Correlation and Foraminifera of the Monmouth Group (Upper Cretaceous) Long Island, New York

GEOLOGICAL SURVEY PROFESSIONAL PAPER 483-I

Prepared in cooperation with the New York State Water Resources Commission, Suffolk County Board of Supervisors, and the Suffolk County Water Authority

U. S. DEPARTMENT OF THE INTERIOR

March 3, 1849

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By NATHANIEL M. PERLMUTTER *and* RUTH TODD

CONTRIBUTIONS TO PALEONTOLOGY

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UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1965

UNITED STATES DEPARTMENT OF THE INTERIOR

STEWART L. UDALL, *Secretary*

GEOLOGICAL SURVEY

Thomas B. Nolan, *Director*

The U.S. Geological Survey Library Catalog card for this publication follows index.

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402

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CORRELATION AND FORAMINIFERA OF THE MONMOUTH GROUP (UPPER CRETACEOUS), LONG ISLAND, NEW YORK

By Nathaniel M. Perlmutter and Ruth Todd

ABSTRACT

Examination of drill cores and cuttings from water wells and test borings in southern Suffolk County, N.Y., has disclosed the presence of a marine fossiliferous greensand unit in the upper part of a thick sequence of deposits formerly referred to as the Magothy(?) Formation of Late Cretaceous age. The microfauna, mineralogy, and general stratigraphic position, however, indicate that the greensand beds are correlative with the Monmouth Group of New Jersey; hence, the same name should be applied to the Long Island beds. The greensand beds contain moderate to large amounts of glauconite, are about 50–200 feet thick, and dip southeast about 30 feet per mile. Seventy-two different species of Foraminifera and a few Ostracoda were identified and most of them are illustrated in the report. Underlying transitional beds of post-Raritan Cretaceous age are thought to be part of the Matawan Group and Magothy Formation undifferentiated.

The report is a byproduct of cooperative ground-water investigations in Long Island.

INTRODUCTION

POST-RARITAN CORRELATION PROBLEMS

The entire sequence of post-Raritan Cretaceous deposits in Long Island was referred to the Magothy Formation as early as 1910 by W. O. Crosby (unpub. data, Board of Water Supply, city of New York). Crosby's correlation apparently was based on little more than a megascopic similarity in lithology between the Long Island strata and those of the Magothy Formation of New Jersey and general regional stratigraphic relations. Since 1937 a question mark has been inserted after the name Magothy in Geological Survey reports dealing with ground water on Long Island, because of the uncertainty regarding Crosby's correlation.

Among the principal problems in correlating the post-Raritan Cretaceous beds of Long Island are the lack of outcrops, the monotonous megascopic similarity in color, texture, and composition of most of the beds, and also the rarity of glauconitic and fossiliferous marine beds, which are common in the equivalent post-Raritan Cretaceous units of New Jersey. Micropaleontologic and mineral analyses of drill samples from water wells and test borings made during this investigation have yielded evidence of marine beds in the uppermost part of the post-Raritan Cretaceous deposits in southern Suffolk County, Long Island, which are believed to be correlative with the Monmouth Group of New Jersey. From data given on pages I3 and I5, it is inferred also that the underlying nonmarine strata of post-Cretaceous age consist of formations equivalent in age to those of the Matawan Group and the Magothy Formation of New Jersey, although criteria for differentiating these units with certainty in Long Island are not yet available. Additional detailed studies of heavy minerals, clay minerals, and pollen and spore analyses might provide such criteria.

LOCATION AND TOPOGRAPHY OF THE AREA

The area investigated is a rectangular strip about 3–5 miles wide and 50 miles long, in southern Suffolk County (pl. 7). It extends from about Sunrise Highway (Route 27) on the north to the Atlantic Ocean on the south and from the Nassau-Suffolk border on the west to the vicinity of Shinnecock Canal on the east.

Most of the south shore of Suffolk County is a low-lying glacial outwash plain, which slopes gently to the south and merges with tidal flats and marshes along the north shore of Great South Bay and other smaller bays. The bays, which lie between the main part of Long Island and sandy barrier islands to the south, are generally 2–4 miles wide, but in a few places in the eastern part of the area, they narrow to a few hundred feet or less. The bays are generally less than 10 feet deep.

The barrier islands are about a quarter to half a mile wide and range in altitude from sea level to about 25 feet above sea level. Drill cuttings and cores of fossiliferous sand and clay of Late Cretaceous age were obtained from deep public-supply wells and test borings for the Fire Island Inlet and Smith Point Bridges. Except for shallow thin lenses of fresh water, which are recharged by local precipitation, the water in the artesian aquifers beneath the barrier islands is derived entirely by ground-water underflow from the main part of Long Island to the north.

PREVIOUS INVESTIGATIONS

A comprehensive report on the subsurface geology of Long Island, prepared cooperatively by the Geological Survey and the New York State Water Resources Commission (Suter and others, 1949), gives correlations of wells, structure-contour maps, and geologic sections based on data collected in the early 1900's (Veatch and others, 1906, and Fuller, 1914) and during the period 1932–49. An article by Perlmutter and Crandell (1959) summarized information on the geology and ground-water conditions along the south shore of Long Island and reported briefly on the occurrence of the glauconitic beds and Foraminifera of Late Cretaceous age that are described in detail in this report. Except for this report, no data on the Cretaceous Foraminifera of Long Island have been previously published. The general geology of parts of southern Suffolk County is described in reports by Pluhowski and Kantrowitz (1962) and by deLaguna (1963).

METHODS OF INVESTIGATION

Several hundred rock samples collected from wells in and near the report area have been examined for general lithology and fossil content by the senior author as part of a series of investigations of the ground-water resources of Suffolk County. Most of the samples were flume or bailer samples that were commonly contaminated to some extent by material from the strata above the depth sampled. Since 1950, uncontaminated cores from test wells have become available, and a special effort has been made to check them for the occurrence of marine microfossils.

The procedure for detecting microfossils consisted of examining the samples under a binocular microscope and washing selected ones free of clay through a 270-mesh sieve. The dried residue was mixed with carbon tetrachloride to float off the Foraminifera, which were concentrated and picked over, and representative specimens were mounted on slides for identification. Preliminary study showed that they were distinctly different from those of the Gardiners Clay of Pleistocene age, which had been identified previously in Suffolk County (Weiss, 1954), and they resembled most closely faunas of Late Cretaceous age found in the Atlantic and Gulf Coastal Plains (Cushman, 1946). In 1958 the Foraminifera were sent to Washington, D.C., where the junior author studied them in detail and confirmed their Late Cretaceous age. Between 1958 and 1961, Foraminifera concentrated from samples from additional wells in the report area were sent to the junior author for identification, illustration, and inclusion with the original faunal assemblage. The illustrated specimens of the Foraminifera in this report are on file at the U.S. National Museum in Washington, D.C.

Wells have been assigned numbers by the New York State Water Resources Commission in the order drilled. For example, in the number S18729T, the letter S is the abbreviation for Suffolk County, and T signifies test well.

ACKNOWLEDGMENTS

The authors express their appreciation to all the well drillers who supplied logs and samples for use in the investigation. Logs of wells were obtained also through the cooperation of the New York State Water Resources Commission, the Suffolk County Water Authority, and the Suffolk County Board of Supervisors, who support ground-water investigations by the U.S. Geological Survey in Suffolk County. The Long Island State Park Commission loaned samples from wells at Captree and Fire Island State Parks and borings for Captree Causeway and Fire Island Inlet Bridge. The Suffolk County Department of Public Works supplied records of test borings and wells at the Smith Point Bridge, south of Shirley, Long Island. Mr. I. G. Sohn, of the Geological Survey, identified several specimens of Ostracoda, and Mr. James Owens, also of the Geological Survey, arranged for heavy-mineral analyses and commented briefly on their significance. The study was begun under the supervision of G. C. Taylor, Jr., former district geologist and was completed under the supervision of R. C. Heath, district geologist, New York District.

SUMMARY OF STRATIGRAPHY OF SOUTHERN SUFFOLK COUNTY

Precambrian-Paleozoic(?) bedrock of indeterminate thickness and overlying unconsolidated deposits of Late Cretaceous, Pleistocene, and Recent age, about 2,000 feet thick, compose the subsurface units beneath southern Suffolk County (table 1). The bedrock consists of granitic and gneissic rocks and schist. The surface of the bedrock ranges in altitude from about 1,450 feet below sea level in the northwest part of the area to about 2,000 feet below sea level in the south-central part and dips southeast about 100 feet per mile (Suter and others, 1949). Deposits of the Upper Cretaceous Series compose the bulk of the strata above bedrock. Pleistocene deposits form a veneer on the irregular surface of the Cretaceous beds.

UPPER CRETACEOUS SERIES

The deposits of the Upper Cretaceous Series beneath the barrier beaches of Suffolk County consist chiefly of transitional beds and some marine beds that have an aggregate thickness of about 1,600–1,800 feet. The beds dip southeast about 30–100 feet per mile—the older beds have the steeper dips. The Upper Cretaceous deposits

TABLE 1.—*Generalized stratigraphic section for southern Suffolk County*

System	Series	Geologic formation or unit	Approximate thickness (feet)	Lithologic properties
Quaternary	Recent	Recent deposits	0–50	Beach sand, dune sand, and gravel, commonly containing shells; some thin layers of clay.
	Pleistocene	Upper Pleistocene deposits —Unconformity—	40–150	Brown and gray sand and gravel and some thin beds of clay.
		Gardiners Clay —Unconformity—	0–50	Gray and greenish-gray silt and clay; contains some lenses of sand and gravel; glauconite, diatoms, and Foraminifera rare to abundant.
Cretaceous	Upper Cretaceous	Post-Raritan Cretaceous deposits[1] —Unconformity—	600–1200	Upper 50–200 ft beneath barrier islands consists of fossiliferous black silty clay and glauconitic sandy clay. Underlying beds consist of fine to medium sand and silt interbedded with gray clay; some gravel zones near the bottom of the unit. Lignite is common; no marine macro- or microfossils have been observed.
		Raritan Formation: Clay Member	200–350	Gray, white, red, and black silt and silty clay; some sandy beds.
		Raritan Formation: Lloyd Sand Member —Unconformity—	200–400	Gray sand and gravel; some lenses and beds of clay and silt.
Precambrian-Paleozoic(?)	—	Crystalline rocks	—	Granitic and gneissic rocks and schist.

[1] Referred to the Magothy (?) Formation in earlier reports. See table 2 for proposed differentiation of these deposits.

of New Jersey (table 2) have been divided into as many as 10 formations (Weller, 1907; Cooke and Stephenson, 1928; Owens and Minard, 1960), but only the Magothy(?) and Raritan Formations have been recognized by most investigators of the Cretaceous of Long Island. In this report the authors propose that the Cretaceous strata of Long Island be divided from oldest to youngest into (1) the Raritan Formation, (2) the Magothy Formation and Matawan Group undifferentiated, and (3) the Monmouth Group undifferentiated. Units 2 and 3, include all beds formerly referred to the Magothy(?) Formation.

TABLE 2.—*Correlation of Upper Cretaceous deposits of New Jersey and Long Island, N.Y.*

Series	New Jersey		Long Island	
	After Owens and Minard (1960)		Perlmutter and Todd (1965)	
Upper Cretaceous	Monmouth Group	Red Bank Sand Navesink Formation Mount Laurel Sand. (Chiefly marine beds; glauconite abundant.)	Monmouth Group[1] undifferentiated	Includes equivalents of Red Bank and Navesink Formations and probably Mount Laurel Sand. (Chiefly marine beds; glauconite abundant.)
	Matawan Group	Wenonah Formation Marshalltown Formation Englishtown Formation Woodbury Clay Merchantville Formation. (Chiefly marine beds; glauconite abundant.)	Magothy Formation and Matawan[1] Group undifferentiated	Probably includes all the equivalent formations of New Jersey. (Chiefly transitional beds lacking marine fossils; glauconite absent to rare.)
	Magothy Formation (Marine and nonmarine beds) — Unconformity —			— Unconformity —
	Raritan Formation (Chiefly nonmarine beds) — Unconformity —		Raritan Formation (Nonmarine beds) — Unconformity —	
Precambrian, Paleozoic, and Mesozoic	Crystalline and sedimentary bedrock		Precambrian and Paleozoic(?)	Crystalline bedrock

[1] Referred to the Magothy(?) Formation in earlier reports.

The Raritan Formation consists of red, white, and gray nonmarine beds, which are divided into a lower unit called the Lloyd Sand Member and an upper unit called the Clay Member. Because the surface of the Raritan is 1,000–1,500 feet below sea level, further discussion of this formation is unnecessary and is beyond the scope of this report.

The transitional part of the post-Raritan Cretaceous deposits consists of the Matawan Group and the Magothy Formation (table 2). It is not yet practical, however, to differentiate these geologic units, on the basis of present knowledge, in most parts of Long Island. The post-Raritan Cretaceous deposits consist mostly of beds and lenses of gray fine to medium quartzose sand, silt, clay, and subordinate gravelly beds in the lower part of the unit. No marine fossils have been found in the deposits, but lignite, pollen, and spores are abundant. The beds were probably laid down mainly in deltaic and lagoonal-estuarine environments. The deposits have a maximum aggregate thickness of about 1,100 feet. Because the Magothy Formation is present at depths too great to be shown on the geologic sections of this report, the lithology of the beds beneath the Monmouth Group, illustrated by columnar sections on plate 8 and described in well logs (table 3), is probably that of the Matawan Group as indicated on plate 8. The fossiliferous and glauconitic beds of Late Cretaceous age that overlie the Matawan Group compose the Monmouth Group (tables 2 and 3 and pl. 8).

PLEISTOCENE AND RECENT SERIES

The Cretaceous deposits are overlain unconformably by the interglacial Gardiners Clay and the upper Pleistocene deposits. Deposits of Recent age are restricted chiefly to the shoreline. They are relatively thin and, in some places, cannot be readily distinguished from underlying Pleistocene deposits.

The Gardiners Clay overlies the Monmouth and Matawan Groups and may be mistaken for Cretaceous beds in well logs or in samples that have not been examined carefully under a microscope. The Gardiners is typically a green and gray silty clay, which contains lenses of sand and gravel in some places. Partly carbonized plant material and the minerals biotite, chlorite, hornblende, muscovite, and quartz are common to abundant in the silt fractions; glauconite is rare to common and is generally weathered pale green and is waterworn because it was redeposited from older beds. Shells, Foraminifera (Weiss, 1954), and diatoms (Lohman, 1939) are rare to abundant in the Gardiners and are readily distinguishable from those of the Monmouth Group (see "Analysis of the microfauna"). Present data suggest that the Gardiners was deposited chiefly in a lagoonal-estuarine environment.

The landward limit of the Gardiners Clay in the report area is at or north of Sunrise Highway (Route 27) in most of the report area, in contrast to the limit of the Monmuoth Group, which is a short distance north of Great South Bay in only a few places (pl. 7). The upper surface of the Gardiners is about 50–100 feet below sea level. The thickness of the formation is generally from 10 to 25 feet and is greatest in former channels and embayments on the Cretaceous surface (pl. 8). Some of these embayments may be strike valleys, which are bounded on the south by low divides on the buried Cretaceous surface that are approximately at the same location as parts of the present barrier islands.

Beds of brown and gray sand and gravel, deposited as outwash in late Wisconsin time, lie directly on the Gardiners Clay. The outwash is overlain by Recent deposits, composed mostly of sand and gravel beneath the barrier islands and of peat, silt, and sand beneath the swamps and bays.

