Smaller Foraminifera From Deep Wells on Puerto Rico and St. Croix

GEOLOGICAL SURVEY PROFESSIONAL PAPER 863

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By RUTH TODD *and* DORIS LOW

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Planktonic and benthonic Foraminifera (about 230 species) from the Miocene and the Oligocene in three test wells along the south-central coast of Puerto Rico. Middle Miocene age of beds in three test wells on St. Croix based on restudy of their planktonic Foraminifera (42 species)

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CONTENTS

ILLUSTRATIONS

[Plates follow index]

TABLES

SMALLER FORAMINIFERA FROM DEEP WELLS ON PUERTO RICO AND ST. CROIX

By RUTH TODD and DORIS LOW

ABSTRACT

Three test wells reveal a thick section of Tertiary sediments along the south-central coast of Puerto Rico. Relatively shallow and nearshore Miocene sediments are characterized by *Amphistegina angulata* and *Elphidium lens.* The Oligocene is of a deeper environment characterized by abundant globigerinids, *Camerina,* and a diverse fauna of mostly deep-water benthonics. The tops of the respective formations are significantly nearer the surface toward the west.

Restudy of the planktonic portion only of the rich fauna in well cuttings from three test wells on St. Croix, Virgin Islands, permits the upper part of the section to be dated as middle part of the middle Miocene (N.12 or N.13) and the lower part as lower part of the middle Miocene (N.9 to N.11).

INTRODUCTION

In 1959–60 the Kewanee Interamerican Oil Company drilled three test wells—CPR–1, CPR–2, and CPR–3—along the coast of southern Puerto Rico between Ponce and Santa Isabel (fig. 1), a distance of about 16 km (10 miles). The wells were drilled by rotary methods, and only cuttings were available for study.

These wells penetrated between 4,000 and 7,500 feet of sedimentary and volcanic rocks. The cuttings from the wells yielded microfossil faunas of variable

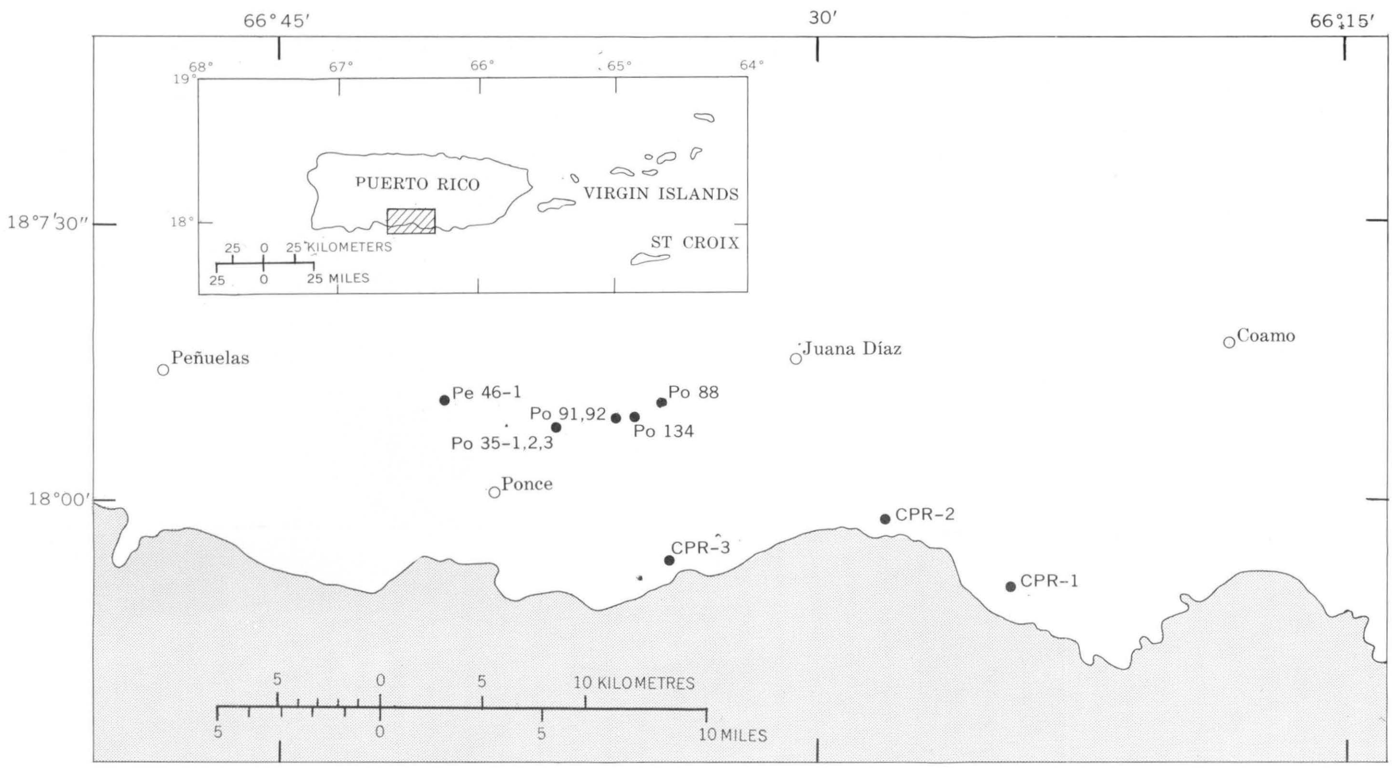


FIGURE 1.—Location of three deep wells and eight outcrop samples of Juana Díaz Formation on Puerto Rico.

richness. In the upper parts of the wells the sediments are Holocene to Miocene in age, and the contained Foraminifera are almost exclusively benthonic. Below the Miocene section are Oligocene sediments (zones N.1 and N.2) containing a predominantly planktonic assemblage of Foraminifera. The Oligocene sediments rest unconformably on sedimentary and volcanic rocks of Cretaceous and Eocene age.

In their upper parts the wells pass through unconsolidated material, mostly sand, gravel, and cobbles, probably of alluvial-fan origin. This alluvial-fan deposit of Holocene to Miocene(?) age is thickest toward the east, where CPR–1 penetrates nearly 3,000 feet of the deposit. To the west it is only about 550 feet thick in CPR–3, and about 1,400 feet thick in CPR–2 (fig. 2).

Underlying the alluvial deposit is the Ponce Limestone, about 750 feet thick in CPR–3 at the west and about 500 feet thick in CPR–1 at the east. The Ponce has not been positively recognized in CPR–2 although the Miocene reef Foraminifera characteristic of it are present in an 1,100-foot interval (1,400 ft to 2,510 ft) in that well.

At 1,300 feet in well CPR–1, in the upper part of the alluvial deposit more than 1,600 feet above the top of the Ponce Limestone, a Miocene assemblage dominated by the two large and robust species *Amphistegina angulata* and *Elphidium lens* is first encountered. This same assemblage is not met in CPR–3 until some several hundred feet below the top of the Ponce Limestone. We have interpreted this *Amphistegina angulata–Elphidium lens* assemblage as a time line in the Miocene. The position of this time line—well above the Ponce Limestone in the east and well below it in the west—leads us to conclude that while the reef limestone was being buried under alluvial material in the east it was still being formed toward the west.

Below the Ponce Limestone, the Juana Díaz Formation of Miocene(?) and Oligocene age is clearly recognizable by its rich assemblage of both planktonic and deep-water benthonic Foraminifera. The tops of this distinctive Oligocene fauna are at 3,500

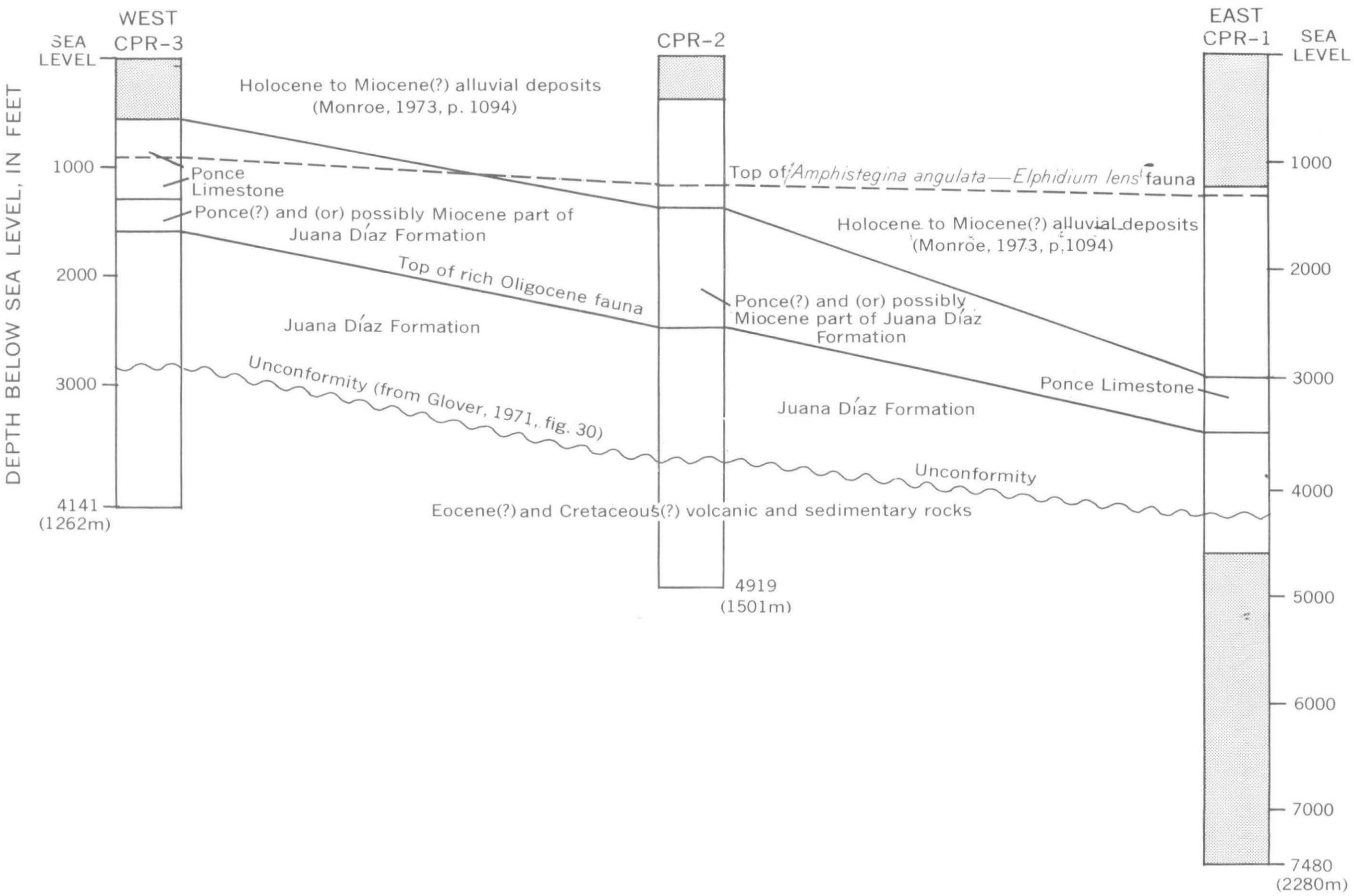


FIGURE 2.—Correlation of drill holes CPR–1, CPR–2, and CPR–3, on the basis of smaller Foraminifera (shaded sections not studied). See figure 1 for well locations.

feet toward the east in CPR–1, at 2,510 feet in CPR–2, and at 1,600 feet toward the west in CPR–3.

Because of extensive downward contamination caused by caving of the poorly consolidated rocks in the wells, the lower limits of the Juana Díaz Formation cannot be detected on the basis of the Foraminifera contained in the cuttings. Other evidence (electric logs and physical examination of cuttings), however, indicates that pre-middle Tertiary volcanic rocks and sedimentary rocks of Eocene and Cretaceous age are penetrated at 4,270 feet in CPR–1, at 3,760 feet in CPR–2, and at 2,848 feet in CPR–3 (Monroe, 1973, p. 1094).

Only a few Eocene Foraminifera, however, are found with the Tertiary species in these lower sections. Foraminifera of Cretaceous age are even sparser, being found only in the lower part of well CPR–2.

Altogether 213 species (one given a new name and six indeterminate) and four subspecies of benthonic Foraminifera were identified. Fourteen planktonic species (none new) constitute the predominating Foraminifera population found in the lower (Oligocene) parts of the wells. Comparison with the various assemblages of Foraminifera in outcrops of the Juana Díaz Formation (shown in fig. 1) confirm the recognition of the Oligocene in the wells. The top of the Oligocene is about 1,900 feet nearer the surface in the westernmost well than in the easternmost well, and in the middle well it is about 1,000 feet nearer the surface than in the easternmost well.

Two previous reports of planktonic Foraminifera from the Juana Díaz Formation (Gordon, 1961, and Pessagno, 1963) are in conflict, possibly because of different definitions of what constitutes the Juana Díaz. Gordon included the Juana Díaz, or at least the part of it that he studied, in the lower Miocene and reported such Miocene forms as *Globoquadrina altispira* and *Globigerinoides trilobus immaturus* in the Juana Díaz. Neither of these are present in the test wells, nor in the Juana Díaz outcrops that we studied. Moreover, the planktonic species that are present in the wells and in the outcrops comprise an association that excludes the *Globoquadrina* and *Globigerinoides* that Gordon reported in the Juana Díaz.

Pessagno (1963, p. 54), in studying the planktonic Foraminifera from three localities in the upper part of the Juana Díaz, reported seven species and three subspecies. On the basis of these forms he correlated the beds with two planktonic zones currently designated N.1 and N.2 and placed in the Oligocene.

In a preliminary report on the Juana Díaz and Ponce Formations, Seiglie and Bermúdez (1969) list many planktonic and benthonic species from both formations. Their dating of the Juana Díaz is the same as that of Pessagno (1963). A revision (Moussa and Seiglie, 1970) of the mid-Tertiary stratigraphy of southwestern Puerto Rico, including discussions of the dating of the Juana Díaz Formation by planktonic Foraminifera, retains the Juana Díaz in zones N.1 and N.2.

Glover, in showing the generalized lithology of the three test wells (1971, p. 75, fig. 30), included tentative formational boundaries. On the basis of the smaller Foraminifera in the well cuttings, slightly different paleontological boundaries can be recognized as indicated in figure 2. We cannot, however, recognize the unconformity that separates the sedimentary rocks from the volcanic rock as shown by Glover (1971, fig. 30). This unconformity appears to be totally obscured through downward contamination by the rich faunas higher in the wells.

In the Virgin Islands, a rich population of Foraminifera in three wells was restudied in order to determine more precisely the age of these sections. These wells, drilled in 1938–39 in the central part of the island of St. Croix, about 185 km (120 miles) east-southeast of the site of the Puerto Rico wells, were originally studied about 30 years ago by Cushman (1946a). In the light of the current planktonic zonation, the deeper well (No. 1, sampled to 1,450 feet) penetrated beds whose faunas indicate a middle Miocene age (N.12 or N.13) in the upper third of the well and a slightly older age (N.9 to N.11) in the lower two-thirds of the well. The faunas in the two shallower wells (Nos. 2 and 3, sampled to about 390 feet and 130 feet respectively) appear to correlate approximately with the lower two-thirds of the section in the deeper well.

Acknowledgments.—We are indebted to many colleagues for advice and criticism in connection with our study of the well cuttings. In particular we acknowledge the aid of Watson H. Monroe and K. Norman Sachs, Jr., who made available comparative material for our study. We are grateful to Richard Margerum who prepared thin sections of some of the specimens, to Robert H. McKinney who photographed some of the larger specimens, and to Jo Ann Sanner who did some of the initial preparation of the well material. The smaller specimens were photographed by the senior author, and all illustrations of specimens were retouched by the junior author.

PUERTO RICO TEST WELLS

Cuttings of three deep wells drilled on the south coast of Puerto Rico contain an abundance of planktonic species. The age of the beds penetrated is based chiefly on these species. Each of these wells passes through, in its upper part, alluvial sand and gravel of indeterminate age and a section of Miocene sediments in which planktonic specimens are very rare or absent. This section extends down to 3,500 feet in well CPR–1, to 2,510 feet in CPR–2, and to 1,600 feet in CPR–3.

At these three levels, the composition of the fauna changes abruptly; the planktonic population increases in quantity and changes in species composition, and the benthonic population becomes more varied, a majority of species having deep-water paleoecologic indications.

PLANKTONIC FAUNA

The age of the planktonic fauna found in these three deep wells can best be determined by the overlapping ranges of several of the species, as indicated in figure 3.

Because the samples are cuttings rather than cores, it is impossible to be precise about the zone or zones of the Oligocene to which these beds belong or whether more than one zone is represented. It seems likely that zones N.1 and N.2 are represented in the part of the Juana Díaz Formation penetrated by these three drill holes.

In the discussions that follow, the occurrences of the planktonics are recorded for each well in figures 4 to 6.

TEST WELL CPR–1

The deepest of the three wells, CPR–1, penetrated the least well preserved planktonic population.

At 3,500 feet an abundance of planktonic specimens abruptly appears (fig. 4). This new fauna is interpreted as the top of the Oligocene. The dominant species are *Globigerina ciperoensis*, *G. conglomerata*, *G. eocaena*, *G. officinalis*, and *G. opima*. Minor elements include *Cassigerinella chipolensis*, *Chiloguem-*

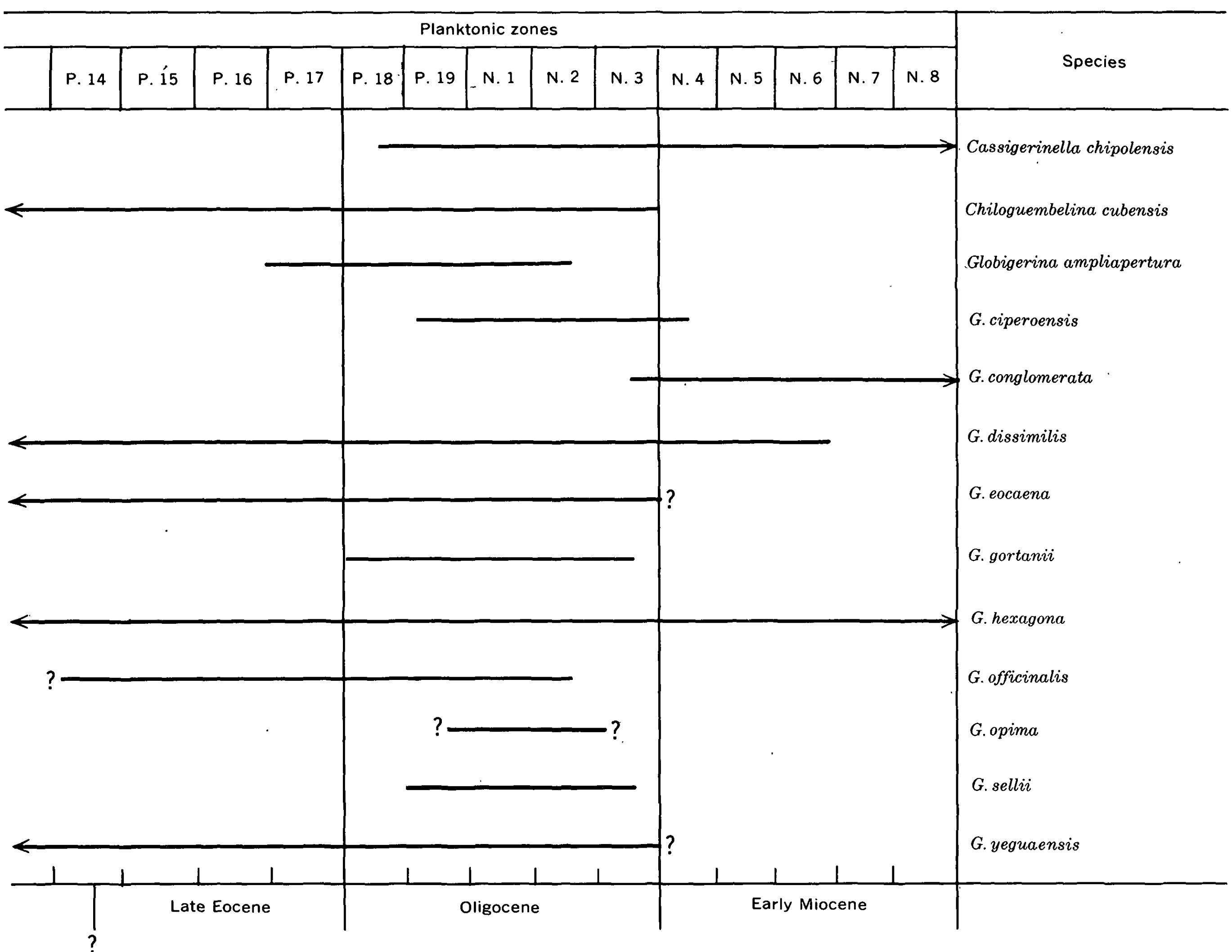


FIGURE 3.—Ranges of the planktonic species from deep wells on Puerto Rico.

belina cubensis, *Globigerina ampliapertura*, *G. dissimilis*, *G. yeguaensis*, *G. hexagona*, and *Globorotalia bolivariana*.

Because the samples are cuttings, the depth at which the rich fauna diminishes cannot be determined. But it appears likely that below about 4,300 feet the fauna is poorer than it is above. Hence the zone of abundant planktonics extends for only about 800 feet in this well.

The only species in the lower part of CPR–1 that is not also present above is *Globorotalia bolivariana*. This species has been reported only in the middle Eocene of Colombia and Peru, and its presence in the lower part of this as well as the other two Puerto Rico wells, even though sparse and scattered, may indicate middle Eocene beds.

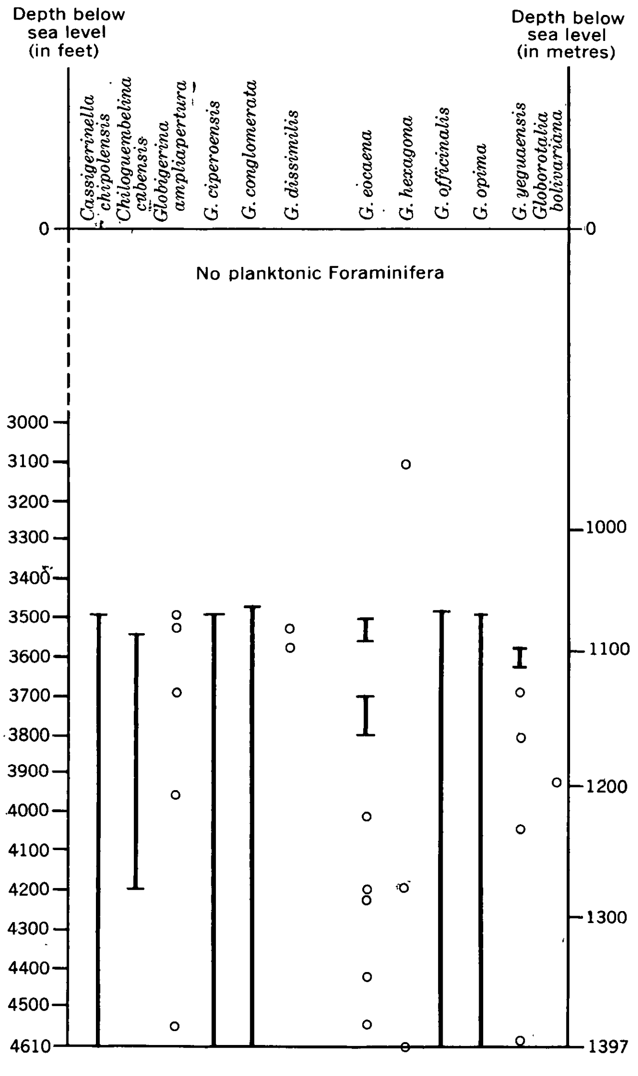


FIGURE 4.—Occurrence of planktonic Foraminifera in CPR–1 well cuttings. Unbroken line indicates more or less continuous occurrence; circle indicates scattered occurrence.

Unlike the other two wells, CPR–1 includes rare planktonics of Miocene age in the Oligocene section, particularly specimens of *Globigerinoides*. Possibly these are cavings from above.

TEST WELL CPR–2

Well CPR–2 penetrates a much thicker Oligocene section than CPR–1. The top of the Oligocene is penetrated nearly 1000 feet higher, at 2,510 feet (fig. 5). Although planktonic fossils are abundant in cuttings to the bottom of the well at 4,900 feet, specimens in the lower part of the well are considered contaminants from higher beds.

In CPR–2 the top of the Oligocene section is signified by the appearance together at 2,510 feet of 8 of the 15 planktonic species; 5 additional species appear respectively at 100 feet (*Globigerina eocaena*), 320 feet (*G. dissimilis*), 390 feet (*G. yeguaensis*), 450 feet (*G. gortanii*), and 570 feet (*G. sellii*) below the top of the Oligocene section.

The first appearance of *Globorotalia bolivariana* in this well at a depth of 4,430 feet probably indicates a middle Eocene age. A single nontypical specimen of the Eocene species *Globorotalia centralis* at 3,850 feet further supports the existence of the Eocene in this well.

Evidence of Cretaceous beds is provided by Cretaceous genera in three samples near the bottom of the well: *Globotruncana* at 4,260 and 4,330 feet and *Heterohelix* and *Rotalipora*? at 4,360 feet. These four Cretaceous specimens appear to have been filled and recrystallized, unlike the far more abundant Tertiary specimens with which they are found. Inasmuch as the samples are cuttings, it is impossible to determine whether the rich Oligocene fauna is a result of contamination from higher in the section or whether the Cretaceous specimens have been redeposited in Eocene or Oligocene sediments.

Approximately 1,045 feet at the bottom of the hole, that is, below about 3,875 feet, is indicated (Glover, 1971, p. 75 and fig. 30) to be within volcanic rocks of pre-middle Tertiary age. However, the cuttings from the presumed barren rock reflect no diminution of Foraminifera fauna until about 4,160 feet.

