Avent No. 1 well, Grenada County, depth 2,730–2,750 feet. U. S. N. M. 104034 (U. S. G. S. 18894).

Family PECTINIDAE

Genus PECTEN Müller, 1776

Subgenus CAMPTONECTES (Agassiz ms.) Meek, 1864

Pecten (Camptonectes) sp.

Plate 32, figures 41–43

The Avent core yielded 10 fragments belonging to *Pecten* (*Camptonectes*), none of which is complete enough for specific assignment. The fragments indicate a medium-sized species with very fine, flattish, radi-

ating costae of the *Camptonectes* sort. The costae cover both the main body and the ears of the shell.

Occurrence: Avent No. 1 well, Grenada County, depth 2,730–2,750 feet. Figured, U. S. N. M. 104036 (U. S. G. S. 18894), U. S. N. M. 104035 (U. S. G. S. 18930); unfigured, U. S. N. M. 104037 (U. S. G. S. 18894), U. S. N. M. 104038 (U. S. G. S. 18930).

Family ANOMIIDAE

Genus ANOMIA Linné, 1758

Anomia acutilinearis Stephenson, n. sp.

Plate 32, figures 38–40

The species is represented in the Avent core by six left valves, none of which is complete in all features.

Shell small, compressed, subcircular in outline, subequilateral. Beak small, nonprominent, set back about 1 mm. from the dorsal margin. The surface is covered with fine, sharp, slightly overlapping growth lamellae. Radiating lines are wanting. The shells are compressed but variable in details of form and sharpness of lining. The external lining is impressed on the internal mold as fairly regular, concentric grooves, as shown by one specimen from which the shell is missing except in a small area in the dorsal region. Internal features not uncovered.

Dimensions of the holotype, a shell partly broken away along the dorsal margin: Length 8.4 mm., height about 9 mm., convexity about 1 mm.

Types: Holotype, U. S. N. M. 104039; two figured paratypes, U. S. N. M. 104040; three unfigured paratypes, U. S. N. M. 104041.

Occurrence: Avent No. 1 well, Grenada County, depth 2,730–2,750 feet (U. S. G. S. 18894).

Family MYTILIDAE

Genus VOLSELLA Scopoli, 1777

Volsella sp.

The genus *Volsella* Scopoli is represented in the Avent core by one incomplete, water-worn, left valve. The umbonal ridge is obtusely subangular in cross section, the anteroventral slope is moderately steep, and the worn surface shows no radial ribbing. The hinge is worn but appears to be edentulous. As preserved the shell is 9 mm. long, about 7 mm. high, and has a convexity of 2.5 mm.

Occurrence: Avent No. 1 well, Grenada County, depth 2,730–2,750 feet. U. S. N. M. 104042 (U. S. G. S. 18894).

Family PLEUROFLORIDAE

Genus ETEA Conrad, 1875

Etea? sp.

Plate 32, figure 28

One left valve shows most of the external features of the shell, but the hinge is poorly preserved. The shell is thin, moderately inflated, inequilateral. Beak moderately prominent, incurved, prosogyrate, situated about two-fifths the length of the shell from the anterior extremity. Umbonal ridge sinuous, obtusely angular in cross section, extending from beak to lower posterior extremity. Anterodorsal margin short, slightly excavated; anterior margin sharply rounded; ventral margin very broadly rounded; posterior margin angular below, strongly truncated above; posterodorsal margin long and broadly arched. Concentric growth lines fine and sharp. The teeth appear to have been worn or broken away; ligamental groove long, narrow.

Dimensions: Length 6.3 mm., height 4.9 mm., convexity 2 mm.

Occurrence: Avent No. 1 well, Grenada County, depth 2,730–2,750 feet. U. S. N. M. 104043 (U. S. G. S. 18930).

Family CRASSATELLIDAE

Genus CRASSATELLA Lamarck, 1799

Crassatella subterrestris Stephenson, n. sp.

Plate 32, figures 21–25

The available material in the Avent core referable to the genus *Crassatella* consists of 1 nearly complete right valve, small for the genus, possibly a young individual, and 10 very small juvenile shells in different stages of completeness. The description is based mainly on the complete shell (holotype), supplemented by the juvenile shells which show the young stage and the beak in sharper detail.

Shell small for the genus, compressed, subtrigonal in outline, inequilateral, equivalve. Umbonal ridge low, forming a broad subobtuse angle in cross section. Beaks low, slightly prominent, prosogyrate, situated about one-fourth the length of the shell from the anterior extremity. Greatest inflation above the midheight and slightly in advance of the midlength; from the highest point the surface rounds broadly and gently to the beak and to the anterior and ventral margins; the steeper posterodorsal slope forms a flattish, radiating, slightly sinuous band extending from the beak to the posterior margin. Lunule of medium length, narrow, rather deep and roughened by growth lines; escutcheon long, narrow and rather deep. Anterodorsal margin short, slightly excavated; anterior margin a little more

sharply rounded than a semicircle; ventral margin broadly rounded anteriorly, becoming nearly straight toward the rear; posterior margin subangular below, followed above by a short subtruncation inclined a little forward; posterodorsal margin long, descending, broadly arched. On the young stage, not exceeding 7 mm. in length, the concentric ornamentation is proportionately coarse and strong, except near the tip of the beak, the ridges being separated by interspaces broadly V-shaped in cross section and extending uninterrupted beyond the umbonal ridge to the dorsal margin; on later stages the concentric ridges are narrower and closer together as far rearward as the umbonal ridge, where every other ridge fades out, the remaining ones continuing to the margin; very fine, obscure, concentric lining is barely detectable on the surfaces between the ridges.

Dimensions of the holotype: Length 13 mm., height 10.7 mm., convexity 2.3 mm.

The dentition on the right valve includes a prominent, narrow, cardinal tooth, sloping a little forward, below the beak; a narrow, weak, oblique anterior cardinal closely paralleling the inner margin of the lunule; the two cardinals separated by a narrow deep socket. The large cardinal is striated in the direction of movement on the side facing forward. The ligament occupied a broad shallow pit back of the large cardinal; this pit does not reach the inner edge of the hinge plate, but is separated from it by a small more deeply inset socket into which fits the lower end of a cardinal tooth of the left valve. There is no lateral dentition proper, but an inner groove along the anterodorsal margin serves as a pseudosocket into which fits the thin edge of the corresponding margin of the left valve. In like manner the narrow posterolateral edge of the right valve fits into a corresponding groove in the margin of the left valve. Adductor scars rather large, elongated, and subequal. Pallial line entire. Inner margin smooth.

The ligamental characters of this species indicate that it belongs to the subgroup of *Crassatella* typified by *C. vadosa* Morton (Stephenson, 1941, pp. 176, 177).

Types: Holotype, U. S. N. M. 104044 (U. S. G. S. 18894); five unfigured paratypes, U. S. N. M. 104045 (U. S. G. S. 18894); two figured paratypes, U. S. N. M. 104046 (U. S. G. S. 18930); three unfigured paratypes, U. S. N. M. 104047 (U. S. G. S. 18930).

Occurrence: Avent No. 1 well, Grenada County, depth 2,730–2,750 feet (U. S. G. S. 18894, 18930).

Family CARDIIDAE

Genus CARDIUM Linné, 1758

Cardium (Trachycardium) grenadense Stephenson, n. sp.

Plate 32, figures 34–36

Shell of medium size, subcircular in outline except for the posterior truncation, moderately inflated, subequilateral, equivalve. Beaks moderately prominent, strongly incurved, nearly direct, approximate, situated slightly in advance of the midlength. Umbonal ridge broadly rounded on the crest. Dorsal slopes steep, the posterior one broadly excavated in the radial direction. Margins regularly rounded except the posterior one which is rather strongly subtruncated, the line of truncation inclining somewhat forward. Surface ornamented with 32 to 34 sharply developed ribs, the coarsest ones of which are on the umbonal inflation from which they decrease regularly in size toward the front; toward the rear the ribs decrease in size, several of them becoming longitudinally bifid. The ribs bear tubercles on their crests; adjacent to the ventral margin on the holotype the tubercles number about 7 in a linear distance of 3 mm.; toward the beak the number increases, and the size decreases; the tubercles are conical to slightly elongated in the concentric direction, and are concentrically alined from one rib to another; the tubercles are most prominent anteriorly and decrease regularly in strength rearward, becoming weak to obscure on the umbonal ridge and posterior slope. In the umbonal region of most specimens the ribs and tubercles are more or less worn.

Dimensions of the holotype, a half-grown left valve chosen because of the well-preserved condition of its surface features: Length 11.8 mm., height 11.7 mm., convexity 3.8 mm. The largest shell in the core, whose surface is considerably worn and corroded measures: Length 23 mm., height about 23 mm., convexity 7 mm.

Ligamental groove opisthodetic, short, narrow. Nymph short and rather stout. Hinge of left valve with two cardinal teeth, the anterior one prominent, trigonal, slightly oblique forward, the posterior one narrow, nonprominent, oblique backward, subparallel to the nymph, the two separated by a deep triangular socket; anterior lateral short, stout, distant; posterior lateral proportionately short and weak and nearer the beak. Hinge of right valve with two cardinal teeth, the anterior one short, weak, and strongly oblique forward, the posterior one stout, trigonal, oblique backward, the two separated by a deep trigonal socket; the posterior lateral dentition consists of a pair of short claspers, the inner element of which is stout, the outer weak and blending with the margin of the shell, the two elements separated by a narrow socket; the anterior lateral dentition presents a similar pair of short claspers. The hinge becomes proportionately thick and rugged in adults. Adductor scars high in the shell, the anterior one subtrigonal in outline, the posterior one larger and somewhat elongated. Pallial line entire. Inner margin strongly crenulated, the indentations corresponding to the ends of the ribs.

The species is closely related to, possibly specifically identical with, poorly-preserved specimens of *Cardium* (*Trachycardium*) from water-laid volcanic sandstone

exposed in a small area on the west flank of Prothro salt dome, Bienville Parish, La. (U. S. G. S. 12870, 12950). (See Spooner, 1926, p. 248.)

Types: Holotype, a half-grown left valve, U. S. N. M. 104048 (U. S. G. S. 18894); 2 figured paratypes, U. S. N. M. 104049 (U. S. G. S. 18894); 57 unfigured paratypes, many fragmentary, U. S. N. M. 104050 (U. S. G. S. 18894); 17 unfigured paratypes, U. S. N. M. 104051 (U. S. G. S. 18930).

Occurrence: Avent No. 1 well, Grenada County, depth 2,730–2,750 feet (U. S. G. S. 18894, 18930).

Family VENERIDAE

Genus FULPIA Stephenson, 1946

Fulpia? subtrigona Stephenson, n. sp.

Plate 32, figures 29, 30

The core yielded only two examples of this species, one an adult right valve and the other a juvenile shell with both valves present.