STRATIGRAPHY AND MICROPALEONTOLOGY OF THE MONMOUTH GROUP (UPPER CRETACEOUS)

DEFINITION AND AREAL EXTENT

The Monmouth Group of Long Island, also referred to informally in this report as the greensand unit, consists of fossiliferous beds of black and gray silty clay and greenish-gray sand and sandy clay, which are overlain by the Gardiners Clay and underlain by nonfossiliferous gray fine sand and sandy clay of the Matawan Group (tables 2 and 3 and pl. 8).

The Monmouth Group does not crop out anywhere in Long Island and has been identified only in samples from wells in southwestern and south-central Suffolk County. The landward limit of the Monmouth Group ranges from a short distance north of Great South Bay in the south-central part of the report area to an unknown distance offshore in the southwestern and southeastern parts (pl. 7). The boundary shown on the map is probably more irregular than illustrated and doubtless is erosional. The lithology and continuity of the Monmouth Group in the offshore area are unknown but probably the unit thickens downdip and is more clayey as the beds grade seaward into deeper water marine facies.

ALTITUDE, STRUCTURE, AND THICKNESS

The upper surface of the Monmouth Group ranges from about 90–140 feet below sea level. The lower surface ranges from about 140–330 feet below sea level and seems to be conformable with the underlying beds of the Matawan Group (pl. 8). The beds strike northeasterly and dip about 30 feet per mile toward the southeast. The Monmouth Group is about 200 feet thick beneath the barrier beach but thins to a few feet at its northern limit which is an erosional boundary.

LITHOLOGY

The Monmouth Group consists chiefly of two major lithologic types: (a) dark gray and black silty and sandy micaceous clay and (b) greenish clay and glauconitic sandy clay (table 3 and pl. 8). The lithologic variations in the beds may have formational significance but studies of the microfauna and mineralogy for this report were not sufficiently detailed to permit definition of specific formation boundaries, although the Foraminifera suggest that both the Red Bank and Navesink Formations are present. (See "Analysis of the microfauna.")

The abundance of glauconite and the foraminiferal assemblage suggest that the beds of the Monmouth Group in Long Island were laid down in the neritic zone under marine conditions in quiescent and probably moderately deep water. The relative abundance of lignite in some beds suggests near-shore deposition.

The beds of dark gray and black silty clay in the Monmouth Group consist chiefly of angular clear quartz, muscovite, chlorite, and clay minerals. Glauconite is generally subordinate in amount but ranges from about 20 to 95 percent of the minerals in some beds. Lignite and pyrite are common. At a few places thin nonfossiliferous beds of gray fine sand and sandy clay are interbedded with the beds of fossiliferous silty clay.

The beds of green sandy clay are rich in glauconite and contain subordinate amounts of quartz, muscovite, and lignite. The glauconite is mostly dark green and generally irregularly rounded and botryoidal, but some grains are the elongated accordion-shaped type. In several wells, zones of rusty-brown weathered glauconite were found near the bottom of the greensand unit, and in a few samples waterworn and faded green grains of glauconite were observed, which suggest second-cycle deposition or possibly a local unconformity. Ehlmann, Hulings, and Glover (1963) explain the genesis and color changes in glauconite as follows: Shells of marine organisms sink to the ocean bottom where an internal mold of detrital clay or colloidal material is formed. The clay undergoes chemical changes and the shell disintegrates. The modified clay pellet reacts with sea water and is converted to a form of glauconite. During the maturation of the glauconite, the color changes from light green to dark green and the shape changes through a variety of forms. An alternative hypothesis is the formation of glauconite from pellets of weathered detrital clay.

Heavy minerals (specific gravity greater than 2.85) constitute about 0.2–4 percent by weight of the Cretaceous sands of Long Island; the remainder of the mineral constituents are mostly quartz and a few percent of feldspar. In order to determine whether heavy minerals are useful for local and regional correlation of the beds, seven samples (1–7) from the Monmouth Group and one sample (8) from the Matawan Group were analyzed semiquantitatively for mineral content (table 4). Twenty different minerals were identified. Of the four opaque minerals listed in the table, pyrite and ilmenite are the most common. Among the nonopaque minerals, garnet, zircon, and staurolite are common to abundant in all samples except in a few, where they are rare. Epidote is common to abundant in four samples and rare in others. Chloritoid ranges from a trace to common in frequency of occurrence.

The data in table 4 suggest that the samples from Long Island contain the full suite of heavy minerals that is generally characteristic of the marine Cretaceous beds of Maryland, Delaware, and New Jersey (Anderson, 1948; Groot, 1955, and Groot and Glass, 1960). The association of epidote, staurolite, chloritoid, and garnet in various combinations and amounts in the Long Island samples is similar to that reported in the sequence of beds between the Mount Laurel Sand and the Red Bank Sand (Monmouth Group) of northern Delaware and New Jersey (Groot, 1955, p. 30 and 145).

The heavy minerals in the Long Island strata of Cretaceous age are derived mainly from weathered crystalline rocks of New York and New England, and from second-cycle deposition of minerals from older Cretaceous deposits. On the other hand, the minerals in the beds of Cretaceous age in New Jersey are mainly from weathered crystalline rocks of the Piedmont Province and sedimentary rocks of the folded Appala-

TABLE 3.—*Typical logs of wells on Fire Island, Suffolk County*

Well S15008

[Ocean Bay Park, Suffolk County, N.Y., lat 40°38′50″, long 73°08′12″, about 0.3 mile west of well S16395. Alt. about 10 ft above mean sea level. Drilled by C. W. Lauman & Co., Inc., August 1956. Driller's log. Flume samples 0–273 ft; core samples 273–479 ft. Correlation and descriptive notes in parentheses based on microscopic examination by N. M. Perlmutter]

	Thickness (feet)	*Depth (feet)*
Quaternary:		
Recent and upper Pleistocene deposits:		
Sand, fine to coarse, brown; grits	30	30
Sand, coarse, gray; grits; sea shells	20	50
Sand, coarse, gray; grits; lumps of gray clay; shells	12	62
Sand, coarse, gray; grits; shells	9	71
Sand, fine, gray; gravel; lumps of gray clay; shells	29	100
Sand; coarse, gray; grits; gravel	15	115
Gardiners Clay:		
Clay, solid, green; streaks of sand	8	123
Clay, solid and sandy, gray, in layers	10	133
Cretaceous:		
Monmouth Group (marine fossils):		
Clay, sandy, dark gray; mica; clam shells	28	161
Clay, solid, gray; layers of sandy clay; lignite	70	231
Clay, solid, green; streaks of sandy clay	37	268
Matawan Group (no marine fossils):		
Sand, fine, gray, sandy clay; mica; lignite. (Composed chiefly of angular quartz grains and a trace of heavy minerals and lignite. No Foraminifera or diatoms present)	8	276
Sand, fine, gray; solid black clay	11	287
Sand, fine, gray; streaks of clay	8	295
Sand, fine, gray; mica; streaks of lignite and solid and sandy clay	27	322
Sand, fine, gray; mica	5	327
Sand, fine, gray; mica; streaks of lignite; sandy clay	9	336
Sand, fine, gray; mica; streaks of lignite	10	346
Sand, fine, gray	6	352
Sand, fine, gray; some clay; mica	4	356
Clay, sandy, fine gray; mica; streaks of lignite	10	366
Sand, fine, gray; mica	40	406
Clay, sandy, fine, gray; streaks of lignite	5	411
Sand, fine, gray	4	415
Clay, sandy, fine, gray, and solid clay; in layers	11	426
Sand, medium, gray	5	431
Sand, fine, gray; streaks of lignite, mica	9	440
Clay, sandy, gray; lignite; and fine gray sand	6	446
Sand, fine, gray; mica	31	477
Clay, sandy, gray; mica	2	479

S18679

[Fire Island Inlet Bridge, Suffolk County, N.Y., boring B–2, lat 40°37′29″, long 73°15′49″. Alt 3.6 ft above mean sea level. Drilled by Giles Drilling Corp., October 1957. Driller's log. Core samples 0–151 ft. Correlation and descriptive notes in parenthesis based on microscopic examination by N. M. Perlmutter]

	Thickness (feet)	Depth (feet)
Quaternary:		
Recent and upper Pleistocene deposits:		
Sand, fine to coarse, gray	17	17
Sand, fine, brown; trace of gravel	5	22
Sand, fine to coarse, gray	36	58
Sand, fine to coarse, gray; trace of gravel and shells	31	89
Gardiners Clay:		
Clay, stiff, grayish-green; some fine sand and gravel. (Washed residue contains some quartz, biotite, glauconite, and a small number of Foraminifera, chiefly *Elphidium* and *Nonion*)	8	97
Cretaceous:		
Monmouth Group (marine fossils):		
Clay, dark-greenish-gray; some fine sand and silt, trace of shells and lignite. (Washed residue contains chiefly quartz and glauconite and some chlorite, muscovite, lignite, and moderate to abundant Foraminifera at 100, 140, and 150 ft)	54	151

chians, as well as from second-cycle deposition. Many more mineral analyses are needed to evaluate further the feasibility of using heavy-mineral techniques to correlate the geologic formations of Long Island with those of New Jersey, as well as to correlate Cretaceous beds from place to place within Long Island.

TABLE 4.—*Heavy-mineral content of Upper Cretaceous samples from southern Suffolk County*

[Analyses by Geochemistry and Petrology Branch on 100-mesh size fraction. VA, very abundant; A, abundant; C, common; R, rare; TR, trace]

Mineral	Relative abundance							
	1	2	3	4	5	6	7	8
Pyrite	------	C	VA	A	VA	A	A	VA
Ilmenite	VA	VA	C	VA	VA	C	VA	A
Leucoxene	R	C	C	A	C–R	------	C–R	C–A
Iron oxide	C	------	------	R	------	------	TR	------
Garnet	A	C–P	C	A	C–A	R	C–A	C–A
Zircon	C–A	C	C	C	C–A	C	C–R	C
Sillimanite	C	C	C	R	------	------	TR	C
Kyanite	R	R	C–R	R	R	R	R	R
Staurolite	C	C–A	C	C	C	R	C–R	C–R
Epidote	R	C–A	C–A	R	C–A	R	C–R	C
Chloritoid	R	C–R	C	C–R	C–R	C–R	TR	C–R
Chlorite	------	TR	C	C	R	------	R	C–A
Muscovite	------	C	A	R	R	------	------	VA
Biotite	TR	------	------	------	TR	R	------	R
Rutile	TR–R	R	R	R	R–TR	R	R–TR	R
Andalusite	TR	------	R–TR	R–TR	TR	A	?	R
Siderite	TR	------	------	------	------	------	------	------
Hornblende	------	------	------	------	------	------	------	------
Tourmaline	C	C	C	C	C–R	C–R	C–R	C
Glauconite	A	A	A	C–R	C	C	TR	R

1. S18480; Mastic School; reverse rotary sample at 180 ft; silt, clayey, dark-green.
2. S18679; Fire Island Inlet Bridge boring B–2; core 100–105 ft; silt, clayey, dark-green.
3. S18528; Smith Point Park; reverse rotary sample at 164 ft; clay, silty, micaceous, dark gray.
4. S18528; Smith Point Park; reverse rotary sample at 282 ft; sand, fine to medium, gray, and lignite.
5. S19317; Cherry Grove; core 246–248 ft; clay and silt, micaceous, gray, and lignite.
6. S19317; Cherry Grove; core 281–282 ft; clay and specks of glauconite, gray.
7. S19317; Cherry Grove; core 331–332 ft; sand and clay, glauconitic, green.
8. S19317; Cherry Grove; core 346–348; sand very fine to fine, silty, micaceous, gray, and lignite.

ANALYSIS OF THE MICROFAUNA

FORAMINIFERA

The discovery of Foraminifera in cores and cuttings of wells along the south shore of southern Suffolk County (pl. 7) is of value in interpreting the geologic history of the area.

LATE CRETACEOUS FAUNA

A meager but moderately well preserved fauna of Late Cretaceous Foraminifera occurs in glauconitic sand and clay of the Monmouth Group.

Samples from 11 Long Island wells and borings yielded a composite fauna of 72 species and 2 varieties; the Fire Island Beach Club well (S7350) and the Smith Point Park well (S18528) yielded the richest fauna. No attempt was made to determine relative abundance of species.

A very small percentage of the species were not identifiable, and only four of the identified species have ranges that are too long to be of significant stratigraphic value. The remaining species have greater or lesser degrees of stratigraphic value.

Table 5 includes a tabulation of the recorded age ranges of each species. The table shows that most of the present species have their previously recorded occurrences elsewhere in beds of Late Cretaceous age. In fact, only one of the identified species has not been previously recorded in beds of Late Cretaceous age. For 7 species, the range is Late Cretaceous to Eocene; for 19, it is Late Cretaceous and Paleocene; and 37 species are apparently restricted to the Late Cretaceous. Thus, the Foraminifera provide good evidence of the Late Cretaceous age of the deposits.

Many of the species have ranges restricted to the uppermost part of the Cretaceous: Navarro Group in the Gulf Coast region or Maestrichtian in Europe. These species, which are discussed in greater detail in the systematic descriptions, suggest the assignment of the Long Island greensand unit to the uppermost Upper Cretaceous beds, probably equivalent to the Navarro Group.

Occurrences of Cretaceous Foraminifera in several nearby areas correlate approximately with the Long Island specimens. In two deep test wells drilled on the eastern shore of Maryland, an assemblage of Navarro age was discovered between 1,360 and 1,390 feet in the Hammond well near Salisbury, Md. (Cushman, 1948a, p. 244), and in a core from 1,709 to 1,728 feet in the Bethards well near Berlin, Md. (Cushman, 1948b, p. 267–268). Table 5 indicates that 27 of the Long Island species (some under different names) occur also in the samples from these Maryland wells.

Of the material collected from the walls of the submarine canyons on the south side of Georges Bank, one sample was found to be of Late Cretaceous (Navarro) age (Cushman, 1936, p. 413–419, pl. 1). Table 5 indicates the 14 species (some species under different names) found both in the Georges Bank material and in the samples from Suffolk County.

Nearer to Long Island than either of these subsurface occurrences are outcrops of Late Cretaceous age in New Jersey. Jennings (1936) reported a few species of Foraminifera from the Mount Laurel Sand and the Navesink Formation (correlated with the Navarro Group of Texas), that are the same as those found in the Long Island well samples. Olsson (1960) described and illustrated rich assemblages from the New Jersey coastal plain, including one from the Red Bank Sand at Atlantic Highlands that shows a close resemblance to the Long Island fauna. A comparison was made with two rich assemblages recently studied (1961) by the junior author from collections received from James Owens and James Minard of the U.S. Geological Survey from: (a) the Red Bank Sand at Bay Street, Highlands, N.J., and (b) the Navesink Formation near New Egypt, N.J. From this comparison it is seen that 22 of the Long Island species are the same as those from New Jersey; 11 are Red Bank species, 5 are Navesink species, and 6 are found in both formations. This analysis is based on only two assemblages studied; one each from the Red Bank and Navesink. Comparison of more material from these formations would undoubtedly change the details, but probably would not change very much the overall picture of the affinity between the Long Island greensand beds and these two New Jersey formations.