TEST WELL CPR–3

CPR–3 contains the richest and best preserved planktonic assemblage and the thickest Oligocene section. The top of the Oligocene is nearer the surface than in the other two wells, being penetrated at 1,600 feet, and the rich planktonic fauna that appears at that level seems to continue essentially un-

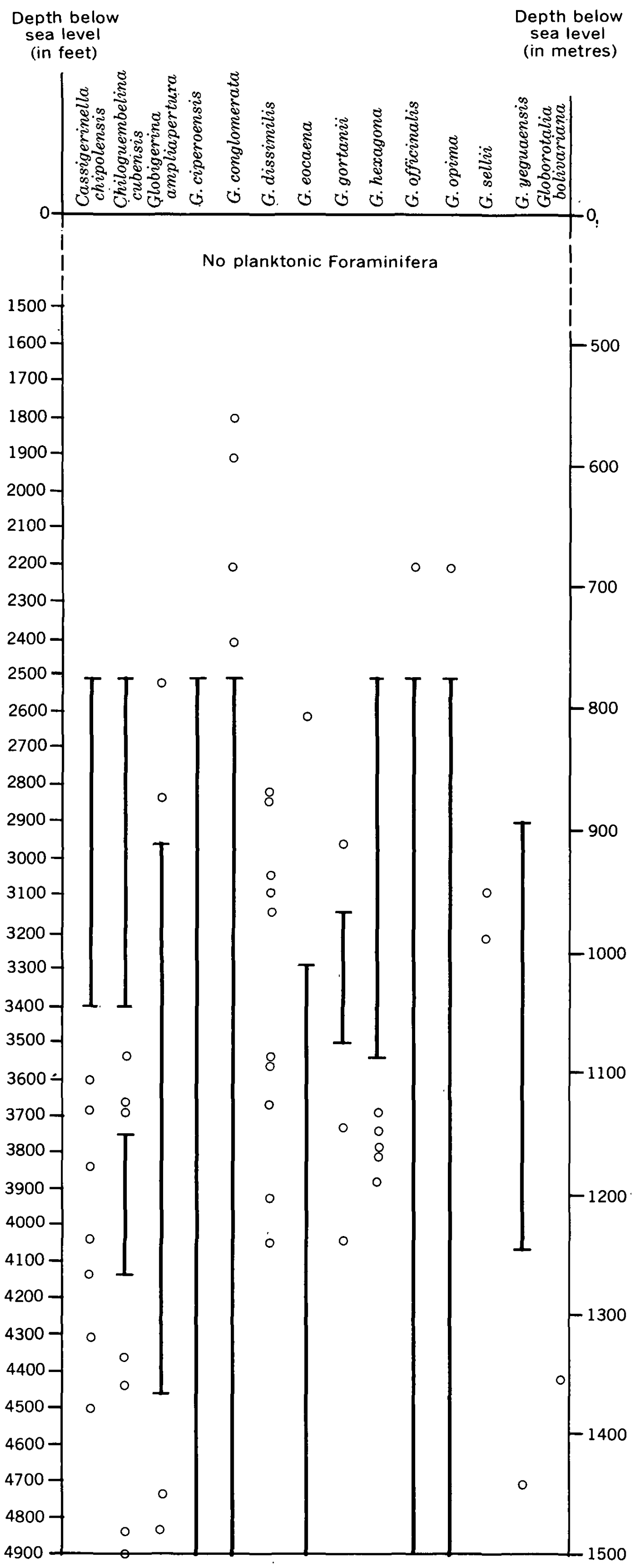


Figure 5.—Occurrence of planktonic Foraminifera in CPR-2 well cuttings. Unbroken line indicates more or less continuous occurrence; circle indicates scattered occurrence.

changed and undiminished to the bottom of the well at 4,140 feet (fig. 6).

The planktonic faunas in CPR-2 and -3 are similar to that in CPR-1 but are better preserved. The dominant species are the same five that are listed for CPR-1, and the six minor elements listed for that well are also present in CPR-2 and -3, along with two additional ones: *Globigerina gortanii* and *G. sellii.*

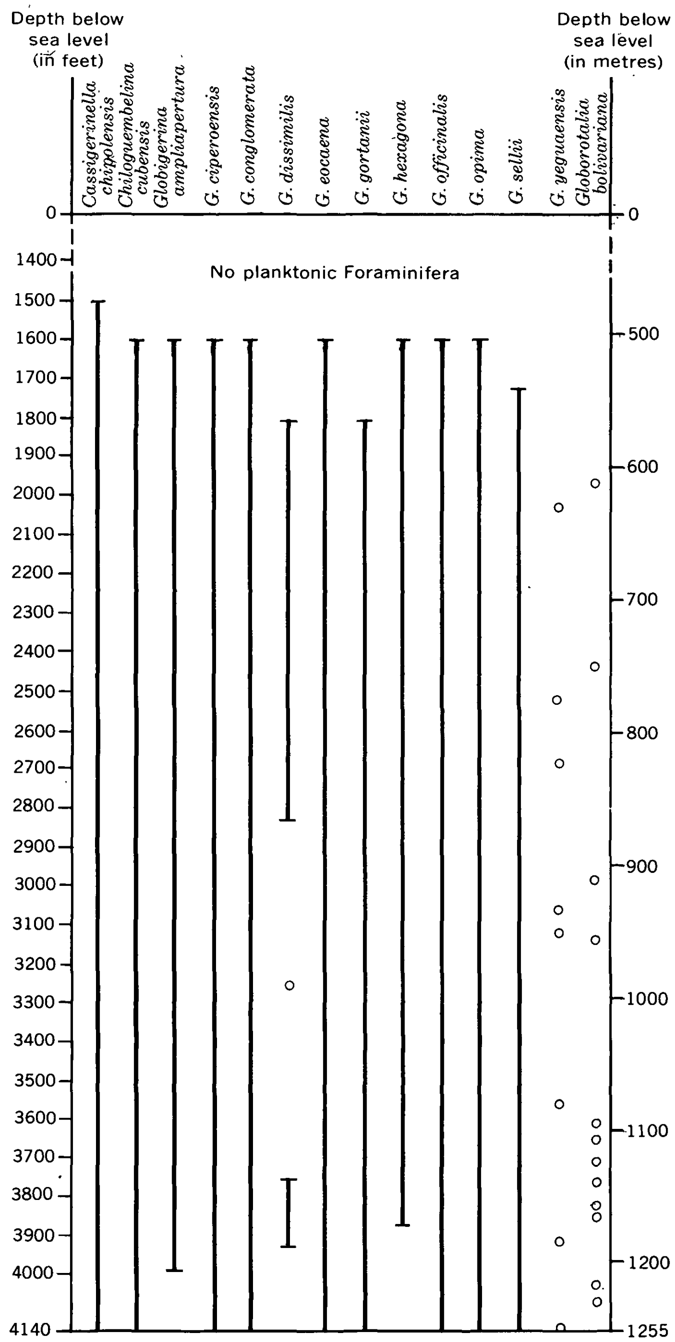


Figure 6.—Occurrence of planktonic Foraminifera in CPR-3 well cuttings. Unbroken line indicates more or less continuous occurrence; circle indicates scattered occurrence.

In CPR–3 all the planktonic species except *Globigerina sellii, G. dissimilis, G. gortanii, G. yeguaensis,* and *Globorotalia bolivariana* first appear together at 1,600 feet, the beginning of the Oligocene section. The five mentioned species appear respectively at 100, 180, 180, 400, and 340 feet below the presumed top of the Oligocene section. The existence of the Eocene species *Globorotalia bolivariana* at 1,940 feet, well above the presumed base of the Oligocene, may be attributed to reworking of underlying Eocene beds.

The only other indications of Eocene in this well are two nontypical specimens of *Globorotalia centralis* at 3,040 feet, but the associated benthonic species are not compatible with an Eocene age.

The generalized stratigraphic sections of the three wells, discussed and diagrammed in Glover (1971, p. 75 and fig. 30), indicate that in CPR–3 the bottom 1,300 feet (±) is in volcanic rocks of pre-middle Tertiary age. The richness of the Foraminifera fauna in the cuttings from the 1,300-foot section below 2,800 feet, however, continues undiminished to the bottom of the well at about 4,140 feet.

BENTHONIC FAUNA

A total of 218 benthonic species was identified from the three test wells; about 85 percent of the species occurred in the lower (Oligocene) parts of each well and over 16 percent were from the upper (Miocene) parts of the wells. About 2½ percent of the species probably occur in both Miocene and Oligocene sections. Because the samples are cuttings rather than cores, there is a large amount of downward contamination throughout the wells which masks the change from one fauna to another and effectively prevents the recognition of the lower boundaries of the faunas.

Of the 188 species in the Oligocene parts of the wells, the majority have more or less restricted ranges and virtually all have been previously reported from nearby areas, such as St. Croix (Cushman, 1946a), the Dominican Republic (Bermúdez, 1949), Haiti (Coryell and Rivero, 1940), Cuba (Hadley, 1934; Palmer, 1940, 1941; Palmer and Bermúdez, 1936), Jamaica (Cushman and Jarvis, 1930; Cushman and Todd, 1945), Barbados (Beckmann, 1953), Panama (Coryell and Embich, 1937), the Goajira Peninsula of Colombia (Becker and Dusenbury, 1958), Venezuela (Blow, 1959; Hedberg, 1937; Renz, 1948), Ecuador (Galloway and Morrey, 1929; Stainforth, 1948), Trinidad (Bolli, 1957; Cushman and Renz, 1947; Cushman and Stainforth, 1945; Nuttall, 1928a), Florida (Cole and Ponton, 1930; Cushman, 1930; Cushman and Ponton, 1932a; Puri, 1953), the Gulf Coastal Plain (Akers, 1955; Cushman, 1922, 1935a; Cushman and Cahill, 1933; Cushman and Ellisor, 1945; Cushman and McGlamery, 1938, 1942; Todd, 1952), and Mexico (Nuttall, 1932).

Galloway and Heminway's (1941) study of the Tertiary Foraminifera of Puerto Rico, a study based on outcrop samples, includes a large proportion of the species present in the three test wells. Their study included both the north and south sides of the island. On the south side of the island, their outcrop samples were taken in the region just west of the site of the wells CPR–1, –2, and –3. Their samples were stated to be from the Ponce Limestone which they considered to be late Oligocene and early Miocene in age and to overlie the Juana Díaz Formation. They studied no samples from the adjacent outcropping Juana Díaz. Fifty-six of the species they reported in the Ponce Limestone on the south shore of Puerto Rico are the same species that we have identified in wells CPR–1, –2, and –3, and 44 of these 56 appear to be restricted to the lower (Oligocene) sections of these wells. Thirty-four of the species they reported from formations along the north shore of Puerto Rico are the same as species we have identified in the three wells, and all but eight of these appear to occur chiefly in the upper (Miocene) sections of these wells. This resemblance to the upper parts of the CPR wells may be due chiefly to facies resemblance.

In general, the benthonic fauna in each well confirms the age and the paleoecology of the planktonic fauna. The upper (Miocene and post-Miocene) section of each well lacks planktonics and contains a nearshore fauna with some brackish components. With the appearance of the Oligocene globigerinids at 3,500 feet in CPR–1, at 2,510 feet in CPR–2, and at 1,600 feet in CPR–3, the associated Oligocene benthonic fauna indicates a deeper water environment farther from shore.

Table 1 shows top occurrences for each benthonic species in the drill holes and species distribution in the eight outcrop samples of the Juana Díaz Formation. (See discussion that follows that of the test wells.)

TEST WELL CPR–1

Preservation in this well is very poor throughout. In the upper 3,500 feet, well CPR–1 passes through a Holocene to Miocene section of varying richness. Down to about 3,000 feet the fauna is generally poorer than in the section between 3,000 and 3,500 feet. In this poorer (upper) section, the assemblage consists of the two large species *Amphistegina angulata* and *Elphidium lens,* accompanied by only rare specimens of the following:

TABLE 1.—*Top occurrences of benthonic Foraminifera in Puerto Rico wells with their age and ecologic indications and their occurrences in outcrop samples of the Juana Díaz Formation*

Species	Wells (Depths in feet; metres=feet × 0.3048)			Age	Ecology[1]	Outcrop localities in Juana Díaz Formation							
	CPR-1	CPR-2	CPR-3			f26290	f26291	f26292	f26293	f25509	f25508	f25507	f25506
Alabamina polita	3,530	2,510	1,940	Miocene		--	--	--	--	×	×	--	--
Allomorphina macrostoma	----	----	1,980	Long ranging		--	--	--	--	--	--	--	--
Ammonia beccarii	1,240	500	900	Miocene to Holocene	Nearshore (brackish?).	--	--	--	--	--	--	--	--
beccarii tepida	1,750	1,200	1,200	do	do	--	--	--	--	--	--	--	--
Ammospirata mexicana	3,540	3,040	1,600	Eocene to Oligocene		×	×	×	--	--	×	--	--
Amphistegina angulata	310	800	600	Oligocene to Miocene	Shallow	--	--	--	--	--	--	--	--
canaensis	----	2,900	----	Miocene		--	--	--	--	--	--	--	--
floridana	3,060	580	490	Oligocene to Miocene	Shallow	--	--	--	--	--	--	×	×
rotundata	3,010	1,800	990	Miocene	Shallow	--	--	--	--	--	--	--	--
sp	----	2,810	----			--	--	--	--	--	--	--	--
Angulogerina cooperensis	4,560	2,510	3,440	Eocene to Oligocene		--	--	×	--	--	--	--	--
jamaicensis	----	3,100	1,980	Miocene		--	--	--	--	--	--	--	--
rugoplicata	4,220	4,070	----	Eocene to Oligocene		--	--	--	--	×	×	×	×
vicksburgensis	3,500	3,340	2,380	do		×	--	--	--	--	--	×	×
Anomalina alazanensis	3,510	3,200	1,600	Eocene to Miocene		--	×	×	--	--	--	--	--
cocoaensis	----	4,360	1,980	Eocene to Oligocene		--	--	--	--	--	--	--	--
glabrata	3,510	----	----	Miocene to Holocene	Shallow	--	--	--	--	--	--	--	--
granosa	----	3,140	1,780	Eocene to Oligocene		--	--	--	--	--	--	--	--
Archaias angulatus	1,240	400	1,420	Oligocene to Holocene	Reef	--	--	--	--	--	--	--	--
Astacolus crepidulus	3,600	3,380	1,900	Long ranging		×	×	×	--	--	×	×	×
Asterigerinata bracteata	3,820	3,160	1,200	Oligocene to Miocene		--	--	×	--	×	--	--	--
Baggina cojimarensis	3,300	1,910	2,540	do		--	--	--	×	--	--	×	×
Bolivina ariana	3,600	----	----	Oligocene		--	×	×	--	--	--	--	--
byramensis	3,520	3,340	2,660	Oligocene to Miocene		×	--	×	--	--	×	×	×
choctawensis	3,510	1,700	900	Oligocene		×	×	×	×	×	×	×	--
difformis	3,630	2,510	1,600	Miocene to Holocene		--	×	×	--	×	×	--	--
isidroensis	3,500	3,140	2,380	Oligocene to Miocene		--	--	×	--	--	--	--	--
mexicana aliformis	3,520	1,800	1,480	Oligocene		×	×	×	--	×	×	×	×
oligocaenica	3,550	2,710	1,600	do		--	--	×	×	--	--	--	--
rhomboidalis	3,500	----	1,600	Long ranging		--	×	×	--	--	--	--	--
tectiformis	3,520	1,910	1,480	Oligocene to Miocene		--	×	×	--	×	×	×	--
tortuosa	3,530	3,160	----	Long ranging		--	--	×	--	--	--	×	×
(*Loxostomum*) *limbata*	----	500	1,600	do		--	--	--	--	--	--	--	--
Bulimina affinis	3,510	2,610	1,600	do		×	×	×	--	×	×	×	×
bleeckeri	3,510	----	----	Oligocene		--	--	×	--	--	×	--	--
exilis tenuata	----	4,330	----	Miocene to Holocene		--	--	--	--	--	--	--	--
impendens	3,530	----	1,680	Eocene		--	×	--	--	--	--	--	--
marginospinata	4,020	3,040	1,980	Pliocene		--	--	--	--	--	--	--	--
sculptilis	3,550	3,000	2,040	Eocene to Oligocene		--	--	×	--	--	--	×	--
Camerina panamensis	3,740	2,710	1,200	Oligocene		--	--	--	--	--	--	--	×
Cancris auriculus	3,540	3,220	1,940	Long ranging		×	×	×	--	×	--	×	×
Cassidulina carapitana	3,530	2,510	3,500	Oligocene		--	--	--	--	--	--	--	--
havanensis	3,500	3,530	2,000	Eocene to Oligocene		--	--	--	--	--	--	--	--
subglobosa	3,510	2,610	1,600	Long ranging		--	--	×	--	×	×	--	×
Cassidulinoides bradyi	----	3,140	1,780	do		--	--	×	--	--	--	--	--
simplex	----	----	1,780	Miocene		--	--	--	--	--	--	--	--
Ceratobulimina alazanensis	3,580	2,510	1,780	Oligocene		×	×	--	--	--	--	--	--
Cerobertina bartrumi	----	----	1,980	Miocene		--	--	--	--	--	--	--	--
Chilostomella cylindroides	3,500	2,510	2,640	Oligocene		--	×	×	--	--	×	--	--
globata	----	3,140	3,040	Oligocene to Miocene		--	×	×	--	--	×	--	--
Chilostomelloides oviformis	----	2,960	2,000	Eocene to Oligocene		--	×	--	--	--	×	--	--
Cibicidella variabilis	----	----	1,480	Long ranging	Shallow	--	--	×	--	--	--	--	--
Cibicides floridanus	3,590	2,510	1,660	Miocene		--	--	--	--	--	--	--	--
lobatulus	1,240	500	900	Long ranging		×	--	×	×	--	--	--	×
mexicanus	3,500	2,510	1,660	Eocene to Miocene		×	×	×	×	--	--	×	--
pseudoungerianus	3,500	1,910	1,600	Long ranging		--	×	×	×	×	×	--	--
robertsonianus	3,590	2,810	1,480	do		--	--	×	--	--	--	--	--
trinitatensis	3,500	2,160	1,600	Eocene to Oligocene		--	×	×	--	--	×	--	--
Cibicidina choctawensis	3,580	4,160	2,320	Oligocene		--	×	×	×	×	--	×	×
mississippiensis	3,540	2,310	1,780	Eocene to Oligocene		--	--	×	--	--	×	×	×
sp	3,540	----	2,720			--	--	×	--	×	×	--	×
Clavulinoides triangularis	3,550	3,660	1,660	Oligocene		×	×	×	--	--	×	--	--
Cribrogloborotalia marielina	3,970	----	----	Eocene		--	--	--	--	--	--	--	--
Cribropullenia marielensis	3,540	----	----	Oligocene		--	--	--	×	--	--	--	--
Cyclammina cancellata	----	3,740	----	Long ranging	Deep water	--	--	--	--	--	--	--	--
Cycloloculina cubensis	4,050	----	----	Eocene to Oligocene		--	--	×	--	--	--	--	--
Cymbaloporetta squammosa	----	----	490	Miocene to Holocene	Shallow	--	×	--	--	--	--	--	--
Dentalina consobrina	----	3,870	1,700	Long ranging		--	--	--	--	×	×	--	--
cooperensis	----	----	3,700	do		--	--	--	--	×	×	--	--
jacksonensis	3,970	4,800	490	Eocene to Oligocene		--	×	--	--	--	--	--	--
mucronata	----	2,960	1,980	Long ranging		--	×	--	--	--	×	--	--
Dorothia cylindrica	3,520	----	1,600	Eocene to Oligocene		--	×	--	--	--	--	--	--
Ehrenbergina bicornis	----	3,140	1,780	Long ranging	Deep water	--	--	--	--	--	--	--	--
Ehrenbergina? aff. *E. pupa*	----	----	1,680		do	--	--	--	--	--	--	--	--
Ellipsocristellaria sp	----	3,140	2,040			--	--	--	--	--	--	--	--
Ellipsoglandulina exponens	----	----	1,600	Eocene to Oligocene		--	--	--	--	--	--	--	--
multicostata	----	2,960	2,820	Oligocene		--	×	--	--	--	--	--	--
Ellipsoidina ellipsoides	3,530	2,550	2,000	Eocene to Miocene		×	×	×	--	×	--	--	×
Elphidium discoidale	1,400	1,800	1,200	Miocene to Holocene	Shallow	--	--	--	--	--	--	--	--
fimbriatulum	3,520	1,200	600	do	do	--	--	--	--	--	--	--	--
lens	1,300	1,200	900	Oligocene to Miocene	do	--	--	--	--	--	--	--	--
lobatum	3,450	----	----	do	do	--	--	--	--	--	--	--	--
mexicanum	2,950	1,200	----	Holocene	do	--	--	--	--	--	--	--	--
poeyanum	1,240	500	900	Oligocene to Holocene	do	--	--	--	--	--	--	--	--
puertoricense	3,020	----	1,100	Oligocene to Miocene	do	--	--	--	--	--	--	--	--
sagra	1,240	----	490	Miocene to Holocene	do	--	--	--	--	--	--	--	--

TABLE 1.—*Top occurrences of benthonic Foraminifera in Puerto Rico wells with their age and ecologic indications and their occurrences in outcrop samples of the Juana Diaz Formation*—Continued

Species	Wells (Depths in feet; metres=feet × 0.3048)			Age	Ecology [1]	Outcrop localities in Juana Díaz Formation							
	CPR–1	CPR–2	CPR–3			f26290	f26291	f26292	f26293	f25509	f25508	f25507	f25506
Entolingulina alazanensis	----	2,850	----	Oligocene		--	×	--	--	--	×	--	--
Eorupertia? sp	3,530	3,650	----	Eocene		--	--	--	--	--	--	×	×
Epistomaroides pontifera	----	----	1,100	Miocene	Shallow	--	--	--	--	--	--	--	--
Eponidella libertadensis	1,400	500	1,200	----do	Brackish	--	--	--	--	--	--	--	--
Eponides ellisorae	1,300	2,960	600	Eocene to Miocene		--	--	--	--	--	--	--	--
parantillarum	3,540	2,010	1,660	Miocene		×	--	×	--	×	×	×	×
Florilus subgrateloupi	1,400	1,200	900	Oligocene to Miocene		--	--	×	--	--	--	--	--
whitsettensis	3,820	1,410	----	Eocene		--	--	--	--	--	--	--	--
Frondicularia cf. *F. digitata*	----	3,040	3,520			--	--	×	--	--	--	--	--
tenuissima	----	3,080	3,040	Eocene to Oligocene		--	×	×	--	×	--	--	--
Gaudryina trinitatensis	3,530	3,080	1,680	Eocene to Miocene		×	--	×	--	×	×	--	--
Glabratella aff. *G. browningi*	----	3,220	----	Miocene		--	--	--	--	--	--	--	--
Guttulina byramensis	----	----	2,380	Oligocene		--	--	--	--	--	--	--	--
Gypsina globula	1,490	2,510	600	Long ranging	Shallow	--	--	--	--	--	--	×	×
Gyroidina altiformis	3,540	2,310	1,600	----do		×	×	×	×	×	×	--	--
vicksburgensis	3,500	3,100	2,480	Oligocene		--	--	--	--	×	--	--	--
Hanzawaia carstensi	1,510	1,800	1,600	Oligocene to Miocene		--	--	--	--	--	--	--	--
mantaensis	3,630	1,910	1,480	----do		--	--	--	×	--	--	×	×
Haplophragmoides coalingensis	----	3,140	1,980	Eocene		--	×	×	--	--	--	--	--
Hoeglundina elegans	----	2,610	1,700	Long ranging	Deep water	×	--	--	--	×	--	--	--
Karreriella bradyi	3,520	----	1,940	----do		--	×	×	--	--	×	--	--
disjuncta	3,630	----	2,320	Eocene		--	--	--	--	--	--	--	--
mexicana	3540	2,810	1,900	Oligocene to Miocene		--	×	×	--	×	×	--	--
Lagena striata	4,170	----	----	Long ranging		--	--	--	--	--	--	--	--
Lagenonodosaria acostaensis	3,550?	2,900	2,320	Miocene		×	--	--	--	×	×	--	--
Lenticulina alatolimbatus	3,510	1,600	1,600	Eocene to Miocene		×	×	×	--	--	×	×	×
americana	3,510	1,500	2,600	Miocene		--	--	--	--	--	×	--	×
grandis	3,520	2,530	2,380	Oligocene to Miocene		--	--	--	--	--	×	--	--
brevispinosa	----	2,530	1,940	----do		×	×	×	--	×	×	--	--
budensis	----	2,610	1,900	Eocene to Miocene		--	--	--	--	--	--	--	--
caroliniana	3,540	3,300	1,660	Eocene to Oligocene		--	--	×	--	×	×	--	--
clericii	3,540	2,310	1,780	Long ranging		--	--	--	--	×	×	--	--
convergens	3,510	2,310	1,600	----do		×	--	--	×	--	--	--	--
melvilli	----	2,830	----	Oligocene to Miocene		--	×	--	--	--	×	--	--
orbicularis	3,510	2,490	2,320	Long ranging		--	×	×	--	×	×	×	--
subpapillosa	3,520	2,810	1,600	Oligocene		--	×	×	--	×	×	--	--
terryi	----	3,790	1,940	Eocene		×	--	×	×	--	--	--	--
Liebusella byramensis	----	3,080	----	Oligocene		--	--	×	--	--	--	--	--
Lingulina wilcoxensis	3,630	----	----	Eocene	Deep water	--	--	--	--	--	--	--	--
Marginopora vertebralis	3,020	600	1,480	Miocene to Holocene	Reef	--	--	--	--	--	--	--	--
Marginulina glabra	3,530	2,530	1,780	Long ranging		--	--	--	--	--	--	--	--
hantkeni	3,520	3,780	1,780	----do		--	--	--	--	--	--	--	--
nuttalli	----	----	1,980	Eocene to Oligocene		--	--	--	--	--	--	--	--
perprocera	4,530?	3,280	1,660	Miocene to Pliocene		--	--	--	--	--	--	--	--
pseudohirsuta	----	3,380	1,780	Oligocene to Miocene		×	×	×	--	×	×	×	×
Matanzia bermudezi	----	3,500	1,900	Oligocene		--	--	--	--	×	--	--	--
Melonis pompilioides	3,500	2,900	1,600	Long ranging	Deep water	--	--	×	×	--	×	×	×
Neoconorbina patelliformis	3,030	----	1,100	----do		--	--	--	--	--	--	--	--
Nodosarella decurta	----	----	1,900	Eocene to Oligocene		×	×	--	×	--	--	--	--
subnodosa	----	----	2,500	Long ranging		--	--	--	--	--	--	--	--
Nodosaria raphanistrum	3,800	2,530	1,900	----do		--	×	×	--	×	×	×	×
Nonion planatum	3,180	----	----	Eocene		--	--	--	--	--	--	--	--
Nonionella pulchella	3,180	4,700	1,600	Miocene to Holocene		--	--	--	--	--	--	--	--
Oridorsalis umbonatus	3,630	2,610	1,660	Long ranging		--	×	×	--	--	×	--	--
Osangularia culter	3,570	3,280	1,700	----do		×	×	×	×	--	×	--	--
Palmerinella palmerae	----	500	490	Miocene to Holocene	Brackish	--	--	--	--	--	--	--	--
Pararotalia byramensis	----	1,100	1,200	Eocene to Oligocene		--	--	--	--	--	--	--	--
mexicana	3,580	3,500	1,780	----do		--	--	--	--	--	--	×	×
Peneroplis proteus	1,300	1,600	900	Miocene to Holocene	Reef	--	--	--	--	--	--	--	--
Planodiscorbis rarescens	3,740	----	3,840	Pliocene to Holocene		--	--	--	--	--	×	--	--
Planularia protuberans	----	3,760	----	Oligocene to Miocene		--	×	×	--	--	×	--	--
torrei	----	3,060	----	Oligocene		--	--	--	--	--	--	--	--
trinae	----	2,010	2,000	----do		×	--	×	--	--	--	--	--
"*Planulina*" *camagueyana*	----	3,750	----	Eocene		--	--	--	--	--	--	--	--
Planulina leoni	3,530	----	1,900	----do		--	×	×	--	--	--	--	--
marialana	3,530	2,960	1,660	Eocene to Miocene		--	×	×	×	×	×	×	--
mexicana	3,550	3,000	1,900	----do		--	--	×	--	×	×	×	×
subtenuissima	3,540	2,810	1,600	Oligocene to Miocene		×	×	×	--	×	×	×	×
sp	----	----	3,950			--	--	--	--	--	--	--	--
Plectofrondicularia jarvisi	3,600	2,730	2,040	Miocene		×	--	×	--	×	×	--	--
trinitatensis	----	2,110	----	Eocene to Oligocene		--	--	×	--	--	--	--	--
yumuriana	----	3,040	2,720	Oligocene to Miocene		--	×	×	×	--	×	--	--
Pleurostomella bierigi	3,530	----	1,600	Eocene to Miocene	Deep water	--	--	--	--	--	×	--	--
elliptica	3,550	3,280	1,600	Oligocene to Miocene	----do	--	--	×	×	--	--	--	--
Pseudoclavulina bullbrooki	----	----	2,380	Miocene		--	--	--	--	×	--	--	--
sp	----	----	1,660			--	--	--	--	--	--	--	--
Pseudonodosaria comatula	3,510	2,810	1,660	Long ranging		×	--	×	--	--	--	--	--
inflata	3,700	2,960	1,600	----do		--	--	×	--	×	×	--	--
Pullenia bulloides	3,510	3,040	1,600	----do	Deep water	--	×	--	--	--	--	--	--
quinqueloba	3,510	----	1,700	----do	----do	--	×	--	--	--	--	--	--
"*Pullenia*" *riveroi*	3,530	----	1780	Oligocene to Holocene	----do	--	--	--	--	--	--	--	--
Pyrgo denticulata	1,300	----	1,780	Miocene to Holocene	Shallow	--	--	--	--	--	--	--	--
inornata	3,710	1,200	600	Long ranging	----do	--	--	×	×	--	×	--	--
Quadrimorphina allomorphinoides.	----	----	1,660	----do		--	×	--	--	--	--	--	--

