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# Late Paleogene (Late Eocene and Oligocene) benthonic foraminiferal biostratigraphy and paleobathymetry of Rockall Bank and Hatton-Rockall Basin

### ABSTRACT

Oligocene benthonic foraminiferal assemblages from Rockall Bank (Deep Sea Drilling Project Site 117) and Hatton-Rockall Basin (DSDP Site 116), are recorded, compared, and discussed. A small Upper Eocene assemblage at Site 116 is also recorded. Dominant Late Eocene elements include *Nuttallides truempyi* (Nuttall) and *Osangularia* sp. There is a marked faunal similarity between the sites in the Oligocene. Dominant elements are *Heterolepa mexicana* (Nuttall), *Siphonina tenuicarinata* (Cushman), and *S. advena* (Cushman), and common accessory species include *Planulina renzi* Cushman and Stainforth, *P. marialana* Hadley, *Gyroidinoides girardanus* (Reuss), *Oridorsalis ecuadorensis* (Galloway and Morrey), and *Cibicidoides trincherasensis* (Bermúdez). Sporadic but persistent occurrences of stilostomellids, pleurostomellids, and uvigerinids support previous interpretations of a middle bathyal depth of deposition during the late Paleogene at these two sites. Neritic faunal elements characteristic of the Oligocene of northwestern Europe occur in the Upper Oligocene of Hole 117, together with the normal bathyal fauna, and may reflect episodic tectonic movements on the western flank of Rockall Bank.

### INTRODUCTION

The present paper is one of a series resulting from a joint research project between the Woods Hole Oceanographic Institution and the Micropaleontological Laboratory of the Société Nationale des Pétroles d'Aquitaine (S.N.P.A.) in Pau, France. It is our intent to examine the biostratigraphic ranges and the biogeographic and paleogeographic distribution patterns of Cenozoic benthonic foraminifera in the circum-Atlantic-Caribbean and Mediterranean regions, as well as in the Atlantic Ocean itself from the inner shelf to abyssal depths. The initial phase of this study was concerned with the Paleocene and Early Eocene (Berggren, 1974). Here we present the results of a study of the Late Paleogene (Late Eocene-Oligocene) benthonic foraminifera of Rockall Bank and Hatton-Rockall Basin.

### GEOLOGIC AND GEOPHYSICAL SETTING

A summary of the geologic and geophysical setting of Hatton-Rockall Basin and Rockall Bank, as well as geographic, bathymetric, and paleogeographic maps, was presented in an earlier paper (Berggren, 1974) dealing with the early Paleogene benthonic foraminifera of this area. The reader is referred to this source as well as to the discussion in Laughton, Berggren, *et al.* (1972, chap. 8) for further details of the geologic history of this region. It was shown (Laughton, Berggren *et al.*, 1972; Berggren, 1975) that Rockall Plateau subsided to about 200 m. below sea level between  $t = \sim 56-53$  m.y. ago and to depths in excess of 600 m. by 51 m.y. ago from a Late Paleocene subaerial level. In this paper we present additional data bearing upon the subsequent (Late Paleogene) subsidence history of Rockall Plateau and Hatton-Rockall Basin.

### BIOSTRATIGRAPHY AND BIOCHRONOLOGY

#### General

Site 116 was drilled on the east side of the Hatton-Rockall Basin in 1151 m. of water. Site 117 was drilled some 37 km. east of Site 116 in 1038 m. of water, at the boundary between the Hatton-Rockall Basin and Rockall Bank, where it was thought possible to obtain a stratigraphic section in continuity with the lowest level sampled at Site 116 (Upper Eocene) and extending down to basement. As it turned out, the Upper Eocene is missing at Site 117, Lower Oligocene limestones lying unconformably on top of Lower Eocene brown clays and silts (Laughton, Berggren, *et al.*, 1972, chap. 8).

The Upper Paleogene sedimentary sequence cored at Site 116 represents the Oligocene and Upper Eocene (see text-figure 1). The Upper

Core data and stratigraphic relationships between Site 116 and Site 117. A. Stratigraphic correlation of the Oligocene. B. Paleogene unconformity and inferred paleobathymetry.

scribed by Berggren (1974; see also Laughton, Berggren, *et al.*, 1972, chap. 8; Berggren, 1972). This paper is concerned with Late Paleogene (Oligocene) faunas of Sites 116 and 117.

The biostratigraphic framework for the stratigraphic correlations of the Paleogene sediments at Sites 116 and 117 shown in text-figure 1 is based on age determinations of calcareous nannoplankton (taken on DSDP

TABLE 1

Biostratigraphic basis for age determinations and correlations shown in text-figure 1. Data from Laughton, Berggren, *et al.*, 1972, and reexamination of foraminiferal material.

## SITE 116

CORE NO.	AGE		
	N	F	R
17	NN1		Calo-cycletta virginis
18	NN1*	LATE P22 OR EARLY N4	
19	—	—	
20	—	LATE P22 OR EARLY N4	Lych. bipes
21	NP25*	P21b	—
22	—	—	—
23	Erica. obruta	P19/20	—
24		P18-	—
25	NP22*	P19/20	—
26	D. * bar-bed		—
27	NP19	P16-P17	—
28	D. * bar-bed		—

\* = BUKRY (SHORE-LAB REPORT)