TABLE 5.—*Distribution of Foraminifera in samples from Long Island and their stratigraphic range and occurrences elsewhere*

Species	Locality																											Stratigraphic range				Other occurrences		
	Captree State Park	Fire Island Inlet Bridge boring B-2		Fire Island Inlet Bridge boring B-3	Fire Island Inlet Bridge boring B-7	Fire Island Beach Club	Cherry Grove			Fire Island Pines	Bellport Coast Guard Station					Shirley Water Works		Smith Point Bridge					Smith Point Park					Upper Cretaceous	Paleocene	Eocene	post-Eocene	Georges Bank (Cushman, 1936)	Maryland wells (Cushman, 1948a; 1948b)	New Jersey (Jennings, 1936; Olsson, 1960)
Well	S11279	S18679	S18679	S18674	S18677	S7350	S19317	S19317	S19317	S18846	S15106T	S15106T	S15106T	S15106T	S15106T	S18729T	S18729T	S15811	S15811	S15811	S15811	S15811	S18528	S18528	S18528	S18528	S18528							
Depth (feet)	104–106	100–105	140–145	93–95	93–95	270–310	246–248	281–283	301	260	162–184	184–190	195–205	205–228	228–241	146–156	203	130–134	134–144	144–154	174–184	224–234	164	184	194	214	228							
Ammodiscidae:																																		
Ammodiscus cretaceus (Reuss)																									X		X	X				X	
Textulariidae:																																		
Spiroplectammina navarroana Cushman?																									X		X						
Verneuilinidae:																																		
Gaudryina laevigata Franke		X			X	X		X															X	X		X	X	X		?		
Pseudoclavulina sp.			X	X		X	X															X										
Valvulinidae:																																		
Eggerella? trochoides (Reuss)												X									X			X				X	X				X	
Dorothia bulletta (Carsey)			X	X	X	X																					X	X	X		X	X	X
Plectina watersi Cushman		X														X		X			X		X	X	X			X						X
Lagenidae:																																		
Robulus muensteri (Roemer)	X										X												X		X		X					X	
navarroensis (Plummer)						X		?													X			X	X	X			X	X				X	X
pondi Cushman				X																								X					X	
Lenticulina spissocostata (Cushman)						X				X													X			X		X	X					
Saracenaria triangularis (d'Orbigny)			X			X																	X			X		X	X				X	X
Astacolus dissonus Plummer		X			X			X											X	X			X	X	X		X						X
navarroanus (Cushman)		X		X																			X	X				X				X		
Marginulina curvatura Cushman			X			X																					X			X		X				X
Vaginulina subgracilis Cushman				X		X				X													X					X						
Dentalina basiplanata Cushman			X			X																	X		X			X	X				X	X
aff. *D. delicatula* Cushman													X																	X	X	X				
fallax Franke																										X		X						
legumen Reuss						X																				X		X	X				X	
Nodosaria affinis Reuss	X			X		X					X												X			X		X	X	X	X	X	X	X
aff. *N. gracilitatis* Cushman																								X		X		X					X	
navarroana Cushman														X															X						
obscura Reuss		X	X	X		X									X	X		X		X			X		X			X					X	
proboscidea Reuss			X																				X				X					X	

TABLE 5.—*Distribution of Foraminifera in samples from Long Island and their stratigraphic range and occurrences elsewhere*—Continued

Species	Locality																											Stratigraphic range				Other occurrences		
	Captree State Park	Fire Island Inlet Bridge boring B-2		Fire Island Inlet Bridge boring B-3	Fire Island Inlet Bridge boring B-7	Fire Island Beach Club	Cherry Grove			Fire Island Pines	Bellport Coast Guard Station					Shirley Water Works		Smith Point Bridge					Smith Point Park											
Well	S11279	S18679	S18679	S18674	S18677	S7350	S19317	S19317	S19317	S18846	S15106T	S15106T	S15106T	S15106T	S15106T	S18729T	S18729T	S15811	S15811	S15811	S15811	S15811	S18528	S18528	S18528	S18528	S18528							
Depth (feet)	104–106	100–105	140–145	93–95	93–95	270–310	246–248	281–283	301	260	162–184	184–190	195–205	205–228	228–241	146–156	203	130–134	134–144	144–154	174–184	224–234	164	184	194	214	228	Upper Cretaceous	Paleocene	Eocene	post-Eocene	Georges Bank (Cushman, 1936)	Maryland wells (Cushman, 1948a; 1948b)	New Jersey (Jennings, 1936; Olsson, 1960)
Polymorphinidae:																																		
Guttulina trigonula (Reuss)						X																						X	X			X	X	
Globulina lacrima Reuss	X	X	X	X		X		X		X										X			X	X	X	X		X	X			X		X
lacrima var. *horrida* Reuss						X																						X	X					
lacrima var. *subsphaerica* (Berthelin)						X					X			X														X	X				X	X
prisca Reuss	X	X																										X						
Pyrulina cylindroides (Roemer)						X																						X	X	X	X		X	
Ramulina sp	X	X	X																							X		X	X	X			X	
Heterohelicidae:																																		
Guembelitria cretacea Cushman					X				X		X			X												X		X	X			X	X	X
Heterohelix globulosa (Ehrenberg)	X	X	X		X	X	X	X	X	X	X	X	X	X		X	X										X	X	X	?		X	X	X
pulchra (Brotzen)							X				X															X		X				X	X	
Pseudoguembelina costulata (Cushman)			X			X		X		X	X			X														X					X	
ultimatumida (White)	X			X		X		X			X	X		X									X					X	X					X
Pseudotextularia elegans (Rzehak)																									X	X		X				X	X	X
Planoglobulina carseyae (Plummer)																										X		X						X
Gublerina acuta de Klasz																								X				X						
Tappanina selmensis (Cushman)	X		X					X	X							X							X					X	X			X		
Trachelinella watersi (Cushman)													X															X						
Pseudouvigerina seligi (Cushman)	X	X			X	X	X	X			X	X		X		X							X		X	X	X	X					X	X
Siphogenerinoides plummeri (Cushman)		X			X																							X						
Buliminidae:																																		
Bulimina arkadelphiana Cushman and Parker			X			X																						X						
kickapooensis Cole	X		X	X		X		X			X	X					X									X		X	X			?		?
prolixa Cushman and Parker											X	X																X	X				X	
reussi Morrow	X	X	X			X					X	X	X	X						X	X					X		X						X
Neobulimina canadensis Cushman and Wickenden														X														X						X
Bolivina (Loxostomum) gemma Cushman	X	X	X	X	X	X		X		X	X	X	X	X		X		X			X		X	X	X	X		X						X
Virgulina sp																										X								
Oolina acuticosta (Reuss)										X																X	X	X	X	X	X			
sp				X																X								X						
Fissurina sp. A										X																								
sp. B						X																												
Stilostomella alexanderi impensia (Cushman)	X		X			X		X			X															X		X						
minuta (Cushman)						X		X				X													X			X						
Discorbidae:																																		
Conorbina sp																						X												
Pulsiphonina prima (Plummer)		X									X	X														X		X	X				X	X
Osangularia texana (Cushman)								X			X					X										X		X						
Gyroidina depressa (Alth)	X					X		X			X	X	X	X		X				X			X	X		X		X	X	X		X	X	X
Cassidulinidae?:																																		
Epistominella? ripleyensis (Sandidge)		?									X	X		X														X						
Alabamina? sp		X																																
Chilostomellidae:																																		
Quadrimorphina allomorphinoides (Reuss)								X			X	X														X		X	X				X	
Allomorphina cf. *A. paleocenica* Cushman	X			X		X																							X					
Ceratobuliminidae:																																		
Hoeglundina supracretacea (ten Dam)			X		X	X					X									X								X	?	?	?			X
Reinholdella brotzeni Olsson			?																						X			X						X
Globigerinidae:																																		
Globigerina (Rugoglobigerina) rugosa Plummer	X	X	X	X		X			X		X	X		X		X		X	X	X	X		X		X	X		X				X		X
(Biglobigerinella) biforaminata Hofker	X			X	X	X	?	X		X	X	X		X	X	X							X		X		X	X						X
Globotruncanidae:																																		
Globotruncana cretacea Cushman		X						?													X			X	X	X		X						
Anomalinidae:																																		
Anomalina pseudopapillosa Carsey																								X				X						
rubiginosa Cushman	X	X	X	X	X	X		X		X	X		X	X			X				X		X		X	X		X	X					X
Cibicidina wadei (Berry)	X	X	X	X	X	X	X	X		X	X	X	X	X	X			X	X	X	X		X		X	X		X						
Cibicides coonensis (Berry)	X				X			X			X	X				X										X		X						

The 29 individual samples that yielded Cretaceous specimens have been given USGS Foraminifera locality numbers which are listed in table 6.

PLEISTOCENE(?) FAUNA

Rare specimens of post-Cretaceous Foraminifera, probably of Pleistocene age and probably originating in sediments that overlie the Monmouth Group, are found with Cretaceous Foraminifera in some flume samples of the greensand unit. They are given as follows:

Buccella frigida (Cushman)
Bulimina marginata d'Orbigny
Buliminella elegantissima (d'Orbigny)
Cibicides pseudoungerianus (Cushman)
Elphidium clavatum Cushman
Globigerina sp.
Globigerinita glutinata (Egger)
Haplophragmoides sp. (flexible, chitinous test)
Trochammina inflata (Montagu)

As the Gardiners Clay (Pleistocene) is present throughout the area investigated, it is likely that these specimens had their origin in that formation, although only one species, *Elphidium clavatum*, is identical with the species already recorded (Weiss, 1954) from the formation. *Haplophragmoides* sp. and *Trochammina inflata* are characteristic of brackish conditions. *Globigerina* sp. and *Globigerinita glutinata* are planktonic forms characteristic of open sea conditions but are capable of being transported into other environments. *Bulimina marginata* is a marine form with wide tolerance of depth and temperature.

TABLE 6.—*Samples examined for Cretaceous Foraminifera*

Well	Location	Depth (feet)	Kind of sample	USGS locality
S7350	Fire Island Beach Club	270–310	Bailer sample	f11698
S11279	Captree State Park	104–106	Core	f11697
S15106T	Bellport Coast Guard Station	162–184	Flume sample	f11699
	do	184–190	do	f11700
	do	195–205	do	f11701
	do	205–228	do	f11702
	do	228–241	do	f11703
	do	263–285	do	f11704
S15811	Smith Point Bridge	120–130	do	f11705
	do	130–134	do	f11706
	do	134–144	do	f11707
	do	144–154	do	f11708
	do	174–184	do	f11709
	do	224–234	do	f11710
S18528	Smith Point Park	164	do	f11965
	do	184	do	f11966
	do	194	do	f11967
	do	214	do	f11968
	do	228	do	f11969
S18674	Fire Island Inlet Bridge, boring B3.	93–95	Core	f11958
S18677	Fire Island Inlet Bridge, boring B7.	93–95	do	f11959
S18679	Fire Island Inlet Bridge, boring B–2.	100–105	do	f11956 and f11960
S18729T	Shirley Water Works	146–156	Flume sample	f11963
	do	203	do	f11964
S18846	Fire Island Pines	at 260	do	f11962
S19317	Cherry Grove	246–248	Core	f25374
	do	281–283	do	f25375
	do	301-303	do	f25376

All the identified species are known as recent forms and none have been recorded from beds older than Miocene. These specimens, although found in flume *samples* of late Cretaceous greensands, are obviously from younger beds and most likely were introduced by contamination of samples during rotary drilling operations.

OSTRACODA

A few ostracodes of Late Cretaceous age were found in samples from several wells. One species, *Trachyleberis communis* (Israelsky) (pl. 6, figs., 22, 23), found at a depth of 270 feet in well S7350, was reported also in the Mount Laurel Sand and Navesink Formation of New Jersey by Jennings (1936). An unidentified species of *Trachyleberis* was found in a sample from a depth of 194 feet at well S18528 and a specimen of *Bairdippilata*, also unidentified as to species, was found in a sample from a depth of 100–105 feet at well S18679. Neither of these specimens is illustrated in this report.

CONCLUSIONS

Marine beds rich in glauconite and in Foraminifera occur in the uppermost part of a thick Late Cretaceous sequence in southern Suffolk County, which has been correlated as the Magothy(?) Formation in previous investigations. Comparison of the Foraminifera with faunas from New Jersey, Maryland, and Georges Bank and the lithology of the beds indicate that the Long Island greensands are part of the Monmouth Group. The Monmouth Group is overlain unconformably by the Gardiners Clay (Pleistocene). It is inferred by regional correlation with the Late Cretaceous sequence of New Jersey that the underlying transitional beds of post-Raritan Cretaceous age in Long Island are part of the Matawan Group and the Magothy Formation.

The name "Magothy(?) Formation" as formerly used in Long Island studies is abandoned. The equivalent post-Raritan Cretaceous deposits are divided into the Monmouth Group (within the approximate geographic limits defined in this report) and the Matawan Group-Magothy Formation undifferentiated. On the basis of general stratigraphic relations and depth considerations, the latter unit may be divided into its two major subdivisions in a few places.

Studies of additional samples of Foraminifera, heavy minerals, and pollen and spores, and electriclogs are required before more specific correlations can be made of the formations that compose the Monmouth and Matawan Groups, and to establish reliable criteria for defining more accurately the contacts between the Matawan Group and the Magothy Formation and also between the Magothy and Raritan Formations.

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SYSTEMATIC DESCRIPTIONS

Order FORAMINIFERA
Family AMMODISCIDAE
Genus AMMODISCUS Reuss, 1861

Ammodiscus cretaceus (Reuss)
Plate 1, figure 1

Ammodiscus cretaceus (Reuss). Cushman, 1946, U.S. Geol. Survey Prof. Paper 206, p. 17, pl. 1, fig. 35.

A single fragmentary specimen of this Upper Cretaceous species was found in well S18528.

Family TEXTULARIIDAE
Genus SPIROPLECTAMMINA Cushman, 1927?

Spiroplectammina navarroana Cushman?
Plate 1, figure 2

A single specimen from well S18528 is questionably referred to this species that was described from the Navarro of Texas and has been reported also from Arkansas and Wyoming.

Family VERNEUILINIDAE
Genus GAUDRYINA d'Orbigny, 1839

Gaudryina laevigata Franke
Plate 1, figure 4

Gaudryina laevigata Franke, 1914, Deutsche geol. Gesell. Zeitschr., v. 66, p. 431, pl. 27, figs. 1, 2.

This species, described from the Upper Cretaceous of Germany, has been widely recorded in Europe and North and South America from beds ranging from Upper Cretaceous to Eocene.

Genus PSEUDOCLAVULINA Cushman, 1936

Pseudoclavulina sp.
Plate 1, figure 3; plate 6, figure 2

A few specimens having a rounded triangular initial stage and an irregularly uniserial later stage are placed in this genus. They seem closest to the Paleocene species *P. amorpha* (Cushman), but the sutures of the uniserial part are more distinctly incised with the chambers consequently somewhat inflated. The wall, although composed of fairly large grains, is smoothly finished. The aperture is simple and without a neck. Broken fragments, lacking the initial part, can be mistaken for *Reophax*.

Family VALVULINIDAE
Genus EGGERELLA? Cushman, 1933

Eggerella? trochoides (Reuss)
Plate 1, figure 5

Eggerella? trochoides (Reuss). Cushman, 1946, U.S. Geol. Survey Prof. Paper 206, p. 43, pl. 12, fig. 2.

The question of correct placement of this form has been discussed elsewhere (Cushman and Todd, 1949, p. 63).

The specimens are calcareous but whether they are finely agglutinated of calcareous grains and belong in *Eggerella* or granular calcareous and belong in *Allomorphina* cannot be settled on the basis of the present material. Single specimens were found in three of the wells. The species has been recorded from beds of Late Cretaceous and Paleocene age.

Genus DOROTHIA Plummer, 1931

Dorothia bulletta (Carsey)
Plate 6, figure 1

Dorothia bulletta (*Carsey*). Cushman, 1946, U.S. Geol. Survey Prof. Paper 206, p. 46, pl. 12, figs. 21–26.

Typical specimens were found in the Fire Island Bridge borings, S18679, S18674, and S18677 and in well S7350. The species was described from the Upper Cretaceous Navarro Group and Taylor Marl of Texas and has been recorded widely in North and South America and Europe. Its geologic range appears to extend from Austin to Navarro in the Gulf Coast region (Cushman, 1946, p. 10) and from Senonian to Lutetian in France (Cuvillier and Szakall, 1949, p. 30).