Shell small, roughly subtrigonal in outline, moderately convex, inequilateral, equivalve. Umbonal ridge weak, rounded. Beak of moderate prominence, incurved, prosogyrate, situated a little in advance of the midlength. Anterodorsal slope steep, excavated; posterodorsal slope steep, gently rounded both radially and transverse to the margin, ending distally in a short marginal subtruncation. Lunule and escutcheon wanting. Surface ornamented only with fine incremental lines and irregularly distributed, stronger, concentric grooves, which mark brief resting stages.

Dimensions of the holotype: Length 12.5 mm., height 11.7 mm., convexity 3.9 mm.

Ligamental groove external, opisthodetic, about 3 mm. long in the holotype. Hinge of right valve not completely preserved. Cardinal teeth three, the anterior one obscure, weak, apparently fused with the margin of the shell, the medial one nearly direct, of moderate thickness, partly broken away, posterior one long, oblique, strong. Anterior cardinal socket narrow, deep, trigonal; medial socket wide, deep, trigonal; posterior socket long, narrow, oblique, deep. The anterior cardinal socket opens in the forward direction into a long, narrow lateral groove or socket which is poorly preserved anteriorly; presumably this groove serves as a socket for a corresponding long anterior lateral tooth of the left valve. Beginning just back of the distal end of the ligamental groove a long, lateral groove or socket extends rearward, becoming obscure in that direction because of poor preservation. Other internal features not uncovered.

This species, though too poorly preserved for positive identification, appears to possess the generic characters of *Fulpia* Stephenson, which was first described from the Woodbine formation of Texas. The Texas material (1946, pp. 68–71, pl. 12) is abundant and well-preserved.

Types: Holotype, U. S. N. M. 104052 (U. S. G. S. 18894); one unfigured paratype, a nearly complete juvenile shell, U. S. N. M. 104053 (U. S. G. S. 18930).

Occurrence: Avent No. 1 well, Grenada County, depth 2,730–2,750 feet (U. S. G. S. 18894, 18930).

Genus APHRODINA Conrad, 1869

Aphrodina sp.

Plate 32, figures 18–20

Three fragmentary specimens in the Avent core are referred to the genus *Aphrodina* Conrad. They include a medium-sized right valve showing most of the hinge, the umbonal region, and part of the exterior, a left valve of a smaller specimen showing part of the hinge, the beak, and part of the exterior, and one very small, incomplete right valve.

The shell is ovate-elongate in outline, smooth, and only moderately inflated. The lunule is long, rather narrowly lanceolate, and bounded by a sharply defined line. Escutcheon wanting. Ligamental groove long, sharply incised, bounded by a well-developed nymph. Beak moderately prominent, prosogyrate. The right hinge bears three cardinal teeth, of which the anterior one is oblique forward, narrow above, and thick distally, the medial one is direct, elongate-trigonal, and prominent, the posterior one is long, oblique rearward, thick, and slightly bifid distally. The anterior and medial sockets are of medium width and depth, and the posterior socket is long, narrow, and shallower than the other two. The anterior lateral dentition consists of a socket of moderate length separating a thick tooth below from a narrow, weak one above. The left hinge bears three cardinal teeth, of which the anterior one is thick, trigonal, and slightly bifid, the medial one is moderately thick and entire, and the posterior one is long, narrow, and weak. Anterior lateral tooth well developed.

Occurrence: Avent No. 1 well, Grenada County, depth 2,730–2,750 feet. U. S. N. M. 104054 (U. S. G. S. 18894).

Family TELLINIDAE

Genus TELLINA Linné, 1758

Tellina harrelli Stephenson, n. sp.

Plate 32, figures 5–8

Shell small for the genus, elongate-subelliptical in outline, compressed, slightly inequilateral. Beaks small, compressed, nonprominent, nearly direct, situated near the midlength. Greatest inflation above the midheight, near the midlength, from which point the surface curves over gently to the anterior and ventral margins and to

the weakly defined, broadly rounded umbonal ridge. Back of the ridge the posterodorsal slope steepens and forms a broadly excavated radial band extending from the beak to the posterior margin; this band bears 10 or 12 fine, closely spaced radial riblets. The rest of the outer surface is marked by fine growth lines, the ones on the umbonal area of unworn shells being the sharpest and coarsest. On some shells 2 or 3 obscure radial lines are present on the anterodorsal slope. Anterodorsal margin nearly straight to very gently arched; anterior margin sharply rounded; ventral margin broadly rounded; posterior margin subtruncated, inclined forward; posterodorsal margin broadly excavated.

None of the shells is sufficiently complete around the margins for an accurate measurement. The holotype, a right valve, measures: Length 8.5+mm., height 5.8+mm., convexity 1.4 mm. One large incomplete left valve must be at least 22 mm. long and is probably 12 mm. or more high.

Ligamental groove long, extending about halfway to the terminus, deeply incised, V-shaped in cross section, bordered within by a narrow but strong nymph. The hinge of the right valve, as seen in the holotype, bears two cardinal teeth, of which the posterior one (broken off in this specimen) is thick, trigonal, slightly oblique to the rear, and presumably bifid; the anterior one is small, narrow, nonprominent, and slightly oblique forward; the two are separated by a deep trigonal socket; behind the large cardinal is a narrow, shallow, oblique socket. About 1 mm. in front of the cardinal area is a pair of short lateral claspers, the outer element of which blends with the margin; the posterior lateral dentition is not clearly seen in the available material. In one of the paratypes, a left valve, the anterior cardinal tooth is prominent, thick, bifid, and slightly oblique forward, and the posterior cardinal is narrow, nonprominent, oblique to the rear, and blends with the margin; the separating socket is wide, deep, and trigonal. The anterior lateral is short and of moderate strength. Posterior lateral not seen. Other internal features not uncovered.

The species is especially characterized by the group of fine radial lines on the posterodorsal slope of both valves.

The species is named in honor of Mr. David Harrell, geologist of the Carter Oil Co., who furnished part of the core material from the Avent well.

Types: Holotype, U. S. N. M. 104055 (U. S. G. S. 18930); one figured paratype, U. S. N. M. 104056 (U. S. G. S. 18930); four unfigured paratypes, U. S. N. M. 104057 (U. S. G. S. 18930); four unfigured paratypes, U. S. N. M. 104058 (U. S. G. S. 18894).

Occurrence: Avent No. 1 well, Grenada County, depth 2,730–2,750 feet (U. S. G. S. 18894, 18930).

Unidentified specimens of Tellina?

The Avent core yielded nine specimens of small *Tellina*-like bivalves (one figured, U. S. G. S. 18894, U. S. N. M. 104059; six shells unfigured, U. S. G. S. 18894, U. S. N. M. 104060; two unfigured shells, U. S. G. S. 18930, U. S. N. M. 104061), the largest of which is less than 7 mm. long. None of the hinges was successfully uncovered. The shell is subtrigonal-elongate, rather compressed, and is regularly ornamented with sharp concentric lines, which are coarsest in the umbonal region. No radiating lines present. Beaks situated a little back of the midlength. Ligament short, external, opisthodetic. These shells are designated *Tellina?* sp. *a*. One of them, interpreted to be a left valve, is figured (pl. 32, fig. 1).

Another small *Tellina*-like species is represented by eight specimens (three specimens, U. S. G. S. 18894, U. S. N. M. 104064; five specimens, U. S. G. S. 18930, one figured, U. S. N. M. 104062, four unfigured, U. S. N. M. 104063). One incomplete right valve is 10+mm. long. This form is designated *Tellina?* sp. *b*. The shell is more compressed than in the preceding (sp. *a*), and the growth lines are so fine that the surface appears quite smooth. The beak is small, nonprominent, and situated back of the midlength. One right valve is figured (pl. 32, fig. 2).

Several fragments having a form and outline suggestive of *Tellina* (U. S. G. S. 18894, one figured, U. S. N. M. 104065, two unfigured, U. S. N. M. 104066; U. S. G. S. 18930, U. S. N. M. 104067, three specimens) are characterized by having the narrow posterodorsal slope cut by a moderately pronounced sulcus extending from the beak to the upper part of the posterior margin. Otherwise the surface bears only fine growth lines. This is *Tellina?* sp. *c*. The hinge of the right valve is essentially like that of *Tellina* with a large trigonal posterior cardinal tooth (broken in the figured specimen), and a weak anterior cardinal; anterior and posterior lateral claspers are well developed. The incomplete right valve shown in the illustration (pl. 32, figs. 3, 4) is 12+mm. long.

Genus LINEARIA Conrad, 1860

Linearia sp.

Plate 32, figure 9

One fragment of a right bivalve shell shows the umbonal area, including part of the hinge and part of the anterodorsal slope. The shell is compressed, and the surface bears narrow radiating costae which are coarsest on the anterodorsal slope and become fine to obscure on the side. The posterodorsal slope is broken away. The surface is further marked by pronounced concentric, rather closely spaced ridges, which, on the side, are much stronger than the radiating riblets. Relation-

ship to the genus *Linearia* Conrad is definitely shown by the closely spaced, rather long pair of cardinal teeth directed with strong obliquity toward the front. There is also a pair of elongated anterior lateral claspers. The fragment is 5 mm. long, and the complete shell would probably be 8 or 10 mm. long.

Occurrence: Avent No. 1 well, Grenada County, depth 2,730–2,750 feet. U. S. N. M. 104068 (U. S. G. S. 18894).

Family DONACIDAE

Genus PROTODONAX Vokes, 1945

Protodonax sp.

Plate 32, figure 10

One small, smooth *Donax*-like left valve is referred to the recently erected genus, *Protodonax* Vokes (1945, pp. 295–308). The outline is elongate-subtrigonal. The posterior slope is short and steep, and the posterior margin is regularly rounded from the hinge down to the ventral margin. The anterior part of the shell is proportionately very long, and the anterior margin is sharply rounded. The anterodorsal margin is long, descending, and nearly straight, and the ventral margin is very broadly rounded. The hinge is not well preserved.

Dimensions: Length 5.6 mm., height 3.5 mm., convexity about 1.2 mm.

Occurrence: Avent No. 1 well, Grenada County, depth 2,730–2,750 feet. U. S. N. M. 104069 (U. S. G. S. 18894).

Family MACTRIDAE

Genus SPISULA Gray, 1837

Spisula brevis Stephenson, n. sp.

Plate 32, figures 26, 27

Shell of medium size, short-subtrigonal in outline, moderately inflated, inequilateral, equivalve. Beaks prominent, strongly incurved, slightly prosogyrate, situated somewhat back of the midlength. Umbonal ridge obtusely subangular in cross section, sinuous in trend. Anterodorsal slope steep, moderately descending. Posterodorsal slope steep and steeply descending toward the lower posterior margin. The anterodorsal slope or lunule is outlined by a shallow, radial sulcus, which is bordered on the inner side by a narrow band marked only by fine growth lines, and between this band and the dorsal margin is a band roughened by closely spaced, sharp-crested, concentric ridges. The posterodorsal slope between the umbonal ridge and the dorsal margin is almost equally divided into two radial bands having surfaces respectively similar to the radial bands on the anterodorsal slope. The main or lateral surface of the shell between the two dorsal slopes is marked only by fine growth lines.