— = NO ZONAL DETERMINATION POSSIBLE

## SITE 117

CORE NO.	AGE		REMARKS
	N	F	
1	—	?P21	
2	?NP25*	P21 (?P21b)	
3	1 117A	?NP23-24 NP25	P19/20

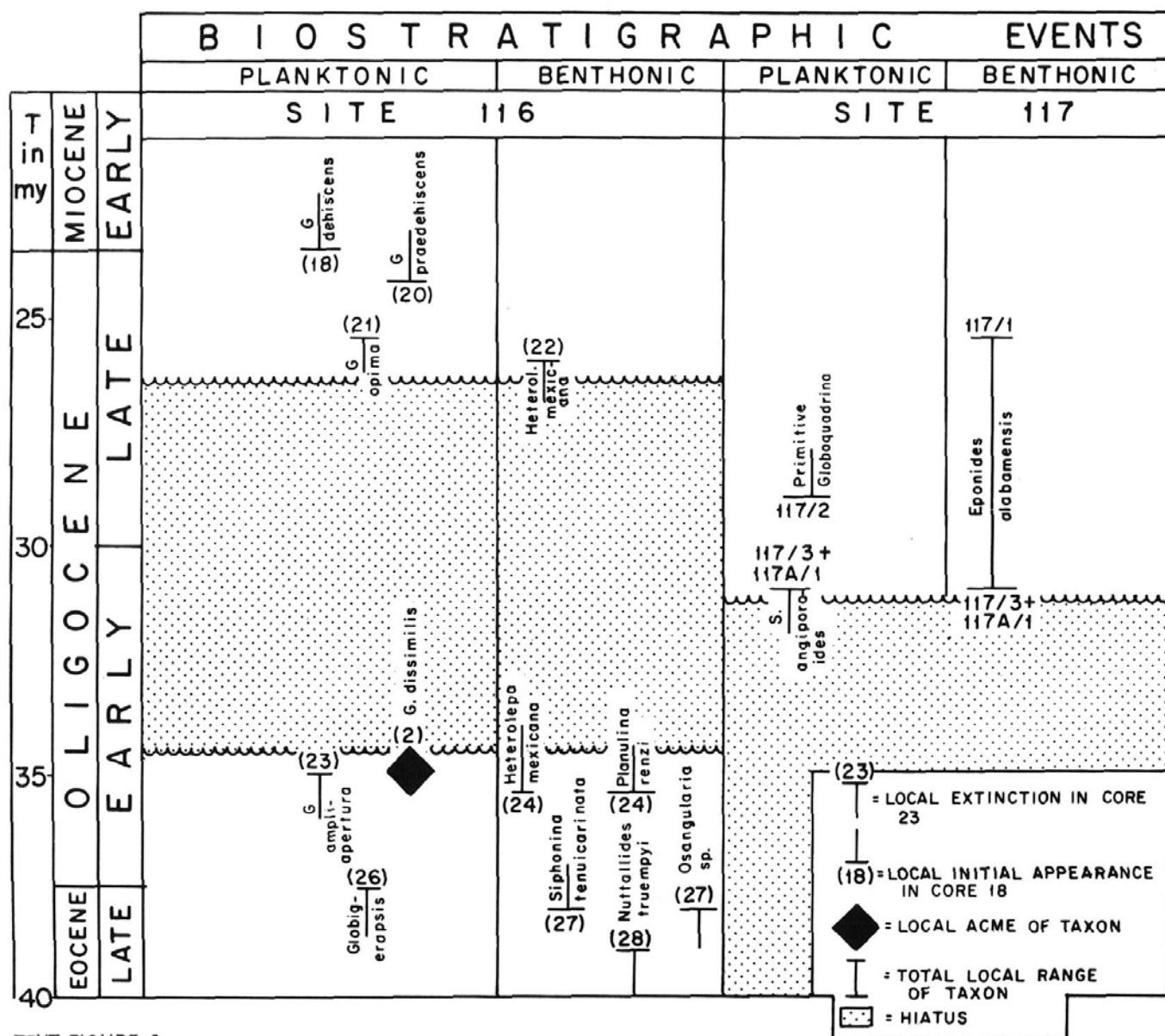
COMMON OCCURRENCE OF *Subbotina angiporoides* IN UPPER PART OF 117/3 AND 117A/1 INDICATES PRESENCE OF P19/20 AND LEADS TO REJECTION OF NANNO. ZONE NP25 (UPPER OLIGOCENE) DATE BY BUKRY. THIS LEVEL IS MORE PROBABLY EQUIVALENT TO NANNO. ZONE NP23 AS QUESTIONABLY INDICATED BY PERCH-NIELSEN.

Leg 12 and supplemented by shore laboratory studies), planktonic foraminifera (supplemented by current reevaluation), and Radiolaria (table 1). Attention is directed to several points:

The unconformity at about 146–147 m. (subbottom) at Site 117 separates sediments of Early Eocene age (*Marthasterites tribrachiatus* Zone) from those of Early Oligocene age (probably the *Sphenolithus predistentus* Zone). This statement is supported by the common occurrence of *Subbotina angiporoides* (Hornibrook) in the upper part of 117/3 and 117A/1 which indicates the presence of planktonic foraminiferal zone P19/20. The Lower/Upper Oligocene boundary is here interpreted as coinciding closely with the extinction of *Subbotina angiporoides* and *S. ampliapertura* (Bolli) and the initial appearance of *Globorotalia opima opima* Bolli and *Globigerina angulicentralis* Bolli. Thus the intra-Paleogene unconformity spans an interval of about 20 m.y. (~51–52 m.y. to ~31–32 m.y.).

The Oligocene/Miocene boundary at Site 116 was placed between Core 18 and Core 19 (~700 m.) based on the presence of calcareous nannoplankton zone NN1 and the initial appearance of *Globoquadrina dehiscens* (Chapman, Parr, and Collins) in Core 18 (see

Laughton, Berggren, *et al.*, 1972, chap. 8, pp. 418–424; table 1 this paper). The Lower/Middle Miocene boundary (= *Orbulina* Biohorizon) was identified within Core 10 (~510 m.). The extension of calculated Early Miocene sedimentation rates [~3 cm./1000 years (uncorrected) or 4 cm./1000 years (corrected)] to the section below the Miocene (*i.e.*, below ~700 m.) would indicate that the Oligocene should have a thickness of about 425 m. The Eocene/Oligocene boundary, however, was cored at 825 m. (between Core 25 and Core 26), and thus the Oligocene is seen to have a thickness of about 125 m. at Site 116, which implies an average sedimentation rate of ~1.0 cm./1000 years for the Oligocene as a whole. Biostratigraphic data indicate, on the other hand, a slightly greater rate of sedimentation during parts of the Oligocene than during the Miocene (a drastically slower rate is needed to accommodate the entire Oligocene in the ~125 m. between 700 and 825 m.). Downward extrapolation from the Oligocene/Miocene boundary at ~700 m. and upward extrapolation from the Eocene/Oligocene boundary at ~925 m., together with the biostratigraphic data on the Oligocene cores, indicate the probable presence of an intra-Oligocene unconformity at about 740 m. (midway between Core



TEXT-FIGURE 2

Intra-Oligocene biochronology at Sites 116 and 117.

22 and Core 23; see text-figures 1 and 2), representing a stratigraphic interval of about 300 m. and a geochronologic interval of about 10 m.y. (~35–25 m.y.). Thus it would appear that the upper surface of the unconformity is not the same age at Site 116 and Site 117.