Genus PLECTINA Marsson, 1878

Plectina watersi Cushman
Plate 1, figure 6

Plectina watersi Cushman, 1933, Cushman Lab. Foram. Research Contr., v. 9, p. 57, pl. 7, fig. 1.

This species occurs in four of the wells in typical form. The species was described from the Upper Cretaceous of Texas and has been recorded from the Navarro Group only.

Family LAGENIDAE
Genus ROBULUS Montfort, 1808

Robulus muensteri (Roemer)
Plate 1, figure 12

Robulus münsteri (Roemer). Cushman, 1946, U.S. Geol. Survey Prof. Paper 206, p. 53, pl. 17, fig. 3–9.

A few specimens may be referable to this species originally described from the Lower Cretaceous of Germany. The species seems to be characterized by large and prominent umbones and tangential and slightly curved sutures.

Robulus navarroensis (Plummer)
Plate 6, figure 5

Cristellaria navarroensis Plummer, 1927, Texas Univ. Bull. 2644, p. 39, text fig. 4.

Robulus navarroensis (Plummer). Cushman, 1946, U. S. Geol. Survey Prof. Paper 206, p. 51, pl. 16, figs. 6–8.

Robulus pseudo-secans Cushman, 1938, Cushman Lab. Foram. Research Contr., v. 14, p. 32, pl. 5, fig. 3.

The distinctions reported between the species described as *navarroensis* and *pseudo-secans* seem to fail as specific distinctions. Contary to the original description, the types of *R. pseudo-secans* do have an enlarged ventral slit extending from the aperture into the apertural face. The other distinctions (8–9 chambers in the final whorl of *R. pseudo-secans* compared with 10–12 in *R. navarroensis* and a slightly wider peripheral flange in the latter species) are not specifically significant. Hence the earlier name should be used.

Typical specimens were found in wells S7350, S15811, and S18528. The species has been recorded from the Navarro Group and Taylor and Austin Formations, but there were more occurrences in the Navarro Group. A few recorded occurrences from the Paleocene indicate the top limit of range of the species.

Robulus pondi Cushman
Plate 1, figure 11

Robulus pondi Cushman, 1946, U.S. Geol. Survey Prof. Paper 206, p. 52, pl. 16, figs. 1–5.

An incomplete specimen, here figured appears to belong in this species because of the knoblike angles around the periphery. In the Gulf Coast region, the species occurs in the Taylor and Navarro parts of the Upper Cretaceous.

Genus LENTICULINA Lamarck, 1804

Lenticulina spissocostata (Cushman)
Plate 1, figure 13; plate 6, figures 3, 4

Robulus spisso-costatus Cushman, 1946, U.S. Geol. Survey Prof. Paper 206, p. 52, pl. 16, figs. 11–14; pl. 17, fig. 1.

Reexamination of types indicates that the aperture does not include a ventral supplementary slit as stated in the original description, hence the species is transferred to *Lenticulina*. The species is characterized by the raised sutures becoming thick and rounded at their inner ends and by the bulging apertural face. The species has been reported from the Navarro Group of the Upper Cretaceous and from the Paleocene. Several specimens were found in wells S7350, S18846, and S18528.

Genus SARACENARIA Defrance, 1824

Saracenaria triangularis (d'Orbigny)
Plate 6, figure 6

Saracenaria triangularis (d'Orbigny). Cushman, 1946, U.S. Geol. Survey Prof. Paper 206, p. 58, pl. 28, figs. 1–3.

Rare specimens from wells S7350 and S18528 are typical of this widely distributed species of the Cretaceous and Paleocene.

Genus ASTACOLUS Montfort, 1808

Astacolus dissonus Plummer
Plate 1, figure 8

Astacolus dissonus Plummer, 1931, Texas Univ. Bull. 3101, p. 145, pl. 11, figs. 17, 18; pl. 15, figs. 2–7.

Rare specimens from several of the wells appear to belong in this species. The walls exhibit variation from smooth to striate but all the specimens are slightly bulging in the middle and carinate around the dorsal periphery which, unlike that of *A. navarroanus*, shows no tendency toward recurving backward at the apertural end. *A. dissonus* is known only from the Navarro Group of the Upper Cretaceous.

Astacolus navarroanus (Cushman)
Plate 1, figure 9

Vaginulina navarroana Cushman, 1946, U.S. Geol. Survey Prof. Paper 206, p. 80, pl. 29, figs. 17–22.

This species was described from Cretaceous greensand of Navarro age from one of the canyons of Georges Bank. It has also been recorded from several localities in the Gulf Coast and seems to be restricted to beds of Navarro age. In addition, a recorded occurrence of *Vaginulina navarroana* in Maestrichtian beds from near the Itongazi River, Natal (Smitter, 1955, p. 105, text fig. 38f), seems, from the illustration, to be very close to the Long Island specimens.

This species is distinguished from *Astacolus dissonus* by its more compressed test that has sharper and more numerous costae, by the tendency for the dorsal border to be recurved backward, and by the initial end being pointed and the greatest breadth of the test being nearer the apertural than the initial end of the test.

Genus MARGINULINA d'Orbigny, 1826

Marginulina curvatura Cushman
Plate 1, figure 10

Marginulina curvatura Cushman, 1938, Cushman Lab. Foram. Research Contr., v. 14, p. 34, pl. 5, figs. 13, 14.

Except for one recorded occurrence in the lower Eocene of Egypt, this species has been recorded only in the Navarro Group of the Upper Cretaceous. Typical specimens were found as single individuals in three of the wells.

Genus VAGINULINA d'Orbigny, 1826

Vaginulina subgracilis Cushman
Plate 6, figure 9

Vaginulina subgracilis Cushman, 1937, Cushman Lab. Foram. Research., Contr., v. 13, p. 103, pl. 15, fig. 13.

Vaginulina gracilis Cushman (not Plummer), 1931, Tenn. Geol. Survey, Bull. 41, p. 34, pl. 4, fig. 11.

A few specimens of this Navarro species were found. They are distinguished by their faintly raised sutures, giving a transversely ridged appearance to the test. This feature is more highly developed in the Paleocene species, *V. gracilis* Plummer, where the sutures are marked by sharp-edged rings. Another similar species is the Upper Cretaceous species, "*Marginulina plummerae* Cushman," which would be more correctly assigned to the genus *Vaginulina* because of its compression. In this latter species, however, the sutures are not raised throughout as in *V. subgracilis* but are instead marked by limbate masses of clear shell material that are most prominent over the two flattened sides of the test. Moreover, *V. plummerae* has a comparatively broader test and a more prominent initial coil.

Genus DENTALINA d'Orbigny, 1826

Dentalina basiplanata Cushman

Plate 6, figure 8

Dentalina basiplanata Cushman, 1938, Cushman Lab. Foram. Research Contr., v. 14, p. 38, pl. 6, figs. 6–8.

This species has been widely recorded from the Upper Cretaceous and Paleocene. Several typical specimens were found.

Dentalina aff. D. delicatula Cushman

A two-chamber fragment of a costate species resembles *Dentalina delicatula* (Cushman, 1938, p. 40, pl. 6, figs. 19, 20) described from the Navarro Group of the Upper Cretaceous and also known from the Paleocene and lower Eocene.

Dentalina fallax Franke

Plate 2, figure 2

Dentalina fallax Franke. Cushman, 1946, U.S. Geol. Survey Prof. Paper 206, p. 66, pl. 23, figs. 15–17.

Only two specimens were found in well S18528. This species was described from the Upper Cretaceous of Germany and has been reported from the Taylor Marl of Texas and Paleocene of England.

Dentalina legumen Reuss

Plate 6, figure 7

Dentalina legumen Reuss. Cushman, 1946, U.S. Geol. Survey Prof. Paper 206, p. 65, pl. 23, fig. 1, 2.

Two single specimens from wells S7350 and S18528 are typical of what has been referred to Reuss' species. However, judging by Reuss' illustration (Reuss, 1851, p. 26, pl. 1, fig. 14) and by two topotypes from the Cretaceous of Lemberg, it is doubtful that the smooth splinter-shaped form with oblique sutures, usually referred to *Dentalina legumen*, is the same as the form that has nearly horizontal sutures and slightly bulging chambers illustrated by Reuss. Nevertheless, whatever its correct name may prove to be, the present specimens are typical of the former which is widely recorded from the Upper Cretaceous and Paleocene of North and South America and Europe.

Genus NODOSARIA Lamarck, 1812

Nodosaria affinis Reuss

Plate 6, figure 10

Nodosaria affinis Reuss, 1845–46, Versteinerungen böhm. Kreideformation, pt. 1, p. 26, pl. 13, fig. 16.

Nodosaria affinis d'Orbigny, 1846, Foraminifères fossiles du bassin tertiaire de Vienne, p. 39, pl. 1, figs. 36–39.

This large and robust *Nodosaria* was described from both the Upper Cretaceous and the Miocene at nearly the same time and, coincidently, given the same name. It is widely recorded in both the Eastern and Western Hemispheres and is especially typical of the Upper Cretaceous and Paleocene. It was found in samples from five wells.

Nodosaria aff. N. gracilitatis Cushman

Plate 2, figure 3

Rare fragmentary specimens from well S18528 seem to belong in or to be closely related to this species (Cushman, 1946, p. 72, pl. 26, figs. 7–10) which was described from the Taylor Marl of Texas.

Nodosaria navarroana Cushman

Nodosaria navarroana Cushman, 1937, Cushman Lab. Foram. Research Contr., v. 13, p. 103, pl. 15, fig. 11.

A single specimen referable to this minute species, known only from the Navarro Group of Texas and Mississippi, was found in well S15106T.

Nodosaria obscura Reuss

Plate 2, figure 1

Nodosaria obscura Reuss, 1845–46, Die Versteinerungen böhm. Kreideformation, pt. 1, p. 26, pl. 13, figs. 7–9.

Cushman, 1931, Tenn. Geol. Survey Bull. 41, p. 32, pl. 4, figs. 3, 4.

Rare specimens having a rather sharply tapering initial end, continuous blunt bladelike costae, and a short tubular collar at the apertural end are placed in this species that is well known in the Lower and Upper Cretaceous of Europe and America.

Nodosaria proboscidea Reuss

Plate 2, figures 4, 5

Nodosaria proboscidea Reuss. Cushman, 1946, U.S. Geol. Survey Prof. Paper 206, p. 72, pl. 26, figs. 12, 13.

Two single specimens having inflated chambers that have continuous sharp bladelike costae, an initial spine, and a short protruding tube at the apertural end compare well with this species described from the Cretaceous of Lemberg. They are from the wells S18528 and S18679.

Family POLYMORPHINIDAE

Genus GUTTULINA d'Orbigny, 1839

Guttulina trigonula (Reuss)

Plate 2, figure 6

Guttulina trigonula (Reuss). Cushman, 1946, U.S. Geol. Survey Prof. Paper 206, p. 95, pl. 40, figs. 6, 7.

This widely recorded Upper Cretaceous and Paleocene species occurs in well S7350.

Genus GLOBULINA d'Orbigny, 1839

Globulina lacrima Reuss

Globulina lacrima Reuss. Cushman, 1946, U.S. Geol. Survey Prof. Paper 206, p. 96, pl. 40, figs. 11, 12.

This globular species with slightly produced apertural end has been widely recorded from the Upper Cretaceous and Paleocene. Rare specimens were found in all but two of the wells. Two variants of this species were found as follows.

Globulina lacrima var. horrida Reuss

Globulina lacrima Reuss var. *horrida* Reuss. Cushman, 1946, U.S. Geol. Survey Prof. Paper 206, p. 97, pl. 40, fig. 14.

A single small specimen with fistulose outgrowths around the apertural end is probably related to *Globulina lacrima*. It was found in well S7350.

Globulina lacrima Reuss var. subsphaerica (Berthelin)

Plate 2, figure 7

Globulina lacrima Reuss var. *subsphaerica* (Berthelin). Cushman, 1946, U.S. Geol. Survey Prof. Paper 206, p. 96, pl. 40, fig. 13.

Several specimens of this compressed variant were found.

Globulina prisca Reuss

Plate 2, figure 10

Globulina prisca Reuss. Cushman, 1946, U.S. Geol. Survey Prof. Paper 206, p. 97, pl. 40, figs. 15–17.

Two single elongate specimens, appearing to belong in this Upper Cretaceous species, were found in wells S11279 and S18679.

Genus PYRULINA d'Orbigny, 1839

Pyrulina cylindroides (Roemer)

Pyrulina cylindroides (Roemer). Cushman, 1946, U.S. Geol. Survey Prof. Paper 206, p. 97, pl. 40, figs. 18, 19.

A single small specimen of this elongate species that has been widely reported from the Upper Cretaceous to the Recent was found in well S7350.

Genus RAMULINA Rupert Jones, 1875

Ramulina sp.

Plate 2, figure 11

Rare specimens, some consisting of slender tubular fragments having coarse and widely set spines, and others consisting of densely hispid spherical chambers between stolonlike connections, were found in several of the wells.

Family HETEROHELICIDAE

Genus GUEMBELITRIA Cushman, 1933

Guembelitria cretacea Cushman

Plate 2, figure 8

Gümbelitria cretacea Cushman, 1946, U.S. Geol. Survey Prof. Paper 206, p. 103, pl. 44, fig. 14.

This species has been recorded from both Europe and North and South America mostly from the Upper Cretaceous but with one recorded occurrence in the Paleocene of Arkansas (Harris and Jobe, 1951, p. 38, pl. 7, fig. 12). Several specimens were found in wells S7350, S15106T, and S18528.

Genus HETEROHELIX Ehrenberg, 1841

Until some 5 years ago this genus was little used and was generally conceived of as being a form of *Guembelina* in which the early planispiral stage constituted a considerable part of the whole test. In her revision of the family Heterohelicidae, Montanaro Gallitelli (1957, p. 137–138) included a reexamination of numerous specimens of various species of *Guembelina* and concluded that the genera *Guembelina* and *Heterohelix* were not generically separable.

Surely, the two genera are closely related, in that rare specimens of *Guembelina* have a coiled initial stage and rare specimens of *Heterohelix* lack it. Yet, this same state of affairs is true of innumerable other pairs or groups of related genera; that is to say that in a single species rare individuals are found showing characters that are ordinarily regarded as of generic significance. Shall we look up this state of affairs as an indication of nongeneric significance of the character in question or as an expected consequence of the natural evolutionary relationships that we see between genera and as supporting evidence of the lack, everywhere in nature, of sharp lines of generic distinction?

For our convenience in nomenclature, arbitary lines of generic distinction need to be supplied (not forgetting they are arbitrary), and no advantage is to be gained by obliterating or blurring them. It would be preferable, therefore, in this instance, to retain the generic name *Guembelina* for those species having poorly developed initial coiling. Two circumstances, however, have combined to favor the transfer of the *Guembelina* concept to *Heterohelix*. The first, and weightiest, circumstance is the wide acceptance already given to the use of *Heterohelix*. The second circumstance is the discovery (Loeblich and Tappan, 1961, p. 625–627) that *Guembelina* Egger, 1899, is a junior synonym of *Guembelina* Kuntz, 1895, a microscopic chitinous genus of Paleozoic corals. Notwithstanding the rules of zoological nomenclature, this latter circumstance is not, in itself, sufficient basis for abandonment of the name *Guembelina* Egger, 1899, because there is virtually no risk of confusion between the well-known foraminifer *Guembelina* and the obscure coral *Guembelina*. Nevertheless, when combined with the circumstance of widespread prior abandonment of *Guembelina* Egger, little is to be gained by continued minority opposition to the transfer of the well-known concept of *Guembelina* from *Guembelina* Egger, 1899, to *Heterohelix* Ehrenberg, 1841.