The incomplete holotype, a right valve, is 11+mm. long, is about 11 mm. high, and has a convexity of about 4 mm. One paratype is the internal mold of the anterior part of a left valve about twice as large as the holotype, with several fragments of shell attached to it.

The ligament appears to have been quite small and has left no certainly recognizable mark of attachment on the margin of the shell; the resilium was large and occupied a very shallow pit on the hinge plate; the ligament and resilium were not separated by a shelly septum and were probably closely associated. There are two cardinal teeth in the right valve, the posterior one of which (broken away in the holotype) is thick, tabular, rather prominent, and closely borders the resilium on its anterior side; at its upper end it coalesces with the end of the shell margin (spur of Dall), and it appears to be separated by a narrow space from the upper end of the anterior cardinal. The anterior cardinal is thin, nonprominent, oblique, and is coalescent with the inner wall of the shell margin; between the two cardinals is a wide trigonal socket. Students of Recent mactroid shells usually treat these two cardinal teeth as the two arms of a compound cardinal tooth; there seems to be no reason in the present species, however, why they should not be regarded as separate cardinal teeth, as the socket separating them receives a cardinal tooth of the left valve. A deep anterior lateral socket separates a pair of claspers, the inner element of which is of medium thickness and fairly prominent, and the outer element of which is weak and coalescent with the shell margin; this lateral socket lies closely in front of the anterior cardinal tooth and is connected with the cardinal socket by a narrow channel below the end of the tooth. From just back of the resilifer a pronounced groove passes posteriorly along the hinge plate merging distally into a deep lateral socket between a pair of claspers which are comparable in strength and relationships to the anterior claspers; the posterior end of these claspers is broken away. Other internal features are not uncovered.

This species differs from the genotype, *Spisula solida* (Linné), from the Recent seas of Europe, in several details, the most important of which is the strong development of the posterior cardinal tooth in the right valve (=posterior arm of compound cardinal tooth of authors). In the genotype and other Recent species the posterior cardinal has been reduced to a thin, short remnant attached to the upper end of the anterior cardinal by the expanding development of the resilium; there is a more intimate relationship of the lateral dentition of *S. brevis* to the cardinal dentition and to the resilifer; and the resilifer is more deeply sunken in the hinge plate. These differences probably warrant a sectional name for the species here under consideration, but a new section should be based on more complete material than is now available.

Types: Holotype, U. S. N. M. 104070; two unfigured paratypes, U. S. N. M. 104071.

Occurrence: Avent No. 1 well, Grenada County, depth 2,730–2,750 feet (U. S. G. S. 18894).

Family CORBULIDAE

Genus CARYOCORBULA Gardner, 1926

Type species: *Corbula alabamiensis* Isaac Lea

Caryocorbula mississippiana Stephenson, n. sp.

Plate 32, figures 11–13

Shell of medium size, subtrigonal, moderately inflated, strongly inequilateral, inequivalve. Beaks of moderate prominence, strongly incurved, prosogyrate, approximate, situated a little back of the midlength; the right beak is more prominent than the left and more strongly incurved. The right valve is most inflated in a curved area extending from the midheight a little back of the umbo forward and downward toward the anterior extremity; from this inflated area the surface rounds down steeply toward and overhangs the anterodorsal margin, less steeply to the ventral margin, and steeply to the posterodorsal margin. The left valve is much less inflated than the right. Anterodorsal margin gently arched, descending; anterior margin sharply rounded; ventral margin broadly rounded; posterior margin short, squarely truncated; posterodorsal margin short, broadly concave. Umbonal ridge sinuous, sharply and obtusely angular in cross section. In front of the ridge on the right valve is a broad, shallow radial sulcus, and back of the ridge the posterodorsal slope is sinuous in the radial direction and broadly excavated on either side of a low central ridge or carina; a corresponding ridge is feebly developed on the left valve. The surfaces of the two valves are about equally marked by fine, somewhat irregular growth lines and irregular ridges, which may become fairly coarse toward the ventral margin of adults. One fragmentary left valve shows a neatly outlined nepionic-like shell capping the umbo, but this may be a fortuitous feature determined by a resting stage in the growth of the animal.

The holotype is an incomplete right valve, the posterior part of which is partly broken away from the internal mold. Its dimensions are: Length about 13.5 mm., height about 11 mm., convexity 4.2 mm.

The hinge of the right valve, as seen in the holotype, presents one prominent, trigonal, slightly upturned cardinal tooth, bordered in front by a round-bottomed trench of medium width and depth, which opens inward and into which the margin of the left valve fits; behind this tooth is a profound pit that receives the chondrophore of the left valve; the right end of the resilium is attached in the upper part of this pit under the overhanging umbo. The left valve bears a partly submerged chondrophore, which protrudes inward and slightly rearward; the surface of this chondrophore includes an elongated, spoon-shaped pit bordered behind by a narrow, shallow groove opening inward in a flaring notch, and in front by a slightly prominent, bicarinate ridge about half as wide as the pit. In front of the chondrophore is a deep triangular socket, which receives the cardinal tooth of the right valve. The inner surface of the shell is smooth with the exception of the slightly impressed adductor scars.

This species is similar in form and size to *Corbula subgibbosa* Conrad from the Snow Hill calcareous member of the Black Creek formation in North Carolina but is shorter in proportion to the height (Stephenson, 1923, pp. 343, 344, pl. 86, figs. 6–12).

Compared with *Caryocorbula alabamiensis* (Lea), the genotype of *Caryocorbula* Gardner (1926, p. 46), this species is shorter in outline but is similar in its surface features and in essential ligamental and hinge characters. Compared with *Corbula* (*Corbula*) *sulcata* Lamarck, Vokes[1] finds that the ligament of the true *Corbula* differs in important respects from that of *Caryocorbula*.

Types: Holotype, U. S. N. M. 104072; one figured paratype, U. S. N. M. 104073; four unfigured paratypes, U. S. N. M. 104074.

Occurrence: Avent No. 1 well, Grenada County, depth 2,730–2,750 feet (U. S. G. S. 18894).

Caryocorbula morsei Stephenson, n. sp.

Plate 32, figures 14–16

The species is represented in the Avent core by four shells, two of which are juvenile.

Shell of medium size, subtrigonal in outline, moderately inflated, inequilateral. Beak prominent, strongly incurved, slightly prosogyrate, centrally located. Anterodorsal slope steep, overhanging near the beak; anterior and ventral-facing slopes rounding down with moderate steepness. Umbonal ridge sharp, sinuous, obtusely angular in cross section. Posterodorsal slope a proportionally narrow, sinuous, broadly excavated band ending distally at the posterior truncation. Between this band and the margin is a well-defined lanceolate, escutcheon-like area bounded by a dull-crested carina. The umbonal part of the shell surface (so-called nepionic shell) is ornamented with fine, closely spaced, concentric ridges. From this area outward the rest of the surface is covered with progressively coarser concentric ridges, those nearest the margin being about half a millimeter wide; approaching the umbonal ridge these concentric ridges fade out somewhat erratically to mere growth lines and are wanting on the posterodorsal slope.

Dimensions of the incomplete holotype: Length 11+ mm., height about 9 mm., convexity about 4 mm.

[1] Vokes, H. E., oral communication.

The hinge of the right valve includes a large trigonal cardinal tooth curving upward at the end, a wide channel opening inward in front of this tooth, and a deep pit back of the tooth for the reception of the chrondrophore of the left valve. A groove just within and paralleling the margin of the shell, best seen on the paratype, indicates that the right valve is a little larger than and slightly overlaps the left valve.

Compared with *Corbula mississippiana* this species is shorter, is more pointed posteriorly, and has a coarser concentric ribbing.

The species is named in honor of Prof. William Clifford Morse.

Types: Holotype, U. S. N. M. 104075 (U. S. G. S. 18930); one figured paratype, U. S. N. M. 104076 (U. S. G. S. 18930); two unfigured paratypes, U. S. N. M. 104077 (U. S. G. S. 18894).

Occurrence: Avent No. 1 well, Grenada County, depth 2,730–2,750 feet (U. S. G. S. 18894, 18930).

Caryocorbula sp. *a*

One large left valve (*Caryocorbula* sp. *a*, pl. 32, fig. 17) resembles *C. oxynema* (Conrad) in form and is of comparable size to that species (Stephenson, 1923, pp. 341, 342, pl. 86, figs. 13–17). The surface and hinge are considerably worn, and the posterior end is broken away. The shell is elongate-subtrigonal in outline and is laterally somewhat compressed.

Dimensions: Length 14+ mm., height about 10.5 mm., convexity 4 mm.

Occurrence: Avent No. 1 well, Grenada County, depth 2,730–2,750 feet. U. S. N. M. 104078 (U. S. G. S. 18894).

Caryocorbula sp. *b*

One small incomplete right valve (*Caryocorbula* sp. *b*) may be a juvenile individual of a larger species. It appears to be a relatively short, high shell with fine, fairly pronounced concentric ribbing, a little sinuous in trend, and becoming coarser ventrally. It has a distinct umbonal ridge, obtusely subangular in cross section. The posterodorsal slope is steep and broadly excavated. The hinge and other internal features are not well preserved.

Dimensions as preserved: Length 2.7+ mm., height 2.2 mm., convexity 1.2 mm.

Occurrence: Avent No. 1 well, Grenada County, depth 2,730–2,750 feet. U. S. N. M. 104079 (U. S. G. S. 18894).

Caryocorbula sp. *c*

Two small, incomplete specimens (*Caryocorbula* sp. *c*), one a right valve and the other a left valve, pertain to a short, very plump species. They may be juvenile. The form and dentition are typically corbuloid, but the preservation is too poor for accurate specific assignment. The right valve measures: Length 4.4+ mm., height 3.2+ mm., convexity 1.9 mm.

Occurrence: Avent No. 1 well, Grenada County, depth 2,730–2,750 feet. Left valve, U. S. N. M. 104080 (U. S. G. S. 18894); right valve, U. S. N. M. 104081 (U. S. G. S. 18930).

Caryocorbula sp. *d*

One fragment of a right valve indicates a somewhat elongated, somewhat depressed species (*Caryocorbula* sp. *d*). It is characterized by a short, steep, anterodorsal slope and a long, wide, and broadly excavated posterodorsal slope. The cardinal tooth is proportionately large and prominent. The fragment is about 6 mm. long.

Occurrence: Avent No. 1 well, Grenada County, depth 2,730–2,750 feet. U. S. N. M. 104082 (U. S. G. S. 18930).

Class SCAPHOPODA

Family DENTALIIDAE

Genus DENTALIUM Linné, 1758

Dentalium sp.

Several fragments of smooth, gently tapering, gently curved tubes appear to pertain to a small *Dentalium*. The smallest fragment measures 0.7 mm. in diameter at the small end, and the maximum diameter of the largest fragment is 1.8 mm. The tubes appear to be broadly subovate in cross section, the longest diameter being at right angles to the plane of curvature of the tube.

Occurrence: Avent No. 1 well, Grenada County, depth 2,730–2,750 feet. Eight specimens, U. S. N. M. 104083 (U. S. G. S. 18894); one specimen, U. S. N. M. 104084 (U. S. G. S. 18930).