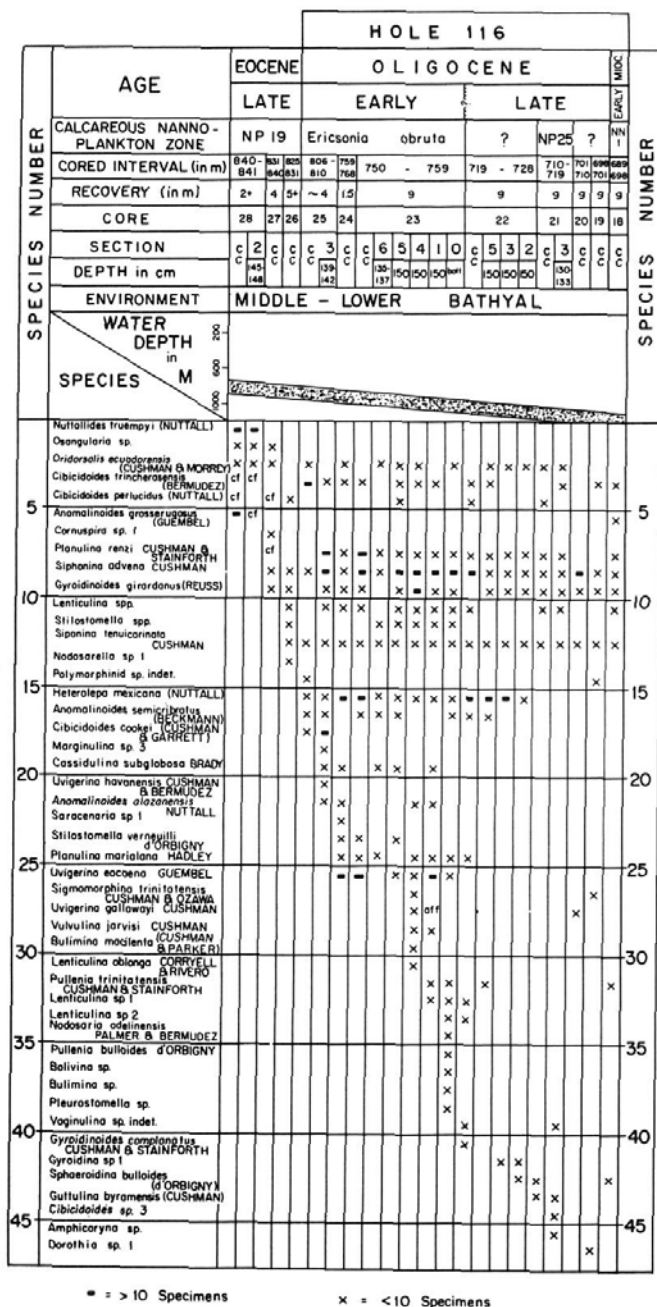
The Upper Oligocene is apparently more complete at Site 117 than at Site 116 (see text-figures 1, 2). Upward extrapolation of Late Oligocene sedimentation rates at Site 117 suggest that the Oligocene/Miocene boundary may be situated in the uncored interval between the sea floor and 50 m., and this is shown in text-figure 1).

In summary, then, the late Paleogene stratigraphic section at Site 116 spans the interval between ~40–35 m.y. and ~25–23 m.y.; that at Site 117 spans the interval between ~32–25 m.y. It is with these intervals that the discussion below on benthonic foraminiferal biostratigraphy and paleoecology is concerned.

#### Benthonic foraminifera

The material from Cores 18–28, Hole 116, Cores 1–3, Hole 117, and Core 1, Hole 117A, was examined in greater detail than was originally possible for the "Initial reports of the Deep Sea Drilling Project, volume 12" (Laughton, Berggren, *et al.*, 1972; Berggren, 1972). In general, specimens were picked from





TEXT-FIGURE 3

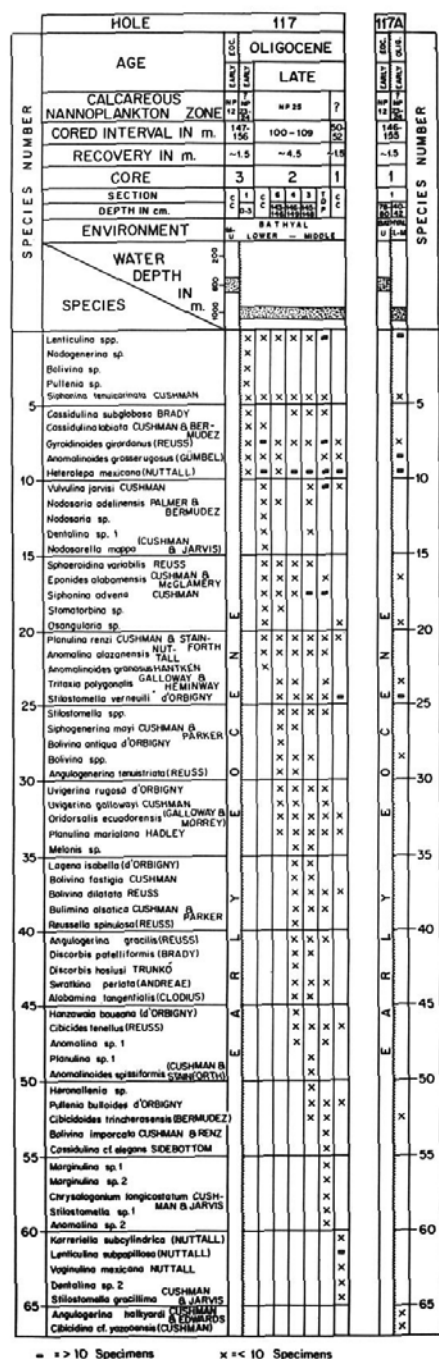
Stratigraphic distribution of benthonic foraminifera in the Upper Eocene-Oligocene of Hole 116.

the 0.149- $\mu$  (100-mesh) screen, but, in the case of stratigraphically important, paleoecologically characteristic, or taxonomically distinct taxa, specimens were picked from smaller screen sizes as well. This proved to be of particular importance in the Upper Oligocene of Hole 117 (Core 2; see discussion below). Because of the indurated nature of the Oligocene at Site 116 and the size range (5 cm.<sup>3</sup> to over 25 cm.<sup>3</sup>) of the

sample, quantitative estimates of relative and absolute taxonomic abundance were not possible, as was also the case with the Upper Paleocene-Lower Eocene benthonic foraminifera at Site 117 (Berggren, 1975). Semi-quantitative estimates based on visual estimates of the dominant taxa were possible, and these are noted in the appropriate places in the discussion below as well as in the figures showing the stratigraphic distribution of taxa. Sporadic absences of forms with a demonstrably long range are probably a function of sample size, as the number of specimens in a given sample has been found to be roughly proportional to sample size. Thus the core-catcher samples have been found to be the most useful for determining the distribution of benthonic taxa, and, indeed, close scrutiny and restudy of the relatively scarce faunas in the samples between core catchers have added little to the data garnered from examination of the core-catcher samples.

The stratigraphic distribution of benthonic foraminiferal taxa recorded at Sites 116 and 117 is shown in text-figures 3 and 4. Approximately 45 species have been recognized in Hole 116 (29 identified, 16 are left in open nomenclature, and two include several indeterminate species, either small or fragmentary in nature). At Site 117 about 65 species have been recognized (47 identified, 18 left in open nomenclature, and two include several indeterminate species, as above). Of the identified species approximately a third are common to both sites; several of the unidentified forms are also apparently identical.