TABLE 1.—*Top occurrences of benthonic Foraminifera in Puerto Rico wells with their age and ecologic indications and their occurrences in outcrop samples of the Juana Diaz Formation*—Continued

Species	Wells (Depths in feet; metres=feet × 0.3048)			Age	Ecology [1]	Outcrop localities in Juana Díaz Formation							
	CPR–1	CPR–2	CPR–3			f26290	f26291	f26292	f26293	f25509	f25508	f25507	f25506
Quinqueloculina akneriana	3,590	500	600	do	--	--	--	--	--	--	--	--	--
ermani	3,030	2,960	900	do	--	--	--	--	--	--	--	--	--
seminulum	1,300	----	2,340	do	--	--	--	--	--	--	--	--	--
Robertina declivis	----	----	3,820	Eocene to Miocene	Deep water	×	--	--	--	--	--	--	--
Rosalina floridensis	1,400	2,310	1,200	Long ranging	Shallow	--	--	×	--	--	--	--	--
Rotorbinella mira	1,400	----	600	Miocene to Holocene	do	--	--	--	--	--	--	--	--
tholus	1,240	500	600	do	do	--	--	--	--	--	--	--	--
Sagrina vicksburgensis	----	3,100	----	Oligocene	--	--	--	--	--	--	--	--	--
Saracenaria arcuata	----	----	2,820	Eocene to Miocene	--	--	--	×	--	×	--	--	--
italica	3,530	3,080	1,900	Long ranging	--	×	×	×	--	--	--	--	--
senni	----	----	2,580	Oligocene to Miocene	--	--	×	--	--	--	×	--	--
Sigmoilina tenuis	4,170	2,830	1,480	Long ranging	--	--	×	×	--	×	×	--	--
Siphogenerina hubbardi	3,740?	----	1,600	Miocene	--	--	--	--	×	--	--	--	--
mexicana	3,590	2,530	1,600	Eocene to Miocene	--	×	--	×	--	--	--	--	--
Siphonina tenuicarinata	3,590	2,530	490	do	--	×	×	×	--	×	×	×	×
Sphaeroidina chilostomata	3,510	3,040	600	Oligocene to Pliocene	--	×	×	×	×	×	×	--	--
Spiroloculina alveata	----	3,040	1,940	Oligocene to Miocene	--	--	×	--	--	--	--	--	--
Spiroplectammina mississippiensis.	3,550	3,040	1,600	Eocene to Miocene	--	--	--	--	--	--	--	--	--
Stilostomella caribaea	3,630	2,900	2,420	Oligocene	--	×	--	×	--	--	--	--	--
verneuili	3,630	3,100	1,600	Long ranging	--	×	×	×	×	×	×	--	--
Textularia bermudezi	----	2,960	1,780	Oligocene to Miocene	--	--	--	×	--	--	×	--	--
aff. T. conica	----	3,140	1,900	--	--	--	--	--	--	--	--	--	--
grenadana	3,520	2,960	3,520	Oligocene	--	--	--	×	--	--	--	--	--
kugleri	3,520	2,960	1,980	Miocene	--	--	--	×	--	--	--	--	--
leuzingeri	----	3,760	3,080	Oligocene to Miocene	--	--	--	--	--	×	×	--	--
yasicaensis	----	----	1,660	Miocene	--	--	--	--	--	--	--	--	--
Textulariella barrettii	----	2,900	1,680	Miocene to Holocene	--	--	--	×	--	×	×	--	--
Triloculina trigonula	3,930	----	----	Long ranging	--	--	--	--	--	--	--	--	--
Tritaxilina mexicana	3,540	2,830	1,660	Eocene to Oligocene	--	×	×	×	--	×	×	--	--
Turrilina robertsi	----	3,220	1,900	do	--	--	×	--	--	×	×	--	--
Uvigerina adelinensis	3,530	3,080	1,600	Eocene to Miocene	--	×	×	×	--	×	×	×	×
barbatula	----	----	1,940	Miocene	--	--	--	--	--	--	--	--	--
elongata	3,550	3,280	2,080	Long ranging	--	--	--	×	--	--	--	--	--
greymouthensis	3,510	2,610	1,660	Eocene	--	--	×	--	--	--	--	--	--
jacksonensis	----	3,380	3,580	Eocene to Oligocene	--	--	--	--	--	--	--	--	--
mantaensis	3,540	----	1,600	Eocene to Miocene	--	--	--	--	--	--	--	--	--
mexicana	3,500	----	1,660	Oligocene to Miocene	--	--	--	--	--	--	--	--	--
nuttalli	3,610	3,750	1,780	do	--	--	×	×	--	--	--	--	--
sp	3,530	2,810	2,340	--	--	--	--	×	--	--	--	--	--
Vaginulinopsis cumulicostata	----	2,610	1,600	Eocene to Miocene	--	--	×	×	--	--	--	--	?
Valvulammina cornucopia	3,440	----	----	Oligocene to Miocene	Shallow	--	--	--	--	--	--	--	--
Valvulineria nuttalli	3,530	2,810	3,540	do	--	--	×	×	--	--	×	--	--
paucilocula	3,630	4,360	----	Oligocene	--	--	--	--	--	--	--	--	--
sculpturata	3,820	3,860	----	do	--	--	--	--	--	--	--	--	--
Virgulina colei	3,820	2,530	1,420	do	--	--	×	--	--	×	×	×	×
pontoni	----	----	2,040	Oligocene to Pliocene	--	--	--	×	--	--	--	--	--
Vulvulina stainforthi	----	2,960	1,660	Oligocene to Miocene	--	--	--	--	--	--	--	--	--
Genus? rel. to *Eggerella bradyi*	----	----	2,720	--	--	--	--	--	--	--	--	--	--

[1] Dash leaders indicate moderate depths or that the species or genus is not ecologically restricted.

Ammonia beccarii and its subspecies *tepida*
Archaias angulatus
Cibicides lobatulus
Elphidium discoidale
E. mexicanum
E. poeyanum
E. sagra
Eponidella libertadensis
Eponides ellisorae
Florilus subgrateloupi
Gypsina globula
Hanzawaia carstensi
Peneroplis proteus
Rosalina floridensis
Rotorbinella mira
R. tholus
rare miliolids

Beginning at 2,990 feet, the above assemblage continues, dominated by the three large species *Amphistegina angulata, Elphidium lens,* and *Gypsina globula,* and the small species *Ammonia beccarii.*

The assemblage is augmented by *Amphistegina rotundata, A. floridana, Baggina cojimarensis, Elphidium lobatum, E. puertoricense, Neoconorbina patelliformis, Nonion planatum, Nonionella pulchella, Quinqueloculina ermani,* and *Valvulammina cornucopia.*

A major faunal change appears in the cuttings at 3,500 feet. This rich and varied planktonic assemblage contains the evidence of Oligocene age, as previously discussed. In addition, the appearance of lenticulinids, bolivinids, uvigerinids, cassidulinids, and rotaliids in the benthonic part of the fauna indicates an ecologic change to a deeper neritic environment, more distant from shore, than that of the overlying sediments. The Oligocene fauna in this hole is poorer than that in CPR–2 and CPR–3.

The major species in this new assemblage are *Amphistegina angulata, Camerina panamensis, Cibicides mexicanus, Elphidium lens, Eponides parantillarum,* and *Gyroidina altiformis.* Of these, only *Camerina panamensis* is restricted to the Oligocene.

The Oligocene age is supported by the associated planktonics and many other benthonic species, among which are the following that are unknown from post-Oligocene beds:

Ammospirata mexicana
Angulogerina cooperensis
A. rugoplicata
A. vicksburgensis
Bolivina ariana
B. choctawensis
B. mexicana aliformis
B. oligocaenica
Bulimina bleeckeri
B. sculptilis
Cassidulina carapitana
C. havanensis
Ceratobulimina alazanensis
Chilostomella cylindroides
Cibicides trinitatensis
Cibicidina choctawensis
C. mississippiensis
Clavulinoides triangularis
Cribropullenia marielensis
Cycloloculina cubensis
Dentalina jacksonensis
Dorothia cylindrica
Gyroidina vicksburgensis
Lenticulina caroliniana
L. subpapillosa
Pararotalia mexicana
Stilostomella caribaea
Textularia grenadana
Tritaxilina mexicana
Valvulineria paucilocula
V. sculpturata
Virgulina colei

In addition, the list below includes species which are characteristic of the Oligocene but which also range downward into the Eocene or upward into the Miocene or both. These species are present in the Oligocene section of well CPR–1, and most of them are also found in the outcropping Juana Díaz Formation.

Amphistegina floridana
Astacolus crepidulus
Asterigerinata bracteata
Baggina cojimarensis
Bolivina byramensis
B. isidroensis
B. tectiformis
Bulimina affinis
Cancris auriculus
Cassidulina subglobosa
Cibicides pseudoungerianus
Ellipsoidina ellipsoides
Gypsina globula
Gyroidina altiformis
Hanzawaia carstensi
H. mantaensis
Karreriella mexicana
Lenticulina alatolimbatus
L. clericii
L. orbicularis
Melonis pompilioides
Nodosaria raphanistrum
Oridorsalis umbonatus
Osangularia culter
Planulina marialina
P. mexicana
P. subtenuissima
Pleurostomella bierigi
P. elliptica
Pseudonodosaria comatula
P. inflata
"Pullenia" riveroi
Siphogenerina mexicana
Siphonina tenuicarinata
Sphaeroidina chilostomata
Spiroplectammina mississippiensis
Stilostomella verneuili
Uvigerina adelinensis
U. mantaensis
U. mexicana
U. nuttalli
Valvulineria nuttalli

Finally, a few species, commonly regarded as Eocene indicators, are associated with the Oligocene fossils in well CPR–1: *Bulimina impendens, Cribrogloborotalia marielina, Eorupertia?* sp., *Florilus whitsettensis, Karreriella disjuncta, Lingulina wilcoxensis, Nonion planatum, Planulina leoni,* and *Uvigerina greymouthensis.* All of these species are found above 4,270 feet, the presumed top of the Eocene section. These species are too few, and the specimens too rare and scattered throughout the Oligocene section, to be regarded as reliable indication that Eocene beds had been reached. Moreover, the absence of a change in the associated planktonic assemblage suggests that the Eocene species should be interpreted as reworked specimens, as indication of a disrupted sequence of faunas due to faulting, or as representing previously unrecognized lengthened ranges of some of the species. An extended range seems the most likely explanation for *Bulimina impendens, Eorupertia?* sp., *Planulina leoni,* and *Uvigerina greymouthensis,* as they have all been found in adjacent outcrops of the Juana Díaz Formation.

In cuttings from the lower (Oligocene) part of well CPR–1 the following species occur as down-hole contaminants from Miocene strata: *Ammonia beccarii, Amphistegina angulata, A. rotundata,* and *Elphidium lens.*

In addition nearly 40 other species have their first appearance or are present in the Oligocene section of this well. None are abundant, and most seem to have little or no age significance, though they include the Oligocene in their reported ranges. Among others in this category are *Bolivina rhomboidalis, B. tortuosa, Cibicides robertsonianus, Lenticulina* *convergens, Marginulina glabra, M. hantkeni, Pullenia bulloides, P. quinqueloba, Pyrgo inornata, Saracenaria italica,* and *Sigmoilina tenuis.*

TEST WELL CPR-2

Down to about 2,510 feet in well CPR-2, the Foraminifera population is poor in both variety of species and number of specimens and is particularly meager down to 1,200 feet, where it becomes somewhat more abundant, though imperfectly preserved.

The two chief constituents in the upper 1,200 feet of the well are *Amphistegina angulata* and *Ammonia beccarii,* the latter indicative of nearshore or brackish conditions. Also rare specimens of two additional brackish species (*Eponidella libertadensis* and *Palmerinella palmerae*) are found in this section, suggesting nearness to a brackish environment.

At 1,200 feet a change to a richer and more varied assemblage can be noted, continuing the *Amphistegina* and *Ammonia* fauna with the addition of the following species as common constituents: *Elphidium lens, E. poeyanum,* and *Camerina panamensis* ?. The last species is undoubtedly reworked from the Oligocene beds because there are no planktonics to confirm the Oligocene above 2,510 feet.

Within the upper (Miocene) part of the well are numerous species that are more abundant or more persistent or better preserved in the Oligocene part. Most of these are long-ranging species, but a few are presumed to be restricted to pre-Miocene rocks: *Florilus whitsettensis, Planularia trinae, Plectofrondicularia trinitatensis, Bolivina mexicana aliformis,* and *B. choctawensis.* Their presence above the 2,510-foot level, where the major change to an Oligocene fauna occurs, suggests that the rocks in this upper part of CPR-2 may be reworked or faulted. An alternative explanation, suggested by Monroe (1973, p. 1094), is that the Ponce is missing in CPR-2 and the alluvium in the upper part of the well overlies Juana Díaz beds of Miocene age; this formation would then occupy the interval between 1,400 and 2,510 feet (fig. 2). But the Foraminifera fauna in this interval is too meager to confirm this possibility. Moreover, species characteristic of the Miocene Ponce beds in the other two test wells are also characteristic of the beds above 2,500 feet in CPR-2. These include *Amphistegina floridana, Archaias angulata, Elphidium discoidale, E. fimbriatulum, E. mexicanum, Marginopora vertebralis, Peneroplis proteus, Quinqueloculina akneriana,* and *Rotorbinella tholus.*

A major faunal change appears in the cuttings at 2,510 feet. Most significant is the appearance of a rich and varied planktonic assemblage by which the age can be determined as Oligocene, as previously discussed. In addition, the appearance of lenticulinids, bolivinids, uvigerinids, cassidulinids, and rotaliids—essentially the same assemblage that appears in CPR-1 at 3,500 feet—indicates an ecologic change to a deeper environment, more distant from shore, than that of the overlying sediments.

The major species in this new assemblage are:

Ammonia beccarii
Amphistegina angulata
Camerina panamensis
Cibicides mexicanus
C. pseudoungerianus
Elphidium lens
Eponides parantillarum
Gyroidina altiformis
Hoeglundina elegans
Lenticulina alatolimbatus
Planulina subtenuissima
Siphonina tenuicarinata
Uvigerina adelinensis

The only species restricted to the Oligocene is *Camerina panamensis.* But the Oligocene age is clearly indicated by the associated planktonic assemblage and by the fact that the rocks contain most of the same benthonic species that are listed for well CPR-1.

The Oligocene assemblage in well CPR-2 is generally richer than that in CPR-1 but differs only by a few exceptions and a few additions. Species which CPR-2 lacks are *Bolivina ariana, Bulimina bleeckeri, Cribropullenia marielensis, Cycloloculina cubensis,* and *Dorothia cylindrica.* Species present in CPR-2 but lacking in CPR-1 are:

Anomalina cocoaensis
A. granosa
Chilostomelloides oviformis
Ellipsoglandulina multicostata
Entolingulina alazanensis
Frondicularia tenuissima
Liebusella byramensis
Matanzia bermudezi
Pararotalia byramensis
Planularia torrei
P. trinae
Plectofrondicularia yumuriana
P. trinitatensis
Sagrina vicksburgensis
Turrilina robertsi
Uvigerina jacksonensis

The Oligocene age of this section in well CPR-2 is further supported by a few additional species that characteristically occur in Oligocene beds but also range into the Eocene or Miocene or both. These species are: *Chilostomella globata, Lenticulina brevispinosa, L. budensis, L. melvilli, Marginulina pseudohirsuta, Planularia protuberans. Spiroloculina alveata, Textularia bermudezi, T. leuzingeri*

Vaginulinopsis cumulicostata, and *Vulvulina stainforthi.*

As in the other two wells, a few Eocene species occur: *Eorupertia?* sp., *Haplophragmoides coalingensis, Lenticulina terryi, "Planulina" camagueyana,* and *Uvigerina greymouthensis.* All but *Lenticulina terryi* are found in the Oligocene section (above 3,760 feet), but only *Lenticulina terryi* and *"Planulina" camagueyana* are found also below 3,760 feet.

Other differences between CPR–2 and CPR–1 are minor or concern species having little or no age significance. In general there are a few more indications of deeper environment in CPR–2 than in CPR–1, such as species in the genera *Cyclammina, Hoeglundina, Cassidulinoides, Chilostomelloides,* and *Ehrenbergina,* plus a greater variety and abundance of lenticulinids. Also, the absence in CPR–2 of certain shallower species, such as *Anomalina glabrata* and some of the miliolids present in CPR–1, is a further indication of a deeper environment in CPR–2.

TEST WELL CPR–3

The upper part of CPR–3 passes through about 550 feet of alluvial-fan deposits—unconsolidated sand and gravel with some limestone beds. Below 550 feet calcarenite of probable Ponce age was penetrated to 1,300 feet (Monroe, 1973, p. 1094) or possibly 1,600 feet as suggested by our examination of the cuttings.

Down to about 1,600 feet in well CPR–3, the Foraminifera population lacks diversity but is rich in specimens. Large specimens of *Amphistegina* are dominant; chiefly the planoconvex *A. angulata* and the thick biconvex *A. rotundata.* Less abundant are smaller and variable specimens of this genus, some of which belong to *A. floridana* and some of which are transitional, probably toward *A. rotundata.* Additional elements occurring commonly in this upper part of the well are: *Ammonia beccarii, Elphidium lens, E. poeyanum, E. puertoricense, Florilus subgrateloupi, Gypsina globula, Pyrgo inornata, Rotorbinella mira,* and *Rosalina floridensis.* Less abundant but characteristic of the upper part of the well are: *Archaias angulatus, Asterigerinata bracteata, Elphidium discoidale, E. fimbriatulum, E. sagra, Eponidella libertadensis, Hanzawaia mantaensis, Marginopora vertebralis, Palmerinella palmerae, Pararotalia byramensis, Peneroplis proteus,* and *Rotorbinella tholus.* This fauna is characteristic of the reef limestone of the restricted Ponce.

A few species that are more abundant or more persistent in the lower (Oligocene) part of the well are first observed in this upper (Miocene) section. Only *Bolivina choctawensis, B. mexicana aliformis,* and *Virgulina colei* are regarded as Oligocene species.

The predominance of *Amphistegina* and the common occurrence of *Gypsina, Elphidium,* and the porcellaneous genera *Archaias, Marginopora,* and *Peneroplis,* combined with the lack of globigerinids, suggest that this Ponce fauna was deposited in a moderately shallow, nearshore environment. The presence of such species as *Ammonia beccarii, Eponidella libertadensis,* and *Palmerinella palmerae* indicates the proximity of a brackish environment from which these forms were probably displaced.

A major faunal change in the cuttings at 1,600 feet corresponds to the change observed at 3,500 feet in CPR–1 and 2,510 feet in CPR–2. As in those wells, most significant is the appearance of a rich and varied Oligocene planktonic assemblage. In addition, the appearance of lenticulinids, bolivinids, uvigerinids, cassidulinids, and rotaliids indicates an ecologic change to a deeper environment, more distant from shore, than that represented by the overlying sediments. Both the benthonic and planktonic assemblages in this well are richer and better preserved than in the two wells already discussed.

The major species in this Oligocene assemblage are:

**Camerina panamensis*
Cibicides mexicanus
Eponides parantillarum
Gyroidina altiformis
Hoeglundina elegans
Lenticulina alatolimbatus
L. brevispinosa
L. budensis
**L. caroliniana*
L. clericii
L. convergens
L. orbicularis
**L. subpapillosa*
Melonis pompilioides
Nodosaria raphanistrum
Oridorsalis umbonatus
Osangularia culter
**Pararotalia mexicana*
Planulina marialana
P. subtenuissima
Pseudonodosaria comatula
Siphonina tenuicarinata
Uvigerina adelinensis
**U. greymouthensis*
U. mexicana
U. nuttalli
Vaginulinopsis cumulicostata

Most of the species that make up the major part of this benthonic assemblage are long-ranging species that include the Oligocene in their ranges. The five starred species in the preceding list, however, are not known from post-Oligocene beds. Only

Eponides parantillarum has not previously been reported from pre-Miocene beds, but it is commonly present in the Juana Díaz Formation. The remainder of the species in the Oligocene section of well CPR–3 are essentially the same as those found in CPR–2 and CPR–1.

As in the other two wells, a few Eocene species occur in the Oligocene as well as in the pre-Oligocene section: *Bulimina impendens, Haplophragmoides coalingensis, Karreriella disjuncta, Lenticulina terryi, Planulina leoni,* and *Uvigerina greymouthensis.* For the most part they are masked in the Eocene section below 2,848 feet by the flood of caved Oligocene specimens from above. All are rare and all are present in one or both of the other drill holes but are too rare and scattered to serve as proof that Eocene beds have been penetrated. As in the other holes, these species are interpreted as not being in place in the Oligocene section, except for *Uvigerina greymouthensis* which probably ranges higher than heretofore recorded.

Other differences between CPR–3 and CPR–2 are minor or concern species having little or no age significance. In general, the paleoecology of CPR–3 appears to be identical with that of CPR–2, that is, deposition under moderately deep conditions.

FORAMINIFERA IN MODERN BOTTOM SEDIMENTS OFF PUERTO RICO

Modern Foraminifera were studied by Brooks (1973) in a small area off the coast directly south of wells CPR–3 and 2. Cluster analysis of 144 species found at 34 stations between 10 and 600 feet show six thanatotopes, or areas in which the dead specimens are deposited. Major species are listed for these areas which are characterized only in part by depth. Other ecologic factors are temperature, sediment distribution, turbulence, and influence of rivers and consequent variability of salinity.

To summarize the observations of Brooks: a nearshore and shallow (to 25 ft) environment, influenced by a perennially-flowing river and wave effects which may be severe, is inhabited by an assemblage of robust species dominated by *Ammonia beccarii* accompanied by miliolids and elphidiids. Farther from the fluviatile effects, where salinity variations are less extreme, the assemblage is similar, with the exception of reduced dominance of *Ammonia* and the addition of *Florilus grateloupi.*

On or associated with patch reefs, in shallow (to 75 ft) clear waters, the assemblage is characterized by *Archaias, Amphistegina,* discorbids, miliolids, and peneroplids. Essentially this same fauna, with a few additions, also exists on the sea bottom and in the submarine channel of the river.

On the outer shelf areas (depths between 75 and 600 ft), in colder temperatures and quiet waters, planktonic species are added to the bottom population. The major benthonic forms are *Amphistegina,* peneroplids, and rotaliids. A variety of arenaceous genera, not significantly present in shallower areas, also are found on the outer shelf.

The environments under which Foraminifera presently live around Puerto Rico give confirming evidence of the paleoecologic interpretations of the Miocene and Oligocene environments under which the fossil counterparts of the same species or genera lived.

OUTCROPS OF THE JUANA DIAZ FORMATION

To permit a comparison of the fauna in the lower (Oligocene) parts of the three wells, we have studied the faunas of eight samples of the Oligocene part of the Juana Díaz Formation taken from discontinuous scattered outcrops in an east-west line about 3 to 9 km north of the south coast of Puerto Rico, and generally northwest of the sites of the three wells. Their positions are shown in figure 1, and more exact data is listed in table 2. All references to the outcrop samples in this paper are by the U.S. Geological Survey locality numbers assigned to the original field collection numbers.

The Juana Díaz exposures include a few species additional to those listed in table 1, but in none of the outcrop samples are these additional species represented by abundant specimens. These outcrop samples provide a basis for estimating the faunal composition of the Juana Díaz Formation.

The planktonic assemblages in these outcrop samples are quite uniform and very similar to those in the three deep wells. The benthonic assemblages, on the other hand, are variable, although a few species are present in greater or lesser abundance in nearly all the outcrop samples. The following benthonic species appear to be more or less consistently present in the Juana Díaz outcrop samples, and probably have broader tolerances to environmental changes and are, therefore, less useful in interpreting facies than some of the other benthonic species:

Astacolus crepidulus
Bolivina byramensis
B. choctawensis
B. mexicana aliformis
B. tectiformis
Bulimina affinis
Cancris auriculus
Cibicides mexicanus

TABLE 2.—*Outcrop samples of the Juana Díaz Formation in southern Puerto Rico*

USGS loc. No.	Field loc. No.	Quadrangle	Coordinates	Location
f26290	Po 134	Ponce	138,520 E., 21,950 N.	Along new superhighway to Ponce.
f26291	91	--do	137,760 E., 21,570 N.	Quarry for new superhighway to Ponce.
f26292	88	--do	139,520 E., 22,620 N.	Do.
f26293	92	--do	137,650 E., 21,640 N.	Near new superhighway to Ponce (near loc. 91).
f25509 [1]	Pe 46–1	Peñuelas	130,240 E., 22,910 N.	Northwest of Ponce along route 10, km 4.33; parking lot of roadhouse "La Arboleda."
f25508 [1]	Po 35–3	Ponce	134,700 E., 22,100 N.	Excavation for new house in La Rambla section in northeast Ponce; northeast-trending segment of Calle G.
f25507	Po 35–2	--do	134,720 E., 22,110 N.	Excavation for next new house to the northeast.
f25506 [1]	Po 35–1	--do	134,720 E., 22,110 N.	Same location but about 1 m lower than Po 35–2 and about 20 m lower than Po 35–3.

[1] USGS locs. f25506, f25508, and f25509 in this paper have been referred to as f35139, f35138, and f35141 respectively in Glover (1971, p. 73).

C. pseudoungerianus
Cibicidina choctawensis
Ellipsoidina ellipsoides
Eponides parantillarum
Gyroidina altiformis
Lenticulina alatolimbatus
L. brevispinosa
L. orbicularis
L. subpapillosa
Marginulina pseudohirsuta
Melonis pompilioides
Nodosaria raphanistrum
Osangularia culter
Planulina marialana
P. mexicana
P. subtenuissima
Siphonina tenuicarinata
Sphaeroidina chilostomata
Stilostomella verneuili
Tritaxilina mexicana
Uvigerina adelinensis
Virgulina colei

The total absence in these outcrop samples of *Amphistegina angulata,* all species of *Elphidium,* and *Ammonia beccarii,* all of which occur in abundance in parts of the Oligocene sections of the three deep wells, leads us to conclude that the origin of these species in the deeper well cuttings is contamination from the Miocene beds above.