Class GASTROPODA

Family NERITIDAE

Genus NERITA Linné, 1758, sensu lato

Nerita nodosa Stephenson, n. sp.

Plate 33, figures 1–3

Shell small, closely involute, with very low spire. Protoconch very small, beadlike, somewhat worn in the available specimens, but apparently a smooth, simple trochoid shell. Whorls about 2, rapidly expanding. Shoulder weakly defined, broadly convex, rounding over to the broadly convex side below. Surface of holotype ornamented with 14 strongly noded primary spiral ribs, with 3 intercalated small secondary ribs appearing in the early stages of the body whorl, 2 on the side, and 1 on the shoulder. The nodes on the spirals are circular in plan and stand up as sharply defined low domes, forming regular rows on each primary spiral; the ribs and nodes are coarsest on the shoulders and upper part of the whorl and on the base. Aperture

subovate with a shallow but rather long, well-defined anal canal curving from the posterior end upward and to the left as seen from in front; anterior end of aperture regularly rounded. Outer lip thick and forming an approximate semicircle slightly modified at the intersection of the shoulder subangle; inner surface of outer lip apparently smooth. Inner lip forming a thick callus, which thins and spreads forward and upward on the parietal wall; the anal canal follows the upper edge of this callus to its upper terminus; inner edge of callus smooth, or with 1 weak tooth near the upper end as seen in 1 paratype.

Dimensions of the holotype: Height about 5 mm., diameter about 4.5 mm.

The species differs from *Nerita denticulata* in the simplicity and more sunken configuration of its inner lip, in the absence of denticulations on the inner surface of the outer lip, and in the greater strength and coarseness of the surface ornamentation.

Types: Holotype, U. S. N. M. 104085 (U. S. G. S. 18894); nine unfigured paratypes, U. S. N. M. 104086 (U. S. G. S. 18894); three unfigured paratypes, U. S. N. M. 104087 (U. S. G. S. 18930).

Occurrence: Avent No. 1 well, Grenada County, depth 2,730–2,750 feet (U. S. G. S. 18894, 18930).

Nerita denticulata Stephenson, n. sp.

Plate 33, figures 4–6

Shell small, semisubglobose, closely involute, with very low spire. Protoconch badly worn. Whorls 2 or 2½, rapidly expanding. Body whorl plumply rounded with a mere trace of a shoulder angulation. Surface covered with about 17 spiral ribs, which are rather badly worn or corroded but which in places show weak tubercles. Aperture subcrescentic with a shallow anal canal curving to the left and upward; anterior margin rounded. Outer lip strongly and asymmetrically arched, thin at the edge, thickening rearward; inner surface a little back of outer lip set with a row of 8 or 9 distinct, spirally elongated denticulations. Inner lip plumply callused, the callus spreading forward and thinning to an edge on the parietal wall; inner edge of lip with 3 strong teeth or plications, the upper one of which is a little thicker than the other 2.

Dimensions: Height about 4 mm., diameter about 5 mm.

This species differs from *Nerita nodosa* in its plump, strongly denticulate inner lip, its more rotund profile, and its weaker and somewhat finer surface ornamentation.

Type: Holotype, U. S. N. M. 104088.

Occurrence: Avent No. 1 well, Grenada County, depth 2,730–2,750 feet (U. S. G. S. 18894).

Family MELANELLIDAE

Genus MELANELLA Bowdich, 1822

Melanella (Eulima?) parva Stephenson, n. sp.

Plate 33, figures 11, 12

Shell very small, smooth, straight, high-turreted with apical angle of about 25°, decreasing somewhat on the larger whorls of the spire below. Protoconch small, smooth, trochoid. Suture line sharp and very shallow. Whorls six or seven, very gently convex, almost flat on the sides. Periphery and base of body whorl broadly rounded. Aperture broadly lanceolate, acutely angular at the rear, sharply rounded in front. Outer lip thin, broadly arched. Inner lip broadly excavated.

Dimensions of the one available shell: Height 3.6 mm., diameter 1.1 mm.

A small smooth shell of this sort affords a very meager basis for generic assignment. It may be juvenile, but it is nearly complete and is therefore given a specific name.

If curvature of the spire, which characterizes the genotype, *Melanella dufresnii* Bowdich, be accepted as of genetic value the name *Eulima* Risso, 1826, may be used with subgeneric rank for straight-spired shells, such as the one here described, as suggested by Vokes (1939, p. 177).

Holotype: U. S. N. M. 104089.

Occurrence: Avent No. 1 well, Grenada County, depth 2,730–2,750 feet (U. S. G. S. 18894).

Family NATICIDAE

Genus NATICA Scopoli, 1777, sensu lato

Unidentified specimens of Natica?

One medium-sized shell from Avent No. 1 well, Grenada County, depth 2,730–2,750 feet, has a low spire, and three and a half or four rapidly expanding whorls (pl. 33, figs. 7, 8). Protoconch worn away. The surface is smooth with the exception of rather pronounced growth lines. A narrow, weakly developed shoulder is present and is limited outwardly by an obtuse subangulation. The side of the body whorl is broadly rounded in profile. Umbilicus deep, narrow. Inner lip forming an expanded callus on the parietal wall. Dimensions: Height about 10 mm., diameter 7+ mm. U. S. N. M. 104090 (U. S. G. S. 18894).

One small shell from the same source, referred questionably to *Natica* (pl. 33, figs. 9, 10), has a small protoconch partly worn away and lacks a shoulder. It is plump in profile and has a small umbilicus. Dimensions: Height 2.7 mm., diameter 2.4 mm. U. S. N. M. 104091 (U. S. G. S. 18894).

Family TURRITELLIDAE

Genus TURRITELLA Lamarck, 1799

Turritella toleri Stephenson, n. sp.

Plate 33, figures 13–15

Shell small for the genus, high-turreted, with spiral angle of about 18°. Protoconch not preserved. Suture closely appressed, moderately impressed. Whorls 11 in the holotype, with 2 or 3 of the apical ones missing, flattish to very gently convex on the side. The sides of the whorls are ornamented with 3 primary and 4 secondary spiral ribs; the lower and middle primaries are a little closer together than the middle and upper ones; the primaries are very feebly noded. In each of the interspaces between the suture below and the suture above is a secondary spiral, all of which are fine and weak except the uppermost one just below the upper suture, which is a little stronger than the others. The secondaries fade out apically and are not seen on the smaller whorls of the spire. The primaries maintain their identity practically to the apex. The periphery of the body whorl bears a pair of spiral ribs separated by a shallow depression, the upper one of which is stronger; as the growing body whorl advanced it covered the lower rib of this pair, and its upper edge rests against the upper rib whose crest remains slightly exposed as a low narrow ridge bordering the suture. The flattish base below the pair of spirals is covered with a series of very fine, obscure spiral lines. From below upward the growth lines on the side of the whorl trend with strong obliquity backward to a point well above the middle, thence curve forward to the suture above; the antispiral sinus is therefore high on the whorl, and the growth-line angle is to the left of the axis instead of to the right, as it is in all the examples figured by Merriam (1941, p. 36, fig. 5). Aperture subcircular. Outer lip and part of the body whorl of the holotype broken away for several millimeters back of the aperture. Inner lip forming a thin callus over the base.

Dimensions of the holotype: Height 19.5 mm., diameter about 6.3 mm.

One fragment consisting of parts of three whorls (maximum diameter 4.3 mm.) has the pattern of ornamentation of the holotype of this species, except that the secondary spiral ribs are decidedly stronger; whether it is a distinct variety or merely an individual variant cannot be determined without a larger suite of specimens for comparison; for the present it is retained in the species.

The species is named in honor of Mr. Henry N. Toler, first president of the Mississippi Geological Society.

Types: Holotype, U. S. N. M. 104092; one unfigured paratype, U. S. N. M. 104093; one unfigured example (var.?), U. S. N. M. 104094.

Occurrence: Avent No. 1 well, Grenada County, depth 2,730–2,750 feet (U. S. G. S. 18894).

Turritella magnoliana Stephenson, n. sp.

Plate 33, figures 16–18

Shell small for the genus, turreted, with spiral angle of about 20°. Protoconch not preserved. Suture closely appressed, deeply impressed. Whorls broadly rounded on the side; four of the larger whorls preserved on the holotype. On the smallest whorl on the holotype (diameter about 3 mm.) are seven somewhat unequal spiral ribs of primary strength; between the second and third primaries from the top, and between the two lowermost primaries, are small secondaries that gradually increase in strength on the succeeding larger whorls but fall short of attaining primary strength; a third secondary makes its appearance between the third and fourth primaries on the antepenultimate whorl, and it too gains slowly in strength but remains comparatively small. An eighth primary spiral is present on the rounded periphery of the body whorl, but its crest appears only as a low ridge just above the suture on the earlier whorls; a narrow, shallow depression parallels the lower side of this rib on the body whorl. Base strongly constricted, very gently convex, smooth with the exception of very obscure spiral lining. Growth lines obscure. Shell broken away for about 5 mm. back of the outer lip of the aperture, which presumably is subcircular.

The preceding description is based mainly on the holotype, the largest and best preserved of four fragmentary specimens. The three paratypes exhibit individual variations, such as are common among the shells of turritelloid species. The largest of the paratypes is flattish on the upper part of the whorl and presents a stronger and more numerous development of secondary and tertiary spirals. There are seven primary spiral ribs, of which the second and fifth ones below the top are the strongest, and the last one below just above the suture is the weakest; secondaries are present in all the interspaces, and several very weak tertiaries can barely be discerned. The periphery is rounded, and the alternation of primary and secondary spirals continues over on to the base with diminishing strength, dying out a little more than halfway across. The advancing callus of the growing shell covers these weaker spirals.

Dimensions of the incomplete holotype: Height 14+ mm., diameter 6+ mm.

Compared with *Turritella toleri* this species has more deeply impressed sutures, the whorls are more convex on the sides, and the spiral ribs are more numerous and offer no suggestion of noding.

The name of this species is derived from "Magnolia," one of the nicknames of the State of Mississippi.

Types: Holotype, U. S. N. M. 104095 (U. S. G. S. 18894); one figured paratype, U. S. N. M. 104096 (U. S. G. S. 18894); one unfigured paratype, U. S. N. M.

104097 (U. S. G. S. 18894); one unfigured paratype, U. S. N. M. 104098 (U. S. G. S. 18930).

Occurrence: Avent No. 1 well, Grenada County, depth 2,730–2,750 feet (U. S. G. S. 18894, 18930).

Family CERITHIIDAE

Genus CERITHIUM Bruguière, 1789

"Cerithium" imlayi Stephenson, n. sp.