The dominant taxa at both sites are *Heterolepa mexicana* (Nuttall) and *Siphonina tenuicarinata* (Cushman). Quantitatively common accessory species include *Gyroidinoides girardanus* (Reuss), *Oridorsalis ecuadorensis* (Galloway and Heminway), *Planulina renzi* Cushman and Stainforth, *P. marialana* Hadley, and *Cibicides trinceransensis* (Bermúdez). *Vulvulina jarvisi* Cushman occurs in Hole 17 and in Core 23 of Hole 116. Of particular interest is the frequent occurrence of *Eponides alabamensis* Cushman and McGlamery at Site 117; it was not observed in Hole 116. It has probably been displaced from shallower (neritic) depths, as it would not be expected to occur normally in a mid-lower bathyal environment as represented here. *Stilostomella* are common at both sites, and *Stilostomella verneuili* d'Orbigny, in particular, is a common form at Site 117. Several types of uvigerinids have been recorded: costate [*Uvigerina eocaena* Gumbel = *U. mexicana* Nuttall; *U. gallowayi* (Cushman)], striate [*U. havanensis* Cushman and Bermúdez], and hispid [*U. rugosa* (d'Orbigny)]. The occurrence of uvigerinids is sporadic at the two sites,



TEXT-FIGURE 4

Stratigraphic distribution of benthonic foraminifera in the Oligocene of Site 117.

but *U. eocaena* occurs commonly in Cores 23 and 24 (Lower Oligocene) of Hole 116.

The Upper Eocene in Hole 116 is characterized by relatively rich benthonic foraminiferal faunas, but individual specimens are broken or corroded, or both, and specific determination is virtually impossible for the most part. Two forms, however, occur commonly which

do not extend into the Oligocene: *Nuttallides truempyi* (Nuttall) and *Osangularia* sp. These two forms are restricted to the Upper Eocene in Hole 116, and their extinction here serves as a reliable guide to the recognition of the Eocene Oligocene boundary.

Although there is a marked similarity between the Oligocene benthonic foraminiferal fauna at Site 116 and that at Site 117, a distinctly different faunal assemblage occurs (in addition to the "indigenous" fauna) in Core 2 of Hole 117 (see text-figure 4). Among the forms that occur here are:

*Svratkina perlata* (Andreae)  
*Alabamina tangentialis* (Clodius)  
*Angulogerina gracilis* (Reuss)  
*Angulogerina halyardii* Cushman and Edwards  
*Angulogerina tenuistriata* (Reuss)  
*Bolivina antiqua* d'Orbigny  
*Bolivina dilatata* Reuss  
*Bolivina fastigia* Cushman  
*Bolivina imbecilis* Cushman and Renz  
*Bulimina alsatica* Cushman and Parker  
*Cibicides tenellus* (Reuss)  
*Discorbis hosi* Trunko  
*Discorbis patelliformis* (Brady)  
*Hanzawaia boueana* (d'Orbigny)  
*Lagena isabella* (d'Orbigny)  
*Reussella spinulosa* (Reuss)  
*Uvigerina rugosa* d'Orbigny

These species constitute a part of the distinct, shallow-water (< 200 m.) Oligocene assemblages characteristic of northwestern Europe (Reuss, 1863, 1870; Schlicht, 1870; Batjes, 1958; Kümmerle, 1963; Grossheide and Trunko, 1965; Butt, 1966, among others). These forms occur in Hole 117 only in the fine fraction; no normal (adult-sized) specimens have been found in the larger (0.149- $\mu$ ) sized fraction.

There would appear to be three possible explanations for this occurrence:

- 1) The small fauna is indigenous at this level, implying a large depth distribution range, if a depth of deposition of about 1000 m. be assumed.
- 2) The large fauna is not indigenous, but the small specimens are, which indicates a marked shallowing of the site followed by rapid sinking again.
- 3) The small fauna has been displaced from shallower depths.

If the first explanation were true, one would expect these faunal elements to occur throughout the Oligocene at both Site 116 and Site 117; however, they are restricted to Core 2, Hole 117. Geologic-tectonic (seismic) considerations (Laughton, Berggren, et al., 1972) rule out the second explanation. There is continuity of the other faunal elements that are characteristic of bathyal depths (*Heterolepa*, *Cibi-*

*doides*, *Planulina*, *Stilostomella*), suggesting that the fauna has been displaced by currents from shallower depths farther upslope on Rockall Bank. Winnowing processes may have resulted in the selective transportation and deposition in Core 2 (Hole 117) of the smaller specimens. The mixed faunal association in Core 2 (Hole 117) has yielded, fortuitously, an insight into the nature of two assemblages (shelf and mid-lower bathyal) which would have been, under normal conditions, areally separated.

In general the stratigraphic distribution of benthonic foraminiferal taxa in Sites 116 and 117 is similar to that recorded by Douglas (1973) from the Paleogene of the central North Pacific. As Douglas (1973, p. 620) and one of us (Berggren, *in* Berggren and Phillips, 1971; Berggren, 1972) have pointed out, there is a marked similarity between the Eocene and Oligocene deep-water (bathyal) benthonic foraminiferal faunas of the Caribbean-West Indies, Mediterranean, North Atlantic, and Pacific. The cosmopolitan nature of Paleogene deep-water faunas is one of its distinguishing characters and is paralleled by a similar distribution pattern on the part of neritic (*i.e.*, shelf-dwelling) faunas (Berggren and Aubert, 1975).

#### PALEOBATHYMETRY

A variety of evidence (micropaleontologic, sedimentologic, petrologic) was used in interpreting the subsidence history of Rockall Plateau (Laughton, Berggren, *et al.*, 1972, chap. 8). In particular, studies on the ostracod (R. H. Benson), bryozoan (A. H. Cheetham and E. Håkansson), and foraminiferal (W. A. Berggren and J. E. Van Hinte) faunas were evaluated in attempts to determine the sequential history of subsidence.

There is a notable discrepancy between paleodepths estimated on the basis of ostracode studies and those based on bryozoan studies. The latter yielded consistently shallower depths at the same level at Site 117. Whereas ostracodal studies suggested Oligocene water depths comparable to those of today, the bryozoans suggested water depths of between 150 and 200 m. in the mid-Oligocene (~30 m.y. ago) and 200–600 m. during the Late Oligocene (~25 m.y. ago). Our own investigations support the ostracodal depth estimates made by Benson (*in* Laughton, Berggren, *et al.*, 1972, p. 427). The Oligocene benthonic foraminiferal fauna is essentially identical at Sites 116 and 117 and implies comparable environments of deposition and depth of water. The fauna consists of a number of species of the genera *Gyroidinoides*, *Oridorsalis*, *Planulina*, *Cibicides*, *Vulvulina*, *Siphonina*, *Heterolepa*, *Stilostomella*, and *Uvigerina*, which are commonly associated with

mid-Cenozoic, bathyal-abyssal deposits in the circum-Caribbean and Mediterranean region. An interpretation of Oligocene water depths comparable to those of today (~1000 m.) is fully consonant with the available data.