Of the eight samples, two (f25506 and f25507) can be grouped together paleoecologically. This grouping is based, first, on meager planktonics and, second, on combinations of species, most of which are not present or, if present, are rare, in the remaining six samples. Five of the samples (f26291 and f26292 and, less strikingly so, f26290, f25509, and f25508) contrast with the two samples mentioned above in that they contain rich planktonics and have different combinations of species. Finally, the eighth sample (f26293), though containing a fauna meager in numbers and ill preserved, represents a similar but possibly distinct facies characterized by a good planktonic assemblage and by common to abundant occurrences of two species, *Cribropullenia marielensis* and *Siphogenerina hubbardi,* not observed in any other outcrop samples.

The three facies represented by the Juana Díaz outcrop samples are not recognizable in the cuttings from the deep wells. However, some tentative correlations between outcrops and wells may be possible by means of comparison of the distinctive species or groups of species that probably have a paleoecologic significance.

For example, the two lower samples from the La Rambla section in the northeastern part of Ponce (samples f25507 and f25506) are quite alike in their faunal assemblages, which are different from those of the other six outcrop samples. Planktonics are poorly represented in these two samples, and the benthonic population lacks the greater variety and many of the typically deep-water genera, such as lenticulines, so characteristic of the other Juana Díaz outcrop samples.

In addition, these two samples both contain common to abundant specimens of the following species not found, or found only very rarely, in the other studied Juana Díaz outcrops: *Amphistegina floridana, Angulogerina vicksburgensis, Baggina cojimarensis, Eorupertia*? sp., *Gypsina globula,* and *Pararotalia mexicana.*

This distinctive association of Foraminifera suggests a somewhat shallower facies than is typically found in other Juana Díaz outcrops. Efforts to recognize this same facies in the wells are hindered by the mixing of specimens in the cuttings, though all the species are present in significant numbers in the wells.

A second example of a unique occurrence is *Cribropullenia marielensis* which is found commonly in sample f26293 but not elsewhere in the outcrop samples. In the cuttings it was found only in well CPR–1, occurring a short distance below the top of the Oligocene section. The only other record of this species is from the Oligocene of Cuba, although a similar, possibly identical, species, *Polystomella*?

obscura Schwager, was described from the Eocene of Egypt (Schwager, 1883, p. 138, pl. 26(4), fig. 2).

Other examples of a possible tie between individual Juana Díaz outcrops and the wells may be listed as follows:

1. *Spiroloculina alveata,* well represented at loc. f26291, is found scattered in the Oligocene sections of wells CPR–2 and CPR–3, very sparsely in CPR–2.
2. *Bolivina ariana,* described from the lower Oligocene of Florida and not recorded elsewhere, is well represented at loc. f26292 and rarely at f26291. In the wells it was found in CPR–1 only.
3. *Cycloloculina cubensis* was described from the upper Eocene of Cuba and has been reported from Miocene and Oligocene beds on both the north and south coasts of Puerto Rico. It is well represented at locs. f26292, but in the well cuttings it is represented by only a small specimen in CPR–1 at 4,050 feet.
4. *Entolingulina alazanensis,* described from the lower Oligocene of Mexico and reported from Texas and Venezuela, is present at loc. f26291 and f25508. In the well cuttings it appears to be restricted to a number of scattered occurrences between 2,850 and 3,760 feet in CPR–2.
5. *Lenticulina melvilli* occurs in the same two outcrop samples (f26291 and f25508) and the same well (CPR–2, rarely, between 2,830 and 4,160 feet) supporting the possible correlation between these three areas.
6. *Liebusella byramensis,* known from the lower Oligocene of the Gulf Coastal Plain, was found only at loc. f26292 and only in well CPR–2 in the lower part of the Oligocene section.
7. The large species, *Planularia protuberans,* was described from the Oligocene of Panama and has been reported from the Oligocene and Miocene of Venezuela and in the Ponce Limestone of southern Puerto Rico as discussed by Galloway and Heminway (1941). It is well represented in locs. f26291, f26292, and f25508. At 3,760 feet in well CPR–2 a single typical specimen was found.
8. The sharply angled and keeled species, *Saracenaria senni,* was described from the upper Oligocene of Venezuela and has been reported also from Trinidad and Colombia. It is present in typical form at locs. f26291 and f25508. Rare specimens were found in only one well, CPR–3.
9. *Siphogenerina hubbardi* occurs commonly at loc. f26293, although the specimens are smaller and proportionally slendered than typical for the species. This species was described by Galloway and Heminway (1941, p. 434, pl. 34, fig. 2) from beds on the south coast of Puerto Rico referred to the Ponce Limestone. In the well cuttings it was found only in CPR–3, fairly well developed but scattered, especially in the upper part of the Oligocene section.

Finally, the deeper water facies of the Juana Díaz, as represented by the five outcrop samples f26290, f26291, f26292, f25509, and f25508, is characterized by a predominance of planktonics plus a number of benthonics of which the following seem to be diagnostic:

Ammospirata mexicana
Anomalina bilateralis
Bolivina ariana
B. difformis
Bulimina sculptilis
Ceratobulimina alazanensis
Chilostomella cylindroides
C. globata
Chilostomelloides oviformis
Cibicides trinitatensis
Clavulinoides triangularis
Dorothia cylindrica
Frondicularia tenuissima
Gaudryina trinitatensis
Haplophragmoides coalingensis
Hoeglundina elegans
Karreriella bradyi
K. mexicana
Lagenonodosaria acostaensis
Lenticulina clericii
L. terryi
Oridorsalis umbonatus
Planularia protuberans
P. trinae
Planulina leoni
Plectofrondicularia jarvisi
P. yumuriana
Pseudonodosaria comatula
P. inflata
Saracenaria italica
Sigmoilina tenuis
Siphogenerina mexicana
Textularia leuzingeri
Textulariella barrettii
Turrilina robertsi
Uvigerina nuttalli
Vaginulinopsis cumulicostata
Valvulineria nuttalli

ST. CROIX TEST WELLS

The smaller Foraminifera found in cuttings from three test wells drilled during the winter of 1938–39 in the central part of the island of St. Croix, Virgin Islands, were originally studied some 30 years ago by J. A. Cushman (1946a).

Although the Foraminifera present in the cuttings are predominantly planktonic kinds, Cushman stated (1946a, p. 13) that no attempt would be made to deal with them in his study because the "family [Globigerinidae] is now being intensively studied in a monographic way and the species from St. Croix, which are represented by abundant specimens, will be included in those studies." Likewise under the family Globorotaliidae, and species *Globorotalia menardii,* he stated (1946a, p. 13) that "studies * * * may show that these Miocene forms are separable from the Recent ones" and that there were "other species of this genus, but all need special study and comparison with those of other areas before satisfactory determinations can be made."

As a result of the impossibility at that time of using the planktonic portion of the total assemblage, Cushman based his interpretation of age of the rocks penetrated by the three test wells on benthonic species, concluding (1946a, p. 2) that test wells Nos. 2 and 3 and the upper part of No. 1 were Miocene and the lower part of No. 1 was Oligocene.

At about the same time as the original study of these Virgin Island test wells took place, some attempts at zonation by planktonic Foraminifera were being made (Cushman and Stainforth, 1945, p. 4–12; LeRoy, 1948; Bronnimann, 1952, fig. 1; Bolli, 1954). But more than a decade passed before the appearance of a major work (Loeblich and collaborators, 1957) setting forth detailed zonations by planktonic Foraminifera for the Cretaceous, Paleocene, Eocene, Oligocene, and Miocene on the basis of the respective sections in Trinidad. (In this major work Bolli's paper (1957, fig. 18) on the Oligocene-Miocene section is of particular importance to our study.) Since then innumerable refinements have been and are still being made, and the zonation by planktonics has been extended upward into the Pliocene and Pleistocene.

Now, some 30 years after the original examination of these rich planktonic assemblages from the St. Croix test wells, it seemed of interest to restudy them with the aim of possibly pinpointing their age more precisely in light of the accumulated information on the restricted ranges of the globigerinids and globorotaliids they contain and in terms of the current planktonic zonation.

The wells on St. Croix are shallower than those on Puerto Rico, test well No. 1 being drilled to a depth of 1,506 feet, No. 2 to 470 feet, and No. 3 to 225 feet.

Figure 7 shows the occurrence of most of the easily recognizable species in each of the three holes. Of the dominant species—*Globigerinoides trilobus, Globoquadrina altispira,* and *Globigerina conglomerata*—only *Globoquadrina altispira* has a restricted range, from early Miocene to Pliocene (zones N.4 to N.20).

Orbulina universa also is fairly well represented in test well No. 1, but only in the upper 450 feet and the genus is also fairly common in test well No. 3 at about 100 feet. In the lower part of test well No. 1, it is largely replaced by *Orbulina suturalis;* this replacement is believed to signify the lower part of the middle Miocene (zone N.9).

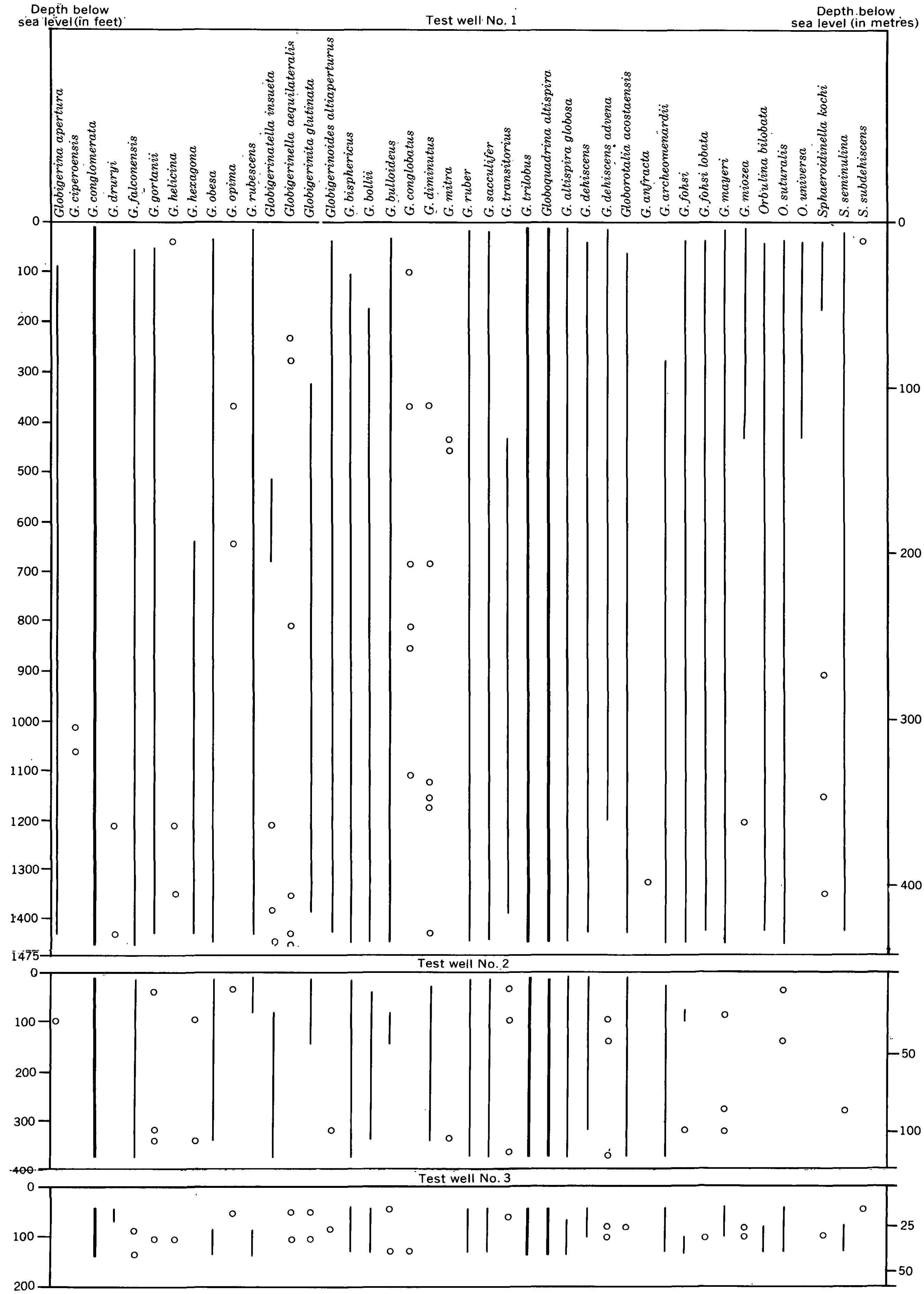
The existence of the following species in the upper one-third of test well No. 1 suggests the possibility of correlation with the middle part of the middle Miocene (zones N.12 or N.13) : *Globigerina falconensis, Globigerinoides bollii, G. mitra, Globorotalia fohsi, G. fohsi lobata, G. mayeri, G. miozea, Sphaeroidinella kochi,* and *S. subdehiscens.* Of these, only *Globorotalia fohsi, G. fohsi lobata,* and *G. mayeri* are narrowly restricted in their ranges; however, the others include zones N.12 and N.13 in their ranges.

The following species, all fairly well restricted to the several zones in the lower part of the middle Miocene (N.9 to N.11), have their highest appearances or sudden increase in abundance at about 500 feet in test well No. 1: *Globigerinatella insueta, Globigerinoides bisphericus, G. diminutus, G. transitorius,* and *Globorotalia archeomenardii.* None of the above species is very abundant, but all tend to confirm a difference in age between the upper one-third and the lower two-thirds of the section in test well No. 1.

A few other species, reportedly having narrow ranges but ranges inconsistent with the majority of the species (and those that are more abundant), as well as inconsistent with each other, are given here with their ranges and ages.

Species	*Zonal range and age*
Globigerina apertura	N.16 to N.19—late Miocene to early Pliocene.
G. ciperoensis	P.19 to N.4—Oligocene to early Miocene.
G. gortanii	P.18 to N.3—Oligocene.
G. opima	P.19 to N.2—Oligocene.
Globigerinoides altiaperturus	N.5 to N.7—early Miocene.
G. bulloideus	N.14 to N.16—middle to late Miocene.
G. conglobatus	N.18 upward—late Miocene to Holocene.
Globorotalia acostaensis	N.16 to N.21—late Miocene to Pliocene.

Among the various possible explanations for such inconsistencies are the facts that (1) the samples are cuttings rather than cores and thus more likely to be contaminated from above; (2) the total range of certain species may not yet be fully known; (3) certain species may have pseudomorphs with totally



Depth below sea level (in feet)
Test well No. 1
Depth below sea level (in metres)
Globigerina apertura
G. ciperoensis
G. conglomerata
G. druryi
G. falconensis
G. gortanii
G. helicina
G. hexagona
G. obesa
G. opima
G. rubescens
Globigerinatella insueta
Globigerinella aequilateralis
Globigerinita glutinata
Globigerinoides altiaperturus
G. bisphericus
G. bollii
G. bulloideus
G. conglobatus
G. diminutus
G. mitra
G. ruber
G. sacculifer
G. transitorius
G. trilobus
Globoquadrina altispira
G. altispira globosa
G. dehiscens
G. dehiscens advena
Globorotalia acostaensis
G. anfracta
G. archeomenardii
G. fohsi
G. fohsi lobata
G. mayeri
G. miozea
Orbulina bilobata
O. suturalis
O. universa
Sphaeroidinella kochi
S. seminulina
S. subdehiscens
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1475
Test well No. 2
400
Test well No. 3
50
25

different ranges; or (4) the identification may be erroneous.

Except for the above-listed eight species, the balance of the planktonic fauna in these Virgin Islands test wells indicates correlation of the upper one-third of test well No. 1 with the middle part of the middle Miocene and of the lower two-thirds of test well No. 1 with the lower part of the middle Miocene.

Correlation of the sections in test wells No. 2 and No. 3 is less clear.

The three dominant species are the same, but a number of the other species listed as critical for age determination in test well No. 1 are missing from one or both of test wells 2 and 3. Their absence may be due to the fact that the sections penetrated are very much shorter than that penetrated by test well No. 1—less than 400 feet in test well No. 2 and less than 150 feet in test well No. 3. The fact that in Nos. 2 and 3 the specimens of *Orbulina* belong in *O. suturalis,* rather than in *O. universa,* suggests that the beds penetrated by these two wells are correlated with the lower two-thirds rather than the upper one-third of well No. 1, thus belonging in the lower part of the middle Miocene.

The original interpretation of age of the sections penetrated by the three wells, which was Miocene for No. 2 and No. 3 and the upper part of No. 1 and Oligocene for the lower part of well No. 1 (Cushman, 1946a, p. 2), is not inconsistent with the present interpretation of middle Miocene because of the downward revision of the Oligocene-Miocene boundary since that original interpretation. This downward revision of the boundary is strikingly shown by comparison of the zonation given by Cushman and Stainforth (1945, p. 7–12) with the placement of the same zones (refined and subdivided) given by Blow (1969, p. 220–245, figs. 1 and 2 on p. 265–266).

FAUNAL REFERENCE LISTS

Two alphabetized lists—one for the planktonic species and one for the benthonic—are included to facilitate reference to the original or to a systematic treatise.

The benthonics from the Virgin Islands samples are not listed here as they were reported earlier by Cushman (1946a) and have not been restudied. The list of planktonic species includes those from both Puerto Rico and St. Croix. Details of occurrence are not given here as that information may be obtained from table 1 for the Puerto Rico benthonics, figures 4–6 for the Puerto Rico planktonics, and from figure 7 for the St. Croix planktonics.

Plate and figure numbers in parentheses in the following lists refer to those illustrated in this report.

PLANKTONIC SPECIES

Cassigerinella chipolensis (Cushman and Ponton). Blow, 1969, p. 377, pl. 51, fig. 5.

Chiloguembelina cubensis (Palmer). Beckmann, 1957, p. 89, pl. 21, fig. 21; text fig. 14, figs. 5–8.

Globigerina ampliapertura Bolli, 1957, p. 108, pl. 22, figs. 4–7. (Pl. 9, fig. 5.)

Globigerina apertura Cushman. Blow, 1959, p. 172, pl. 8, fig. 35.

Globigerina ciperoensis Bolli. Pessagno, 1963, p. 56, pl. 2, figs. 5–7, 10. (Pl. 9, fig. 1; pl. 10, fig. 12.)

Globigerina conglomerata Schwager. Banner and Blow, 1960, p. 7, pl. 2, fig. 3. (Pl. 9, figs. 13, 16; pl. 10, fig. 14.)

The following species are here considered synonyms of *Globigerina conglomerata: G. venezuelana* Hedberg (1937, p. 681, pl. 92, fig. 7) from the upper Oligocene of Venezuela and *G. eximia* Todd (1957, p. 300, pl. 78, fig. 8) from the lower Miocene of Saipan, Mariana Islands.

Globigerina dissimilis Cushman and Bermúdez, 1937, p. 25, pl. 3, figs. 4–6. (Pl. 9, figs. 8, 9.)

Globigerina druryi Akers, 1955, p. 654, pl. 65, fig. 1.

Globigerina eocaena Gümbel. *Globigerina* (*Subbotina*) *eocaena* Gümbel. Hagn and Lindenberg, 1969, p. 236, pl. 1, figs. 1–6; text figs. 3, 6a. (Pl. 9, fig. 11.)

Globigerina falconensis Blow, 1959, p. 177, pl. 9, figs. 40, 41.

Globigerina gortanii (Borsetti). *Catapsydrax gortanii* Borsetti, 1959, p. 205, pl. 1, fig. 1. (Pl. 9, figs. 14, 15; pl. 10, fig. 5.)

Globigerina helicina d'Orbigny. Brady, 1884, p. 605, pl. 81, figs. 4, 5. (Pl. 11, fig. 15.)

Globigerina hexagona Natland. Phleger, Parker, and Peirson, 1953, p. 12, pl. 1, figs. 13, 14. (Pl. 9, figs. 3, 4; pl. 10, figs. 1, 4.)

Globigerina obesa (Bolli). *Globorotalia obesa* Bolli, 1957, p. 119, pl. 29, figs. 2, 3. (Pl. 10, fig. 3.)

Globigerina officinalis Subbotina. Blow and Banner, 1962, p. 88, pl. 9, figs. A–C. (Pl. 9, fig. 2.)

Globigerina opima (Bolli). *Globorotalia opima opima* Bolli, 1957, p. 117, pl. 28, figs. 1, 2.

Globigerina rubescens Hofker. Parker, 1967, p. 152, pl. 19, figs. 3, 4. (Pl. 10, fig. 2.)

Globigerina sellii (Borsetti). *Globoquadrina sellii* Borsetti, 1959, p. 209, pl. 1, fig. 3. (Pl. 9, figs. 7, 12.)

Globigerina oligocaenica Blow and Banner (1962, p. 88, pl. 10, figs. G, L–N), described from the Oligocene of East Africa, is included here as a synonym of *G. sellii.*

Globigerina yeguaensis Weinzierl and Applin, 1929, p. 408, pl. 43, fig. 1. (Pl. 9, fig. 10.)

Globigerinatella insueta Cushman and Stainforth, 1945, p. 69, pl. 13, figs. 7–9. (Pl. 11, fig. 13.)

FIGURE 7.—Occurrence of planktonic Foraminifera in three wells on St. Croix Virgin Islands. Unbroken line indicates continuous occurrence; heavy line indicates dominant species; circle indicates scattered occurrence.

Globigerinella aequilateralis (Brady). Todd, 1965, p. 64, pl. 25, figs. 4, 5.

Globigerinita glutinata (Egger). Parker, 1967, p. 146, pl. 17, figs. 3–5.

Globigerinoides altiaperturus Bolli. *Globigerinoides triloba altiapertura* Bolli, 1957, p. 113, pl. 25, figs. 7, 8; text fig. 21, fig. 3. (Pl. 11, fig. 3.)

Globigerinoides bisphericus Todd. Bolli, 1957, p. 114, pl. 27, fig. 1. (Pl. 11, figs. 9, 10.)

Globigerinoides bollii Blow, 1969, p. 324, pl. 20, figs. 2, 3.

Globigerinoides bulloideus Crescenti, 1966, p. 43, text fig. 8, fig. 3; text fig. 9. (Pl. 11, figs. 1, 2.)

Globigerinoides conglobatus (Brady). Parker, 1967, p. 154, pl. 20, figs. 3, 4. (Pl. 11, fig. 8.)

Globigerinoides diminutus Bolli, 1957, p. 114, pl. 25, fig. 11. (Pl. 11, fig. 14.)

Globigerinoides mitra Todd. Bolli, 1957, p. 114, pl. 26, figs. 1–4.

Globigerinoides ruber (d'Orbigny). Bolli, 1957, p. 113, pl. 25, figs. 12, 13; text fig. 21, fig. 7. (Pl. 11, figs. 4, 6.)

Globigerinoides sacculifer (Brady). Parker, 1967, p. 156, pl. 21, figs. 1, 2, 4; text fig. 5. (Pl. 11, fig. 11.)

Globigerinoides transitorius Blow. *Globigerinoides transitoria* Blow, 1956, p. 65, text fig. 2, figs. 12–15, (Pl. 11, fig. 7.)

Globigerinoides trilobus (Reuss). Blow, 1956, p. 62, text fig. 1, figs. 1–3. (Pl. 11, fig. 5.)

Globoquadrina altispira (Cushman and Jarvis). *Globigerina altispira* Cushman and Jarvis, 1936, p. 5, pl. 1, figs. 13, 14. (Pl. 10, figs. 6–8.)

Globoquadrina altispira globosa Bolli, 1957, p. 111, pl. 24, figs. 9, 10. (Pl. 10, fig. 10.)

Globoquadrina dehiscens (Chapman, Parr, and Collins). *Globorotalia dehiscens* Chapman, Parr, and Collins, 1934, p. 569, pl. 11, fig. 36. (Pl. 10, figs. 9, 11.)

Globoquadrina dehiscens advena Bermúdez. *Globoquadrina quadraria* (Cushman and Ellisor) var. *advena* Bermúdez, 1949, p. 287, pl. 22, figs. 36–38. (Pl. 10, fig. 13.)

Globorotalia acostaensis Blow, 1959, p. 208, pl. 17, figs. 106, 107. (Pl. 12, figs. 1, 2.)

Globorotalia anfracta Parker, 1967, p. 175, pl. 28, figs. 3–8.

Globorotalia archeomenardii Bolli, 1975, p. 119, pl. 28, fig. 11. Pl. 12, fig. 5.)

Globorotalia archeomenardii Bolli, 1957, p. 119, pl. 28, fig. 11. (Pl. 12, fig. 5.)

Stainforth (1948, p. 117, pl. 26, figs. 1–3) reported some specimens as *Globigerina wilsoni* (?) Cole which appear to be synonyms of *Globorotalia bolivariana* (Petters). These were from beds of late middle Eocene to early Oligocene age in coastal Ecuador.

Globorotalia centralis Cushman and Bermúdez, 1937, p. 26, pl. 2, figs. 62–65.

Globorotalia fohsi Cushman and Ellisor. Blow and Banner, 1966, p. 290, pl. 1, figs. 5–7; pl. 2, figs. 8, 9, 12. (Pl. 12, fig. 4.)

Globorotalia fohsi lobata Bermúdez. Bolli, 1957, p. 119, pl. 28, figs. 13, 14. (Pl. 12, fig. 6.)

Globorotalia mayeri Cushman and Ellisor, 1939, p. 11, pl. 2, fig. 4. (Pl. 12, fig. 3.)

Globorotalia miozea Finlay. Blow, 1969, p. 366, pl. 45, fig. 7. (Pl. 12, fig. 8.)

Orbulina bilobata (d'Orbigny). Bolli, 1957, p. 116, pl. 27, fig. 6.

Orbulina suturalis Bronnimann, 1951, p. 135, text fig. II, figs. 1–15; text fig. III, figs. 3–8, 11, 13–16, 20–22; text fig. IV, figs. 2–4, 7–12, 15, 16, 19–22; text fig. V (part). (Pl. 11, fig. 12.)

Orbulina universa d'Orbigny. Bolli, 1957, p. 115, pl. 27, fig. 5.

Sphaeroidinella kochi (Caudri). Cifelli, 1965, p. 83, pl. 2, figs. 14, 15. (Pl. 12, fig. 10.)

Sphaeroidinella seminulina (Schwager). Parker, 1967, p. 161, pl. 23, figs. 1–5. (Pl. 12, figs. 7, 9.)

Sphaeroidinella subdehiscens Blow. Parker, 1967, p. 162, pl. 23, figs. 6, 7.

BENTHONIC SPECIES

Alabamina polita Becker and Dusenbury, 1958, p. 40, pl. 7, fig. 3. (Pl. 6, fig. 9.)

Allomorphina macrostoma Karrer. Cushman and Todd, 1949a, p. 68, pl. 12, figs. 4, 5. (Pl. 4, fig. 8.)

Ammonia beccarii (Linné). *Streblus beccarii* (Linné). Renz, p. 167, pl. 9, fig. 2. (Pl. 5, fig. 5.)

Ammonia beccarii tepida (Cushman). *Streblus beccarii* (Linné) var. *tepida* (Cushman). Bermúdez, 1949, p. 234, pl. 15, figs. 49–51.

Ammospirata mexicana (Cushman). *Pavonina mexicana* Cushman, 1926, p. 22, pl. 6, figs. 7–9. (Pl. 1, fig. 19.)