Heterohelix globulosa (Ehrenberg)

Plate 2, figures 9, 13

Gümbelina globulosa (Ehrenberg). Cushman, 1946, U.S. Geol. Survey Prof. Paper 206, p. 105, pl. 45, figs. 9–15.

Test compressed, periphery rounded; chambers slightly inflated, early ones broader than high, later ones about equal in breadth and height; sutures distinct, incised; wall smooth, very finely hispid with the very faint ornamentation arranged in curved longitudinal rows; aperture a low arched opening with a slightly thickened rim. Length about 0.25 mm, thickness about 0.10 mm.

This species, widely recorded in Upper Cretaceous, Paleocene, and possibly younger rocks, is characterized by globular chambers having only a faint alinement of perforations. Specimens are fairly common in all nine of the wells. It appears to be the same as the one referred erroneously to *Guembelina tessera* (Ehrenberg) from the Navesink Formation of New Jersey (Jennings, 1936, p. 27, pl. 3, fig. 10).

Heterohelix pulchra (Brotzen)

Gümbelina pulchra Brotzen, 1936, Sveriges geol. undersökning, ser. C, no. 396, p. 121, pl. 9, figs. 2, 3.
Gümbelina tessera (Ehrenberg). Cushman, 1936, Geol. Soc. America Bull., v. 47, p. 418, pl. 1, fig. 9.
Gümbelina pseudotessera Cushman, 1946, U.S. Geol. Survey Prof. Paper 206, p. 106, pl. 45, figs. 16–20.

Two single specimens, both incomplete, were found in wells S15106T and S18528. The species is distinctive in its smooth and shiny surface and in having the outer edges of the chambers pinched together resulting in a blunt angle around the periphery. The test is broadly flaring and the chambers increase rapidly in size.

The species was described from the lower Senonian of Eriksdal, Sweden, and has been recorded from the Upper Cretaceous of Austin and Taylor age of the Gulf Coast region. A specimen obtained from greensand dredged from one of the Georges Bank canyons is identical.

Genus PSEUDOGUEMBELINA Bronnimann and Brown, 1953

Pseudoguembelina costulata (Cushman)
Plate 2, figure 14

Gümbelina costulata Cushman, 1946, U.S. Geol. Survey Prof. Paper 206, p. 108, pl. 46, figs. 10–12.

This and the following species, both distinctly costate, are placed in the genus *Pseudoguembelina* because of the presence of supplementary apertures that result from the chambers tending to be reniform rather than globular, with short open tubular projections extending backward from each side of the apertural face.

Rare specimens were found in samples from four of the wells. The species has been reported from many Upper Cretaceous but no Tertiary localities.

Pseudoguembelina ultimatumida (White)
Plate 6, figure 14

Gümbelina ultimatumida White. Cushman, 1946, U.S. Geol. Survey Prof. Paper 206, p. 107, pl. 46, figs. 6, 7.

Specimens from five of the wells studied belong in a species which undoubtedly belongs in *Pseudoguembelina*. The illustrated specimen, though incomplete, shows the tubular opening of the supplementary aperture. Moreover, the present species seems to be identical with that described as *Guembelina ultimatumida*. No supplementary apertures, however, have been observed by any of the authors who have reported *G. ultimatumida*, although Bronniman and Brown (1953, p. 153) imply they are to be expected. *G. ultimatumida* has been widely recorded from the Upper Cretaceous. No verifiable recorded occurrences from the Paleocene are known.

These two species of *Pseudoguembelina* are distinguished from one another by the compressed shape and flattened curved kidney-shaped outline of chambers in *P. costulata* and the strongly inflated test having globular chambers separated by incised sutures in *P. ultimatumida*.

Genus PSEUDOTEXTULARIA Rzehak, 1891

Pseudotextularia elegans (Rzehak)
Plate 2, figure 17

Pseudotextularia elegans (Rzehak). Montanaro Gallitelli, 1957, U.S. Natl. Mus. Bull. 215, p. 138, pl. 33, fig. 6.
Olsson, 1960, Jour. Paleontology, v. 34, no. 1, p. 28, pl. 4, figs. 9, 10.
Gümbelina plummerae Loetterle, 1937, Nebraska Geol. Survey Bull., 2d ser., Bull. 12, p. 33, pl. 5, figs. 1, 2.
Cushman, 1946, U.S. Geol. Survey Prof. Paper 206, p. 104, pl. 45, figs. 1–3.

Two single specimens of this species that is distinguished by its compression being at right angles to the usual plane of compression were found in well S18528. This species has been widely recorded in the Upper Cretaceous of Europe and America.

Genus PLANOGLOBULINA Cushman, 1927

Planoglobulina carseyae (Plummer)
Plate 2, figure 15

Ventilabrella carseyae Plummer, 1931, Texas Univ. Bull. 3101, p. 178, pl. 9, figs. 7–10.
Cushman, 1946, U.S. Geol. Survey Prof. Paper 206, p. 112, pl. 48, figs. 1–5.
Planoglobulina carseyae (Plummer). Montanaro Gallitelli, 1957, U.S. Natl. Mus. Bull. 215, p. 141, pl. 32, fig. 13.
Olsson, 1960, Jour. Paleontology, v. 34, no. 1, p. 29, pl. 4, fig. 13.

A single specimen of this species that is widely reported from the uppermost Cretaceous of the Western Hemisphere was found in well S18528.

Genus GUBLERINA Kikoine, 1948

Gublerina acuta de Klasz
Plate 2, figure 18

Gublerina acuta de Klasz, 1953, Geol. Bavarica, no. 17, p. 246, pl. 8, fig. 3.

A single specimen was found in well S18528. This rather distinctive Upper Cretaceous genus has been recorded from France, Bavaria, Cuba, California, and Indonesia. *Gublerina acuta* was described from Upper Bavaria, where it was reported to range from upper Campanian to the lower part of the upper Maestrichtian. It has also been recorded as *G. hedbergi* Bronnimann and Brown (1953, p. 155, text figs. 11, 12) from the Maestrichtian of Cuba.

Genus TAPPANINA Montanaro Gallitelli, 1955

Tappanina selmensis (Cushman)

Plate 2, figure 16

Tappanina selmensis (Cushman). Montanaro Gallitelli, 1956, Cushman Found. Foram. Research Contr., v. 7, p. 37, pl. 7, figs. 3, 4.

Rare specimens were found in four of the wells. This species is known from the Upper Cretaceous and Paleocene of Europe and North America.

Genus TRACHELINELLA Montanaro Gallitelli, 1956

Trachelinella watersi (Cushman)

Plate 2, figure 12

Bolivina watersi Cushman, 1927, Cushman Lab. Foram. Research Contr., v. 2, p. 88, pl. 12, fig. 6.

Trachelinella watersi (Cushman). Montanaro Gallitelli, 1956, Cushman Found. Foram. Research Cont., v. 7, p. 38, pl. 7, figs. 8–10.

A single typical specimen was found in well S15106T. The species has been recorded only from the Upper Cretaceous, Navarro Group and Taylor Marl, of Texas and Mississippi.

Genus PSEUDOUVIGERINA Cushman, 1927

Pseudouvigerina seligi (Cushman)

Plate 2, figure 19

Pseudouvigerina seligi (Cushman). Cushman, 1946, U.S. Geol. Survey Prof. Paper 206, p. 117, pl. 49, figs. 21–24.

This Upper Cretaceous species is found commonly in seven of the wells.

Genus SIPHOGENERINOIDES Cushman, 1927

Siphogenerinoides plummeri (Cushman)

Plate 2, figure 20

Siphogenerina plummeri Cushman, 1926, Cushman Lab. Foram. Research Contr., v. 2, p. 15, pl. 1, fig. 7.

Siphogenerinoides plummeri (Cushman). Cushman, 1946, U.S. Geol. Survey Prof. Paper 206, p. 117, pl. 50, fig. 1.

Typical specimens of this species, a good marker for Navarro-equivalent beds, were found in three of the wells.

Family BULIMINIDAE
Genus BULIMINA d'Orbigny, 1826

Bulimina arkadelphiana Cushman and Parker

Plate 6, figure 13

Bulimina arkadelphiana Cushman and Parker, 1935, Cushman Lab. Foram. Research Contr., v. 11, p. 96, pl. 15, figs. 1, 2.

Two single specimens, one from well S7350 and the other from well S18679, seem to belong in this species described from the Arkadelphia Marl of Navarro age of Arkansas and also recorded from rocks of Maestrichtian age at Kjölby-Gaard, Denmark.

Bulimina kickapooensis Cole

Plate 3, figure 2

Bulimina kickapooensis Cole. Cushman, 1946, U.S. Geol. Survey Prof. Paper 206, p. 123, pl. 51, figs. 11, 12, 14; pl. 66, fig. 12.

Specimens of this widely recorded species were found in seven of the Long Island wells. The reported range of *Bulimina kickapooensis* includes the Navarro Group and Taylor and Austin Formations of the Gulf Coast region. If *B. aspera* Cushman and Parker can be included within the limits of *B. kickapooensis*, which seems quite likely from comparison of type and other specimens of each species, then the stratigraphic range should probably be extended to include the Paleocene, as *B. aspera* has been reported from the Lizard Springs Formation (Paleocene) of Trinidad.

Bulimina prolixa Cushman and Parker

Plate 3, figure 3

Bulimina prolixa Cushman and Parker. Cushman, 1946, U.S. Geol. Survey Prof. Paper 206, p. 122, pl. 51, figs. 19–22.

A few typical specimens were found in well S15106T. This species has been widely reported from the Upper Cretaceous and Paleocene.

Bulimina reussi Morrow

Plate 3, figure 1

Bulimina reussi Morrow, 1934, Jour. Paleontology, v. 8, p. 195, pl. 29, fig. 12.
Cushman and Parker, 1947, U.S. Geol. Survey Prof. Paper 210–D, p. 84, pl. 19, fig. 31; pl. 20, figs. 1–5.

Bulimina reussi Morrow var. *navarroensis* Cushman and Parker, 1935, Cushman Lab. Foram. Research Contr., v. 11, p. 100, pl. 15, fig. 11.

Buliminella carseyi Plummer var. *plana* Cushman and Parker, 1936, Cushman Lab. Foram, Research Contr., v. 12, p. 8, pl. 2, fig. 7.
Cushman, 1946, U.S. Geol. Survey Prof. Paper 206, p. 120, pl. 50, figs. 16, 21, 22.

This name was first proposed for a species described as *Bulimina ovulum* from the Upper Cretaceous of Bohemia. It has been widely reported in the Upper Cretaceous, both in North and South America and Europe. The variety *navarroensis* seems not sufficiently distinct to be recognized. Examination of the types of *Buliminella carseyi* Plummer var. *plana* Cushman and Parker leads us to conclude this form is not related to *Buliminella carseyae* Plummer but is a synonym of *Bulimina reussi*.

The species occurs rather commonly in six of the Long Island wells.

Genus NEOBULIMINA Cushman and Wickenden, 1928

Neobulimina canadensis Cushman and Wickenden
Plate 3, figure 4

Neobulimina canadensis Cushman and Wickenden. Cushman, 1946, U.S. Geol. Survey Prof. Paper 206, p. 125, pl. 52, figs. 11, 12.

Rare specimens of this Upper Cretaceous species were found in well S15106T. They differ from typical specimens of *N. canadensis* in that the chambers are not inflated and consequently the sutures not incised.

Genus BOLIVINA d'Orbigny, 1839

Subgenus LOXOSTOMUM Ehrenberg, 1854

The separation of *Loxostomum* as a genus distinct from *Bolivina* has been made on the basis of its terminal aperture and its tendency to become uniserial. As there seems to be a gradual transition from species with no tendency toward becoming uniserial, and hence lacking a terminal aperture, to species in which nearly all the adult individuals exhibit a uniserial stage, it seems more logical to regard *Loxostomum* as a subgenus.

Bolivina (Loxostomum) gemma Cushman
Plate 6, figure 11

Bolivina gemma Cushman, 1927, Cushman Lab. Foram. Research Contr., v. 2, p. 87, pl. 12, fig. 3.

This Upper Cretaceous species was found fairly commonly in all the Long Island wells studied. It is distinctive in the limbation of the sutures resulting in a beaded appearance along the median line of the test.

Genus VIRGULINA d'Orbigny, 1826

Virgulina sp.
Plate 3, figure 5

Rare specimens belonging in this genus were found in well S18528, but are too poor for specific identification.

Genus OOLINA d'Orbigny, 1839

Oolina acuticosta (Reuss)
Plate 3, figure 9

Lagena acuticosta Reuss, 1861 (1862), Sitz. Akad. Wiss. Wien, v. 44, pt. 1, p. 305, pl. 1, fig. 4.

Rare specimens appear to belong to this widely recorded species.

Oolina sp.
Plate 1, figure 7

This species has been recognized and described as new in the Pierre Shale of South Dakota (James Mello, oral communication, April 1963). The presence of a short internal tube in this species requires its placement in *Oolina*. Otherwise, it is similar to the widely reported species *Lagena hispida* Reuss.

Genus FISSURINA Reuss, 1850

Fissurina sp. A
Plate 3, figure 6

A single specimen from well S18846 seems distinctive in possessing four heavy blunt keels around the periphery and an elongate aperture surrounded by a thick rim. The same species was found in the Pierre Shale of South Dakota by James Mello (oral commun., April 1963).

Fissurina sp. B
Plate 3, figure 8

A single specimen of a species of *Fissurina* was found in well S7350. It is circular in section (0.13 mm in diameter) and has an elongated and compressed apertural end and a long narrow slit aperture.

Genus STILOSTOMELLA Guppy, 1894

Stilostomella alexanderi impensia (Cushman)
Plate 6, figure 12

Ellipsonodosaria alexanderi Cushman var. *impensia* Cushman, 1938, Cushman Lab. Foram. Research Contr., v. 14, p. 48, pl. 8, figs. 4, 5.

This subspecies has been reported only from the upper part of the Upper Cretaceous both in North and South America and in Egypt. Fragments were found in six of the wells.

Stilostomella minuta (Cushman)
Plate 3, figure 10

Ellipsonodosaria minuta Cushman, 1938, Cushman Lab. Foram. Research Contr., v. 14, p. 48, pl. 8, fig. 6.

Small fragments of a slender spinose species, apparently referable to this Upper Cretaceous species, were found in wells S7350, S15106T, and S18528.

Family DISCORBIDAE
Genus CONORBINA Brotzen, 1936

Conorbina sp.

A single specimen from well S15811 seems to belong in this genus. It is planoconvex and tight coiled and has a high blunt spire. About five chambers compose the final whorl, as may be observed on the flat ventral face of the test. The dorsal sutures are indistinct. Its dimensions are 0.16 mm in diameter and 0.11 mm for height of spire.

Genus PULSIPHONINA Brotzen, 1948

Pulsiphonina prima (Plummer)
Plate 3, figure 11

Siphonina prima Plummer. Cushman, 1946, U.S. Geol. Survey Prof. Paper 206, p. 143, pl. 59, figs. 3–5.

This species, described from the Paleocene and also known from the Upper Cretaceous, is characterized by its lack of an apertural neck. Rare specimens were found in three of the wells.

Genus OSANGULARIA Brotzen, 1940

Osangularia texana (Cushman)

Plate 3, figure 12

Pulvinulinella texana Cushman, 1938, Cushman Lab. Foram. Research Contr., v. 14, p. 49, pl. 8, fig. 8.