The data obtained by geologists on DSDP Leg 12 suggested that Site 116 probable underwent progressive subsidence from middle bathyal depths in Early Oligocene time to present depths during the Early-Middle Miocene (Laughton, Berggren, *et al.*, 1972, p. 453). At Site 117 subsidence began soon after near-shore neritic sediments were deposited (~56 m.y. ago). By Early Eocene (51 m.y. ago) the basement had subsided to a depth of 600–700 m. at a mean rate of 14 cm./1000 years. Extension of this rate to the present basement depth of 1350 m. indicates that subsidence would have ceased in the Middle Eocene (47 m.y. ago). On the other hand the subsidence rate may have decreased or stopped during the Early Eocene, and renewed tectonic activity may have brought it to its present depth. In this latter case the depth interpretation of the ostracodes would take precedence over that of the bryozoans. The steplike bottom and subbottom topography of the west flank of Rockall Bank (Laughton, Berggren, *et al.*, 1972, text-fig. 10) suggests that faulting was widespread in the region, and several episodes of tectonic activity are likely to have occurred at Site 117. The presence of a (apparently transported) neritic benthonic foraminiferal fauna in the Upper Oligocene of Hole 117 may be a reflection of such episodic tectonic activity.

Available evidence suggests that substantial relative vertical movement occurred between Site 116 and Site 117. Inferred Oligocene paleodepths (based on faunal evidence) are similar, so that the differential subsidence was Early Miocene or younger. In conclusion, Rockall Plateau appears to be a continental fragment that became detached from Greenland about 60 m.y. ago and subsequently subsided by at least 1400 m., and probably by as much as 2500 m. in the center (Laughton, Berggren, *et al.*, 1972, chap. 8).

#### TAXONOMIC NOTES

A thorough taxonomic discussion of the Late Eocene and Oligocene benthonic foraminifera of Rockall Bank and Hatton-Rockall Basin is beyond the scope of this article. We present, instead, a brief discussion of several species the taxonomy or general occurrence of which is pertinent to the theme of this paper. Two distinct assemblages have been found: an indigenous bathyal fauna at both Site 116 and Site 117 and a shallow-water, displaced fauna at Site 117. Elements of these two faunas are discussed separately.

***Vulvulina jarvisi*** Cushman, 1932

Plate 1, figure 1

*Vulvulina jarvisi* CUSHMAN, 1932, p. 84, pl. 10, fig. 20.—BERMÚDEZ, 1938, p. 26.—CUSHMAN and STAINFORTH, 1945, p. 16, pl. 1, fig. 27.—CUSHMAN and RENZ, 1947, p. 5, pl. 1, fig. 12.

**Remarks:** This form exhibits strong variability in which the early biserial part may be reduced or extended. The Rockall Bank material consists almost exclusively of specimens with an early biserial part (about one-third of the length of the test) followed by an extended uniserial sequence of chambers. It has been recorded widely in mid-Tertiary sediments of the Atlantic-Caribbean region by various authors. *Vulvulina granulosa* Finlay, 1947, from the Oligocene of New Zealand appears to be a closely related, if not synonymous, form. *Vulvulina jarvisi* occurs sporadically in the Oligocene at Rockall Bank.

***Karrerella subcylindrica*** (Nuttall), 1928

Plate 1, figure 2

*Gaudryina subcylindrica* NUTTALL, 1928, p. 76, pl. 3, figs. 17–18. *Karrerella subcylindrica* (Nuttall).—CUSHMAN and STAINFORTH, 1945, p. 18, pl. 2, fig. 11.—BERMÚDEZ, 1949, p. 91, pl. 3, figs. 21–24.

**Remarks:** Originally described from the (subsurface) Naparima Marl of Trinidad, this species has been widely recorded in Caribbean localities.

***Tritaxia polygonalis*** (Galloway and Heminway), 1941

Plate 1, figure 3

*Clavulinoides polygonalis* GALLOWAY and HEMINWAY, 1941, p. 327, pl. 7, fig. 4.

**Remarks:** This species was originally described from the Quebrellas Formation of Puerto Rico. It has, characteristically, a relatively small test with short, initial, triangular, triserial section and an elongate, essentially parallel-sided test which tapers abruptly at the apical end to a rounded terminal part with a polygonal-shaped aperture. The agglutinated test is relatively smooth, and the sutures are obscure. This form occurs rarely at Site 117.

***Vaginulinopsis mexicana*** (Nuttall), 1932

Plate 1, figure 4

*Vaginulina elegans mexicana* NUTTALL, 1932, p. 16, pl. 3, figs. 12, 16. *Vaginulina mexicana* Nuttall.—BERMÚDEZ, 1949, p. 156, pl. 9, fig. 38.

**Remarks:** Originally described from the Alazan Formation (Oligocene) of Mexico, this large, robust form has been widely recorded among Late Paleogene and Neogene faunas, particularly in the Caribbean region.

***Stilostomella gracillima*** (Cushman and Jarvis), 1934

Plate 1, figure 5

*Ellipsonodosaria nuttalli* Cushman and Jarvis, var. *gracillima* CUSHMAN and JARVIS, 1934, p. 72, pl. 10, fig. 7.—CUSHMAN and STAINFORTH, 1945, p. 56, pl. 9, figs. 14, 15.

*Siphonodosaria nuttalli* (Cushman and Jarvis) var. *gracillima* (Cushman and Jarvis).—BERMÚDEZ, 1949, p. 226, pl. 14, figs. 22, 23.

**Remarks:** See below under *Stilostomella verneuili* (d'Orbigny).

***Stilostomella verneuili*** (d'Orbigny), 1846

Plate 1, figure 6

*Dentalina verneuili* D'ORBIGNY, 1846, p. 48, pl. 2, figs. 7, 8.

*Siphonodosaria verneuili* (d'Orbigny).—BERMÚDEZ, 1949, p. 227, pl. 14, fig. 24 (see additional synonymy).

**Remarks:** *Stilostomellids* occur sporadically, and are generally broken or poorly preserved, or both, in the Rockall Oligocene sequence. Two well-preserved specimens are figured here: the delicate, sinuous *Stilostomella gracillima* and the robust, relatively broad *verneuili*. These forms are characteristic of late Paleogene and Neogene bathyal assemblages.

***Siphonina advena*** Cushman, 1922

Plate 1, figures 10–13

*Siphonina advena* CUSHMAN, 1922, p. 98, pl. 22, figs. 1–2.—GALLOWAY and HEMINWAY, 1941, p. 402, pl. 26, fig. 1.—BERMÚDEZ, 1949, p. 243, pl. 16, figs. 28–30.