Amphistegina angulata (Cushman). Galloway and Heminway, 1941, p. 407, pl. 28, fig. 6. (Pl. 6, fig. 4.)

Amphistegina canaensis Bermúdez, 1949, p. 262, pl. 19, figs. 16–18.

Large, flat, evolute on both sides; about 20 chambers; pebbly surface.

Amphistegina floridana Cushman and Ponton, 1932a, p. 96, pl. 14, figs. 6, 7. (Pl. 6, figs. 6, 8.)

Included as probable synonyms of this variable species are *Amphistegina chipolensis* Cushman and Ponton (1932a, p. 96, pl. 15, fig. 1) and *Asterigerina choctawensis* Cushman and McGlamery (1938, p. 111, pl. 28, fig. 2). The former was described as being ancestral to *Amphistegina floridana* in the Miocene of Florida, and the latter was described from the Oligocene of Alabama. All are more compressed than either *A. angulata* or *A. rotundata*. Number of chambers ranges from 9 to 15 or more. Some of our specimens are typical, but others tend to be larger and to have more chambers than types of any of the three species here regarded as synonyms.

Amphistegina rotundata (Cushman). Bermúdez, 1949, p. 264, pl. 19, figs. 22–24.

Amphistegina? sp. (Pl. 6, fig. 11.)

Planoconvex like *Amphistegina angulata*, but reversed, that is, the flat side shows chambers only partially covering the previous whorl. Sutures on the conical side are angled and strongly recurved. About 14 chambers in the final whorl. This is possibly a unique specimen.

Angulogerina cooperensis Cushman. Galloway and Heminway, 1941, p. 436, pl. 34, fig. 13.

Angulogerina jamaicensis Cushman and Todd, 1945, p. 53, pl. 8, fig. 3. (Pl. 4, fig. 12.)

Angulogerina rugoplicata Cushman, 1935b, p. 33, pl. 5, fig. 5. (Pl. 4, fig. 10.)

Angulogerina vicksburgensis Cushman, 1935b, p. 33, pl. 5, figs. 3, 4. (Pl. 4, fig. 11.)

Anomalina alazanensis Nuttall, 1932, p. 31, pl. 8, figs. 5–7. (Pl. 7, fig. 13.)

By comparison with the types of this species from the lower Oligocene of Mexico, our specimens are larger, thicker, and more robust, and have one to three fewer chambers per final whorl. They seem quite typical of specimens assigned to this species from the Oligocene of Cuba (Palmer and Bermúdez, 1936) and of Trinidad (Cushman and Renz, 1947). The sutures are limbate on both sides, the spire is depressed on both sides, and the more involute side is less densely punctate than the side showing the earlier whorls.

Anomalina cocoaensis Cushman, 1928, p. 75, pl. 10, fig. 4. (Pl. 7, fig. 14.)

Anomalina glabrata Cushman, 1924, p. 39, pl. 12, figs. 5–7.

Anomalina granosa (Hantken). *Anomalinoides granosus* (Hantken). Hagn and Ohmert, 1971, p. 138, text fig. 6. (Pl. 7, fig. 11.)

Archaias angulatus (Fichtel and Moll). Cole, 1931, p. 38, pl. 5, figs. 2, 3. (Pl. 1, figs. 17, 18.)

Astacolus crepidulus (Fichtel and Moll). Loeblich and Tappan, *in* Loeblich, Tappan, and others, 1964, p. 514, fig. 401, 3. (Pl. 3, fig. 1.)

Asterigerinata bracteata (Cushman). *Asterigerina bracteata* Cushman, 1929. p. 48, pl. 8, fig. 6.

Baggina cojimarensis Palmer. Cushman and Renz, 1947, p. 37, pl. 7, fig. 22. (Pl. 5, fig. 7.)

Bolivina ariana Cole and Ponton. Cushman, 1937a, p. 73, pl. 8, figs. 29, 30.

Test distinctively flattened; sutures raised and dark with depressed or sunken chambers.

Bolivina byramensis Cushman, 1937b, p. 69, pl. 8, figs. 18–20. (Pl. 3, fig. 32.)

Bolivina choctawensis Cushman and McGlamery. Todd, 1952, p. 29, pl. 4, fig. 25. (Pl. 3, fig. 26.)

Bolivina difformis (Williamson). Cushman, 1937b, p. 164, pl. 15, figs. 13–17. (Pl. 3, fig. 33.)

Bolivina isidroensis Cushman and Renz, 1941, p. 20, pl. 3, fig. 16. (Pl. 3, fig. 36.)

Bolivina mexicana aliformis Cushman. Cushman, 1937b, p. 66, pl. 8, figs. 9, 10. (Pl. 3, fig. 35.)

Bolivina oligocaenica Spandel. Cushman, 1937b, p. 74, pl. 9, figs. 1, 2. (Pl. 3, fig. 27.)

Bolivina rhomboidalis (Millett). Cushman and Todd, 1945, p. 47, pl. 7, fig. 19. (Pl. 3, fig. 25.)

Bolivina tectiformis Cushman, 1937b, p. 67, pl. 8, figs. 12–14. (Pl. 3, fig. 34.)

Bolivina tortuosa Brady. Cushman and Todd, 1945, p. 44, pl. 7, fig. 6.

Bolivina (Loxostomum) limbata (Brady). *Loxostoma limbatum* (H. B. Brady). Cushman, 1937b, p. 186, pl. 21, figs. 26–29. (Pl. 3, fig. 19.)

Bulimina affinis d'Orbigny. Cushman and Parker, 1947, p. 122, pl. 28, figs. 23–25. (Pl. 3, fig. 20.)

Bulimina illingi Cushman and Stainforth (1945, p. 41, pl. 6, fig. 7) from the Cipero Formation of Trinidad appears to be a synonym of *B. affinis.*

Bulimina bleeckeri Hedberg, 1937, p. 675, pl. 91, figs. 12, 13.

Top of test stout, smooth, bulging; lower half with heavy sharp costae, ending in spines.

Bulimina exilis tenuata (Cushman). *Bulimina exilis* H. B. Brady var. *tenuata* (Cushman). Cushman and Parker, 1947, p. 124, pl. 28, fig. 29. (Pl. 3, fig. 22.)

Bulimina impendens Parker and Bermudez. Cushman and Parker, 1947, p. 100, pl. 23, figs. 6, 7. (Pl. 3, fig. 23.)

Bulimina marginospinata Cushman and Parker, 1938, p. 57, pl. 9, fig. 11. (Pl. 3, fig. 29.)

Bulimina sculptilis Cushman. Cushman and Parker, 1947, p. 103, pl. 24, fig. 12. (Pl. 3, fig. 28.)

Camerina panamensis (Cushman). Cole, 1966, p. 256, 261, 263, pl. 20, figs. 1–10, 12; pl. 25, fig. 5; pl. 27, fig. 5.

Complanate or slightly bulging, about 3½ whorls, not much flaring; chambers 18 to 30 per final whorl; sutures limbate but not raised.

Cancris auriculus (Fichtel and Moll). Cushman and Todd, 1942, p. 74, pl. 18, figs. 1–11; pl. 23, fig. 6. (Pl. 5, fig. 8.)

Cassidulina carapitana Hedberg, 1937, p. 680, pl. 92, fig. 6. (Pl. 4, fig. 25.)

Cassidulina havanensis Cushman and Bermúdez, 1936a, p. 36, pl. 6, fig. 11.

Cassidulina subglobosa Brady. *Cassidulina subglobosa* var. *horizontalis* Cushman and Renz, 1941, p. 26, pl. 4, fig. 8. (Pl. 4, fig. 29.)

Cassidulinoides bradyi (Norman). Cushman and Todd, 1945, p. 63, pl. 10, fig. 14. (Pl. 4, fig. 17.)

Cassidulinoides simplex Cushman and Todd, 1945, p. 63, pl. 10, fig. 15. (Pl. 4, fig. 16.)

Ceratobulimina alazanensis Cushman and Harris. Cushman, 1946b, p. 111, pl. 18, figs. 17, 18. (Pl. 4, fig. 24.)

Cerobertina bartrumi Finlay, 1939, p. 118, pl. 11, figs. 2, 3. (Pl. 4, figs. 15, 20.)

Chilostomella cylindroides Reuss. Cushman and Todd, 1949b, p. 87, pl. 15, figs. 8–10. (Pl. 4, figs. 19, 23.)

Chilostomella globata Galloway and Heminway, 1941, p. 409, pl. 28, fig. 3. (Pl. 4, fig. 9.)

Chilostomelloides oviformis (Sherborn and Chapman). Cushman and Todd, 1949b, p. 94, pl. 16, figs. 7–9. (Pl. 4, fig. 27.)

Cibicidella variabilis (d'Orbigny). Cushman and Ponton, 1932a, p. 102, pl. 15, figs. 5–7.

Cibicides floridanus (Cushman). Cushman, 1930, p. 61, pl. 12, fig. 3. (Pl. 8, fig. 1.)

Cibicides lobatulus (Walker and Jacob). Cushman, 1935a, p. 52, pl. 22, figs. 4–6.

Cibicides mexicanus Nuttall, 1932, p. 33, pl. 9, figs. 7–9. (Pl. 8, fig. 4.)

Cibicides pseudoungerianus (Cushman). Cushman and Todd, 1945, p. 70, pl. 12, fig. 7. (Pl. 8, fig. 3.)

Cibicides robertsonianus (Brady). Phleger and Parker, 1951, p. 31, pl. 16. figs. 10–13. (Pl. 8, fig. 2.)

Cibicides trinitatensis (Nuttall). Nuttall, 1932, p. 33, pl. 7, fig. 9. (Pl. 8, fig. 5.)

Cibicidina choctawensis (Cushman and McGlamery). *Cibicides choctawensis* Cushman and McGlamery, 1938, p. 111, pl. 28, fig. 6.

Cibicidina mississippiensis (Cushman). *Anomalina mississippiensis* Cushman, 1922, p. 98, pl. 21, figs. 6–8.

Cibicidina sp. (Pl. 7, fig. 12.)

A high conical form, almost concave on the flat side, keeled on the periphery, having only six chambers in the final whorl and distinct but not limbate sutures. The lipped aperture is situated on the periphery.

Clavulinoides triangularis (Nuttall). Galloway and Heminway, 1941, p. 327, pl. 7, fig. 5.

Cribrogloborotalia marielina Cushman and Bermúdez, 1936b, p. 63, pl. 11, figs. 17–19.

Cribropullenia marielensis (Palmer). *Nonion*? *marielensis* Palmer, 1936, p. 127, text figs. 1–3. (Pl. 7, fig. 5.)

Cyclammina cancellata Brady. Flint, 1899, p. 282, pl. 27, fig. 3; pl. 28, fig. 1.

Cycloloculina cubensis Cushman and Bermúdez, 1936b, p. 61, pl. 11, figs. 15, 16.

Cymbaloporetta squammosa (d'Orbigny). Bermúdez, 1949, p. 266, pl. 19, figs. 40–42.

Dentalina consobrina d'Orbigny, 1846, p. 46, pl. 2, figs. 1–3.

Dentalina cooperensis Cushman. Cushman, 1935a, p. 20, pl. 8, figs. 3, 4.

Dentalina jacksonensis (Cushman and Applin). Cushman, 1935a, p. 20, pl. 8, figs. 7–9.

Dentalina mucronata Neugeboren. Cushman and Todd, 1945, p. 21, pl. 3, figs. 14, 15.

Dorothia cylindrica (Nuttall). Galloway and Heminway, 1941, p. 322, pl. 6, fig. 7.

Ehrenbergina bicornis Brady. Cushman, 1927a, p. 2, pl. 1, fig. 5. (Pl. 4, fig. 26.)

Ehrenbergina? aff. *E. pupa* (d'Orbigny). *Ehrenbergina pupa* (d'Orbigny). Cushman, 1927a, p. 7, pl. 2, figs. 5, 6. (Pl. 4, fig. 28.)

Ellipsocristellaria sp. (Pl. 2, fig. 13.)

A smooth-walled lenticuline with six chambers and a slit aperture with no trace of radiate markings. Though the genus was described from the Lower Cretaceous, our specimens fit its diagnosis.

Ellipsoglandulina exponens (Brady). Galloway and Heminway, 1941, p. 441, pl. 36, fig. 1.

Ellipsoglandulina multicostata (Galloway and Morrey). Nuttall, 1932, p. 24, pl. 4, fig. 4.

Ellipsoidina ellipsoides Seguenza. Hadley, 1934, p. 123, pl. 2, figs. 18, 19.

Elphidium discoidale (d'Orbigny). Cushman, 1939, p. 56, pl. 15, figs. 5–7.

Elphidium fimbriatulum (Cushman). Cushman, 1939, p. 47, pl. 12, fig. 13.

Elphidium panamense Cushman (1936a, p. 79, pl. 14, fig. 3) from the Oligocene of Panama appears to be a synonym of *E. fimbriatulum.*

Elphidium lens Galloway and Heminway, 1941, p. 361, pl. 14, fig. 10. (Pl. 7, fig. 10.)

Elphidium lobatum Galloway and Heminway, 1941, p. 362, pl. 14, fig. 8.

Elphidium mexicanum Kornfeld. Todd and Low, 1971, p. C16, pl. 3, fig. 4.

Elphidium poeyanum (d'Orbigny). Cushman and Cahill, 1933, p. 21, pl. 7, fig. 7. (Pl. 7, fig. 6.)

Elphidium puertoricense Galloway and Heminway, 1941, p. 364, pl. 15, fig. 2. (Pl. 7, fig. 7.)

Elphidium sagra (d'Orbigny). Cushman, 1939, p. 55, pl. 15, figs. 1–3.

Entolingulina alazanensis (Nuttall). *Frondicularia alazanensis* Nuttall, 1932, p. 17, pl. 3, fig. 15; pl. 4, fig. 1. (Pl. 2, figs. 14, 15.)

Eorupertia? sp.

Heavy walled, coarsely perforate, globular chambers coiled in an irregular trochoid spire.

Epistomaroides pontifera (Galloway and Heminway). *Epistomaria pontifera* Galloway and Heminway, 1941, p. 386, pl. 24, fig. 2.

The following are here considered synonyms of *Epistomaroides pontifera: Epistomaria*? *cubana* Palmer (1941, p. 195, pl. 16, figs. 7, 11) from the upper Oligocene of Cuba and *Epistomaria dominicana* Bermúdez (1949, p. 242, pl. 16, figs. 22–24) from the lower Miocene of Dominican Republic.

Eponidella libertadensis Cushman and Hedberg, 1935, p. 14, pl. 3, figs. 1–4. (Pl. 5, fig. 1.)

Eponides ellisorae Garrett. Galloway and Heminway, 1941, p. 372, pl. 17, fig. 4. (Pl. 6, fig. 7.)

Eponides parantillarum Galloway and Heminway, 1941, p. 374, pl. 18, fig. 1. (Pl. 6, fig. 5.)

Florilus subgrateloupi (Galloway and Heminway). *Nonion subgrateloupi* Galloway and Heminway, 1941, p. 358, pl. 14, figs. 2, 3. (Pl. 7, fig. 3.)

Florilus whitsettensis (Cushman and Applin). *Nonion whitsettense* (Cushman and Applin). Cushman, 1939, p. 7, pl. 1, fig. 27. (Pl. 7, fig. 4.)

Frondicularia cf. *F. digitata* d'Orbigny. *Frondicularia digitata* d'Orbigny. Parker, Jones, and Brady, 1871, p. 162, pl. 10, fig. 65. (Pl. 3, fig. 11.)

Frondicularia tenuissima Hantken, 1881, p. 43, pl. 13, fig. 11. (Pl. 3, fig. 10.)

Gaudryina trinitatensis Nuttall, 1928a, p. 76, pl. 3, figs. 15, 16.

Glabratella aff. *G. browningi* Redmond, 1953, p. 725, pl. 76, fig. 4. (Pl. 5, fig. 6.)

Guttulina byramensis (Cushman). Cushman and Todd, 1946, p. 86, pl. 15, fig. 3.

Gypsina globula (Reuss). Cushman, 1935a, p. 54, pl. 23, figs. 4, 5.

Gyroidina altiformis R. E. and K. C. Stewart. *Gyroidina soldanii altiformis* R. E. and K. C. Stewart. Coryell and Rivero, 1940, p. 337, pl. 43, fig. 19. (Pl. 5, fig. 14.)

Gyroidina vicksburgensis (Cushman). Todd, 1952, p. 38, pl. 5, fig. 17. (Pl. 5, fig. 13.)

Hanzawaia carstensi (Cushman and Ellisor). *Cibicides carstensi* Cushman and Ellisor, 1939, p. 13, pl. 2, fig. 8. (Pl. 5, fig. 12.)

Hanzawaia mantaensis (Galloway and Morrey). Becker and Dusenbury, 1958, p. 45, pl. 7, fig. 4.

Haplophragmoides coalingensis Cushman and Hanna, 1927, p. 210, pl. 13, fig. 4.

Hoeglundina elegans (d'Orbigny). Bermúdez, 1949, p. 250, pl. 17, figs. 34–36. (Pl. 6, fig. 1.)

Karreriella bradyi (Cushman). Cushman, 1937a, p. 135, pl. 16, figs. 6–11.

Karreriella disjuncta (Cushman and Jarvis). *Gaudryina disjuncta* Cushman and Jarvis, 1929, p. 6, pl. 2, fig. 7. (Pl. 1, fig. 9.)

Karreriella mexicana (Nuttall). *Verneuilina mexicana* Nuttall, 1932, p. 6, pl. 2, figs. 1, 2. (Pl. 1, figs. 7, 8.)

Lagena striata (d'Orbigny). Cushman and Todd, 1945, p. 34, pl. 5, fig. 16.

Lagenonodosaria acostaensis Blow, 1959, p. 122, pl. 7, fig. 10. (Pl. 3, fig. 12.)

Lenticulina alatolimbatus (Gümbel). *Robulus alato-limbatus* (Gümbel). Cushman, 1935a, p. 15, pl. 6, fig. 2.

Lenticulina americana (Cushman). *Robulus americanus* (Cushman). Cushman, 1930, p. 24, pl. 3, fig. 7.

Lenticulina americana grandis (Cushman). *Robulus americanus* var. *grandis* (Cushman). Becker and Dusenbury, 1958, p. 11, pl. 2, fig. 23. (Pl. 2, figs. 6, 9.)

Lenticulina brevispinosa (Nuttall). *Robulus brevispinosus* (Nuttall). Becker and Dusenbury, 1958, p. 12, pl. 2, fig. 20. (Pl. 2, fig. 7.)

Lenticulina budensis (Hantken). *Cristellaria budensis* (Hantken). Nuttall, 1932, p. 9, pl. 1, fig. 5. (Pl. 2, fig. 10.)

Lenticulina caroliniana (Cushman). *Robulus arcuato-striatus* (Hantken) var. *carolinianus* Cushman, 1933, p. 4, pl. 1, fig. 9. (Pl. 2, fig. 8.)

Lenticulina clericii (Fornasini). *Robulus clericii* (Fornasini). Renz, 1948, p. 158, pl. 3, fig. 8. (Pl. 2, fig. 4.)

Lenticulina convergens (Bornemann). *Robulus convergens* (Bornemann). Bermúdez, 1949, p. 123, pl. 7, figs. 43, 44, 49–52. (Pl. 2, figs. 2, 3.)

Lenticulina melvilli (Cushman and Renz). *Robulus melvilli* Cushman and Renz, 1941, p. 12, pl. 2, fig. 12.

Lenticulina orbicularis (d'Orbigny). *Robulus orbicularis* (d'Orbigny). Bermúdez, 1949, p. 129, pl. 7, figs. 33, 34. (Pl. 2, fig. 1.)

Lenticulina subpapillosa (Nuttall). *Cristellaria subpapillosa* Nuttall, 1932, p. 12, pl. 1, fig. 12. (Pl. 2, fig. 11.)

Lenticulina terryi (Coryell and Embich). *Robulus terryi* Coryell and Embich, 1937, p. 299, pl. 41, fig. 17. (Pl. 2, fig. 5.)

Liebusella byramensis (Cushman). Cushman and Todd, 1946, p. 78, pl. 13, fig. 20. (Pl. 1, fig. 12.)

Lingulina wilcoxensis Cushman and Ponton, 1932b, p. 58, pl. 7, fig. 14.

Marginopora vertebralis Quoy and Gaimard. *Marginopora vertebralis* Blainville. Boltovskoy, 1959, p. 74, pl. 10, figs. 6, 10.

Marginulina glabra d'Orbigny. Puri, 1953, p. 98, pl. 10, figs. 3, 4. (Pl. 3, fig. 3.)

Marginulina hantkeni Bandy, 1949, p. 46, pl. 6, fig. 9. (Pl. 3, fig. 2.)

Marginulina nuttalli Todd and Kniker, 1952, p. 14, pl. 2, figs. 30, 31.

Marginulina perprocera (Schwager). Cushman and Todd, 1945, p. 19, pl. 3, fig. 10. (Pl. 3, fig. 9.)

Marginulina pseudohirsuta Nuttall. Becker and Dusenbury, 1958, p. 16, pl. 1, fig. 14. (Pl. 3, fig. 15.)

Matanzia bermudezi Palmer, 1936, p. 126, pl. 5, figs. 14–18. (Pl. 1, fig. 10.)

Melonis pompilioides (Fichtel and Moll). Parker, 1964, p. 626, pl. 100, figs. 15, 16. (Pl. 7, figs. 8, 9.)

Neoconorbina patelliformis (Brady). Todd, 1965, p. 16, pl. 2, fig. 1.

Nodosarella decurta (Bermúdez). Bermúdez, 1949, p. 231, pl. 14, fig. 32.

Nodosarella subnodosa (Guppy). Cushman and Stainforth, 1945, p. 53, pl. 9, fig. 3. (Pl. 4, fig. 22.)

Nodosaria raphanistrum (Linné). Silvestri, 1896, p. 165, pl. 4, figs. 25–28, 33–36; pl. 5, figs. 2, 6–9, 22.

The variety *caribbeana*, named by Hedberg (1937, p. 671, pl. 91, fig. 1), was erected for the form common in the Tertiary of the Caribbean region only because of uncertainty regarding the exact characters of Linné's species. It now seems unneeded.

Nonion planatum Cushman and Thomas. Cushman, 1939, p. 4, pl. 1, fig. 15.

Nonionella pulchella Hada. Cushman, 1939, p. 34, pl. 9, fig. 11. (Pl. 7, fig. 2.)

Oridorsalis umbonatus (Reuss). *Eponides umbonatus* (Reuss). Cushman and Stainforth, 1945, p. 62, pl. 11, fig. 4. (Pl. 6, fig. 10.)

Osangularia culter (Parker and Jones). Todd, 1965, p. 25, pl. 15, fig. 1. (Pl. 6, fig. 3.)

Palmerinella palmerae Bermúdez. Bermúdez, 1949, p. 290, pl. 23, figs. 10–12.

Pararotalia byramensis (Cushman). *Rotalia byramensis* Cushman. Todd, 1952, p. 39, pl. 5, figs. 21, 22.

Pararotalia mexicana (Nuttall). *Rotalia mexicana* Nuttall, 1928b, p. 374, pl. 50, figs. 6–8. (Pl. 6, fig. 2.)

Rotalia choctawensis Cushman and McGlamery (1938, p. 110, pl. 27, fig. 4) from the Oligocene of Alabama appears to be a synonym of *Pararotalia mexicana.*

Peneroplis proteus d'Orbigny. Cushman and Ponton, 1932a, p. 71, pl. 10, figs. 7–11, 14.

Planodiscorbis rarescens (Brady). *Discorbina rarescens* Brady, 1884, p. 651, pl. 90, figs. 2, 3. (Pl. 5, fig. 9.)

Planularia protuberans (Cushman). *Robulus protuberans* (Cushman). Galloway and Heminway, 1941, p. 351, pl. 11, fig. 13.

Planularia venezuelana Hedberg (1937, p. 670, pl. 90, fig. 14) described from the Oligocene of Venezuela appears to be a synonym of *P. protuberans.*

Planularia torrei Palmer, 1940, p. 277, pl. 51, figs. 5, 6.

Planularia trinae Bermúdez, 1949, p. 138, pl. 8, figs. 39, 40. (Pl. 2, fig. 12.)

"Planulina" camagueyana Bermúdez. *Planulina camagueyana* Bermúdez, 1937, p. 148, pl. 18, fig. 13; pl. 19, fig. 1. (Pl. 5, fig. 2.)

Eponides ornatissimus Galloway and Heminway (1941, p. 373, pl. 17, fig. 2), described from Oligocene-Miocene beds in Puerto Rico, appears to be a synonym of this species described from the Eocene of Cuba.

Planulina leoni Bermúdez, 1937, p. 148, pl. 18, figs. 8–10. (Pl. 8, fig. 6.)

Planulina marialana Hadley, 1934, p. 131, pl. 4, figs. 4–6. (Pl. 8, fig. 9.)

Planulina mexicana Cushman, 1927b, p. 113, pl. 23, fig. 5. (Pl. 8, fig. 8.)

Planulina subtenuissima (Nuttall). Renz, 1948, p. 151, pl. 11, fig. 4. (Pl. 8, fig. 7.)

Planulina sp. (Pl. 8, fig. 10.)

Large compressed test is depressed in the center of both sides; lobulate periphery is rimmed by a limbate keel; wall is densely perforate on both sides.

Plectofrondicularia jarvisi Cushman and Todd, 1945, p. 38, pl. 6, fig. 4. (Pl. 3, fig. 13.)

Plectofrondicularia trinitatensis Cushman and Jarvis, 1929, p. 11, pl. 2, fig. 16.

Plectofrondicularia yumuriana Palmer. *Plectofrondicularia*?, *yumuriana* Palmer, 1940, p. 294, pl. 53, figs. 3, 4. (Pl. 3, fig. 14.)

Pleurostomella bierigi Palmer and Bermúdez, 1936, p. 294, pl. 17, figs. 7, 8. (Pl. 4, fig. 31.)

Pleurostomella elliptica Galloway and Heminway, 1941, p. 438, pl. 35, fig. 3. (Pl. 4, fig. 30.)

Pseudoclavulina bullbrooki Cushman, 1936b, p. 18, pl. 3, fig. 7.

Pseudoclavulina sp. (Pl. 1, fig. 11.)

A large, smooth-surfaced species with only slightly incised sutures.

Pseudonodosaria comatula (Cushman). Becker and Dusenbury, 1958, p. 20, pl. 3, fig. 1. (Pl. 3, fig. 18.)

Pseudonodosaria inflata (Bornemann). *Glandulina inflata* Bornemann, 1855, p. 320, pl. 12, figs. 6, 7.

Pullenia bulloides d'Orbigny. Becker and Dusenbury, 1958, p. 26, pl. 7, fig. 2.

Pullenia quinqueloba (Reuss). Becker and Dusenbury, 1958, p. 27, pl. 6, fig. 3.

"*Pullenia*" *riveroi* Bermúdez, 1939, p. 11, pl. 2, figs. 1–6. (Pl. 7, fig. 1.)

Our specimens bear minute sutural pores, similar to those on *Candeina*, as originally described and as shown on Oligocene specimens from the Oceanic Formation of the Barbados (Beckmann, 1953, p. 389, pl. 24, fig. 14.)

Pyrgo denticulata (Brady). Cushman and Ponton, 1932a, p. 56, pl. 7, figs. 7, 8.

Pyrgo inornata (d'Orbigny). Galloway and Heminway, 1941, p. 311, pl. 4, fig. 3.