Several specimens were found in three of the wells. They clearly show the aperture characteristic of this genus. Occurrences of *Osangularia texana* have been recorded from the Navarro Group and Taylor Marl of the Upper Cretaceous in the Gulf Coast region and from the lower part of the upper Campanian in Upper Bavaria (Hagn, 1953, p. 90).

Genus GYROIDINA d'Orbigny, 1826

Gyroidina depressa (Alth)

Plate 4, figure 4

Gyroidina depressa (Alth). Cushman, 1946, U.S. Geol. Survey Prof. Paper 206, p. 139, pl. 58, figs. 1–4.

This Upper Cretaceous and Paleocene species occurs fairly commonly in all but three of the Long Island wells studied. The specimens are slightly less compressed than usual for this species.

Family CASSIDULINIDAE?
Genus EPISTOMINELLA Husezima and Maruhasi, 1944?

Epistominella? ripleyensis (Sandidge)

Plate 4, figure 2

Pulvinulinella ripleyensis Sandidge, 1932, Am. Midland Naturalist, v. 13, p. 315, pl. 29, figs. 7–9.

Pulvinulinella glabrata Cushman, 1938, Cushman Lab. Foram. Research Contr., v. 14, p. 66, pl. 11, fig. 4.

Rare specimens were found in well S15106T. The two species included in the synonymy are apparently identical and are limited to the upper part of the Upper Cretaceous.

The generic assignment of this species is questionable, but it is placed here pending study of more and better preserved specimens.

Genus ALABAMINA Toulmin, 1941?

Alabamina? sp.

Plate 4, figure 3

A single broken specimen from the core at 100–105 feet in well S18679 is placed questionably in this genus. In shape it seems quite close to specimens of *Alabamina* reported from the Paleocene and Upper Cretaceous under several different specific names.

Family CHILOSTOMELLIDAE
Genus QUADRIMORPHINA Finlay, 1939

Quadrimorphina allomorphinoides (Reuss)

Plate 3, figure 7

Quadrimorphina allomorphinoides (Reuss). Cushman and Todd, 1949, Cushman Lab. Foram. Research Contr., v. 25, p. 69, pl. 12, figs. 10–12.

This distinctive species was described from the Upper Cretaceous of Germany and has been widely recorded from the Upper Cretaceous of Europe and North America and the Paleocene of the Gulf Coast region. Rare specimens were found in wells S15106T and S18528.

Genus ALLOMORPHINA Reuss, 1850

Allomorphina cf. A. paleocenica Cushman

Plate 3, figures 14, 15

Rare specimens found in three of the wells appear to be more similar to this species reported from the Paleocene (Cushman, 1952, p. 58, pl. 16, figs. 19–22) than to any of those described from the Upper Cretaceous. However, they are not entirely typical of *A. paleocenica*, differing in that the two penultimate chambers are less protruding and are about equal in prominence. In this respect, as well as in the elongate apertural opening, the present Long Island specimens show features transitional between the genera *Allomorphina* and *Chilostomella*.

Family CERATOBULIMINIDAE
Genus HOEGLUNDINA Brotzen, 1948

Hoeglundina supracretacea (ten Dam)

Plate 6, figures 17, 18

Epistomina supracretacea ten Dam, 1948, Rev. Instit. Francais Petrole et Ann. Combust. liq., v. 3, no. 6, p. 163, pl. 1, fig. 8.

Höglundina supracretacea (ten Dam). Olsson, 1960, Jour. Paleontology, v. 34, no. 1, p. 37, pl. 6, figs. 10–12.

Epistomina caracolla (Roemer). Cushman, 1946, U.S. Geol. Survey Prof. Paper 206, p. 142, pl. 59, fig. 2 (not fig. 1).

Typical specimens of this widely distributed Upper Cretaceous species were found rarely in four of the wells. The question of relationship between this species and other closely related or possibly identical ones found in the Paleocene, Eocene, Oligocene, and Miocene to Recent cannot be settled on the basis of the present material. It will not be unexpected if they are all found to belong to a single species. That species would then be called *Hoeglundina elegans* (d' Orbigny), as *elegans* appears to be the earliest specific name applied to any of these specimens. Should this sequence of specimens eventually be recognized as a single species, a gradual evolution between Upper Cretaceous and Recent would be illustrated by several of its features: (a) increasing average size, (b) number of chambers in adult whorl increasing from 5 or 6 in the Cretaceous to as many as 10 in the Recent, and (c) increasing degree of flattening of the whole test from nearly planoconvex with dorsal side being the flat side to almost biconvex in Recent specimens.

Genus REINHOLDELLA Brotzen, 1948

Reinholdella brotzeni Olsson

Plate 3, figure 13

Reinholdella brotzeni Olsson, 1960, Jour Paleontology, v. 34, no. 1, p. 40, pl. 7, figs. 11–13.

A single specimen from well S18528 seems identical with this species described from the Red Bank Sand. In being composed of aragonite rather than calcite, it probably belongs, together with the aragonite genus *Hoeglundina*, within the family Ceratobuliminidae. All the other known species of *Reinholdella* are from rocks of Jurassic age, and the occurrence of this genus in the uppermost Cretaceous is therefore open to doubt. Nevertheless, the specific identity with the Red Bank form, whatever its generic assignment should become, is undoubted.

Family GLOBIGERINIDAE

Genus GLOBIGERINA d'Orbigny, 1826

Within recent years the generic concept, *Globigerina*, has been more and more fragmented and reduced in size by differentiating a multitude of globigerine genera.

As a result of their being no biologic criterion as to what constitutes a genus, the classification of species into taxonomic units (genera) becomes a matter of judgment or a matter of opinion. There is little uniformity of opinion on this matter. On the one hand stands Hofker (1959, p. 8) who wrote that "there exists only a single genus of planktonic globigerine species: *Globigerina*." On the other, stand various authors for whom the genus *Globigerina* does not exist at all in the Upper Cretaceous. It is our opinion that a more plausible position may be somewhere between these two extremes. Hence, we choose to include in the genus *Globigerina* those species whose external appearance suggests the globigerine nature and to subdivide such species groups by means of subgenera.

Subgenus RUGOGLOBIGERINA Bronnimann, 1952

Globigerina (Rugoglobigerina) rugosa Plummer

Plate 5, figure 4

Globigerina rugosa Plummer, 1927, Texas Univ. Bull. 2644, p. 38, pl. 2, fig. 10.

Rugoglobigerina rugosa rugosa (Plummer). Bronnimann, 1952, Bull. Am. Paleontology, v. 34, no. 140, p. 28, text figs. 11–13.

Hamilton, 1953, Jour. Paleontology, v. 27, p. 227, pl. 30, figs. 1–3.

Rugoglobigerina rugosa (Plummer). Bolli, Loeblich, and Tappan, 1957, U.S. Natl. Mus. Bull. 215, p. 43, pl. 11, fig. 2

A few specimens of this species described from the Navarro Group of Texas were found in all but one of the Long Island wells. Though preservation is not perfect, it is sufficiently good to permit recognition of broken edges of the umbilical tegilla. Some specimens show the crude alinement of surface rugosities that is characteristic of this subgenus (Bronnimann, 1952, p. 17), which was originally described as one of two subgenera in the genus *Rugoglobigerina*. It seems preferable, however, to regard the two subgenera as synonyms (following Bolli and others, 1957, p. 43) and to regard *Rugoglobigerina* as a subgenus of *Globigerina*. Bronnimann's (1952, text fig. 1) chart shows the range of this species in Trinidad to be Maestrichtian and rarely in the Turonian-Senonian. The subgenus probably became extinct before the beginning of the Tertiary.

Globigerina (*Rugoglobigerina*) *rugosa* is probably very widely distributed in the uppermost Upper Cretaceous. Besides Texas and Trinidad, recorded occurrences from the mid-Pacific seamounts, Peru, and Holland appear to be authentic, judging from the illustrations. There are undoubtedly other occurrences of this species under other names and still unverified. This species is one of the best available for age determination of the strata penetrated by the Long Island wells, confirming its Late Cretaceous, probably Maestrichtian, age.

Subgenus BIGLOBIGERINELLA Lalicker, 1948

Globigerina (Biglobigerinella) biforaminata Hofker

Plate 5, figures 2, 3

Globigerina biforaminata Hofker, 1956, Paläont. Zeitschr., v. 30, p. 76, pl. 9, fig. 68; 1960, Natuurhist. Maandblad, v. 49, nos. 3, 4, p. 36, 38, pl. 1, fig. D; pl. 2, fig. D.

Globigerinella biforaminata Hofker, 1956, Natuurhist. Maandblad, v. 45, nos. 5, 6, p. 53, text figs. 2, 5; 1956, Annales Soc. Géol. Belgique, v. 80, p. B212, fig. 20.

Bukowy and Geroch, 1957, Annales Soc. Géol. Pologne, v. 26, pt. 4, Année 1956, p. 317, pl. 28, fig. 3.

Biglobigerinella biforaminata (Hofker). Olsson, 1960, Jour. Paleontology, v. 34, p. 44, pl. 8, figs. 7, 8.

Globigerinella aspera (Ehrenberg). Cushman, 1931, Tenn. Geol. Survey Bull. 41, p. 59, pl. 11, fig. 5.

Brotzen, 1936, Sveriges geol. undersökning, ser. C, no. 396, p. 170, pl. 13, fig. 2; text fig. 62.

Nauss, 1947, Jour. Paleontology, v. 21, p. 337, pl. 48, fig. 9.

Glazunova, Balakhmatova, Lipman, Romanova, and Chochlova, 1960, Russia Vses. nauchno-issl. geol. instit., Trudy, n. ser., v. 29, p. 117, pl. 22, figs. 1–4.

Hofker, 1960, Micropaleontology, v. 6, p. 317, pl. 2, figs. 18–29.

A few specimens of this species that has been widely recorded from the Upper Cretaceous were found in all but two of the Long Island wells. They have five or six chambers in the final whorl; some are quite compact and the final one or two chambers are somewhat elongated; and the umbilicus is small and deep. The aperture is high arched and in most specimens is on the periphery. Rare individuals show the biforaminate aperture typical of the adult development of this species. The wall is densely and finely hispid.

Globigerina biforaminata was described from the Maestrichtian of western Germany and has been reported from Belgium, the Netherlands, Denmark, and the Carpathians, as well as from the Navesink and Red Bank of New Jersey. Recorded occurrences under other names show the species to be probably of worldwide distribution in the equatorial belt.

The nomenclature of this species might be handled in any of several different ways. The species was originally conceived as specifically distinct from *Globigerinella aspera* (Ehrenberg) in that it possessed two apertures, one on either side of the peripheral plane. It was also thought of as related to, although distinct from, the genus *Biglobigerinella.*

The author of the species, in subsequently reconsidering the problem of what to call it (Hofker, 1960) conceived of the biforaminate specimens as merely "*Biglobigerinella*" stages of a single gens, the "*Globigerina aspera* gens," whose range was shown as extending from Albian to Maestrichtian.

Other authors have illustrated biforaminate specimens under the generic names of *Globigerinella* and *Biglobigerinella*, but have not made it clear whether they regarded the biforaminate specimens as specifically distinct from the single-aperture ones or merely as variant or aberrant specimens.

Still other authors (see synonymy above) have illustrated biforaminate specimens under the specific name *aspera*, implying that they conceive of biforaminate individuals as belonging to a single species which includes both single-aperture and double-aperture forms.

This latter interpretation, which in effect concurs with that of Hofker (1960), seems the most reasonable one. For reasons discussed below, however, we would prefer to call this species by the recently proposed name, *biforaminata*, rather than the old one, *aspera*.

Because the true nature of the original specimen or specimens of *aspera* is beyond the possibility of determination and because the name *aspera* has long been used for a variety of forms of planispiral planktonics, it would seem unwise to transfer the name to a changed concept of the species, At least it would seem unwise to do this at this time without an investigation of the limits of variability of the species that has been known as *aspera*, or without even determining whether the specimens known as *aspera* belong in a single species or several separable ones.

The material available to us from the Long Island wells is insufficient to establish the close relationship between the single-aperture and double-aperture individuals. We are, however, indebted to James Mello who pointed out to us the existence of double-aperture individuals among those from Long Island and their probable specific identity with the single-aperture individuals. An impressive supporting argument for the identity of the two forms of this species is James Mello's complete series of beautifully preserved specimens from the Pierre shale, illustrating a gradual transition from the simple planispiral form having a single peripheral aperture, through the biforaminate form having a broadened final chamber, to a completely biglobigerine form that has a pair of final chambers and each has a separate aperture.

It seems unlikely that this species should be classified with the genus *Globigerinella*, the common and well-developed group of species in the late Tertiary to Recent. Thus we retain it in the genus *Globigerina* and the subgenus *Biglobigerinella.*

Family GLOBOTRUNCANIDAE
Genus GLOBOTRUNCANA Cushman, 1927

Globotruncana cretacea Cushman
Plate 5, figure 5

Globotruncana cretacea Cushman, 1946, U.S. Geol. Survey Prof. Paper 206, p. 151, pl. 62, fig. 7.

Rare specimens of this Upper Cretaceous species were found in three of the wells. With the more typical specimens are some that may belong in another species. They differ by being more compactly coiled, and the chambers are slightly bulging below the keeled periphery. The genus is unknown in post-Cretaceous rocks, and the range of this species is Austin Chalk, Taylor Marl, and Navarro Group of the Gulf Coast.

Family ANOMALINIDAE
Genus ANOMALINA d'Orbigny, 1826

Anomalina pseudopapillosa Carsey
Plate 5, figure 1

Anomalina pseudopapillosa Carsey. Cushman, 1946, U.S. Geol. Survey Prof. Paper 206, p. 154, pl. 64, fig. 1.

A single specimen from 184 feet in well S18528 seems to be identifical with this Navarro species.

Anomalina rubiginosa Cushman
Plate 6, figures 19–21

Anomalina rubiginosa Cushman, 1926, Am. Assoc. Petroleum Geologists Bull., v. 10, p. 607, pl. 21, fig. 6.

Anomalina pinguis Jennings, 1936, Bull. Am. Paleontology, v. 23, no. 78, p. 37, pl. 5, fig. 1.

Anomalina grosserugosa Plummer (not Gümbel), 1931, Texas Univ. Bull. 3101, p. 201, pl. 14, fig. 9.

This species was found rarely to commonly in all the Long Island wells studied. Originally described from

Paleocene beds of Mexico, *Anomalina rubiginosa* also is recorded in the Upper Cretaceous, both in North and South America and in Europe.

Genus CIBICIDINA Bandy, 1949

Cibicidina wadei (Berry)

Plate 6, figures 15, 16

Anomalina wadei W. Berry, *in* W. Berry and Kelley, 1929, U.S. Natl. Mus. Proc., v. 76, art. 19, p. 14, pl. 3, figs. 20–22.

This species seems to have not been reported since its original description from the Upper Cretaceous Ripley Formation from Coon Creek, Tenn. The placing (Frizzell, 1950, p. 117) of it in synonymy with *Anomalina coonensis* Berry seems, on the basis of examination of the types, to be unwarranted. As the species is planoconvex and equally involute on both sides, it is more properly placed in the genus *Cibicidina*. Typical specimens occur commonly to abundantly in all but one of the Long Island wells studied.

Genus CIBICIDES Montfort, 1808

Cibicides coonensis (Berry)

Plate 4, figure 1

Truncatulina coonensis W. Berry, *in* W. Berry and Kelley, 1929, U.S. Natl. Mus. Proc., v. 76, art. 19, p. 12, pl. 3, figs. 1–3.

Cibicides coonensis (W. Berry). Cushman, 1946, U.S. Geol. Survey Prof. Paper 206, p. 160, pl. 65, fig. 15 (holotype redrawn).