Plate 33, figures 19–22

Shell of medium size, high-turreted, with spiral angle of about 13°. Protoconch not preserved. Suture closely appressed, deeply impressed. Whorls probably 15 or more, flattish on the side, descending gently to the sutural depression above and steeply to the depression below. Each whorl bears 2 primary spiral lirae of medium strength and a third weak spiral just below the upper suture. The spirals are crossed by regularly spaced axials of medium strength, which number 20 or 21 on the largest whorl (diameter 5.1 mm.) and decrease to about 16 on the smallest whorl preserved (diameter 1.8 mm.). At each intersection of a primary spiral with an axial there is a prominent roundish beadlike node; at each intersection of the third weak spiral with an axial is a small node elongate in the direction of the spiral; the strength of the third spiral, including the nodes, varies somewhat on different individuals. The periphery of the body whorl, as seen on one of the paratypes, bears a prominent, thick, rugged spiral ridge; the upper edge of the growing body whorl rests against the crest of this ridge with the result that the suture does not follow the bottom of the sutural depression but lies well up its lower side. Base of shell strongly constricted, broadly excavated, crossed by rugged growth lines whose trend is rather strongly convex toward the aperture. On the side of the whorl above the base the growth lines trend obliquely upward and backward to the lower primary spiral, thence directly upward to the upper primary spiral, thence obliquely forward to the upper suture line; this indicates a deep wide notch in the outer lip of the aperture. The aperture appears to be broadly lanceolate with an obtuse anal angulation at the rear and a sharply rounded anterior margin. Outer lip broken away; inner lip forming a thin callus, which spreads forward a little on the excavated base.

Dimensions of the holotype, which is incomplete at both ends: Height 12+mm., diameter at large end 4.4 mm., diameter at small end 2.6 mm.

The species is named in honor of Dr. Ralph W. Imlay, geologist, U. S. Geological Survey.

Types: Holotype, U. S. N. M. 104099 (U. S. G. S. 18894); two figured paratypes, U. S. N. M. 104100 (U. S. G. S. 18894); two unfigured paratypes, U. S. N. M. 104101 (U. S. G. S. 18894); one unfigured paratype, U. S. N. M. 104102 (U. S. G. S. 18930).

Occurrence: Avent No. 1 well, Grenada County, depth 2,730–2,750 feet (U. S. G. S. 18894, 18930).

"Cerithium" sp. *a*

Plate 33, figure 23

One fragment of a fairly large whorl appears to belong to some member of the Cerithiidae. The sculpture consists of regularly spaced, rather weak axials crossed by four heavily noded spirals, the uppermost one, bordering the suture, being a little thicker and heavier than the others. The trend of the growth lines is concave toward the aperture.

Occurrence: Avent No. 1 well, Grenada County, depth 2,730–2,750 feet. U. S. N. M. 104103 (U. S. G. S. 18930).

"Cerithium" sp. *b*

Plate 33, figure 24

Shell small, turreted, with spiral angle of 25°. Suture closely appressed, slightly impressed. Whorls six or seven (estimated), gradually expanding, flat on the sides. Body whorl subobtusely angulated at the periphery. Base steep, broadly convex. Body whorl with five rather strong primary spiral ribs, and one secondary rib lies between the two uppermost primaries; the three uppermost primaries and the secondary rib are distinctly noded, the coarseness of the noding being proportional to the thickness; the two lowermost primaries are weakly noded. The upper edge of the growing body whorl rests against the lower flank of the lowermost primary. The outer area of the base bears six closely spaced spiral ribs, which are smaller than the primaries above and the successive ones of which decrease in strength inward and die out before reaching the center. Growth lines sinuous, being convex in trend toward the front on the base and strongly concave in the same direction on the side of the whorl above the periphery; the greatest depth of the latter curve is a little above the middle of the side.

Dimensions of the one available incomplete shell: Height 7+mm., diameter 3.7 mm.

Occurrence: Avent No. 1 well, Grenada County, depth 2,730–2,750 feet. U. S. N. M. 104104 (U. S. G. S. 18894).

Family STROMBIDAE

Genus PUGNELLUS Conrad, 1860

Pugnellus calcaris Stephenson, n. sp.

Plate 33, figures 25–32

Shell medium to large, some fragments indicating a size probably twice that of the selected holotype, smooth, plump-fusiform in stage immediately preceding that of the adult. Spire of medium height, spiral angle on the larger whorls about 65°; apical angle about 72°. Protoconch a simple smooth trochoid shell of not more

than two turns. Whorls six, evenly and regularly convex on the side. Suture closely appressed, moderately impressed. Body whorl elongated, with a slight, narrow constriction just below the suture, broadly excavated on the base. Growth lines sinuous, being gently sinuous low on the body whorl, strongly convex toward the aperture higher up toward the periphery, and concave in the same direction between the periphery and the suture above. Aperture at stage of growth shown in plate 33, figure 31, elongate, about three-fifths the height of the shell, asymmetrically lanceolate, with an acute angle at the rear and an open siphonal canal at the front. At this stage the outer lip is broadly arched above, becoming broadly concave below. Inner lip broadly excavated centrally and forming a thin callus on the parietal wall; remnants of this callus present on different parts of the shell indicate a general spread of the mantle over the exterior. At a shortly subsequent stage the outer lip thickens abruptly and puts out a short, thick, upturned, slightly twisted, spurlike projection, which bears a thick, round-crested, longitudinal ridge on the exterior above its lower border, and a narrow, longitudinal channel on its inner surface just below its upper border. Some fragments in the collection indicate that adult shells become much larger, perhaps twice as large as the holotype. Although the figured specimens do not show an excessive development of callus over the exterior of the shell, some fragments presumably of this species show a strong growth of callus extending up over and completely enveloping the spire.

Dimensions of the paratype shown in plate 33, figures 30, 31: Height about 36 mm., diameter 20 mm.

The species is not closely similar to any described species in the American Upper Cretaceous. However, one gastropod from water-laid volcanic sandstone exposed in a small area on the west flank of the Prothro salt dome, Bienville Parish, La., appears to be specifically identical with this one.

Types: Holotype, U. S. N. M. 104105; 4 figured paratypes, U. S. N. M. 104106; 30 unfigured rather incomplete paratypes, including also numerous uncounted fragments, U. S. N. M. 104107. All these are from the part of the core numbered 18894. About a dozen fragments were obtained from the part of the core numbered 18930 (U. S. N. M. 104108).

Occurrence: Mississippi, Avent No. 1 well, Grenada County, depth 2,730–2,750 feet (U. S. G. S. 18894, 18930).

Louisiana, questionably in water-laid volcanic sandstone exposed on west flank of Prothro salt dome. Bienville Parish (U. S. G. S. 11227, 12870).

Family PYROPSIDAE

Genus HERCORHYNCUS Conrad, 1869

Hercorhyncus? sp.

Plate 33, figures 41, 42

This species is represented by 1 very incomplete shell, which includes part of the body whorl and a small part of the penultimate whorl. The shell is fusiform with an elongated body whorl and a spire of moderate height. Collar well developed, below which the body whorl bears an estimated 9 or 10 short, thick axials, which from below upward are slightly oblique toward the rear; they end above at the shoulder in a blunt, ill-defined node and die out downward on the upper part of the basal slope. The base bears 4 rather strongly flattish-topped spirals separated by wider interspaces; above these spirals are several weaker spirals which become progressively more obscure upward and can barely be detected on the upper part of the body whorl; below the strong spirals are 2 or 3 obscure spirals. Growth lines sinuous, following the trend of the ribs to the edge of the shoulder, thence bending strongly forward across the shoulder and collar to the suture. Aperture rather wide above, passing anteriorly into a moderately long, somewhat twisted canal. Outer lip thin, arched, subangular at the intersection with the shoulder. Inner lip broadly excavated, forming a thin callus on the parietal wall. Columella smooth.

Occurrence: Avent No. 1 well, Grenada County, depth 2,730–2,750 feet. U. S. N. M. 104109 (U. S. G. S. 18894).

Family PALADMETIDAE

Genus PALADMETE Gardner, 1916

Paladmete caveola Stephenson, n. sp.

Plate 33, figures 33–36

This species is based on four specimens, one, the holotype, a medium-sized, nearly complete shell, one an incomplete adult, and two young individuals.

Shell of medium size, plump, low spire, with spiral angle of about 70°. Protoconch not preserved. Suture closely appressed, deeply impresed. Whorls 5 in the adult, broadly rounded on the side, with narrow, slightly excavated shoulder dipping gently inward to the suture and rounding sharply over to the steep side. Periphery of body whorl rounding over to the constricted base, with a weak suggestion of an obtuse angulation. Body whorl of adult ornamented with 15 round-crested axials, which, from below upward, cross the side of the whorl to the edge of the shoulder, thence bending sharply forward die out quickly about halfway across the

narrow shoulder; the axials fade out rather abruptly below where they intersect the periphery. The axials number 14 on the penultimate and 12 on the antepenult whorl; the number of axials on the body whorl of the large adult is estimated to be 23. The body whorl of the holotype bears about 10 small, obscure spirals, which are smallest and most closely spaced above near the shoulder; on and just below the periphery is a group of 4 spirals, which are stronger and more widely spaced than those above; the base below this group is smooth. Aperture broadly sublanceolate, with a very wide subobtuse angle at the rear, and a short, slightly twisted, wide open siphonal canal in the front.

The nearly complete holotype measures: Height 10.3+ mm., diameter 7 mm. The best preserved of the two young shells measures: Height 3.7+ mm., diameter 2.8 mm. The diameter of the large, incomplete adult is about 12 mm.

Compared with *Paladmete cancellaria* (Conrad), the genotype, this species has a more twisted and narrower siphonal canal, a much weaker development of spiral ribs, more numerous and more regularly spaced axial ribs, and a narrower and less steeply sloping shoulder; there is also only a slight tendency toward the development of varices in this species.

Types: Holotype, U. S. N. M. 104110 (U. S. G. S. 18894); one figured paratype, U. S. N. M. 104111 (U. S. G. S. 18894); one unfigured paratype, U. S. N. M. 104112 (U. S. G. S. 18894); one figured paratype, U. S. N. M. 104113 (U. S. G. S. 18930).

Occurrence: Avent No. 1 well, Grenada County, depth 2,730–2,750 feet (U. S. G. S. 18894, 18930).

Paladmete? sp.

Plate 33, figures 37, 38

One small, well-preserved gastropod, apparently a very young individual, questionably referred to *Paladmete*, has a spire of medium height, plump, evenly rounded whorls, and an aperture about equal in length to the height of the spire. Protoconch small, smooth, trochoid. Suture moderately impressed. The upper part of the body whorl bears 25 or more closely spaced axial ribs of uniform size, and the penultimate whorl is similarly ribbed. No spirals observed. Perimeter of body whorl broadly rounded. Aperture acutely angular at rear, broadly rounded on front margin.

Dimensions: Height 1.5 mm., diameter 0.9 mm.

Occurrence: Avent No. 1 well, Grenada County, depth 2,730–2,750 feet. U. S. N. M. 104114 (U. S. G. S. 18894).

Family FUSIDAE

Genus FUSINUS Rafinesque, 1815

"Fusinus" sp.

Plate 33, figures 39, 40

One small gastropod exhibits shell characters that would seem to justify its reference to a new genus. It is, however, incomplete and is probably juvenile and is therefore hardly adequate to serve as the type of either a genus or a species.