Quadrimorphina allomorphinoides (Reuss). Cushman and Todd, 1949a, p. 69, pl. 12, figs. 10–12. (Pl. 4, fig. 21.)

Quinqueloculina akneriana d'Orbigny, 1846, p. 290, pl. 18, figs. 16–21.

Quinqueloculina ermani Bornemann, 1855, p. 351, pl. 19, fig. 6. (Pl. 1, fig. 14.)

Quinqueloculina seminulum (Linné). Cushman, 1930, p. 19, pl. 2, figs. 1, 2.

Robertina declivis (Reuss). Cushman and Parker, 1936, p. 94, pl. 16, fig. 5. (Pl. 4, fig. 18.)

Robertina imperatrix (Karrer) from the Miocene of Hungary (Cushman and Parker, 1936, p. 95, pl. 16, figs. 6, 7) appears to be a synonym of *R. declivis*, originally described from the Oligocene of Germany.

Rosalina floridensis (Cushman). *Discorbis bertheloti* (d'Orbigny) var. *floridensis* Cushman, 1931, p. 17, pl. 3, figs. 3–5. (Pl. 5, figs. 3, 4.)

Rotorbinella mira (Cushman). *Discorbis mira* Cushman. Bermúdez, 1949, p. 239, pl. 15, figs. 28–30.

Rotorbinella tholus (Galloway and Heminway). *Rotalia tholus* Galloway and Heminway, 1941, p. 382, pl. 20, fig. 2.

Sagrina vicksburgensis (Howe). *Bitubulogenerina vicksburgensis* Howe, 1934, p. 420, pl. 51, fig. 7. (Pl. 3, fig. 24.)

Saracenaria arcuata (d'Orbigny). Galloway and Heminway, 1941, p. 333, pl. 9, fig. 6.

Saracenaria italica Defrance. Cole and Ponton, 1930, p. 35, pl. 6, fig. 5. (Pl. 3, fig. 8.)

Saracenaria senni Hedberg, 1937, p. 674, pl. 90, fig. 18. (Pl. 3, fig. 7.)

Sigmoilina tenuis (Czjzek). Cushman and Todd, 1945, p. 10, pl. 2, fig. 4. (Pl. 1, fig. 15.)

Siphogenerina hubbardi Galloway and Heminway, 1941, p. 434, pl. 34, fig. 2. (Pl. 4, fig. 14.)

Siphogenerina mexicana Cushman. Galloway and Heminway, 1941, p. 434, pl. 34, fig. 1. (Pl. 4, fig. 13.)

Siphonina tenuicarinata Cushman. Bermúdez, 1949, p. 244, pl. 16, figs. 37–39. (Pl. 5, fig. 10.)

Sphaeroidina chilostomata Galloway and Morrey. *Sphaeroidina bulloides* d'Orbigny var. *chilostomata* Galloway and Morrey, 1929, p. 32, pl. 5, fig. 1.

Spiroloculina alveata Cushman and Todd, 1944, p. 28, pl. 4, figs. 29, 30. (Pl. 1, fig. 16.)

Spiroplectammina mississippiensis (Cushman). *Textularia mississippiensis* Cushman, 1922, p. 90, pl. 14, fig. 4. (Pl. 1, fig. 4.)

Stilostomella caribaea (Palmer and Bermúdez). *Ellipsonodosaria caribaea* Palmer and Bermúdez, 1936, p. 297, pl. 18, figs. 10, 11. (Pl. 3, fig. 16.)

Stilostomella verneuili (d'Orbigny). Becker and Dusenbury, 1958, p. 37, pl. 4, fig. 19. (Pl. 3, fig. 17.)

Textularia bermudezi Cushman and Todd, 1945, p. 3, pl. 1, fig. 7. (Pl. 1, fig. 3.)

Textularia aff. *T. conica* d'Orbigny. *Textularia conica* d'Orbigny, 1839, p. 143, pl. 1, figs. 19, 20. (Pl. 1, fig. 2.)

Textularia grenadana Hedberg, 1937, p. 667, pl. 90, figs. 5, 6.

Textularia kugleri Cushman and Renz, 1941, p. 5, pl. 1, figs. 8, 9.

Textularia leuzingeri Cushman and Renz, 1941, p. 3, pl. 1, fig. 2. (Pl. 1, fig. 1.)

Textularia isidroensis Cushman and Renz (1941, p. 4, pl. 1, fig. 7) is here considered a synonym of *T. leuzingeri*. Both species were described from the Agua Salada Formation of Venezuela.

Textularia yasicaensis Bermúdez, 1949, p. 65, pl. 2, figs. 37, 38.

Textulariella barrettii (Jones and Parker). Cushman, 1937a, p. 66, pl. 7, figs. 5–8.

Triloculina trigonula (Lamarck). Cushman and Ponton, 1932a, p. 52, pl. 6, fig. 6.

Tritaxilina mexicana Cushman, 1925, p. 64, pl. 10, fig. 4. (Pl. 1, fig. 5.)

Turrilina robertsi (Howe and Ellis). *Bulimina robertsi* Howe and Ellis *in* Howe, 1939, p. 63, pl. 8, figs. 32, 33. (Pl. 3, fig. 21.)

Uvigerina adelinensis (Palmer and Bermúdez). *Uvigerina cubana* Palmer and Bermúdez, 1936, p. 292, pl. 17, figs. 5, 6. (Pl. 4, fig. 1.)

Uvigerina barbatula Macfadyen, 1930, p. 92, pl. 3, fig. 26.

Test is narrowed and smooth or finely striate toward the apertural end. Wall is ornamented by sharp costae overhanging the apical end with backward-projecting spines.

Uvigerina elongata Cole. Galloway and Heminway, 1941, p. 428, pl. 33, fig. 5.

Uvigerina greymouthensis Todd and Low, new name. *Uvigerina bortotara* (Finlay) var. *costata* Dorreen, 1948, p. 293, pl. 38, fig. 5. (Not *Uvigerina costata* Bieda, 1936, p. 265, pl. 8, fig. 3.) (Pl. 4, fig. 2.)

Test short and stout, about 1½ times as long as broad, widest at the penultimate chamber, initial end blunt; chambers moderately distinct, only slightly inflated; sutures distinct in later part, somewhat obscured by costae between early chambers; wall covered by well raised bladelike costae, those of each chamber independent of the next, those projecting at the initial end of well preserved specimens appearing as short spines, those on last chamber extending unbroken to base of apertural neck; aperture terminal on very short slightly rimmed neck, which on some specimens appears to be tucked into convergence of the final two chambers.

Dimensions of the holotype from New Zealand are length 0.65 mm and width 0.40 mm. Our Puerto Rican specimens measure 0.50–0.80 mm in length and 0.35–0.45 mm in width.

Holotype (Cushman colln. No. 64175) from the upper Eocene Omotumotu Formation of the type Kaiatan Stage, Ethel Creek, Greymouth, New Zealand.

Our specimens of *Uvigerina greymouthensis* new name and those of Dorreen compare very well in their short stocky tests and in that the costae continue over the final chamber to the base of the apertural neck. Examination of paratypes of *Hopkinsina bortotara* Finlay in the U.S. National Museum collections (USNM 689091) shows this species to be more attenuated and loosely coiled with the costae broken into hispid spines on the late chambers. These differences are consistent enough to warrant a specific rather than a subspecific designation for our costate species.

In surface ornamentation, *U. greymouthensis* seems related to *U. havanensis* Cushman and Bermúdez (1936b, p. 59, pl. 10, figs. 19–21) from the Eocene of Cuba. It differs, however, in its having a shorter and more robust test and in its neck being less protruding. A distinctive characteristic in both *U. greymouthensis* and *U. havanensis* is that, toward the apertural end, the parallel costae of one chamber lie at an angle to the parallel costae of the adjacent chamber.

The highly appropriate name *costata* was erected for another species of *Uvigerina* by Bieda in 1936 necessitating a new name for *U. bortotara costata* Dorreen described in 1948, from upper Eocene beds in Greymouth, New Zealand.

Uvigerina jacksonensis Cushman. Cushman, 1935a, p. 40, pl. 16, figs. 1–3.

Uvigerina mantaensis Cushman and Edwards, 1938, p. 84, pl. 14, fig. 8. (Pl. 4, fig. 5.)

Uvigerina mexicana Nuttall, 1932, p. 22, pl. 5, figs. 12, 13. (Pl. 4, figs. 6, 7.)

Uvigerina nuttalli Cushman and Edwards, 1938, p. 82, pl. 14, figs. 3–5. (Pl. 4, fig. 4.)

Uvigerina sp. (Pl. 4, fig. 3.)

Characterized by scalloped sutures, and by few costae so blunted as to appear as if melted onto the test wall.

Vaginulinopsis cumulicostata (Gümbel). *Cristellaria cumulicostata* Gümbel, 1870, p. 638, pl. 1, fig. 67. (Pl. 3, figs. 4–6.)

The following are here considered synonyms of *Vaginulinopsis cumulicostata: Vaginulina elegans* d'Orbigny var. *mexicana* Nuttall (1932, p. 16. pl. 3, figs. 12, 16) from the Alazan Shale of Mexico and *Cristellaria saundersi* G. D. Hanna and M. A. Hanna (1924, p. 61, pl. 13, figs. 5, 6, 15.) from the Eocene of Washington State.

Valvulammina cornucopia Galloway and Heminway, 1941, p. 320, pl. 6, fig. 4. (Pl. 1, fig. 6.)

Valvulineria nuttalli Palmer and Bermúdez, 1936, p. 300, pl. 19, figs. 3–5. (Pl. 5, fig. 11.)

Valvulineria paucilocula Cushman, 1935b, p. 37, pl. 5, fig. 7.

Valvulineria sculpturata Cushman, 1935b, p. 37, pl. 5, fig. 10.

Virgulina colei Cushman. *Virgulina colei* Cushman, 1937b, p. 12, pl. 2, figs. 9, 10. (Pl. 3, figs. 30, 31.)

Virgulina pontoni Cushman. *Virgulina pontoni* Cushman, 1937b, p. 19, pl. 2, figs. 26–28.

Vulvulina stainforthi Cushman and Renz, 1947, p. 6, pl. 1, fig. 14. (Pl. 1, figs. 20, 21.)

Genus? related to *Eggerella bradyi* (Cushman). (Pl. 1, fig. 13.)

Appears to have a fine-grained and smoothly finished arenaceous wall and to be an arenaceous isomorph of *Sphaeroidina*.

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INDEX

PLATES 1-12

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PLATE 1

FIGURE 1. *Textularia leuzingeri* Cushman and Renz (p. 24).
USNM 688873, × 50; CPR–2, 3.760–3,770 ft. *a*, Side view; *b*, edge view.

2. *Textularia* aff. *T. conica* d'Orbigny (p. 24).
USNM 688994, × 50; CPR–3, 4,020–4,030 ft. *a*, Side view; *b*, top view.

3. *Textularia bermudezi* Cushman and Todd (p. 24).
USNM 688850, × 50; CPR–2, 2,960–2,980 ft. *a*, Side view; *b*, edge view.

4. *Spiroplectammina mississippiensis* (Cushman) (p. 24).
USNM 688854, × 40; CPR–2, 3,040–3,060 ft.

5. *Tritaxilina mexicana* Cushman (p. 24).
USNM 688910, × 50; CPR–3, 1,900–1,920 ft.

6. *Valvulammina cornucopia* Galloway and Heminway (p. 25).
USNM 688833, × 50; CPR–1, 3,520–3,530 ft.

7, 8. *Karreriella mexicana* (Nuttall) (p. 23).
7. USNM 688856, × 50; CPR–2, 3,080–3,100 ft.
8. USNM 688865, × 30; CPR–2, 3,280–3,300 ft.

9. *Karreriella disjuncta* (Cushman and Jarvis) (p. 22).
USNM 688977, × 25; CPR–3, 3,440–3,450 ft.

10. *Matanzia bermudezi* Palmer (p. 23).
USNM 688870, × 30; CPR–2, 3,660–3,670 ft.

11. *Pseudoclavulina* sp. (p. 24).
USNM 688969, × 25; CPR–3, 3,160–3,180 ft.

12. *Liebusella byramensis* (Cushman) (p. 23).
USNM 688877, × 25; CPR–2, 4,040–4,050 ft.

13. Genus? related to *Eggerella bradyi* (Cushman) (p. 25).
USNM 688967, × 50; CPR–3, 3,080–3,100 ft. *a*, Dorsal view; *b*, ventral view; *c*, edge view.

14. *Quinqueloculina ermani* Bornemann (p. 24).
USNM 688849, × 50; CPR–2, 2,960–2,980 ft.

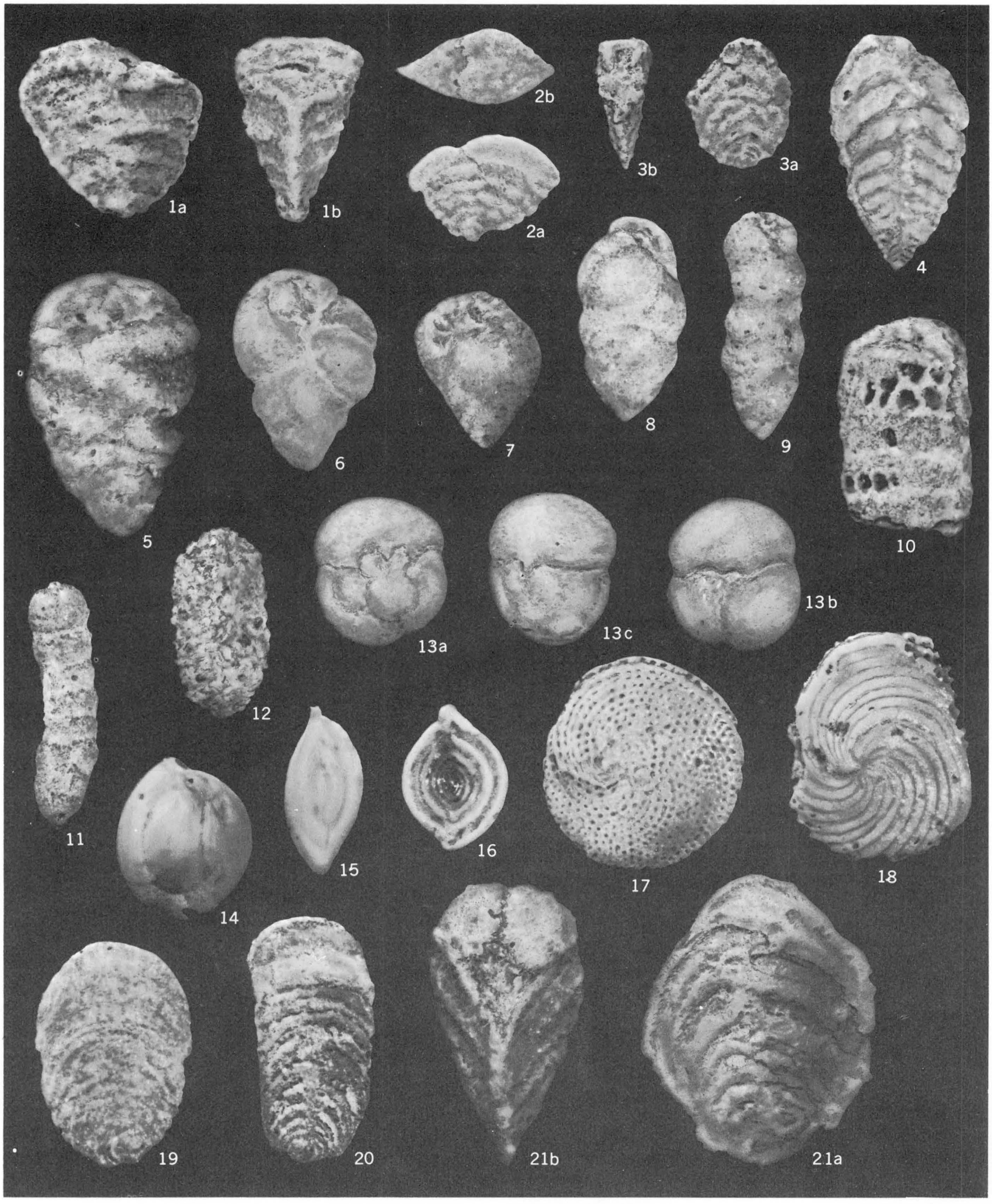
15. *Sigmoilina tenuis* (Czjzek) (p. 24).
USNM 688993, × 50; CPR–3, 3,950–3,960 ft.

16. *Spiroloculina alveata* Cushman and Todd (p. 24).
USNM 688936, × 40; CPR–3, 2,340–2,360 ft.

17, 18. *Archaias angulatus* (Fichtel and Moll) (p. 21).
17. USNM 688869, × 30; CPR–2, 3,400–3,420 ft.
18. USNM 688829, × 30; CPR–1, 1,300–1,310 ft.

19. *Ammospirata mexicana* (Cushman) (p. 20).
USNM 688912, × 25; CPR–3, 1,940–1,960 ft.

20, 21. *Vulvulina stainforthi* Cushman and Renz (p. 25).
20. USNM 688959, × 25; CPR–3, 2,820–2,840 ft.
21. USNM 688887, × 50; CPR–2, 1,660–1,680 ft. *a*, Side view; *b*, edge view.



BENTHONIC SMALLER FORAMINIFERA FROM PUERTO RICO TEST WELLS

PLATE 2

[*a*, Side view; *b*, edge view, except as indicated]

FIGURE 1. *Lenticulina orbicularis* (d'Orbigny) (p. 23).
USNM 688861, × 30; CPR–2, 3,160–3,180 ft.

2, 3. *Lenticulina convergens* (Bornemann) (p. 23).
2. USNM 688907, × 40; CPR–3, 1,900–1,920 ft.
3. USNM 688963, ×, 40; CPR–3, 3,000–3,020 ft.

4. *Lenticulina clericii* (Fornasini) (p. 23).
USNM 688898, × 50; CPR–3, 1,780–1,800 ft.

5. *Lenticulina terryi* (Coryell and Embich) (p. 23).
USNM 688915, × 50; CPR–3, 1,940–1,960 ft.

6, 9. *Lenticulina americana grandis* (Cushman) (p. 23).
6. USNM 688938, × 30; CPR–3, 2,380–2,400 ft.
9. USNM 688866, × 30; CPR–2, 3,280–3,300 ft.

7. *Lenticulina brevispinosa* (Nuttall) (p. 23).
USNM 688928, × 30; CPR–3, 2,000–2,020 ft.

8. *Lenticulina caroliniana* (Cushman) (p. 23).
USNM 688962, × 30; CPR–3, 3,000–3,020 ft.

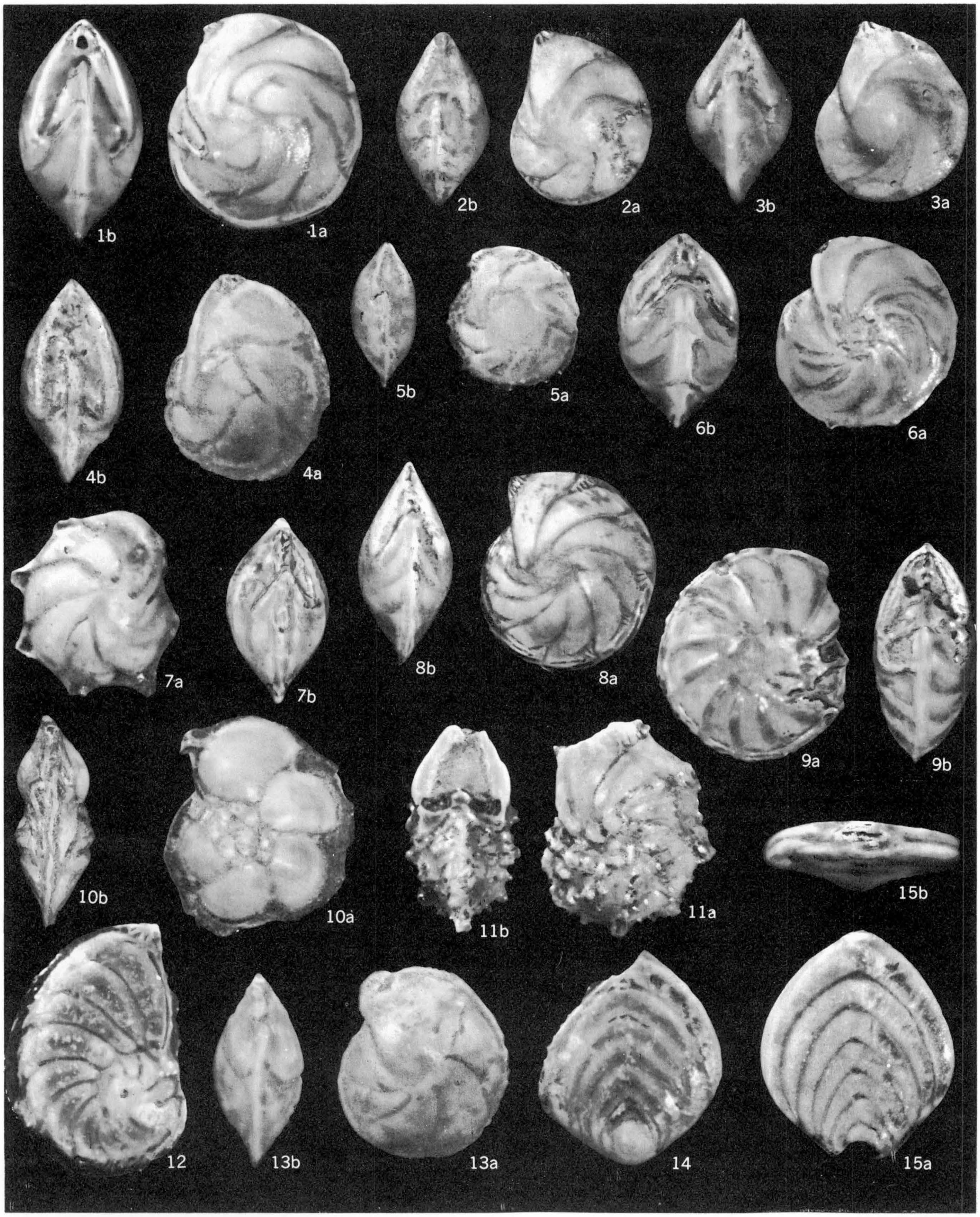
10. *Lenticulina budensis* (Hantken) (p. 23).
USNM 688958, × 30; CPR–3, 2,820–2,840 ft.

11. *Lenticulina subpapillosa* (Nuttall) (p. 23).
USNM 688929, × 30; CPR–3, 2,000–2,020 ft.

12. *Planularia trinae* Bermúdez (p. 23).
USNM 688872, × 30; CPR–2, 3,680–3,690 ft.

13. *Ellipsocristellaria* sp. (p. 22).
USNM 688860, × 50; CPR–2, 3,140–3,160 ft.

14, 15. *Entolingulina alazanensis* (Nuttall) (p. 22).
14. USNM 688862, × 30; CPR–2, 3,200–3,220 ft.
15. USNM 688864, × 30; CPR–2, 3,280–3,300 ft.
a, Side view; *b*, top view.



BENTHONIC SMALLER FORAMINIFERA FROM PUERTO RICO TEST WELLS

PLATE 3

FIGURE 1. *Astacolus crepidulus* (Fichtel and Moll) (p. 21).
USNM 688991, × 50; CPR–3, 3,950–3,960 ft.

2. *Marginulina hantkeni* Bandy (p. 23).
USNM 688875, × 50; CPR–2, 3,780–3,790 ft.

3. *Marginulina glabra* d'Orbigny (p. 23).
USNM 688899, × 50; CPR–3, 1,780–1,800 ft.
a, Side view; *b*, edge view.

4–6. *Vaginulinopsis cumulicostata* (Gümbel) (p. 25).
4. USNM 688947, × 30; CPR–3, 2,600–2,620 ft.
5. USNM 688911, × 25; CPR–3, 1,900–1,920 ft.
6. USNM 688956, × 25; CPR–3, 2,700–2,720 ft.

7. *Saracenaria senni* Hedberg (p. 24).
USNM 688946, × 50; CPR–3, 2,580–2,600 ft.
a, Side view; *b*, edge view.

8. *Saracenaria italica* Defrance (p. 24).
USNM 688909, × 50; CPR–3, 1,900–1,920 ft.
a, Side view; *b*, edge view.

9. *Marginulina perpsocera* (Schwager) (p. 23).
USNM 688867, × 50; CPR–2, 3,280–3,300 ft.

10. *Frondicularia tenuissima* Hantken (p. 22).
USNM 688855, × 50; CPR–2, 3,080–3,100 ft.

11. *Frondicularia* cf. *F. digitata* d'Orbigny (p. 22).
USNM 688852, × 50; CPR–2, 3,040–3,060 ft.

12. *Lagenonodosaria acostaensis* Blow (p. 23).
USNM 688858, × 50; CPR–2, 3,100–3,120 ft.

13. *Plectofrondicularia jarvisi* Cushman and Todd (p. 23).
USNM 688868, × 50; CPR–2, 3,380–3,400 ft.

14. *Plectofrondicularia yumuriana* Palmer (p. 23).
USNM 688857, × 50; CPR–2, 3,080–3,100 ft.

15. *Marginulina pseudohirsuta* Nuttall (p. 23).
USNM 688981, × 25, CPR–3, 3,640–3,650 ft.

16. *Stilostomella caribaea* (Palmer and Bermúdez) (p. 24).
USNM 688942, × 25; CPR–3, 2,460–2,480 ft.

17. *Stilostomella verneuili* (d'Orbigny) (p. 24).
USNM 688996, × 25; CPR–3, 4,040–4,050 ft.

18. *Pseudonodosaria comatula* (Cushman) (p. 24).
USNM 688940, × 50; CPR–3, 2,380–2,400 ft.

FIGURE 19. *Bolivina* (*Loxostomum*) *limbata* (Brady) (p. 21).
USNM 688851, × 60; CPR–2, 3,040–3,060 ft.

20. *Bulimina affinis* d'Orbigny (p. 21).
USNM 688986, × 30; CPR–3, 3,840–3,850 ft.

21. *Turrilina robertsi* (Howe and Ellis) (p. 24).
USNM 688979, × 75; CPR–3, 3,550–3,560 ft.

22. *Bulimina exilis tenuata* (Cushman) (p. 21).
USNM 688884, × 60; CPR–2, 4,330–4,340 ft .

23. *Bulimina impendens* Parker and Bermúdez (p. 21).
USNM 688990, × 50; CPR–3, 3,920–3,930 ft.

24. *Sagrina vicksburgensis* (Howe) (p. 24).
USNM 688859, × 75; CPR–2, 3,100–3,120 ft.

25. *Bolivina rhomboidalis* (Millett) (p. 21).
USNM 688944, × 75; CPR–3 2,540–2,560 ft.

26. *Bolivina choctawensis* Cushman and McGlamery (p. 21).
USNM 688950, × 75; CPR–3, 2,640–2,660 ft.

27. *Bolivina oligocaenica* Spandel (p. 21).
USNM 688970, × 50; CPR–3, 3,220–3,240 ft.

28. *Bulimina sculptilis* Cushman (p. 21).
USNM 688960, × 50; CPR–3, 2,960–2,980 ft.

29. *Bulimina marginospinata* Cushman and Parker (p. 21).
USNM 688933, × 60; CPR–3, 2,340–2,360 ft.