A few specimens were found in five of the wells. The species is a compact fairly thick nearly planoconvex form that has the flat dorsal surface slightly bulging. The perforations of the wall are rather coarse and dense. The species was described from the Upper Cretaceous Ripley Formation of Coon Creek, Tenn., and has not been reported elsewhere.

Because of the taxonomic complication resulting from the specific name *coonensis* having been used under both *Truncatulina* and *Anomalina*, both of which species proved to belong in *Cibicides*, the former retained the specific name *coonensis* and the latter was given the name *Cibicides subcarinatus*. There is some possibility of confusion with *Cibicides subcarinatus* Cushman and Deaderick, but *C. subcarinatus* can be distinguished from *C. coonensis* by its limbate sutures and its more distinctly planoconvex shape.

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INDEX

[Italic numbers indicate descriptions]

PLATES 1–6

PLATE 1

FIGURE 1. *Ammodiscus cretaceus* (Reuss) (p. I 10).
USNM 638671, × 60; Smith Point Park well S18528, 214 ft. USGS loc. f11968.

2. *Spiroplectammina navarroana* Cushman? (p. I 10).
USNM 638672, × 70; Smith Point Park well S18528, 214 ft. USGS loc. f11968.

3. *Pseudoclavulina* sp. (p. I 10).
USNM 638660, × 60; Fire Island Inlet Bridge boring S18679 140–145 ft. USGS loc. f11961; *a*, side view; *b*. apertural view.

4. *Gaudryina laevigata* Franke (p. I 10).
USNM 627158, × 44; Fire Island Beach Club well S7350, 270–310 ft. USGS loc. f11698.

5. *Eggerella*? *trochoides* (Reuss) p. I 10).
USNM 627163, × 150; Smith Point Bridge well S15811, 174–184 ft. USGS loc. f11709; *a*, top view; *b*, basal view; *c*, side view.

6. *Plectina watersi* Cushman (p. I 10).
USNM 638662, × 50; Smith Point Park well S18528, 164 ft. USGS loc. f11965; *a*, front view; *b*, side view showing aperture.

7. *Oolina* sp. (p. I 16).
USNM 627192, × 110; Smith Point Bridge well S15811, 144–154 ft. USGS loc. f11708.

8. *Astacolus dissonus* (Plummer) (p. I 11).
USNM 627177, × 110; Smith Point Bridge well S15811, 174–184 ft. USGS loc. f11709; *a*, side view; *b*, peripheral view.

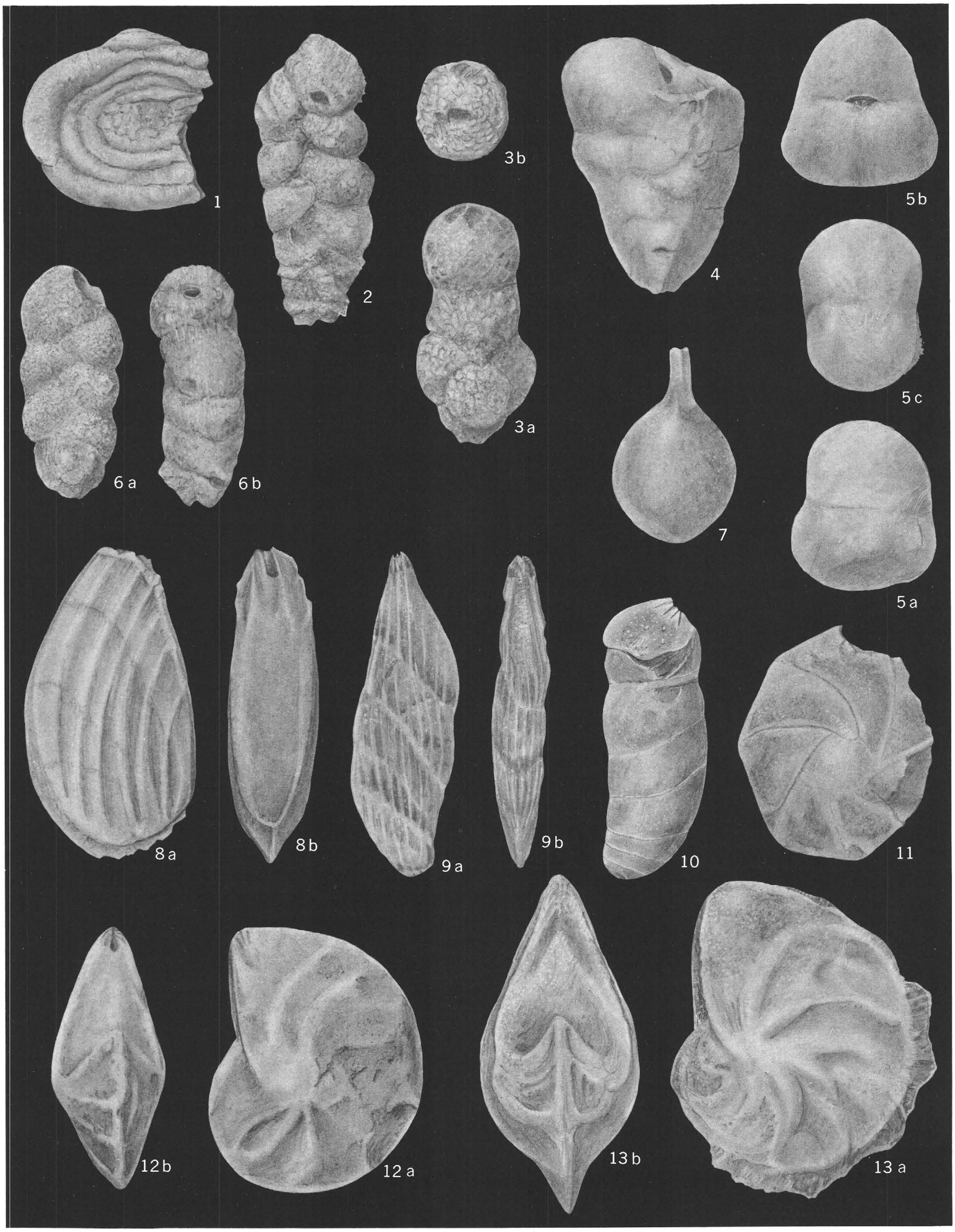
9. *Astacolus navarroanus* (Cushman) (p. I 11).
USNM 638663, × 70; Smith Point Park well S18528, 164 ft. USGS loc. f11965; *a*, side view; *b*, peripheral view.

10. *Marginulina curvatura* Cushman (p. I 11).
USNM 627178, × 66; Fire Island Beach Club well S7350, 270–310 ft. USGS loc. f11698.

11. *Robulus pondi* Cushman (p. I 11).
USNM 638657, × 50; Fire Island Bridge boring S18674, 93–95 ft. USGS loc. f11958.

12. *Robulus muensteri* (Roemer) (p. I 10).
USNM 627166, × 34; Captree State Park well S11279T, 104–106 ft. USGS loc. f11697; *a*, side view; *b*, peripheral view.

13. *Lenticulina spissocostata* (Cushman) (p. I 11).
USNM 638673, × 50; Smith Point Park well S18528, 214 ft. USGS loc. f11968; *a*, side view; *b*, peripheral view.



UPPER CRETACEOUS FORAMINIFERA FROM LONG ISLAND WELLS

PLATE 2

FIGURE 1. *Nodosaria obscura* Reuss (p. I 12).
USNM 627187, × 105; Smith Point Bridge well S15811, 130–134 ft. USGS loc. f11706.

2. *Dentalina fallax* Franke (p. I 12).
USNM 638674, × 90; Smith Point Park well S18528, 214 ft. USGS loc. f11968.

3. *Nodosaria* aff. *N. gracilitatis* Cushman (p. I 12).
Fragment consisting of one chamber, USNM 638665, × 90; Smith Point Park well, S18528, 184 ft. USGS loc. f11966.

4, 5. *Nodosaria proboscidea* Reuss (p. I 12).
4. USNM 638666, × 60; Smith Point Park well S18528, 184 ft. USGS loc. f11966.
5. Fragment of apertural end, USNM 638656, × 105; Fire Island Bridge boring S18679, 140–142 ft. USGS loc. f11957.

6. *Guttulina trigonula* (Reuss) (p. I 12).
USNM 627193, × 66; Fire Island Beach Club well S7350, 270–310 ft. USGS loc. f11698.

7. *Globulina lacrima* Reuss var. *subsphaerica* (Berthelin) (p. I 13).
USNM 627199, × 66; Fire Island Beach Club well S7350, 270–310 ft. USGS loc. f11698.

8. *Guembelitria cretacea* Cushman (p. I 13).
USNM 627206, × 220; Bellport Coast Guard Station well S15106T, 162–184 ft. USGS loc. f11699.

9, 13. *Heterohelix qlobulosa* (Ehrenberg) (p. I 13).
9. USNM 627216, × 220; Bellport Coast Guard Station well S15106T, 184–190 ft. USGS loc. f11700; *a*, side view; *b*, peripheral view.
13. USNM 627209, × 220: Fire Island Beach Club well S7350, 270–310 ft. USGS loc. f11698.

10. *Globulina prisca* Reuss (p. I 13).
USNM 627203, × 66; Captree State Park well S11279T, 104–106 ft. USGS loc. f11697.

11. *Ramulina* sp. (p. I 13).
USNM 627205, × 140; Captree State Park well S11279T, 104–106 ft. USGS loc. f11697.

12. *Trachelinella watersi* (Cushman) (p. I 15).
USNM 627258, × 220; Bellport Coast Guard Station well S15106T, 195–205 ft. USGS loc. f11701.

14. *Pseudoguembelina costulata* (Cushman) (p. I 14).
USNM 627223, × 150; Bellport Coast Guard Station well S15106T, 205–228 ft. USGS loc. f11702.

15. *Planoglobulina carseyae* (Plummer) (p. I 14).
USNM 638675, × 105; Smith Point Park well S18528, 214 ft. USGS loc. f11968.

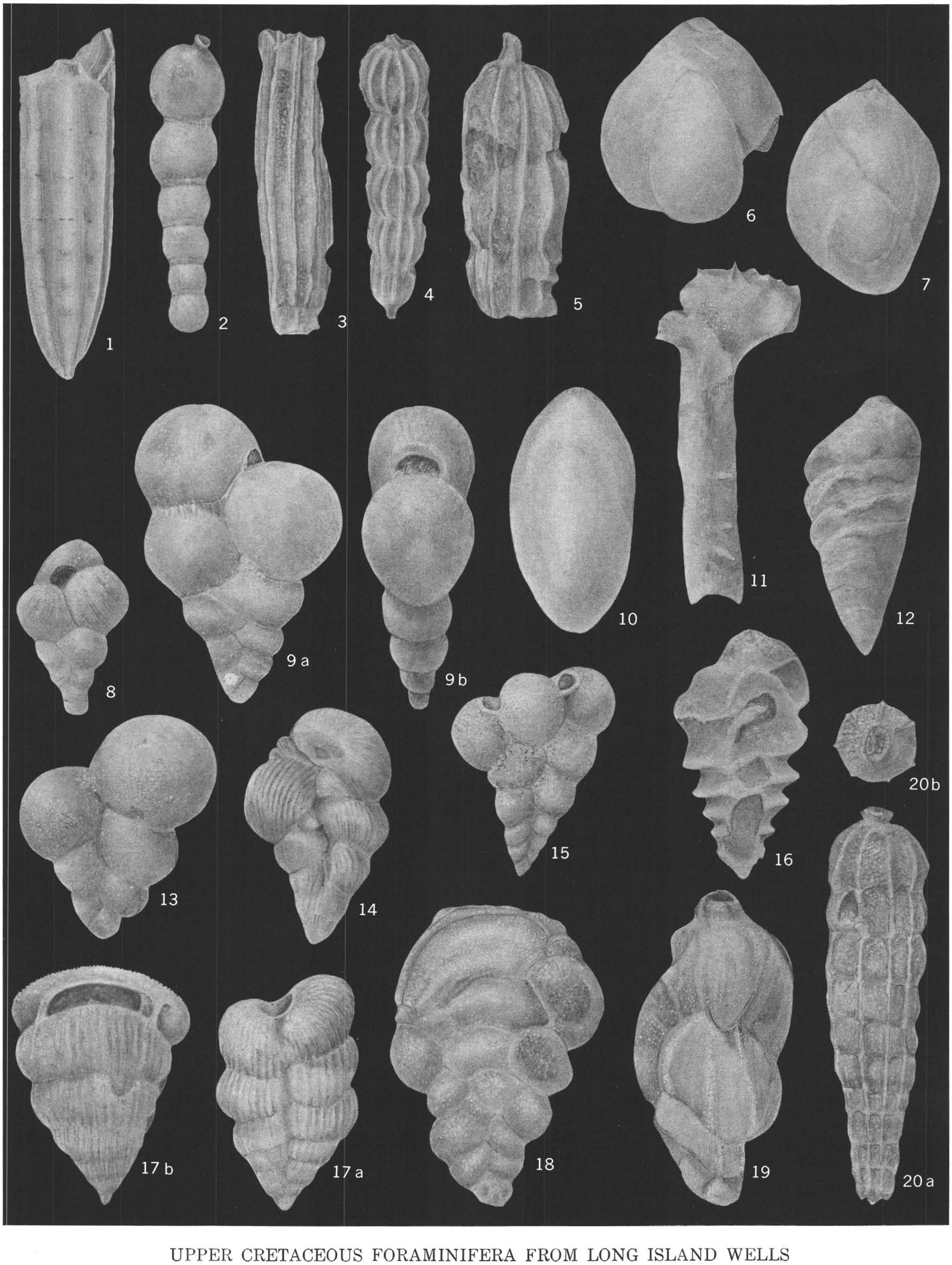
16. *Tappanina selmensis* (Cushman) (p. I 15).
USNM 638664, × 220; Smith Point Park well S18528, 164 ft. USGS loc. f11965.

17. *Pseudotextularia elegans* (Rzehak) (p. I 14).
USNM 638669, × 100; Smith Point Park well S18528, 194 ft. USGS loc. f11967; *a*, *b*, views 90° apart to show compression is at right angles to usual plane of compression.

18. *Gublerina acuta* de Klasz (p. I 14).
USNM 638667, × 120; Smith Point Park well S18528, 184 ft. USGS loc. f11966.

19. *Pseudouvigerina seligi* (Cushman) (p. I 15).
USNM 627232, × 220; Fire Island Beach Club well S7350, 270–310 ft. USGS loc. f11698.

20. *Siphogenerinoides plummeri* (Cushman) (p. I 15).
USNM 638655, × 85; Fire Island Inlet Bridge boring S18679, 100–105 ft. USGS loc. f11956; *a*, side view; *b*, apertural view.



UPPER CRETACEOUS FORAMINIFERA FROM LONG ISLAND WELLS

PLATE 3

FIGURE 1. *Bulimina reussi* Morrow (p. I 15).
USNM 627238, × 220; Fire Island Beach Club well S7350, 270–310 ft. USGS loc. f11698.

2. *Bulimina kickapooensis* Cole (p. I 15).
USNM 627248, × 140; Captree State Park well S11279T, 104–106 ft. USGS loc. f11697.

3. *Bulimina prolixa* Cushman and Parker (p. I 15).
USNM 627253, × 220; Bellport Coast Guard Station well S15106T, 184–190 ft. USGS loc. f11700.

4. *Neobulimina canadensis* Cushman and Wickenden (p. I 16).
USNM 627256, × 220; Bellport Coast Guard Station well S15106T, 205–228 ft. USGS loc. f11702.

5. *Virgulina* sp. (p. I 16).
USNM 638676, × 220; Smith Point Park well S18528, 214 ft. USGS loc. f11968.