Spire rather low with spiral angle of about 68°. Protoconch not preserved. Whorls about 3, rapidly expanding. Body whorl with 2 prominent, unequal spiral ribs, the smaller one at the periphery and the larger one, which is high and sharp-crested, about halfway between the periphery and the suture above. The small rib is engulfed by the upper border of the advancing body whorl and is not exposed on the earlier whorls. Between, above, and below the 2 ribs the surface is covered with small obscure lirae. The space between the 2 prominent spirals is crossed by submerged fairly regular axials (estimated 16 on the body whorl), which are inclined slightly forward and are separated by wider interspaces; these axials ascend the lower slope of the large spiral rib and form low nodes on its crest. On the base the growth lines are slightly convex toward the front in trend. Between the spirals they follow the trend of the axials, and above the upper spiral they trend obliquely forward to the suture. Aperture rather broadly lanceolate, obtusely subangular at the rear; the anterior part of the shell is broken away, but the nearly straight columella suggests either a short siphonal canal or a sharply rounded or angular terminus. Outer lip broadly arched, angular at the intersection of the large spiral. Inner lip broadly excavated above at the parietal wall. Dimensions of the incomplete shell: Height 3.5+ mm., diameter 2.6 mm.

Occurrence: Avent No. 1 well, Grenada County, depth 2,730–2,750 feet. U. S. N. M. 104115 (U. S. G. S. 18894).

PART 2. A NEW VENERICARDIA FROM UVALDE COUNTY, TEXAS

INTRODUCTION

The new species of bivalve mollusk here described under the name *Venericardia uvaldana* is part of an unrecorded fauna mainly of pelecypods and gastropods, but including echinoids, bryozoans, and other organisms, from a locality on Nueces River about 0.3 mile upstream from the Southern Pacific R. R. bridge, 7 miles northwest of Uvalde, Uvalde County, Tex. (U. S. G. S. 15340, 16152, 16172, 16177). When the first collection was made in May 1930 the fossil-bearing rock was well-exposed low in the left bank and in the immediately adjacent dry bed of the River. In 1932 the rock was still exposed essentially as it was in 1930. When the locality was visited again in 1941, stream

erosion had cut the bank back toward the east a distance of fully 75 feet, and the site of the fossil-bearing rock had become covered by the shifting gravel of the river bed.

The rock that yielded *Venericardia uvaldana* and its numerous associated fossils consists of soft brownish-yellow marl and limestone; samples of the marl are highly calcareous and react vigorously to cold dilute hydrochloric acid. This rock formed part of a jumbled mass of marl, limestone, and weathered, tuffaceous water-laid volcanic material at that time poorly exposed to a height of 3 or 4 feet above the bed of the river along a linear distance of 200 feet or more. Some of the fossil shells are partly or wholly silicified as the result of the circulation of silica-bearing waters within the mass; the silica that replaced the calcium carbonate has taken the form of closely packed rosettes of chalcedony. The fauna is interpreted to indicate that the containing rock formed part of the Anacacho limestone (Upper Cretaceous). A few fossils found in chalky limestone indicate that part of the mass belonged to the Austin chalk (Upper Cretaceous), and there was inconclusive fossil evidence that the Grayson marl (Del Rio) of the upper part of the Comanche series might be represented in the mixture. These Cretaceous rocks were overlain by 25 feet or more of alluvial terrace gravel and loam of Pleistocene age.

The Anacacho age of the brownish-yellow marl and limestone, which yielded the major portion of the fauna, was at first not suspected. It seemed from the geographic and hypsographic position of the exposed mass that it should not include rocks younger than the Austin chalk. The fauna is made up mainly of undescribed species. However, certain species that appear to be identical with species in the Anacacho limestone, notably two undescribed echinoids, are accepted as indicating the Anacacho age of the fauna. One of the Anacacho echinoids is a *Hemiaster* from a locality on the Grosenbacher road 1.2 miles southeast of Potranco school, Bexar County (U. S. G. S. 17990), and the other is an *Echinobrissus* (U. S. G. S. 7709) from Sabinal River a few hundred yards downstream from the Southern Pacific R. R. bridge, a mile west of Sabinal, Uvalde County (U. S. G. S. 7709).

The geologic conditions in Uvalde County and adjacent areas have been described by Vaughan (1900, pp. 1–7, maps) and later by Lonsdale (1927, pp. 15–35, 103–110, 124–126, pl. 1), Getzendaner (1931, pp. 93–111, fig. 10), and Sayre (1936, pp. 21–32, 53–58, pl. 1). These writers have shown that during and following Cretaceous time a broad area in the vicinity of Uvalde, frequently spoken of as the Uvalde uplift (see geologic map of Texas, 1937), was uplifted and subjected to intensive intrusive and extrusive volcanic activity. This is indicated at many places by sills, stocks, larger masses of basic igneous rocks, and water-laid tuffaceous rock, and by many faults which cut and displace the sedimentary rocks of the area; columnar lava is well-developed in some of the stocks. If there had not been disturbances of this sort one would not expect to find an exposure of the Anacacho limestone at the locality on Nueces River described above. However, in view of the known dislocations in the area, some of which have operated to raise the rocks above and some to lower them below their otherwise normal positions, the presence of the Anacacho at the place indicated may be readily accounted for by downfaulting, by collapse of the rocks in sinks connected with limestones of the Comanche series, which underlie the Uvalde area, or by other structural disturbances associated with the igneous activity. The exact stratigraphic position of the fossiliferous brownish-yellow limestone within the Anacacho limestone is not determined, but it probably belongs near the base of that unit.

My purpose in describing the species, *Venericardia uvaldana*, at this time is to facilitate comparison with the closely analogous species, *V. subterrea*, from depths of 3,931 to 3,937 feet and 3,970 to 3,980 feet in the well of Baker, Ridgway, et al., McRae No. 1, in Hinds County, Miss. (See p. 167.) The two species are so closely similar in form and ornamentation as to suggest approximate, though not necessarily exact, synchroneity of the containing rocks at the two widely separated localities.

SYSTEMATIC DESCRIPTION

Phylum MOLLUSCA

Class PELECYPODA

Order TELEODESMACEA

Family CARDITIDAE

Genus VENERICARDIA Lamarck, 1801

Venericardia uvaldana Stephenson, n. sp.

Plate 31, figures 47–50

Shell of medium size and inflation, thick-walled, subcircular in outline, subequilateral, equivalve; a broad, gentle radial swell passes from the beak to the middle of the ventral margin. Beaks prominent, incurved, prosogyrate, approximate, situated a little in advance of the midlength. Greatest inflation about midway of the length, above the midheight, from which point the surface rounds off broadly to the margins in all directions, except toward the dorsal slopes, which, near the beaks, are steep and overhanging. Lunule small, short, outlined by a deeply incised groove, which widens noticeably toward the distal end. Escutcheon wanting. Surface cancellated by radial ribs and concentric grooves. The radial ribs number 32 on the holotype and are broadly curved in trend with the concave side toward the front; they are flattish-topped and are separated by

deep, much narrower interspaces; the ribs are coarsest on the anterior half of the surface and become progressively narrower and more crowded toward the rear. The concentric grooves are much narrower and shallower than the radial interspaces and are so spaced as to cut the surface into squarish and rectangular, flattish-topped nodes.

Dimensions of the holotype, a left valve: Length 25 mm., height 27 mm., convexity 9 mm. A smaller specimen measures: Length 19.6 mm., height 20 mm., convexity 6.8 mm.

The ligamental groove is narrow and is rather deeply submerged beneath a sharp, overhanging margin. The nymph is very narrow and deeply submerged. The hinge is heavy for the size of the shell. On the left valve are two cardinal teeth; the anterior cardinal is short, thick, trigonal, prominent, and faintly striated in the direction of movement on the anterior and posterior faces; the posterior cardinal is long, narrow, strongly oblique, broadly arched in trend, finely striated on the sides in the direction of movement; the cardinals are separated by a wide, deep, oblique, elongated trigonal socket. A squeeze made from the hinge of the left valve indicates the presence of a large medial cardinal in the right valve with the anterior and posterior cardinals so much reduced as to be practically obsolete. On the hinge plate just below the distal end of the groove delineating the lunule is a short, distinct protuberance which may function as a weak pseudolateral. Adductor scars of medium size, subequal, situated high in the shell. Pallial line entire. Inner margin strongly crenulated, the indentations marking the ends of the radial ribs.

Compared with *Venericardia subterrea* (p. 167, pl. 31, figs. 34–37, of this paper), the species is a little more convex, has a stronger development of the surface ornamentation, a somewhat larger lunule, and a broader and less oblique anterior cardinal tooth in the left valve; the lunule, though larger and less steep, is of the same sort as in *subterrea*. The two species are closely related.

Types: Holotype, a left valve, U. S. N. M. 103981; nine paratypes, including a medium-sized left valve, three juvenile left valves, four internal molds, two of which are of right and two of left valves, and one incomplete external mold of a right valve, U. S. N. M. 103982.

Occurrence: Bed of Nueces River, 0.3 mile upstream from the bridge of the Southern Pacific R. R., Uvalde County, Tex. (U. S. G. S. 15340).

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PLATES 31–33

PLATE 31

Fossils from the Avent well, Grenada County, Miss.