30, 31. *Virgulina colei* Cushman (p. 25).
30. USNM 688881, × 50; CPR–2, 4,070–4,080 ft.
31. USNM 688995, × 75; CPR–3, 4,020–4,030 ft.

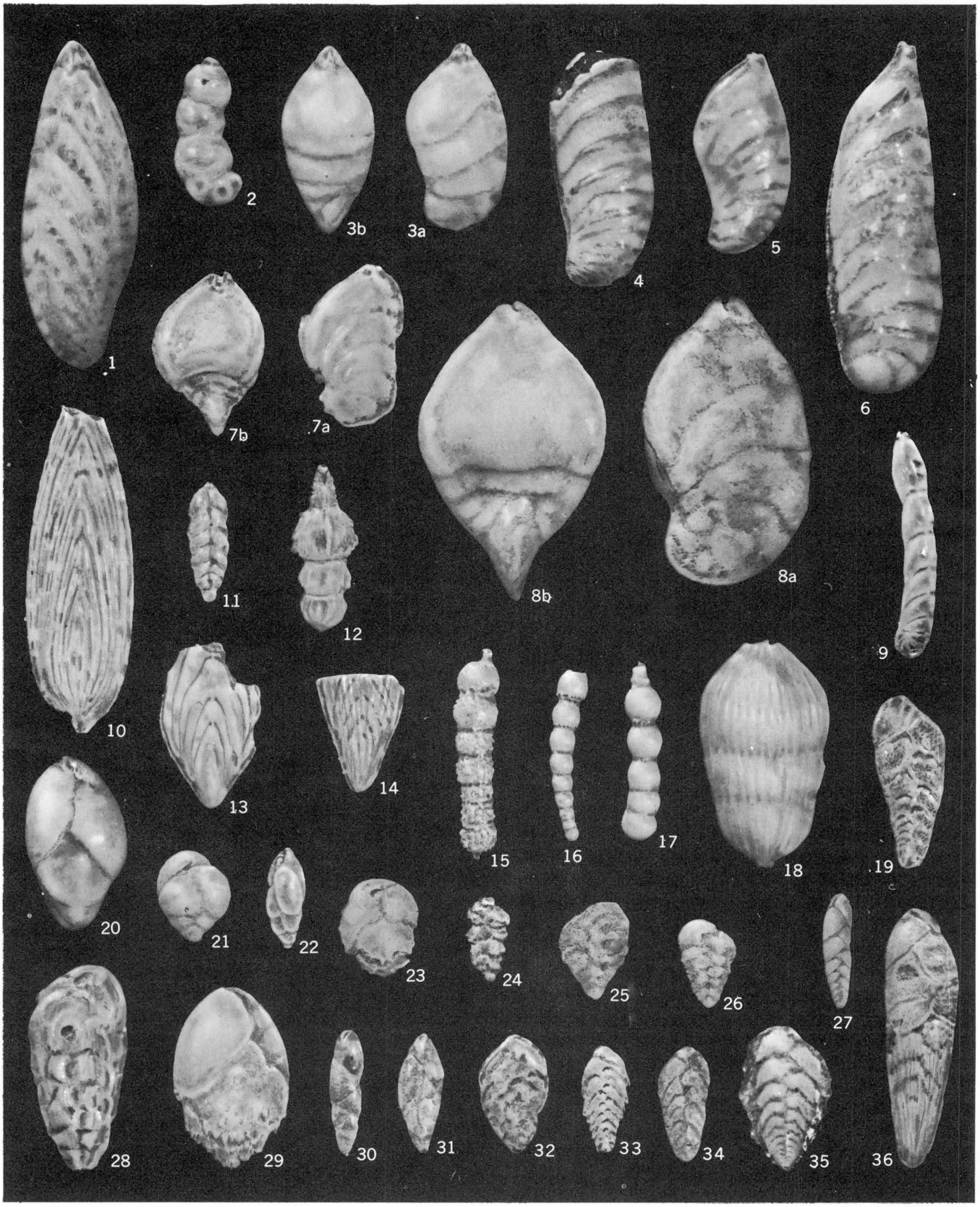
32. *Bolivina byramensis* Cushman (p. 21).
USNM 688874, × 50; CPR–2, 3,780–3,790 ft.

33. *Bolivina difformis* (Williamson) (p. 21).
USNM 688848, × 60; CPR–2, 2,830–2,840 ft.

34. *Bolivina tectiformis* Cushman (p. 21).
USNM 688951, × 50; CPR–3, 2,640–2,660 ft.

35. *Bolivina mexicana aliformis* Cushman (p. 21).
USNM 688932, × 25; CPR–3, 2,340–2,360 ft.

36. *Bolivina isidroensis* Cushman and Renz (p. 21).
USNM 688937, × 60; CPR–3, 2,380–2,400 ft.



BENTHONIC SMALLER FORAMINIFERA FROM PUERTO RICO TEST WELLS

PLATE 4

FIGURE 1. *Uvigerina adelinensis* (Palmer and Bermúdez) (p. 24).
USNM 688902, × 30; CPR–3, 1,780–1,800 ft.

2. *Uvigerina greymouthensis* Todd and Low, new name (p. 24).
USNM 688903, × 30; CPR–3, 1,780–1,800 ft.

3. *Uvigerina* sp. (p. 25).
USNM 688941, × 30; CPR–3, 2,380–2,400 ft.

4. *Uvigerina nuttalli* Cushman and Edwards (p. 25).
USNM 688906, × 30; CPR–3, 1,780–1,800 ft.

5. *Uvigerina mantaensis* Cushman and Edwards (p. 25).
USNM 688924, × 60; CPR–3, 1,980–2,000 ft.

6, 7. *Uvigerina mexicana* Nuttall (p. 25).
6. USNM 688904, × 30; CPR–3, 1,780–1,800 ft.
7. USNM 688905, × 50; CPR–3, 1,780–1,800 ft.

8. *Allomorphina macrostoma* Karrer (p. 20).
USNM 688968, × 30; CPR–3, 3,120–3,140 ft. *a*, Side view; *b*, top view.

9. *Chilostomella globata* Galloway and Heminway (p. 21).
USNM 688982, × 50; CPR–3, 3,680–3,690 ft. *a*, *b*, Views 90° apart.

10. *Angulogerina rugoplicata* Cushman (p. 21).
USNM 688882, × 75; CPR–2, 4,160–4,170 ft.

11. *Angulogerina vicksburgensis* Cushman (p. 21).
USNM 688883, × 60; CPR–2, 4,330–4,340 ft.

12. *Angulogerina jamaicensis* Cushman and Todd (p. 21).
USNM 688949, × 60; CPR–3, 2,640–2,660 ft.

13. *Siphogenerina mexicana* Cushman (p. 24).
USNM 688935, × 60; CPR–3, 2,340–2,360 ft.

14. *Siphogenerina hubbardi* Galloway and Heminway (p. 24).
USNM 688923, × 30; CPR–3, 1,980–2,000 ft.

15, 20. *Cerobertina bartrumi* Finlay (p. 21).
15. USNM 688919, × 50; CPR–3, 1,980–2,000 ft.
20. USNM 688964, × 50; CPR–3, 3,040–3,060 ft. *a*, Dorsal view; *b*, view; *c*, edge view.

16. *Cassidulinoides simplex* Cushman and Todd (p. 21).
USNM 688983, × 50; CPR–3, 3,750–3,760 ft.

17. *Cassidulinoides bradyi* (Norman) (p. 21).
USNM 688957, × 60; CPR–3, 2,720–2,740 ft.

18. *Robertina declivis* (Reuss) (p. 24).
USNM 688985, × 50; CPR–3, 3,820–3,830 ft.

19, 23. *Chilostomella cylindroides* Reuss (p. 21).
19. USNM 688971, × 25; CPR–3, 3,220–3,240 ft. *a*, Side view; *b*, top view.
23. USNM 688839, × 25; CPR–1, 3,900–3,910 ft.

21. *Quadrimorphina allomorphinoides* (Reuss) (p. 24).
USNM 688954, × 60; CPR–3, 2,660–2,680 ft.

22. *Nodosarella subnodosa* (Guppy) (p. 23).
USNM 688989, × 25; CPR–3, 3,870–3,880 ft.

24. *Ceratobulimina alazanensis* Cushman and Harris (p. 21).
USNM 688918, × 50; CPR–3, 1,980–2,000 ft.

25. *Cassidulina carapitana* Hedberg (p. 21).
USNM 688837, × 60; CPR–1, 3,630–3,640 ft.

26. *Ehrenbergina bicornis* Brady (p. 22).
USNM 688976, × 50; CPR–3, 3,410–3.420 ft.

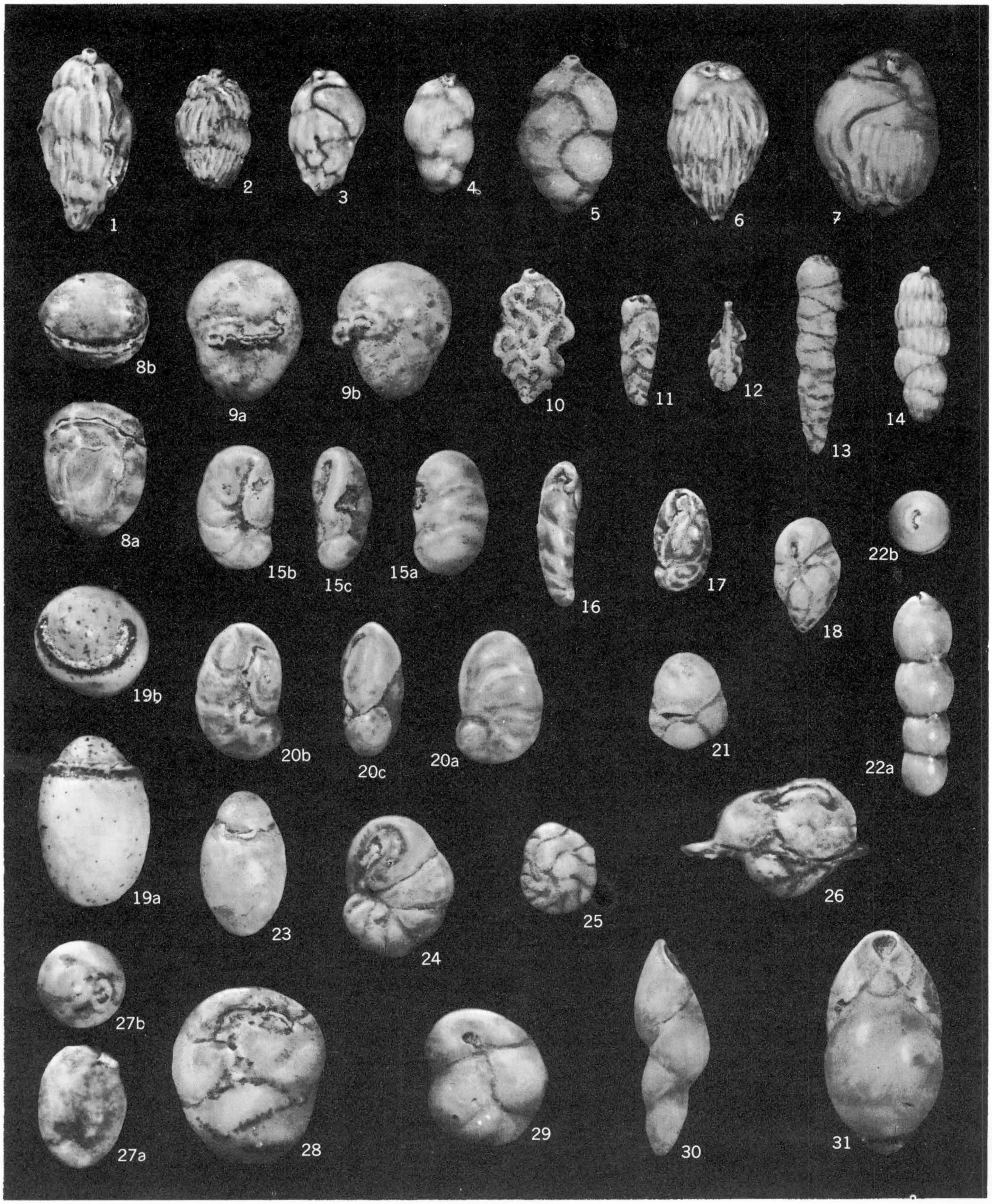
27. *Chilostomelloides oviformis* (Sherborn and Chapman) (p. 21).
USNM 688925, × 30; CPR–3, 2,000–2,020 ft. *a*, Side view; *b*, top view.

28. *Ehrenbergina*? aff. *E. pupa* (d'Orbigny) (p. 22).
USNM 688890, × 50; CPR–3, 1,780–1,800 ft.

29. *Cassidulina subglobosa* Brady (p. 21).
USNM 688888, × 50; CPR–3, 1,780–1,800 ft.

30. *Pleurostomella elliptica* Galloway and Heminway (p. 24).
USNM 688934, × 50; CPR–3, 2,340–2,360 ft.

31. *Pleurostomella bierigi* Palmer and Bermúdez (p. 24).
USNM 688945, × 60; CPR–3, 2,580–2,600 ft.



BENTHONIC SMALLER FORAMINIFERA FROM PUERTO RICO TEST WELLS

PLATE 5

[*a*, Dorsal view; *b*, ventral view; *c*, edge view, except as indicated]

FIGURE 1. *Eponidella libertadensis* Cushman and Hedberg (p. 22).
USNM 688871, × 60; CPR–2, 3,680–3,690 ft.

2. *"Planulina" camagueyana* Bermúdez (p. 23).
USNM 688878, × 50; CPR–2, 4,040–4,050 ft. *a*, *b*, Opposite sides.

3, 4. *Rosalina floridensis* (Cushman) (p. 24).
3. USNM 688835, × 30; CPR–1, 3,590–3,600 ft. Ventral view.
4. USNM 688955, × 50; CPR–3, 2,660–2,680 ft. Dorsal view.

5. *Ammonia beccarii* (Linné) (p. 20).
USNM 688831, × 50; CPR–1, 3,500–3,510 ft.

6. *Glabratella* aff. *G. browningi* Redmond (p. 22).
USNM 688863, × 50; CPR–2, 3,220–3,240 ft.

7. *Baggina cojimarensis* Palmer (p. 21).
USNM 688842, × 60; CPR–1, 4,430–4,440 ft.

8. *Cancris auriculus* (Fichtel and Moll) (p. 21).
USNM 688987, × 50; CPR–3, 3,840–3,850 ft.

9. *Planodiscorbis rarescens* (Brady) (p. 23).
USNM 688988, × 50; CPR–3, 3,840–3,850 ft.

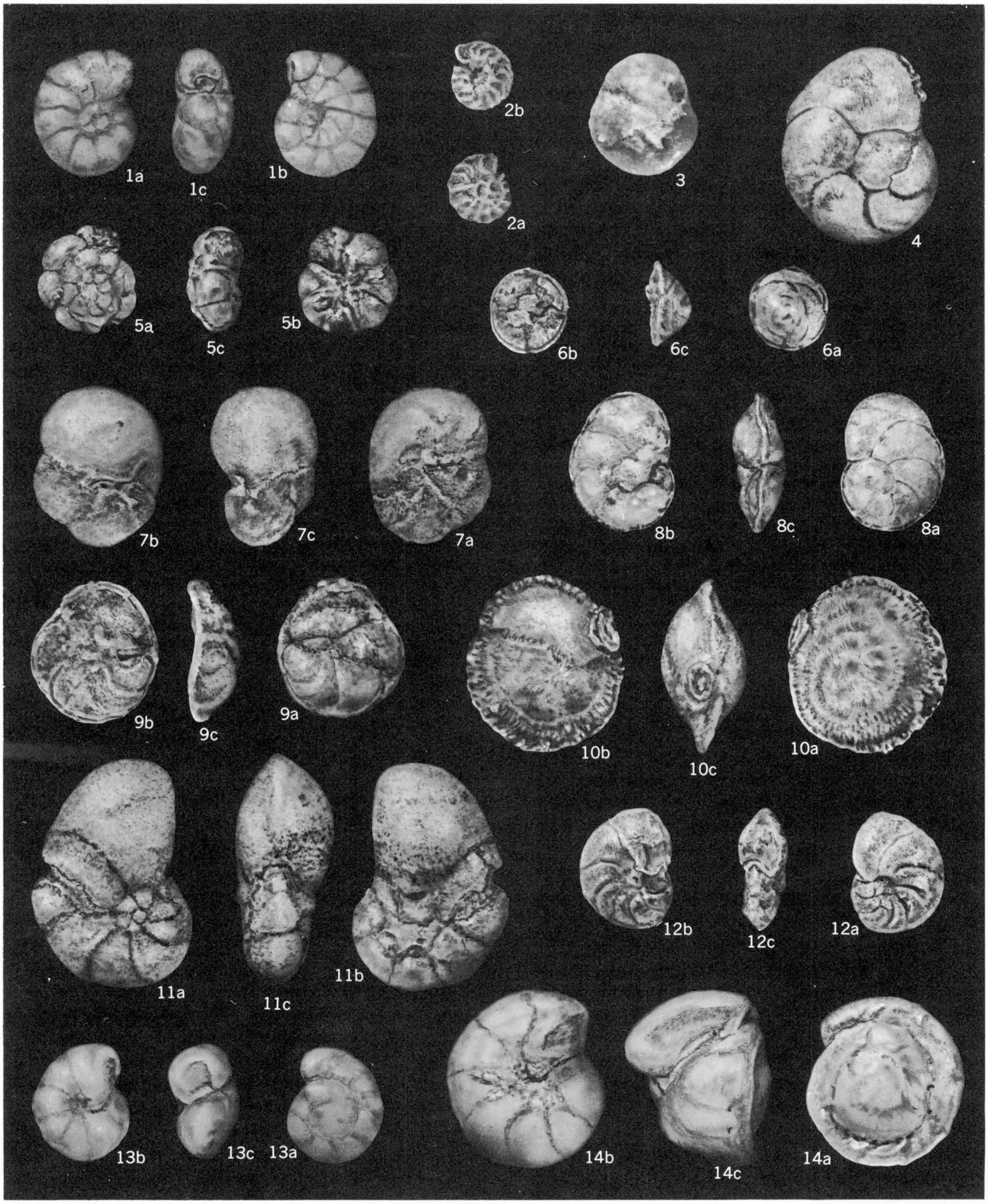
10. *Siphonina tenuicarinata* Cushman (p. 24).
USNM 688886, × 50; CPR–3, 1,660–1,680 ft.

11. *Valvulineria nuttalli* Palmer and Bermúdez (p. 25).
USNM 688973, × 50; CPR–3, 3,280–3,300 ft.

12. *Hanzawaia carstensi* (Cushman and Ellisor) (p. 22).
USNM 688880, × 50; CPR–2, 4,070–4,080 ft.

13. *Gyroidina vicksburgensis* (Cushman) (p. 22).
USNM 688965, × 50; CPR–3, 3,040–3,060 ft.

14. *Gyroidina altiformis* R. E. and K. C. Stewart (p. 22).
USNM 688922, × 50; CPR–3, 1,980–2,000 ft.



BENTHONIC SMALLER FORAMINIFERA FROM PUERTO RICO TEST WELLS

PLATE 6

[*a*, Dorsal view; *b*, ventral view; *c*, edge view]

FIGURE 1. *Hoeglundina elegans* (d'Orbigny) (p. 22).
USNM 688853, × 30; CPR–2, 3,040–3,060 ft.

2. *Pararotalia mexicana* (Nuttall) (p. 23).
USNM 688900, × 30; CPR–3, 1,780–1,800 ft.

3. *Osangularia culter* (Parker and Jones) (p. 23).
USNM 688972, × 30; CPR–3, 3,240–3,260 ft.

4. *Amphistegina angulata* (Cushman) (p. 20).
USNM 688830, × 30; CPR–1, 3,090–3,100 ft.

5. *Eponides parantillarum* Galloway and Heminway (p. 22).
USNM 688930, × 30; CPR–3; 2,040–2,060 ft.

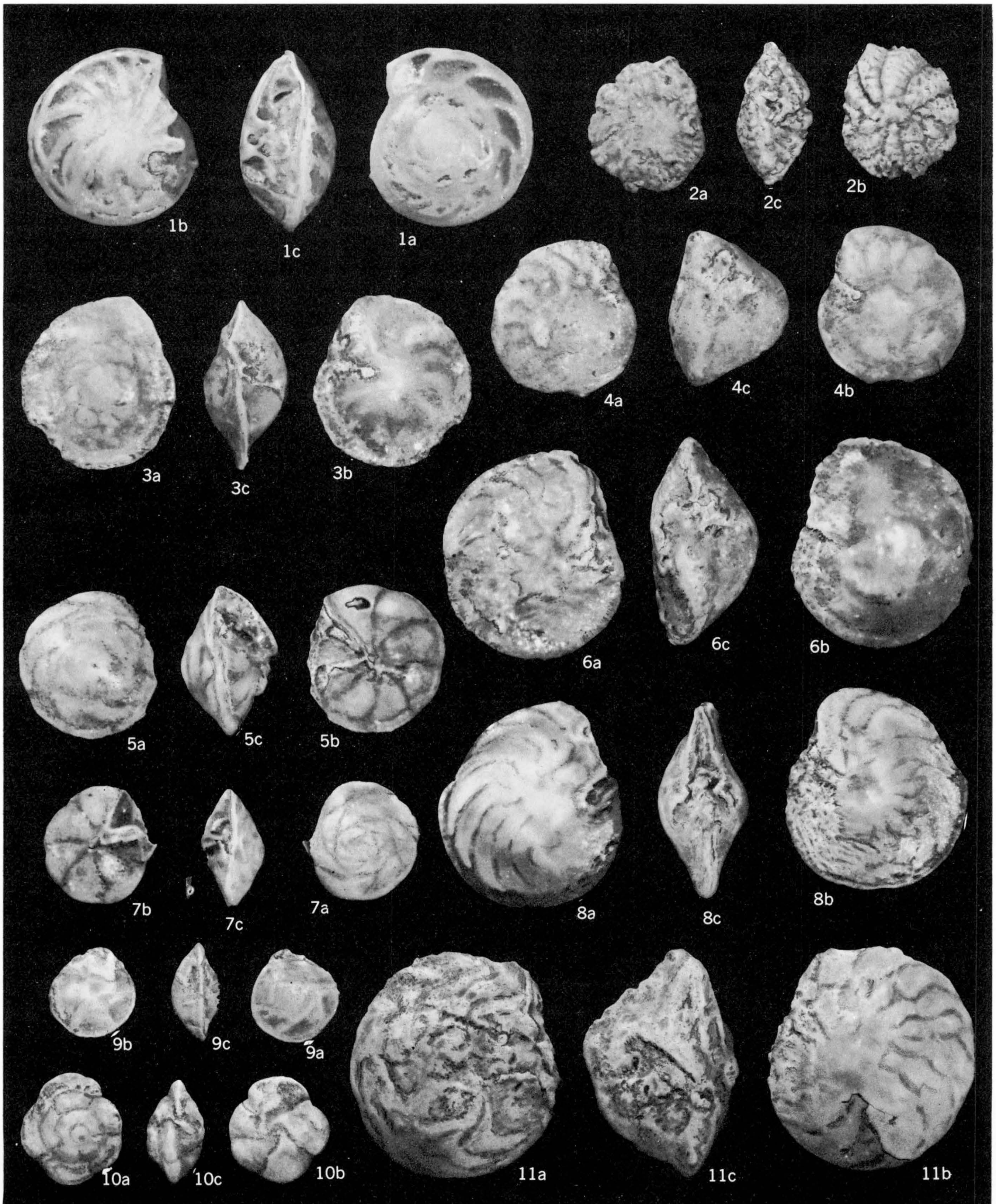
6, 8. *Amphistegina floridana* Cushman and Ponton (p. 20).
6. USNM 688845, × 30; CPR–2, 2,510–2,520 ft.
8. USNM 688843, × 30; CPR–2, 1,200–1,210 ft.

7. *Eponides ellisorae* Garrett (p. 22).
USNM 688876, × 30; CPR–2, 3,820–3,830 ft.

9. *Alabamina polita* Becker and Dusenbury (p. 20).
USNM 688948, × 60; CPR–3, 2,640–2,660 ft.

10. *Oridorsalis umbonatus* (Reuss) (p. 23).
USNM 688978, × 50; CPR–3, 3,500–3,510 ft.

11. *Amphistegina*? sp. (p. 20).
USNM 688846, × 50; CPR–2, 2,810–2,820 ft.



BENTHONIC SMALLER FORAMINIFERA FROM PUERTO RICO TEST WELLS

PLATE 7

FIGURE 1. *"Pullenia" riveroi* Bermúdez (p. 24).
USNM 688834, × 50; CPR–1, 3,550–3,560 ft. *a*, Side view; *b*, edge view.

2. *Nonionella pulchella* Hada (p. 23).
USNM 688836, × 50; CPR–1, 3,600–3,610 ft.

3. *Florilus subgrateloupi* (Galloway and Heminway) (p. 22).
USNM 688838, × 50; CPR–1, 3,630–3,640 ft.

4. *Florilus whitsettensis* (Cushman and Applin) (p. 22).
USNM 688844, × 40; CPR–2, 1,410–1,420 ft. *a*, Side view; *b*, edge view.

5. *Cribropullenia marielensis* (Palmer) (p. 22).
USNM 688841, × 60; CPR–1, 4,220–4,230 ft. *a*, Side view; *b*, edge view.

6. *Elphidium poeyanum* (d'Orbigny) (p. 22).
USNM 688840, × 50; CPR–1, 4,200–4,210 ft. *a*, Side view; *b*, edge view.

7. *Elphidium puertoricense* Galloway and Heminway (p. 22).
USNM 688832, × 50; CPR–1, 3,500–3,510 ft. *a*, Side view; *b*, edge view.

8, 9. *Melonis pompilioides* (Fichtel and Moll) (p. 23).
8. USNM 688916, × 50; CPR–3, 1,940–1,960 ft. *a*, Side view; *b*, edge view.
9. USNM 688939, × 50; CPR–3, 2,380–2,400 ft.