**Remarks:** This is a relatively common form in the Oligocene at Rockall Bank. It was originally described from the Byram Marl (Vicksburg Group) of Mississippi and is a common form in the Caribbean and Atlantic Late Paleogene-Neogene assemblages, particularly of bathyal depths. It is characterized by a subacute peripheral margin from which a keel is absent or on which a keel is only poorly developed as a thickened rim.

***Siphonina tenuicarinata*** Cushman, 1927

Plate 4, figure 26

*Siphonina tenuicarinata* CUSHMAN, 1927, p. 166, pl. 26, figs. 11, 12.—BERMÚDEZ, 1949, p. 244, pl. 16, figs. 37–39.—BERGGREN, 1972, pl. 10, figs. 12, 13.

**Remarks:** This species was originally described from the Alazan Formation (Oligocene) of Mexico. It is characterized by its sharply acute, keeled periphery, moderate to large-sized test (up to 0.6 mm. in diameter), and by having nearly straight, radial sutures on the apertural side and gently curving, tangential sutures on the spiral side. It is a common component of the Rockall Oligocene-Early Miocene faunas (see Berggren, 1972). A small specimen found together with displaced elements is figured here, but the bathymetric distribu-



tion of this form appears to have been primarily bathyal.

***Heterolepa mexicana*** (Nuttall), 1932

Plate 2, figures 1–3

*Cibicides mexicanus* NUTTALL, 1932, p. 33, pl. 9, figs. 7–9.—BERMÚDEZ, 1949, p. 302, pl. 26, figs. 13–15.

*Heterolepa mexicana* (Nuttall).—BERGGREN, 1972, p. 994, pl. 10, figs. 2–4.

**Remarks:** This is one of the two dominant benthonic foraminiferal species in the Oligocene at Rockall Bank. It is characterized by its relatively large size and smooth and strongly convex umbilical side; the earlier whorls on the spiral side are depressed below a sharp peripheral rim. This form is widespread in Oligocene bathyal sediments in the Atlantic, Caribbean, and Mediterranean regions.

***Cibicidoides trincherasensis*** (Bermúdez), 1949

Plate 2, figures 4–6

*Cibicides trincherasensis* BERMÚDEZ, 1949, p. 307, pl. 25, figs. 1–3.—BERGGREN, 1972, p. 994, pl. 10, fig. 1.

**Remarks:** Originally described from the Oligocene (Trinchera Formation) of the Dominican Republic, this species is characterized by a plano-convex test, subacute but unkeeled peripheral margin, 10–12 chambers in the last whorl, and gently curving sutures on both sides. This is a stratigraphically persistent and relatively common form in the Oligocene at Rockall Bank.

***Anomalinoides semicribratus*** (Beckmann), 1954

Plate 2, figure 11

*Anomalina pompilioides* Galloway and Heminway, var. *semicribrata* n. var. BECKMANN, 1954, p. 400, pl. 27, fig. 3, text-figs. 24, 25.

*Anomalinoides semicribrata* (Beckmann).—BERGGREN and AUBERT, 1976, pl. 4, figs. 12, 13.

**Remarks:** Originally described from the Upper Eocene Oceanic Formation of Barbados, this form has recently been recorded from the Middle Eocene of the Labrador Sea (Berggren and Aubert, 1976). It is characterized by the coarse pores on the umbilical side and the relatively smooth spiral side.

***Anomalinoides alazanensis*** (Nuttall), 1932

Plate 2, figures 14–17

*Anomalina alazanensis* NUTTALL, 1932, p. 31, pl. 8, figs. 5–7.—BERMÚDEZ, 1949, p. 288, pl. 22, figs. 44–46.

**Remarks:** Originally described from the Oligocene of Mexico, this is one of the most common anomalinids in the Oligocene of the Atlantic-Caribbean region. It is characterized by an involute test with finely perforate umbilical and coarsely perforate spiral sides, and thin,

moderately curved sutures, those on the umbilical side being somewhat sinuous and thickened. The umbilical region is, in some instances, partially occluded by a relatively transparent, semi-opaque plug. At Rockall Bank this form is stratigraphically persistent and relatively common.

***Nuttallides truempyi*** (Nuttall), 1930

Plate 2, figures 12–13

*Eponides truempyi* NUTTALL, 1930, pp. 274, 287, pl. 24, figs. 9, 13, 14.—BERMÚDEZ, 1949, p. 249, pl. 17, figs. 16–18.

*Nuttallides truempyi* (Nuttall).—BERGGREN, 1972, pl. 12, figs. 1–3.—DOUGLAS, 1973, pp. 662, 668, pl. 21, figs. 4–6, pl. 24, figs. 1, 2.—BERGGREN and AUBERT, 1976, pl. 4, figs. 3, 4.

**Remarks:** This is one of the most distinctive bathyal species in Paleogene assemblages. It occurs commonly (although specimens are mostly broken) in the Upper Eocene at Site 116 and in the Eocene of the Labrador Sea (Berggren, 1972; Berggren and Aubert, 1976) and has been recorded from the Eocene of the central North Pacific (Douglas, 1973). Its extinction serves as a useful marker in determining the approximate position of the Eocene/Oligocene boundary.

***Osangularia* sp.**

Plate 2, figures 20–21

**Remarks:** Poorly preserved or broken specimens of an osangulariid species occur commonly in the Upper Eocene at Site 116. The poor preservation inhibits comparison with *Osangularia granulosa* (Bykova) from the Eocene of the Labrador Sea (Berggren and Aubert, 1976), but the absence of definite evidence of a thick, peripheral keel and the granular texture of the test suggest that the forms seen at Rockall may be a different species.

***Planulina marialana*** Hadley, 1934

Plate 3, figures 3–4

*Planulina marialana* HADLEY, 1934, p. 27, pl. 4, figs. 4–6.—GALLOWAY and HEMINWAY, 1941, p. 339, pl. 25, fig. 4.—BERMÚDEZ, 1949, p. 291, pl. 23, figs. 28–30.

**Remarks:** Originally described from the Oligocene of Cuba, this species is characterized by its strongly curved, slightly depressed sutures (see remarks under *Planulina renzi* below). *Planulina marialana* is a stratigraphically persistent and relatively common form in the Oligocene at Rockall Bank.

***Planulina renzi*** Cushman and Stainforth, 1945

Plate 3, figures 5–7

*Planulina renzi* CUSHMAN and STAINFORTH, 1945, p. 72, pl. 15, fig. 1.—BERMÚDEZ, 1949, p. 292, pl. 23, figs. 31–33.—BERGGREN, 1972, p. 994, pl. 10, figs. 7, 8.