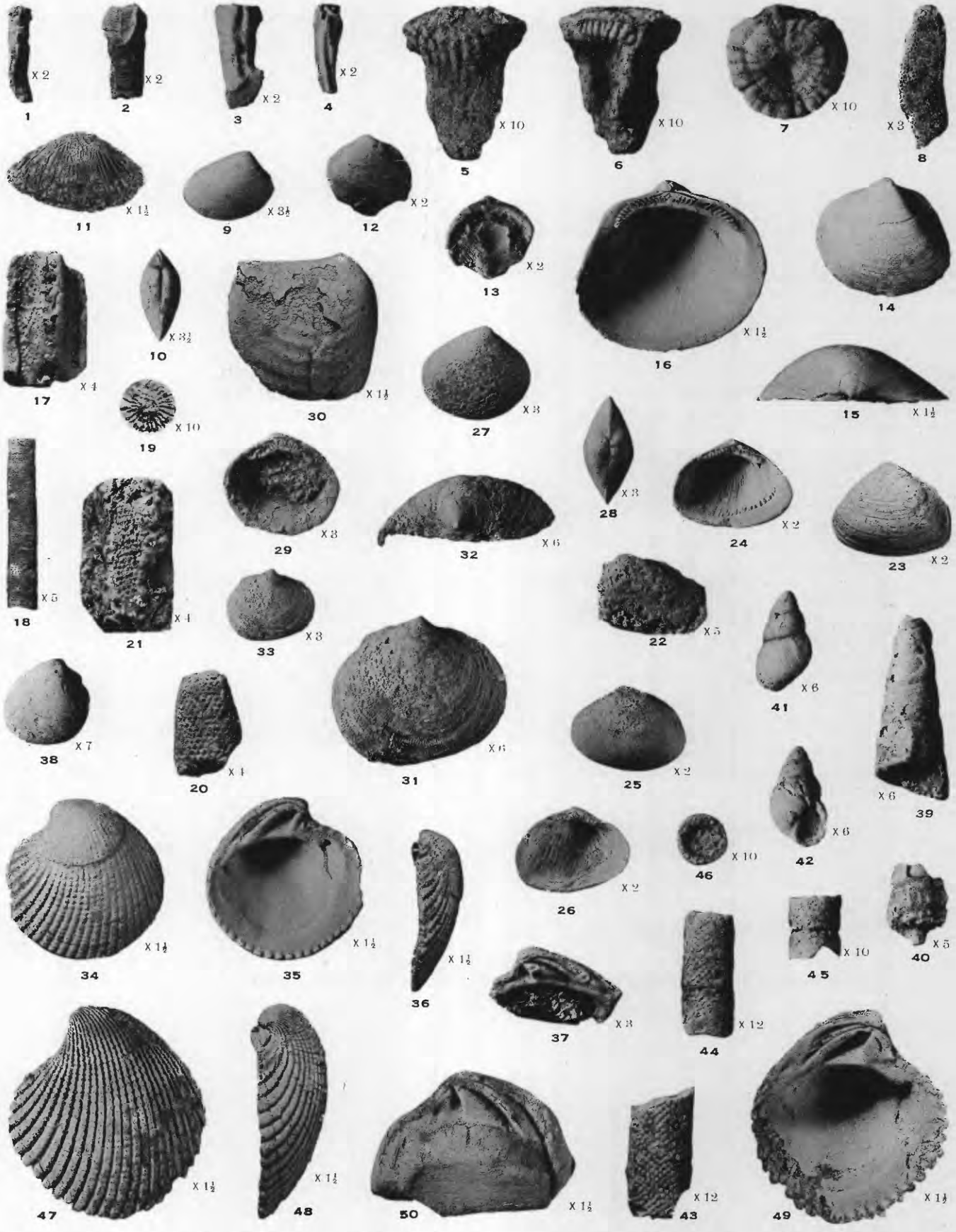
FIGURES 1, 2. *Serpula* sp. (p. 169). Tubes, × 2 (U. S. G. S. 18930; U. S. N. M. 104012).
FIGURES 3, 4. *Hamulus onyx* Morton (p. 169).
3. Incomplete tube, × 2 (U. S. G. S. 18894; U. S. N. M. 104014),
4. Incomplete tube, × 2 (U. S. G. S. 18930; U. S. N. M. 104014a).
FIGURES 5–7. *Hamulus?* sp. (p. 170). Operculum, × 2 (U. S. G. S. 18894; U. S. N. M. 104016).
FIGURE 8. *Membranipora* sp. (p. 170). A poorly preserved specimen, × 3 (U. S. G. S. 18930; U. S. N. M. 104017).
FIGURES 9, 10. *Nucula nulla* n. sp. (p. 170). Holotype, × 3½ (U. S. G. S. 18894; U. S. N. M. 104018).
FIGURE 11. *Barbatia?* sp. (p. 171). A poorly preserved right valve, × 1½ (U. S. G. S. 18894; U. S. N. M. 104021).
FIGURES 12, 13. *Breviarca* sp. (p. 171). Exterior and interior of left valve, × 2 (U. S. G. S. 18894; U. S. N. M. 104023).
FIGURES 14–16. *Trigonarca munda* n. sp. (p. 171).
14. Holotype, a left valve, × 1 (U. S. G. S. 18894; U. S. N. M. 104024).
15, 16. Top and interior views of holotype, × 1½.

Fossils from the McRae well, Hinds County, Miss. (U. S. G. S. 18884)

FIGURE 17. Madreporaria (p. 164). A fragment, × 4 (U. S. N. M. 103984).
FIGURES 18, 19. Crinoidea (p. 165).
18. Fragment of column, × 5 (U. S. N. M. 103985).
19. Cross section of same column, × 10.
FIGURES 20, 21. Bryozoa (Cheilostomata) (p. 165).
20. Fragment, × 4 (U. S. N. M. 103987).
21. Inner surface of wall, × 4 (U. S. N. M. 103987).
FIGURE 22. *Barbatia?* sp. (p. 165). Left valve, × 5 (U. S. N. M. 103988).
FIGURES 23–26. *Vetoarca hindsana* n. sp. (p. 165).
23, 24. Exterior and interior of paratypes, left valves, × 2 (U. S. N. M. 103990).
25, 26. Exterior and interior of holotype, a left valve, × 2 (U. S. N. M. 103989).
FIGURES 27–29. *Postligata monroei* n. sp. (p. 166).
27. Right valve of holotype, × 3 (U. S. N. M. 103992).
28. Top view of holotype, × 3.
29. Interior of a paratype, a right valve (U. S. N. M. 103994).
FIGURE 30. *Inoceramus* sp. (p. 166). Right valve, × 1½ (U. S. N. M. 103997).
FIGURES 31–33. *Anomia microlirae* n. sp. (p. 167). Views of the holotype, × 3 and × 6 (U. S. N. M. 103998).
FIGURES 34–37. *Venericardia subterrea* n. sp. (p. 167).
34–36. Views of the holotype, a left valve, × 1½ (p. 167) (U. S. N. M. 104001).
37. Hinge of the right valve of a paratype, × 3 (p. 167) (U. S. N. M. 104000).
FIGURE 38. *Tenea?* sp. (p. 168). Right valve, × 7 (U. S. N. M. 104005).
FIGURE 39. *Turritella* sp. (p. 168). A fragment, × 6 (U. S. N. M. 104006).
FIGURE 40. *"Cerithium"* sp. (p. 168). A small fragment, × 5 (U. S. N. M. 104008).
FIGURES 41, 42. *Odostomia mcraei* n. sp. (p. 168). Holotype, back and front views, × 6 (U. S. N. M. 104009).
FIGURES 43–46. Undetermined species of algae (p. 169).
43, 44. Fragments of stems showing tubercles, × 12 (U. S. N. M. 104010).
45, 46. Views of a fragment showing constriction at joint, and cross section, × 10; part below joint subsequently broken off and lost (U. S. N. M. 104010).

A new Venericardia from Uvalde County, Tex. (U. S. G. S. 15340)

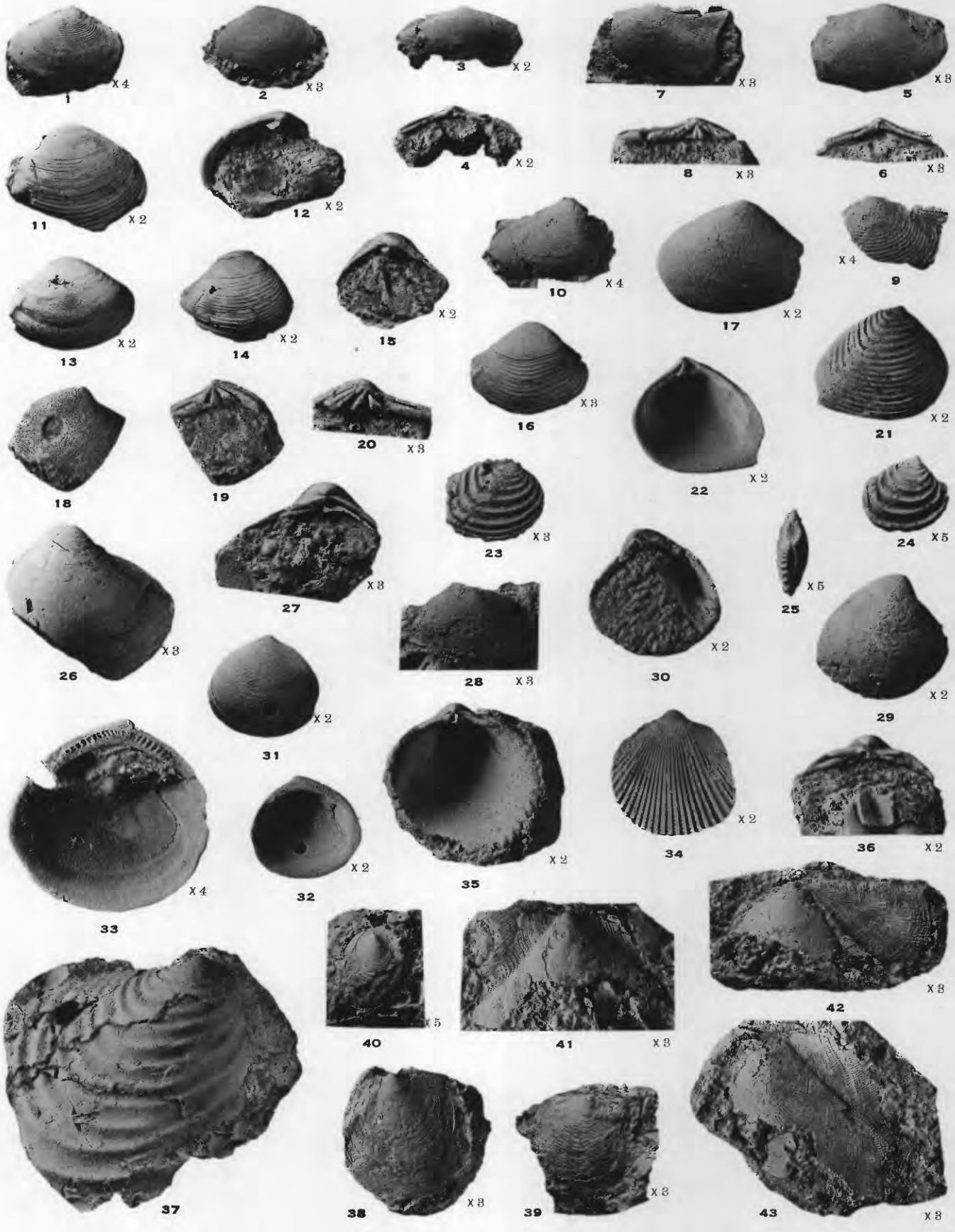
FIGURES 47–50. *Venericardia uvaldana* n. sp. (p. 186).
47–49. Views of the holotype, a left valve, × 1½ (U. S. N. M. 103981).
50. A squeeze made from the hinge of the holotype, × 1½ (U. S. N. M. 103983).



FOSSILS FROM THE AVENT AND McRAE WELLS IN MISSISSIPPI, AND A NEW VENERICARDIA FROM UVALDE COUNTY, TEX.