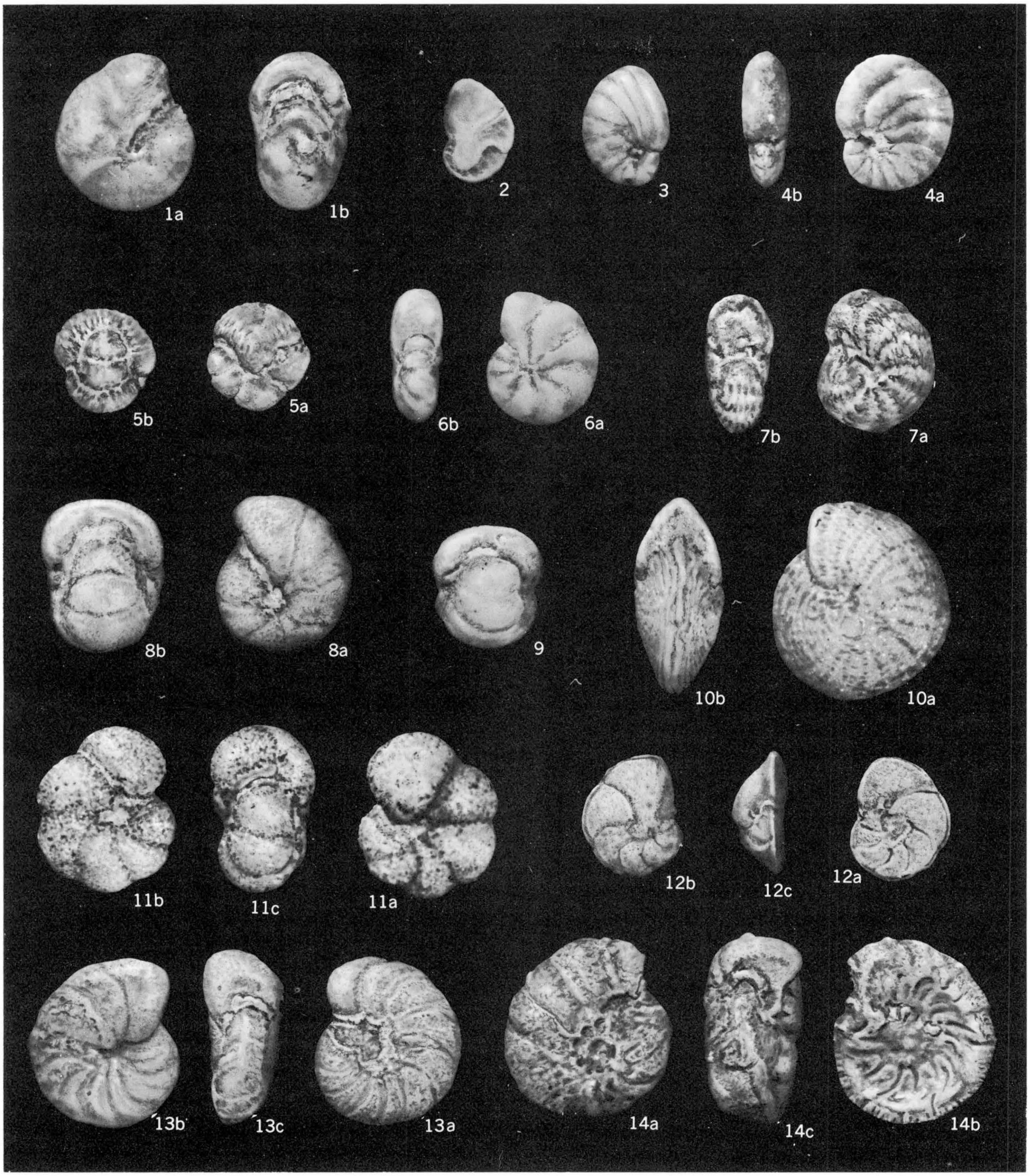
10. *Elphidium lens Galloway and* Heminway (p. 22).
USNM 688885, × 30; CPR–3, 900–910 ft. *a*, Side view; *b*, edge view.

11. *Anomalina granosa* (Hantken) (p. 21).
USNM 688917, × 30; CPR–3, 1,980–2,000 ft. *a*, Dorsal view; *b*, ventral view; *c*, edge view.

12. *Cibicidina* sp. (p. 22).
USNM 688961, × 50; CPR–3, 3,000–3,020 ft. *a*, Dorsal view; *b*, ventral view; *c*, edge view.

13. *Anomalina alazanensis* Nuttall (p. 21).
USNM 688913, × 50; CPR–3, 1,940–1,960 ft. *a*, Dorsal view; *b*, ventral view; *c*, edge view.

14. *Anomalina cocoaensis* Cushman (p. 21).
USNM 688974, × 50; CPR–3, 3,410–3,420 ft. *a*, Dorsal view; *b*, ventral view; *c*, edge view.



BENTHONIC SMALLER FORAMINIFERA FROM PUERTO RICO TEST WELLS

PLATE 8

[*a*, Dorsal view; *b*, ventral view; *c*, edge view]

FIGURE 1. *Cibicides floridanus* (Cushman) (p. 21).
USNM 688926, × 50; CPR–3, 2,000–2,020 ft.

2. *Cibicides robertsonianus* (Brady) (p. 22).
USNM 688952, × 60; CPR–3, 2,660–2,680 ft.

3. *Cibicides pseudoungerianus* (Cushman) (p. 21).
USNM 688847, × 50; CPR–2, 2,810–2,820 ft.

4. *Cibicides mexicanus* Nuttall (p. 21).
USNM 688927, × 40; CPR–3, 2,000–2,020 ft.

5. *Cibicides trinitatensis* (Nuttall) (p. 22).
USNM 688889, × 40; CPR–3, 1,780–1,800 ft.

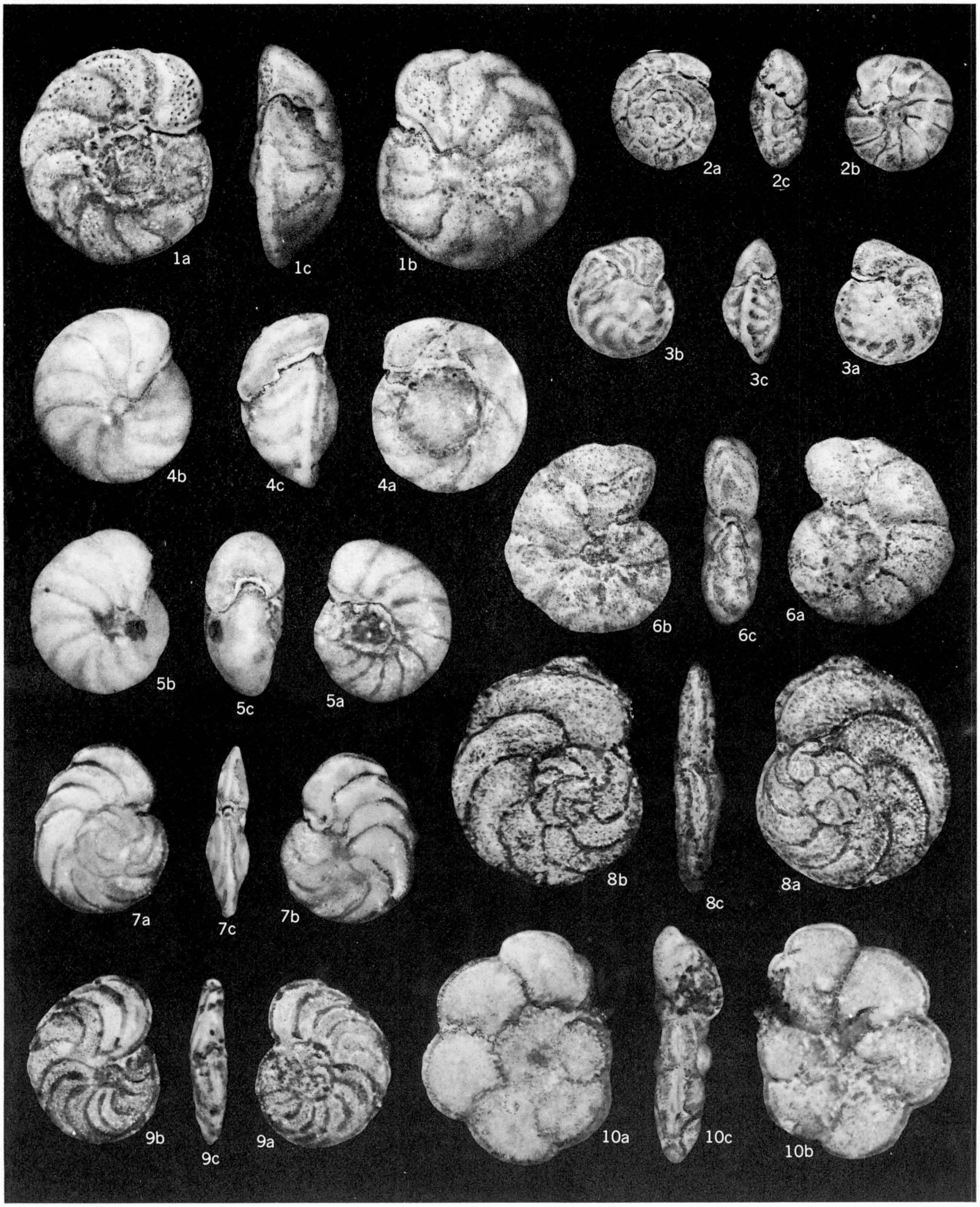
6. *Planulina leoni* Bermúdez (p. 23).
USNM 688975, × 50; CPR–3, 3,410–3,420 ft.

7. *Planulina subtenuissima* (Nuttall) (p. 23).
USNM 688931, × 30; CPR–3, 2,080–2,100 ft.

8. *Planulina mexicana* Cushman (p. 23).
USNM 688908, × 50; CPR–3, 1,900–1,920 ft.

9. *Planulina marialana* Hadley (p. 23).
USNM 688901, × 30; CPR–3, 1,780–1,800 ft.

10. *Planulina* sp. (p. 23).
USNM 688992, × 40; CPR–3, 3,950–3,960 ft.



BENTHONIC SMALLER FORAMINIFERA FROM PUERTO RICO TEST WELLS

PLATE 9

[*a*, Dorsal view; *b*, ventral view; *c*, edge view, except as indicated. All figures × 50]

FIGURE 1. *Globigerina ciperoensis* Bolli (p. 19).
USNM 688980; CPR–3, 3,620–3,630 ft.

2. *Globigerina officinalis* Subbotina (p. 19).
USNM 688897; CPR–3, 1,780–1,800 ft.

3, 4. *Globigerina hexagona* Natland (p. 19).
3. USNM 688895; CPR–3, 1,780–1,800 ft.
4. USNM 688896; CPR–3, 1,780–1,800 ft.

5. *Globigerina ampliapertura* Bolli (p. 19).
USNM 688879; CPR–2, 4,070–4,080 ft.

6. *Globorotalia bolivariana* (Petters) (p. 20).
USNM 688984; CPR–3, 3,820–3,830 ft. *a*, Side view; *b*, edge view.

7, 12. *Globigerina sellii* (Borsetti) (p. 19).
7. USNM 688966; CPR–3, 3,080–3,100 ft.
12. USNM 688943; CPR–3, 2,480–2,500 ft.

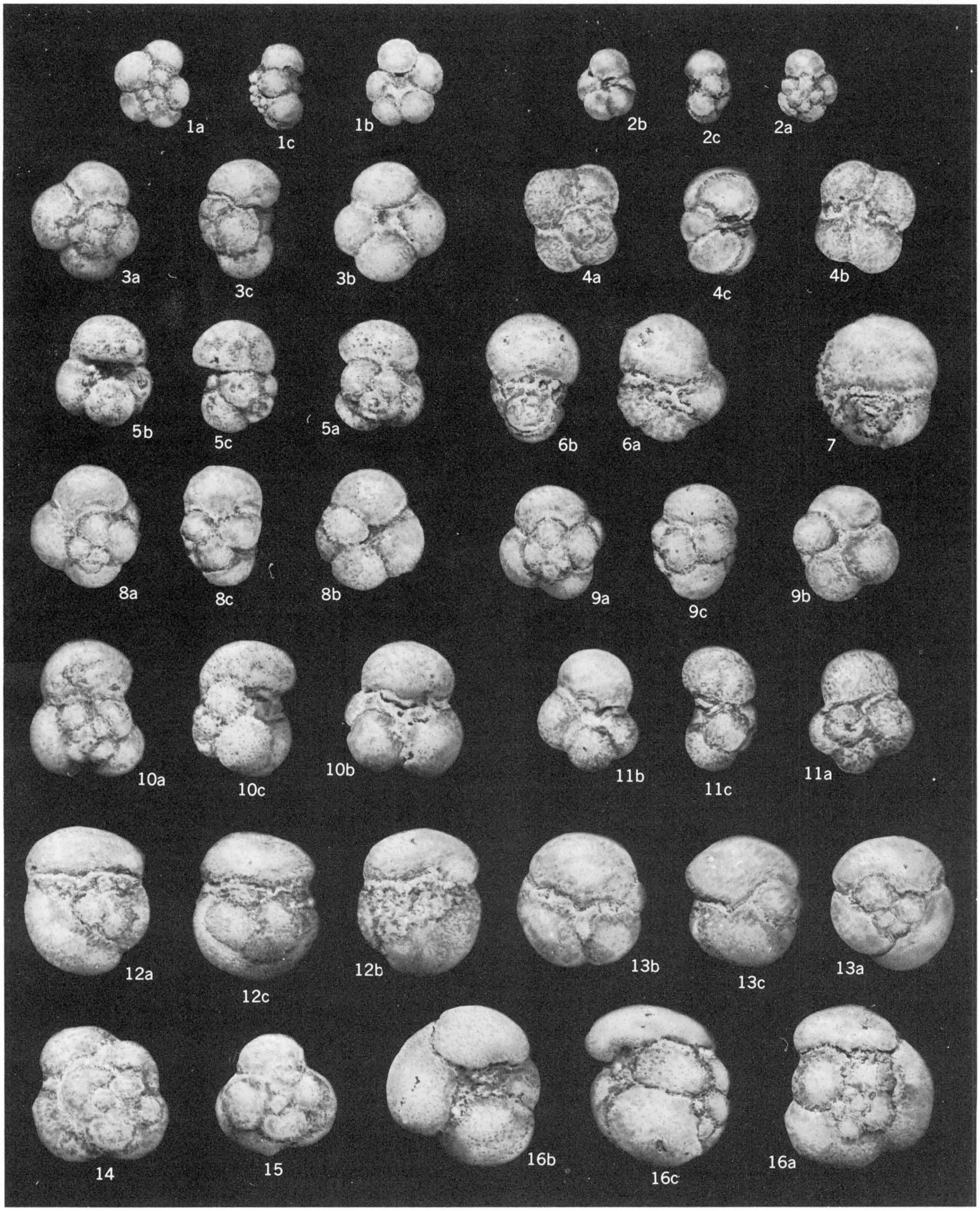
8, 9. *Globigerina dissimilis* Cushman and Bermúdez (p. 19).
8. USNM 688892; CPR–3, 1,780–1,800 ft.
9. USNM 688914; CPR–3, 1,940–1,960 ft.

10. *Globigerina yeguaensis* Weinzierl and Applin (p. 19).
USNM 688953; CPR–3, 2,660–2,680 ft.

11. *Globigerina eocaena* Gümbel (p. 19).
USNM 688921; CPR–3, 1,980–2,000 ft.

13, 16. *Globigerina conglomerata* Schwager (p. 19).
13. USNM 688891; CPR–3, 1,780–1,800 ft.
16. USNM 688920; CPR–3, 1,980–2,000 ft.

14, 15. *Globigerina gortanii* (Borsetti) (p. 19).
14. USNM 688894; CPR–3, 1,780–1,800 ft.
15. USNM 688893; CPR–3, 1,780–1,800 ft.



PLANKTONIC SMALLER FORAMINIFERA FROM PUERTO RICO TEST WELLS

PLATE 10

[*a*, Dorsal view; *b*, ventral view; *c*, edge view. All are from test well No. 1, except as indicated; depths are approximate]

FIGURES 1, 4. *Globigerina hexagona* Natland (p. 19).
1. USNM 688819, × 50; sample F3552 (1,190 ft).
4. USNM 688827, × 50; test well No. 2, sample F3564 (100 ft).

2. *Globigerina rubescens* Hofker (p. 19).
USNM 688791, × 65; sample F3527 (30 ft).

3. *Globigerina obesa* (Bolli) (p. 19).
USNM 688800, × 65; sample F3528 (70 ft).

5. *Globigerina gortanii* (Borsetti) (p. 19).
USNM 688818, × 65; sample F3548 (1,080 ft).

6–8. *Globoquadrina altispira* (Cushman and Jarvis) (p. 20).
6. USNM 688815, × 50; sample F3546 (960 ft).
7. USNM 688801, × 50; sample F3528 (70 ft).
8. USNM 688823, × 50; sample F3558 (1,390 ft).

9, 11. *Globoquadrina dehiscens* (Chapman, Parr, and Collins) (p. 20).
9. USNM 688808, × 50; sample F3534 (370 ft).
11. USNM 688822, × 50; sample F3553 (1,200 ft).

10. *Globoquadrina altispira globosa* Bolli (p. 20).
USNM 688824, × 50; sample F3558 (1,390 ft).

12. *Globigerina ciperoensis* Bolli (p. 19).
USNM 688817, × 65; sample F3548 (1,080 ft).

13. *Globoquadrina dehiscens advena* Bermúdez (p. 20).
USNM 688802, × 50; sample F3528 (70 ft).

14. *Globigerina conglomerata* Schwager (p. 19).
USNM 688803, × 50; sample F3529 (100 ft).

PLANKTONIC SMALLER FORAMINIFERA FROM ST. CROIX, VIRGIN ISLANDS

PLATE 11

[*a*, Dorsal view; *b*, ventral view; *c*, edge view, except as indicated. All are from test well no. 1; depths are approximate]

FIGURES 1, 2. *Globigerinoides bulloideus* Crescenti (p. 20).
1. USNM 688816, × 65; sample F3547 (1,010 ft).
2. USNM 688793, × 50; sample F3527 (30 ft).

3. *Globigerinoides altiaperturus* Bolli (p. 20).
USNM 688792, × 65; sample F3527 (30 ft).

4, 6. *Globigerinoides ruber* (d'Orbigny) (p. 20).
4. USNM 688807, × 50; sample F3534 (370 ft).
6. USNM 688812, × 50; sample F3538 (570 ft).

5. *Globigerinoides trilobus* (Reuss) (p. 20).
USNM 688794, × 50; sample F3527 (30 ft).

7. *Globigerinoides transitorius* Blow (p. 20).
USNM 688813, × 50; sample F3545 (910 ft).

8. *Globigerinoides conglobatus* (Brady) (p. 20).
USNM 688804, × 50; sample F3529 (100 ft.)

9, 10. *Globigerinoides bisphericus* Todd (p. 20).
9. USNM 688821, × 50; sample F3553 (1,200 ft).
10. USNM 688814, × 50; sample F3546 (960 ft).

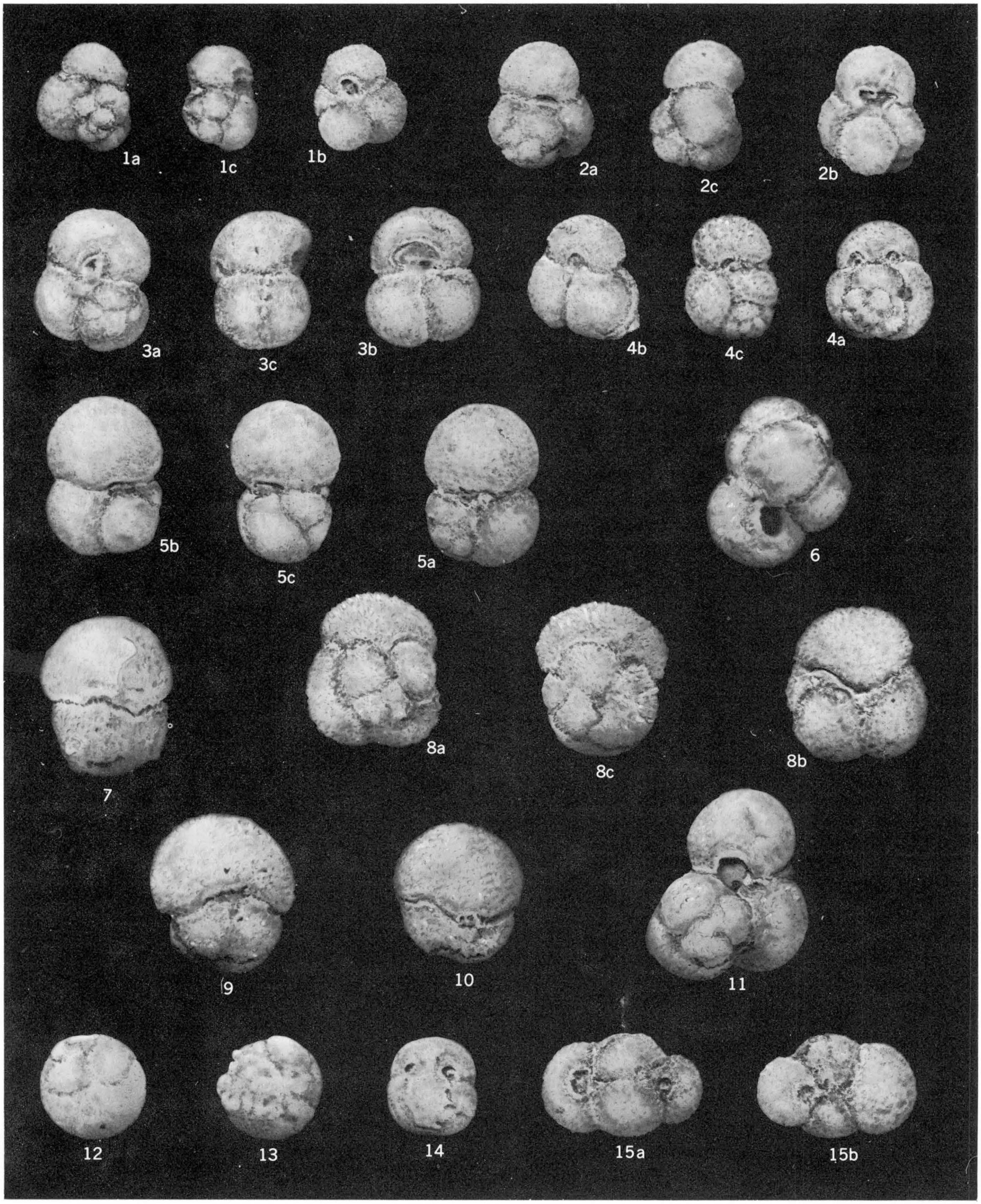
11. *Globigerinoides sacculifer* (Brady) (p. 20).
USNM 688825, × 50; sample F3560 (1,450 ft).

12. *Orbulina suturalis* Bronnimann (p. 20).
USNM 688826, × 50; sample F3560 (1,450 ft).

13. *Globigerinatella insueta* Cushman and Stainforth (p. 19).
USNM 688810, × 50; sample F3537 (510 ft).

14. *Globigerinoides diminutus* Bolli (p. 20).
USNM 688820, × 65; sample F3552 (1,190 ft).

15. *Globigerina helicina* d'Orbigny (p. 19).
USNM 688790, × 65; sample F3527 (30 ft). *a, b,* Opposite sides.



PLANKTONIC SMALLER FORAMINIFERA FROM ST. CROIX, VIRGIN ISLANDS

PLATE 12

[*a*, Dorsal view; *b*, ventral view; *c*, edge view. All are from test well No. 1, except as indicated; depths are approximate]

FIGURES 1, 2. *Globorotalia acostaensis* Blow (p. 20).
1. USNM 688811, × 65; sample F3537 (510 ft).
2. USNM 688828, × 65; test well No. 2, sample F3564 (100 ft).

3. *Globorotalia mayeri* Cushman and Ellisor (p. 20).
USNM 688805, × 50; sample F3529 (100 ft).

4. *Globorotalia fohsi* Cushman and Ellisor (p. 20).
USNM 688806, × 50; sample F3532 (280 ft).

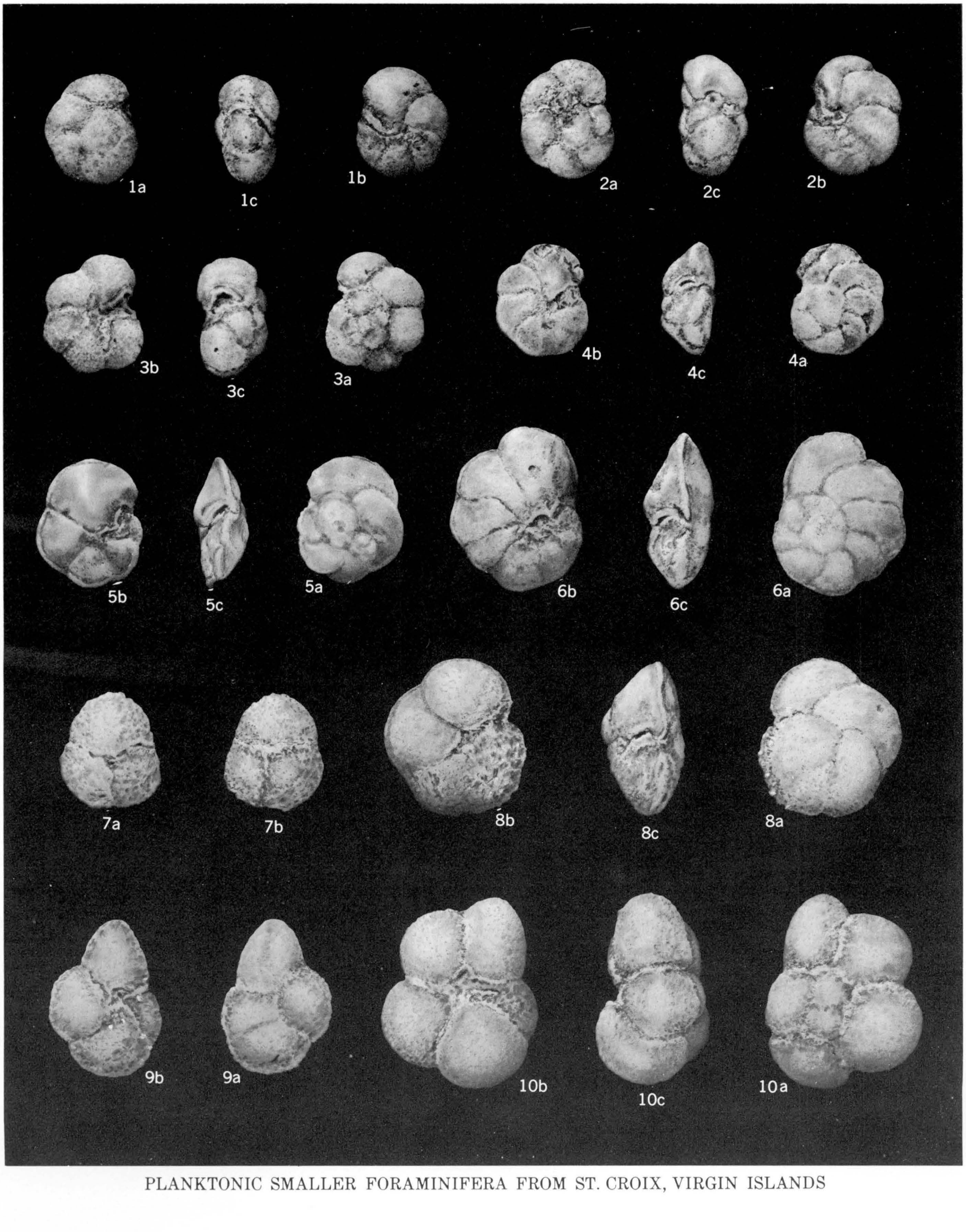
5. *Globorotalia archeomenardii* Bolli (p. 20).
USNM 688809, × 50; sample F3534 (370 ft).

6. *Globorotalia fohsi lobata* Bermúdez (p. 20).
USNM 688795, ×50; sample F3527 (30 ft.)

7, 9. *Sphaeroidinella seminulina* (Schwager) (p. 20).
7. USNM 688799, × 50; sample F3527 (30 ft).
9. USNM 688798, × 50; sample F3527 (30 ft).

8. *Globorotalia miozea* Finlay (p. 20).
USNM 688796, × 50; sample F3527 (30 ft).

10. *Sphaeroidinella kochi* (Caudri) (p. 20).
USNM 688797, × 50; sample F3527 (30 ft).



PLANKTONIC SMALLER FORAMINIFERA FROM ST. CROIX, VIRGIN ISLANDS