**Remarks:** This robust form, originally described from the Oligocene part of the Cipero Formation, Trinidad, is characterized by its strongly limbate raised sutures on the spiral side, numerous chambers, distinct peripheral keel, and coarsely perforate test. These characters serve to distinguish the species from *Planulina marialana* Hadley with which it is associated at Rockall Bank as well as elsewhere. This form has been recorded from numerous localities in the Atlantic-Caribbean region as well as the Mediterranean region. Douglas (1973) has recently recorded it from the Oligocene of the central North Pacific and indicates that it may be confined to the Oligocene. At Rockall Bank *P. renzi* is one of the most common and stratigraphically persistent forms in the Oligocene.

***Bulimina macilenta*** Cushman and Parker, 1939  
Plate 3, figures 8–9

*Bulimina macilenta* CUSHMAN and PARKER, 1939, p. 93.—CUSHMAN and PARKER, 1947, p. 98, pl. 23, figs. 2, 3.

**Remarks:** This form was originally described from the Eocene (Martinez Formation) of Ventura County, California, and is characterized by an ovate, smooth test, tapering sharply apically, with distinct crenulations along the sutural margins. The form has been reported widespread from uppermost Cretaceous through Oligocene levels. It occurs as a rare form at Rockall Bank and was also observed in the Eocene at Orphan Knoll (Labrador Sea; Berggren and Aubert, 1976).

***Uvigerina havanensis*** Cushman and Bermúdez, 1936  
Plate 3, figure 10

*Uvigerina havanensis* CUSHMAN and BERMÚDEZ, 1936, p. 59, pl. 10, figs. 19–21.

**Remarks:** This form belongs to the hispid-costate group of uvigerinids, more particularly to the *Uvigerina rippensis* species group which is characteristic of bathyal depths to over 1000 m. It is distinguished by its elongate, fusiform shape with long, low, costate ornament. Boersma (MS.) included *havanensis* within the *Uvigerina rippensis* species group and noted that forms in which the costae are broken into species have been identified as *spinicostata* Cushman and Jarvis; the name *havanensis* Cushman and Bermúdez is retained here. It occurs sporadically in the Oligocene at Rockall Bank.

***Uvigerina proboscidea*** Schwager, 1866  
Plate 3, figure 11

*Uvigerina proboscidea* SCHWAGER, 1866, p. 250, pl. 7, fig. 96.

**Remarks:** This species belongs to the hispid group of uvigerinids; the *Uvigerina proboscidea* group is

characteristic of water depths below 1000 m. The species is characterized by its hispid to finely spinose ornament. The shape varies markedly from short and squat to elongate; the test periphery is commonly strongly lobulate. A general tendency toward size increase in time within this group was noted by Boersma (MS.). The form occurs sporadically in the Oligocene at Rockall Bank.

***Uvigerina gallowayi*** Cushman, 1929  
Plate 3, figure 12

*Uvigerina gallowayi* CUSHMAN, 1929, p. 94, pl. 13, figs. 33, 34.—BOERSMA, MS., p. 49, pl. 12, figs. C–E.

**Remarks:** Originally described from the Oligocene of Ecuador, this form is characterized by a wide range of variation in test shape and surface ornament. These variants have been grouped under the name of "*Uvigerina gallowayi* Cushman Species Group" by Boersma (MS.). They include the "taxa" *bealli* Bermúdez and *rivasensis* Bermúdez (costae restricted to earlier chambers), *gallowayi basicordata* Cushman and Renz and *guayacanensis* Bermúdez (short, squat forms with strongly developed caudal costae), and *woodringi* Bermúdez (fusiform morphotypes). This form occurs sporadically in the Oligocene at Rockall Bank.

***Uvigerina laviculata*** Coryell and Rivero, 1940  
Plate 3, figures 13–14

*Uvigerina laviculata* CORYELL and RIVERO, 1940, p. 343, pl. 44, fig. 24.—BERMÚDEZ, 1949, p. 207, pl. 13, fig. 34.

**Remarks:** This species belongs to the "*Uvigerina laviculata* species group" (Boersma, MS.) which includes forms having fine to pronounced striae. Some forms are nearly smooth (*gaspensis* Bermúdez) or smooth with striae in the apical region (*carapitana* Hedberg). Similar finely striate forms with differing test shapes have been described as *finelineata* Keizer, *laeviapicata* Bermúdez, *flintii* Cushman, among others (see Bermúdez, 1949). This form occurs sporadically in the Oligocene at Site 117 and has the same distribution as *U. gallowayi* (it is not recorded in text-figure 4).

***Uvigerina eocaena*** Gümbel, 1868  
Plate 3, figures 15–18

*Uvigerina eocaena* GÜMBEL, 1868, p. 645, pl. 2, fig. 78a, b.—BOERSMA, MS., p. 44, pl. 2, figs. B–D.  
*Uvigerina havanensis* BERGGREN, 1972, pl. 8, figs. 10, 11 (non Cushman and Bermúdez).

**Remarks:** This species belongs to the group of costate uvigerinids characteristic of bathyal water depths. It is characterized by a broadly triangular test, tapering sharply at the apical end. Forms with large, distinct costae appear to have been identified as *Uvigerina*

*mexicana* Nuttall, whereas elongate forms with more continuous costae have been identified as *U. semivestita* Bermúdez. Several intergrading variants were grouped in this species by Boersma (MS.) who discussed the affinities of this group in greater detail. This form occurs together with *U. gallowayi* Cushman in bathyal deposits and may well be its progenitor (Boersma, MS.).

#### Displaced fauna

The forms discussed below appear to have been displaced from shallower depths into a bathyal environment. They constitute a significant faunal element in the Late Oligocene of Site 117. In addition to the forms discussed here, it is possible that other forms such as *Cibicidina yazooensis* (plate 2, figures 18, 19) and small cibicidids, cibicidinids, and bolivinids not specifically identifiable, but present in Site 117 material, may also have been displaced.

#### *Angulogerina halkyardi* Cushman and Edwards, 1937 Plate 4, figure 1

?*Uvigerina angulosa* Williamson.—HALKYARD, 1919, p. 100.  
*Angulogerina halkyardi* CUSHMAN and EDWARDS, 1937, p. 60, pl. 8, fig. 14a, b.  
? *Angulogerina angulosa* (Williamson).—KÜMMERLE, 1963, p. 43, pl. 6, fig. 2a, b.

**Remarks:** Cushman and Edwards (1937) noted that their new species *halkyardi* was characterized by a sharply triangular form, had distinct keels and a costate surface, and was probably the form recorded, but not illustrated, by Halkyard (1919) as "*Uvigerina angulosa* Williamson" from the Blue Marls of Biarritz. The specimen illustrated by Kümmerle (1963) from the Meeressand (Chattian) of Cassel, northwestern Germany, and assigned to *Angulogerina angulosa* (Williamson) is a smooth (non-striate) form and is doubtfully included here. "*Uvigerina angulosa* Williamson" is wholly striate and somewhat less angular in cross section than *Angulogerina halkyardi*.