PLATE 32

FIGURE 1. *Tellina?* sp. *a* (p. 177). Left valve, × 4 (U. S. G. S. 18894; U. S. N. M. 104059).
FIGURE 2. *Tellina* sp. *b* (p. 177). Right valve, × 3 (U. S. G. S. 18930; U. S. N. M. 104062).
FIGURES 3, 4. *Tellina* sp. *c* (p. 177). Right valve, × 2 (U. S. G. S. 18894; U. S. N. M. 104065).
FIGURES 5–8. *Tellina harrelli* n. sp. (p. 176).
5, 6. Holotype, a right valve, × 3 (p. 176) (U. S. G. S. 18930; U. S. N. M. 104055).
7, 8. Incomplete paratype, a left valve, × 3 (p. 176) (U. S. G. S. 18930; U. S. N. M. 104056).
FIGURE 9. *Linearia sp.* (p. 177). Incomplete right valve, × 4 (U. S. G. S. 18894; U. S. N. M. 104068).
FIGURE 10. *Protodonax sp.* (p. 178). Left valve, × 4 (U. S. G. S. 18894; U. S. N. M. 104069).
FIGURES 11–13: *Caryocorbula mississippiana* n. sp. (p. 179).
11, 12. Holotype, a right valve, × 2 (U. S. G. S. 18894; U. S. N. M. 104072).
13. A paratype, a right valve, × 2 (U. S. G. S. 18894; U. S. N. M. 104073).
FIGURES 14–16. *Caryocorbula morsei* n. sp. (p. 179).
14, 15. Holotype, a right valve, × 2 (U. S. G. S. 18930; U. S. N. M. 104075).
16. Paratype, a right valve, × 3 (U. S. G. S. 18930; U. S. N. M. 104076).
FIGURE 17. *Caryocorbula* sp. *a* (p. 180). Left valve, × 2 (U. S. G. S. 18894; U. S. N. M. 104078).
FIGURES 18–20. *Aphrodina* sp. (p. 176).
18, 19. Incomplete right valve, × 1 (U. S. G. S. 18894; U. S. N. M. 104054).
20. Incomplete left valve showing hinge, × 3 (U. S. G. S. 18894; U. S. N. M. 104054).
FIGURES 21–25. *Crassatella subterrestris* n. sp. (p. 174).
21, 22. Holotype, a right valve, × 2 (U. S. G. S. 18894; U. S. N. M. 104044).
23. A paratype, a young right valve, × 3 (U. S. G. S. 18930; U. S. N. M. 104046).
24, 25. Views of a complete young shell, × 5 (U. S. G. S. 18930; U. S. N. M. 104046).
FIGURES 26, 27. *Spisula brevis* n. sp. (p. 178). Holotype, an incomplete right valve, × 3 (U. S. G. S. 18894; U. S. N. M. 104070)
FIGURE 28. *Etea?* sp. (p. 174). Left valve, × 3 (U. S. G. S. 18930; U. S. N. M. 104043).
FIGURES 29, 30. *Fulpia? subtrigona* n. sp. (p. 176). Holotype, a right valve, × 2 (U. S. G. S. 18894; U. S. N. M. 104052).
FIGURES 31–33. *Postligata aventi* n. sp. (p. 172).
31, 32. Holotype, a right valve, × 2 (U. S. G. S. 18930; U. S. N. M. 104025).
33. A paratype, a left valve, × 4 (U. S. G. S. 18894; U. S. N. M. 104026).
FIGURES 34–36. *Cardium* (*Trachycardium*) *grenadense* n. sp. (p. 175).
34. Holotype, a left valve, × 2 (p. 175) (U. S. G. S. 18894; U. S. N. M. 104048).
35, 36. Paratypes, left and right valves to show hinges, × 2 (p. 175) (U. S. G. S. 18894; U. S. N. M. 104049).
FIGURE 37. *Inoceramus* sp. (p. 173). Right valve, × 1 (U. S. G. S. 18894; U. S. N. M. 104030).
FIGURES 38–40. *Anomia acutilinearis* n. sp. (p. 174).
38. Holotype, a left valve, × 3 (U. S. G. S. 18894; U. S. N. M. 104039).
39, 40. Paratypes, × 3 and × 5 (U. S. G. S. 18894; U. S. N. M. 104040).
FIGURES 41–43. *Pecten* (*Camptonectes*) sp. (p. 173).
41. Fragment of left valve, × 3 (U. S. G. S. 18930; U. S. N. M. 104035).
42, 43. Fragments of a right and a left valve, × 3 (U. S. G. S. 18894; U. S. N. M. 104036).



FOSSILS FROM THE AVENT WELL IN MISSISSIPPI.

PLATE 33

FIGURES 1–3. *Nerita nodosa* n. sp. (p. 180). Views of the holotype, × 4 (U. S. G. S. 18894; U. S. N. M. 104085).

FIGURES 4–6. *Nerita denticulata* n. sp. (p. 181). Views of the holotype, × 4 (U. S. G. S. 18894; U. S. N. M. 104088).

FIGURES 7, 8. *Natica* sp. (p. 181). Back and front views, × 2 (U. S. G. S. 18894; U. S. N. M. 104090).

FIGURES 9, 10. *Natica?* sp. (p. 181). Back and front views, × 6 (U. S. G. S. 18894; U. S. N. M. 104091).

FIGURES 11, 12. *Melanella* (*Eulima?*) *parva* n. sp. (p. 181). Back and front views of the holotype, × 5 (U. S. G. S. 18894; N. S. N. M. 104089).

FIGURES 13–15. *Turritella toleri* n. sp. (p. 182). Views of the holotype, × 3 (U. S. G. S. 18894; U. S. N. M. 104092).

FIGURES 16–18. *Turritella magnoliana* n. sp. (p. 182).

16, 17. Back and front views of the holotype, × 3 (U. S. G. S. 18894; U. S. N. M. 104095).

18. Fragment of a paratype, × 3 (U. S. G. S. 18894; U. S. N. M. 104096).

FIGURES 19–22. *"Cerithium" imlayi* n. sp. (p. 183).

19. Holotype, × 3 (U. S. G. S. 18894; U. S. N. M. 104099).

20–22. Views of two paratypes, × 3 (U. S. G. S. 18894; U. S. N. M. 104100).

FIGURE 23. *"Cerithium"* sp. *a* (p. 183). A fragment, × 4 (U. S. G. S. 18930; U. S. N. M. 104103).

FIGURE 24. *"Cerithium"* sp. *b* (p. 183). A young incomplete specimen, × 4 (U. S. G. S. 18894; U. S. N. M. 104104).

FIGURES 25–32. *Pugnellus calcaris* n. sp. (p. 183).

25, 26. Front and back views of the holotype, × 1 (U. S. G. S. 18894; U. S. N. M. 104105).

27–32. Paratypes (U. S. G. S. 18894; U. S. N. M. 104106).

27. Back view of an adult, × 1.

28, 29. Front and back views of expanded lip and spur, × 1.

30, 31. Front and back views of a shell at stage just preceding the expansion of the outer lip, × 1.

32. Apex of a young shell, × 5.

FIGURES 33–36. *Paladmete caveola* n. sp. (p. 184).

33, 34. Back and front views of the holotype, × 3 (U. S. G. S. 18894; U. S. N. M. 104110).

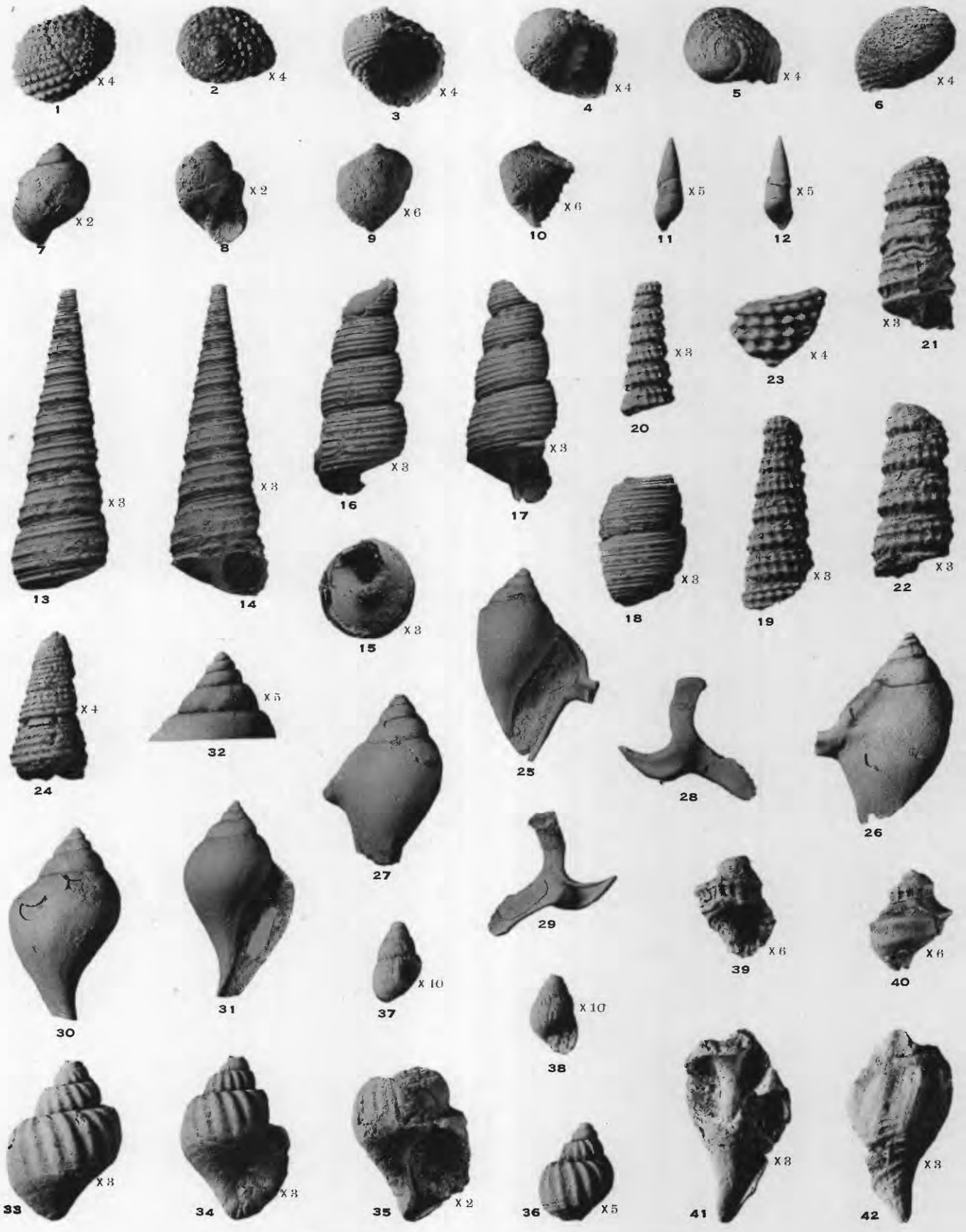
35. A larger incomplete paratype, × 2 (U. S. G. S. 18894; U. S. N. M. 104111).

36. A young paratype, × 5 (U. S. G. S. 18930; U. S. N. M. 104113).

FIGURES 37, 38. *Paladmete?* sp. (p. 185). Back and front views, × 10 (U. S. G. S. 18894; U. S. N. M. 104114).

FIGURES 39, 40. *"Fusinus"* sp. (p. 185). Front and back views, × 6 (U. S. G. S. 18894; U. S. N. M. 104115).

FIGURES 41, 42. *Hercorhyncus?* sp. (p. 184). Front and back views, × 3 (U. S. G. S. 18894; U. S. N. M. 104109).



FOSSILS FROM THE AVENT WELL IN MISSISSIPPI.

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