6. *Fissurina* sp. A (p. I 16).
USNM 638661, × 180; Fire Island Pines well S18846, 260 ft. USGS loc. f11962; *a*, side view; *b*, top view.

7. *Quadrimorphina allomorphinoides* (Reuss) (p. I 17).
USNM 627298, × 140; Bellport Coast Guard Station well S15106T, 184–190 ft. USGS loc. f11700; ventral view showing broken final chamber.

8. *Fissurina* sp. B (p. I 16).
USNM 627268, ×140; Fire Island Beach Club well S7350, 270–310 ft. USGS loc. f11698; apertural view.

9. *Oolina acuticosta* (Reuss) (p. I 16).
Specimen lost after illustration. × 220; Fire Island Pines well S18846, 260 ft. USGS loc. f11962.

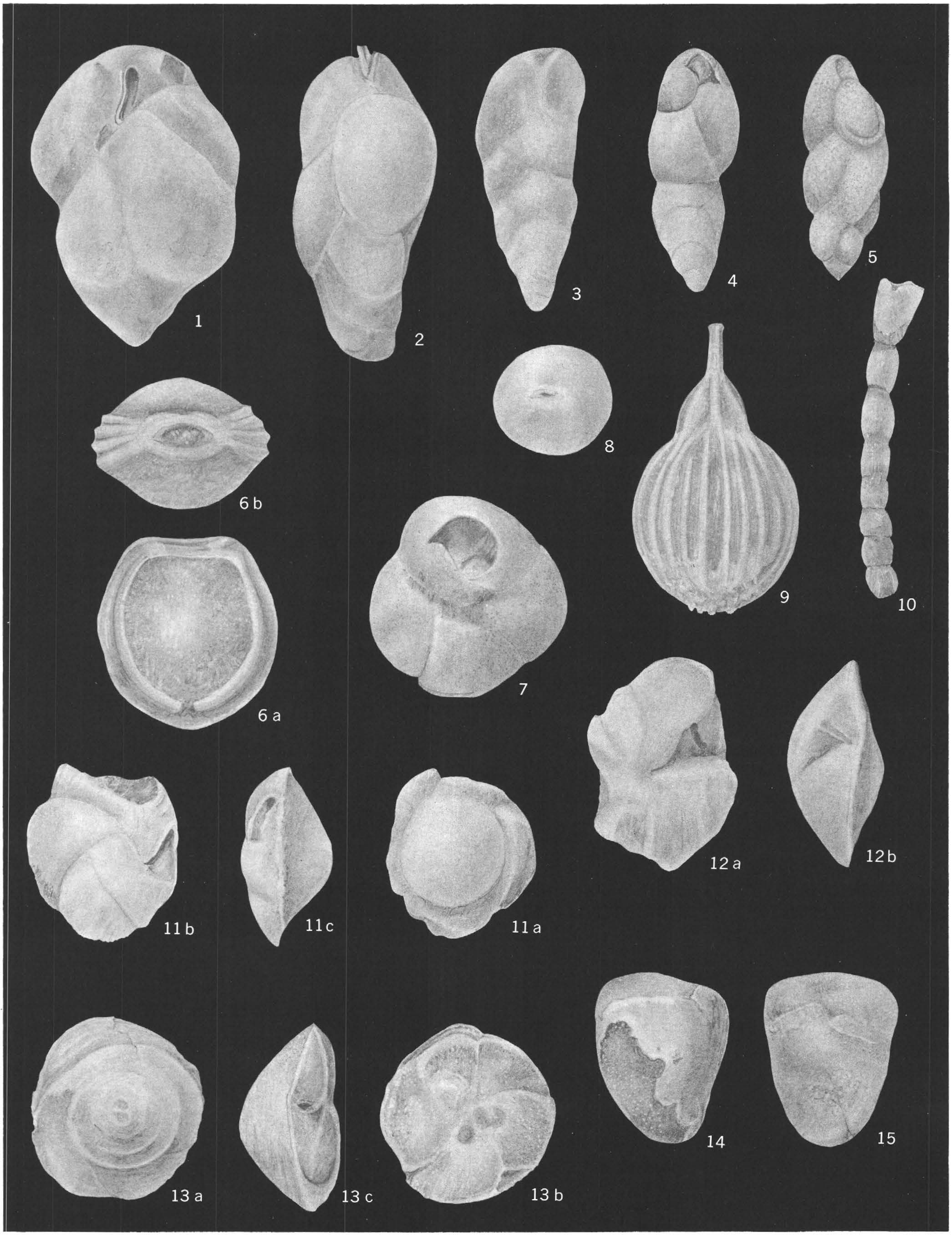
10. *Stilostomella minuta* (Cushman) (p. I 16).
USNM 627273, × 140; Bellport Coast Guard Station well S15106T, 184–190 ft. USGS loc. f11700.

11. *Pulsiphonina prima* (Plummer) (p. I 16).
USNM 627277, × 140; Bellport Coast Guard Station well S15106T, 162–184 ft. USGS loc. f11699; *a*, dorsal view; *b*, ventral view; *c*, peripheral view.

12. *Osangularia texana* (Cushman) (p. I 17).
USNM 627285, × 140; Bellport Coast Guard Station well S15106T, 162–184 ft. USGS loc. f11699; *a*, ventral view; *b*, peripheral view.

13. *Reinholdella brotzeni* Olsson (p. I 18).
USNM 638670, × 105; Smith Point Park well S18528, 194 ft. USGS loc. f11967; *a*, dorsal view; *b*, ventral view; *c*, peripheral view.

14, 15. *Allomorphina* cf. *A. paleocenica* Cushman (p. I 17).
14. USNM 627301, × 66; Fire Island Beach Club well S7350, 270–310 ft. USGS loc. f11698).
15. USNM 638658, × 105; Fire Island Bridge boring S18674, 93–95 ft. USGS loc. f11958.

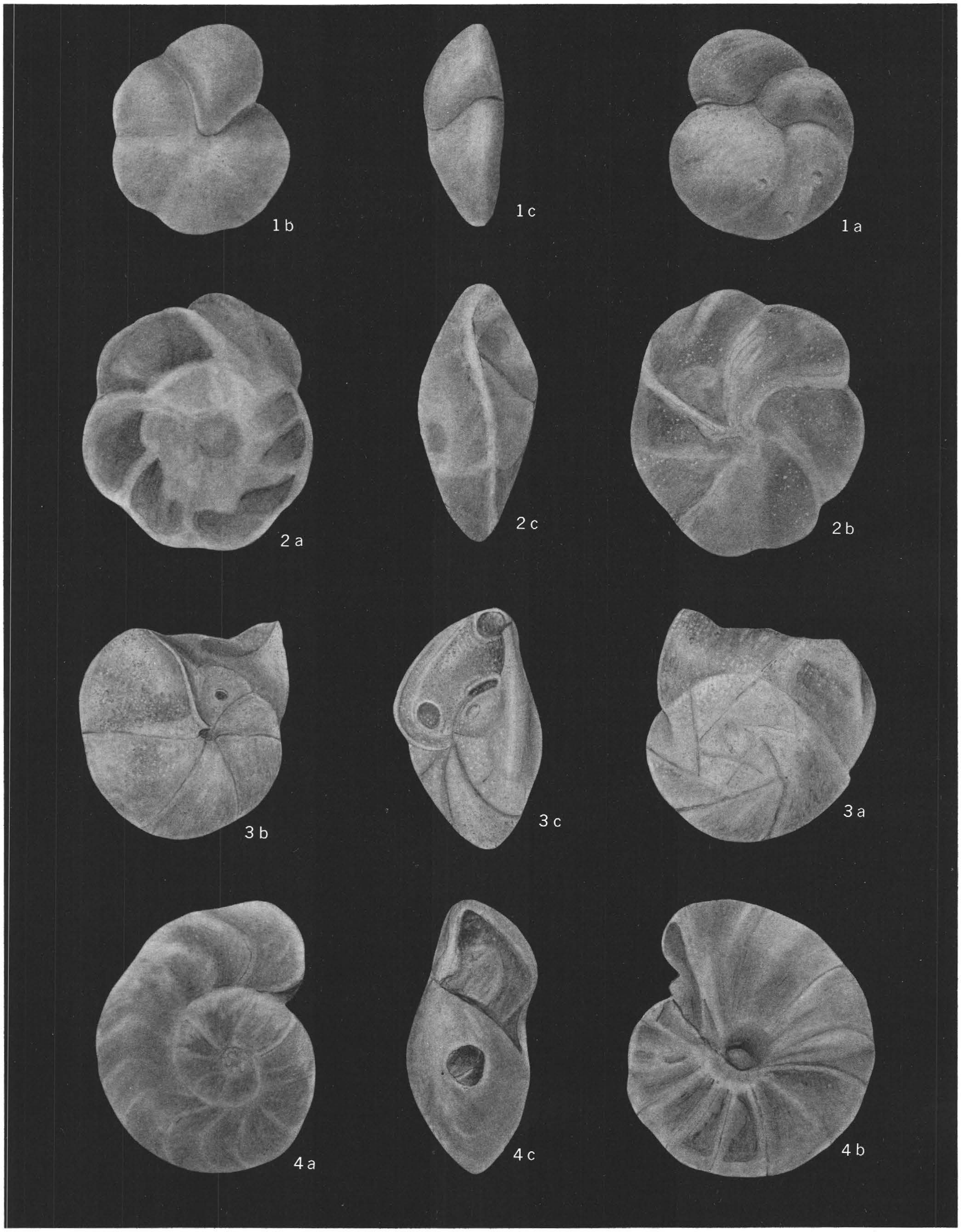


UPPER CRETACEOUS FORAMINIFERA FROM LONG ISLAND WELLS

PLATE 4

[*a*, dorsal view; *b*, ventral view; *c*, peripheral view]

FIGURE 1. *Cibicides coonensis* (Berry) (p. I 20).
USNM 627344, × 140; Bellport Coast Guard Station well S15106I, 184–190 ft. USGS loc. f11700.
2. *Epistominella*? *ripleyensis* (Sandidge) (p. I 17).
USNM 627294, × 220; Bellport Coast Guard Station well S15106T, 162–184 ft. USGS loc. f11699.
3. *Alabamina*? sp. (p. I 17).
USNM 638659, × 175; Fire Island Bridge well S18679, 100–105 ft. USGS loc. f11960.
4. *Gyroidina depressa* (Alth) (p. I 17).
USNM 627286; × 220; Fire Island Beach Club well S7350, 270–310 ft. USGS loc. f11698.



UPPER CRETACEOUS FORAMINIFERA FROM LONG ISLAND WELLS

PLATE 5

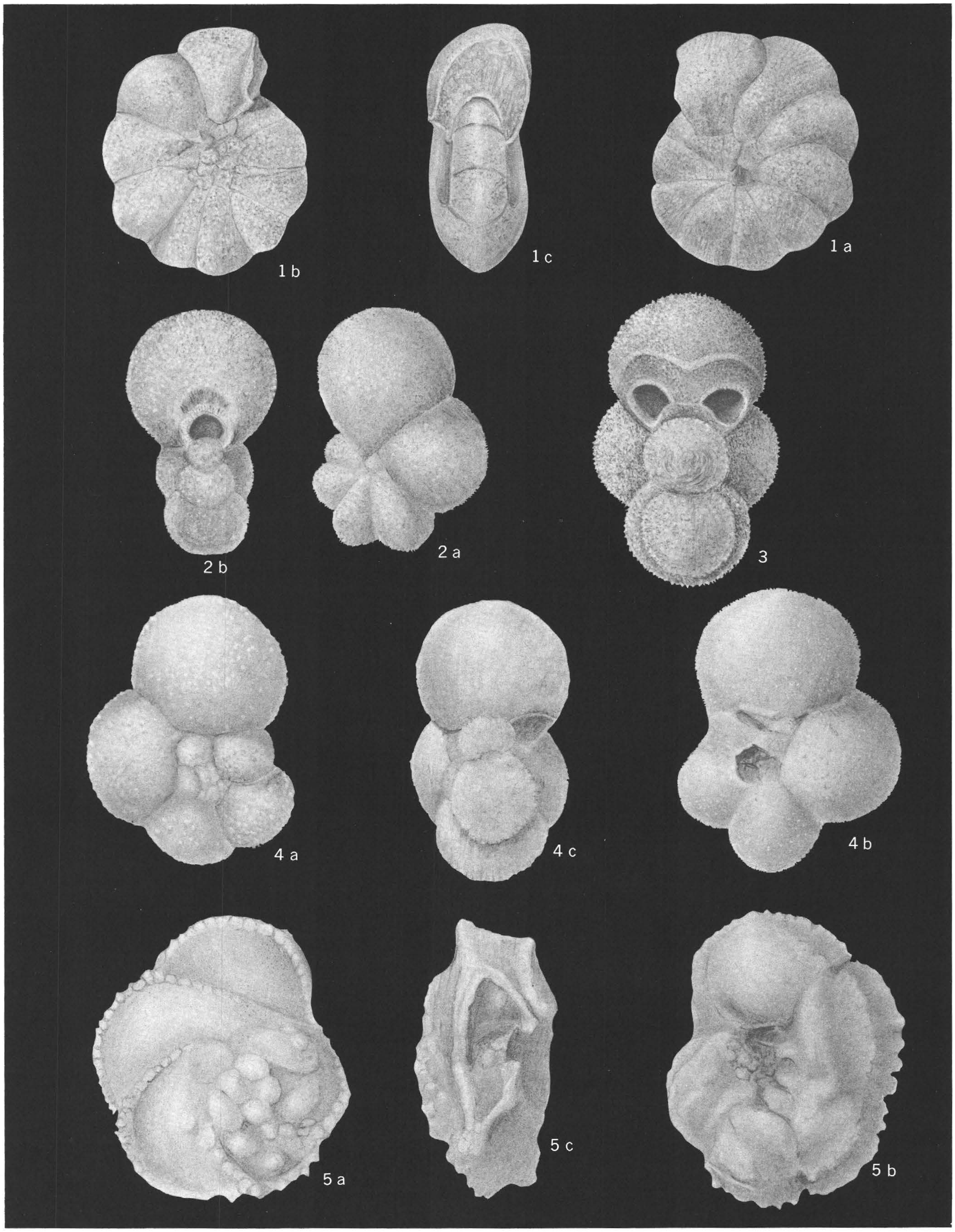
[Unless otherwise indicated, *a*, dorsal view; *b*, ventral view; *c*, peripheral view]

FIGURE 1. *Anomalina pseudopapillosa* Carsey (p. I 19).
USNM 638668, × 100; Smith Point Park well S18528, 184 ft. USGS loc. f11966.

2, 3. *Globigerina* (*Biglobigerinella*) *biforaminata* Hofker (p. I 18).
2. USNM 627314, × 220; Bellport Coast Guard Station well S15106T, 205–228 ft. USGS loc. f11702; *a*, sideview; *b*, peripheral view.
3. USNM 639565, × 220; Fire Island Pines well S18846, 260 ft. USGS loc. f11962. Peripheral view.

4. *Globigerina* (*Rugoglobigerina*) *rugosa* Plummer (p. I 18).
USNM 627304, × 140; Bellport Coast Guard Station well S15106T, 162–184 ft. USGS loc. f11699.

5. *Globotruncana cretacea* Cushman (p. I 19).
USNM 627321, × 140; Smith Point Bridge well S15811, 174–184 ft. USGS loc. f11709.



UPPER CRETACEOUS FORAMINIFERA FROM LONG ISLAND WELLS

UNITED STATES DEPARTMENT OF THE INTERIOR

STEWART L. UDALL, *Secretary*

GEOLOGICAL SURVEY

Thomas B. Nolan, *Director*

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[The letters in parentheses preceding the titles designate separately paged and published chapters]