#### *Angulogerina tenuistriata* (Reuss), 1870 Plate 4, figures 2–3

*Uvigerina tenuistriata* REUSS, 1870, p. 485.—KÜMMERLE, 1963, p. 41, pl. 6, fig. 1a–c.  
*Angulogerina tenuistriata* (Reuss).—CUSHMAN and EDWARDS, 1938, p. 84, pl. 15, figs. 1–9.—BHATIA, 1955, p. 682, pl. 66, fig. 18.  
*Angulogerina oligocaenica* CUSHMAN and EDWARDS, 1938, p. 86, pl. 15, figs. 9, 10.  
*Angulogerina gracilis* (Reuss) var. *tenuistriata* (Reuss).—BATJES, 1958, p. 136, pl. 6, fig. 5.

**Remarks:** Numerous small and striate specimens of *Angulogerina* from Site 117 are assigned to this species. They closely resemble the figures of Kümmerle (1963) who discussed the widespread distribution of

this species in shallow-water deposits of the Middle and Upper Oligocene in northern and central Europe.

#### *Uvigerina rugosa* d'Orbigny, 1852 Plate 4, figures 4–5

*Uvigerina rugosa* D'ORBIGNY, 1852, p. 194 [not figured].—FORNASINI, 1897, pl. 1, fig. 4; p. 11, tf. ("figure inedite di d'Orbigny rappresentanti l'*Uvigerina rugosa* del Tableau").—BUTT, 1966, p. 50, pl. 2, fig. 18.

**Remarks:** This species was originally described from the Pliocene of Italy. Our specimens are closely similar to the figures of d'Orbigny; they exhibit the same rugose surface and a final chamber with a stout neck.

#### *Bolivina* spp. Plate 4, figures 7–11

**Remarks:** Several small bolivinids have been observed in our material. They are consistently small and show evidence of abrasion or corrosion, or both, interpreted here as due to displacement from shallow water. The specimens illustrated here probably represent at least four different species, those shown on figures 9 and 10 of plate 4 probably being conspecific.

#### *Bolivina imporata* Cushman and Renz, 1941 Plate 4, figure 12

*Bolivina floridana* Cushman var. *regularis* CUSHMAN and RENZ, 1941, p. 17, pl. 3, fig. 7.  
*Bolivina floridana* Cushman var. *imporata* CUSHMAN and RENZ (nom. nov.), 1944, p. 78.—DROOGER, 1953, vol. 4, p. 130, pl. 21, figs. 7, 8.  
*Bolivina imporata* Cushman and Renz.—RENTZ, 1948, p. 118, pl. 7, fig. 3a–b.  
*Bolivina floridana* Cushman var. *imporata* Cushman and Renz.—BATJES, 1958, p. 132, pl. 8, fig. 13.

**Remarks:** Small specimens with the typical tapering test and longitudinal ridges have been assigned to this species. They are very rare in our material.

#### *Bolivina fastigia* Cushman, 1936 Plate 4, figures 13–14

*Bolivina fastigia* CUSHMAN, 1936, p. 51, pl. 7, fig. 17a, b.—CUSHMAN, 1937, p. 76, pl. 9, figs. 12–14.—MARKS, 1951, p. 59.—BHATIA, 1955, p. 684, pl. 66, fig. 15, text-fig. 5.—BATJES, 1958, p. 131, pl. 5, fig. 12.—KÜMMERLE, 1963, p. 44, pl. 6, fig. 3.—BUTT, 1966, p. 47, pl. 2, fig. 12.—ANDREIEFF *et al.*, 1974, p. 33, pl. 3, fig. 10.

**Remarks:** Originally described from the Upper Oligocene of north Germany, this form is one of the most representative bolivinids in the Upper Oligocene at Rockall. Although badly preserved, specimens have the characteristic subparallel sides, limbate sutures lobed near the longitudinal axis of the test, and the median longitudinal ridge and branching ribs, particularly on the earlier part of the test. The test is coarsely punctate.

**Heronallenia** sp.

Plate 4, figures 15–16

**Remarks:** A single specimen of this genus has been found in our material. It shows an almost flat dorsal side (with the exception of the initial part which forms a slight boss) and a gently convex ventral side. The sutures are limbate and curved on the dorsal side and depressed and curved on the ventral side. It shows a rather large carina on the dorsal side. The aperture is an elongate, radiate opening in the umbilical area.

This form is closely related to *Heronallenia vicksburgensis* Cushman, 1935, from the Lower Oligocene of Vicksburg, Mississippi, but specific determination is not possible with only a single specimen.

**Discorbis** spp.

Plate 4, figures 17–18

**Remarks:** Individuals of two indeterminate species of *Discorbis* are illustrated here. These shallow-water elements have certainly been displaced over a considerable bathymetric range.

**Alabamina tangentialis** (Clodius), 1922

Plate 4, figures 19–20

*Pulvinulina tangentialis* CLODIUS, 1922, p. 138, pl. 1, fig. 14.  
*Alabamina tangentialis* (Clodius).—BATJES, 1958, p. 155, pl. 8, fig. 7.—BUTT, 1966, p. 59, pl. 5, figs. 1–3.

**Remarks:** Small and broken specimens have been included in this species. They possess five chambers in

the final whorl, and the aperture is subparallel to the periphery. Originally described from the Oligocene of Germany, this species has also been found in the Middle Miocene of Germany.

**Svratkina perlata** (Andreae), 1884

Plate 4, figures 21–22

*Pulvinulina perlata* ANDREAE, 1884, p. 216, pl. 8, fig. 12.  
*Alabamina perlata* (Andreae, 1884).—BATJES, 1958, p. 157, pl. 8, figs. 8, 9.—KIESEL, 1962, p. 71, pl. 10, fig. 12.—TRUNKO, 1965, p. 140, pl. 13, fig. 12a–c.—BUTT, 1966, p. 60, pl. 5, fig. 4.—KÜMMERLE, 1963, p. 50, pl. 8, fig. 2a–c.  
*Svratkina perlata* (Andreae, 1884).—ANDREIEFF *et al.*, 1974, pl. 11, figs. 11–12.

**Remarks:** This species, originally described from the Septaria clay of Alsace, shows great variability in its ornamentation. The specimens found in Site 117 do not show the scattered tubercles on the surface of the test (cf. Andreae's type figures and pl. 8, fig. 9, of Batjes, 1958) but only the pores on the periphery and on the dorsal side. All our specimens are corroded.

**Eponides alabamensis** Cushman and McGlamery, 1938

Plate 4, figures 23–25

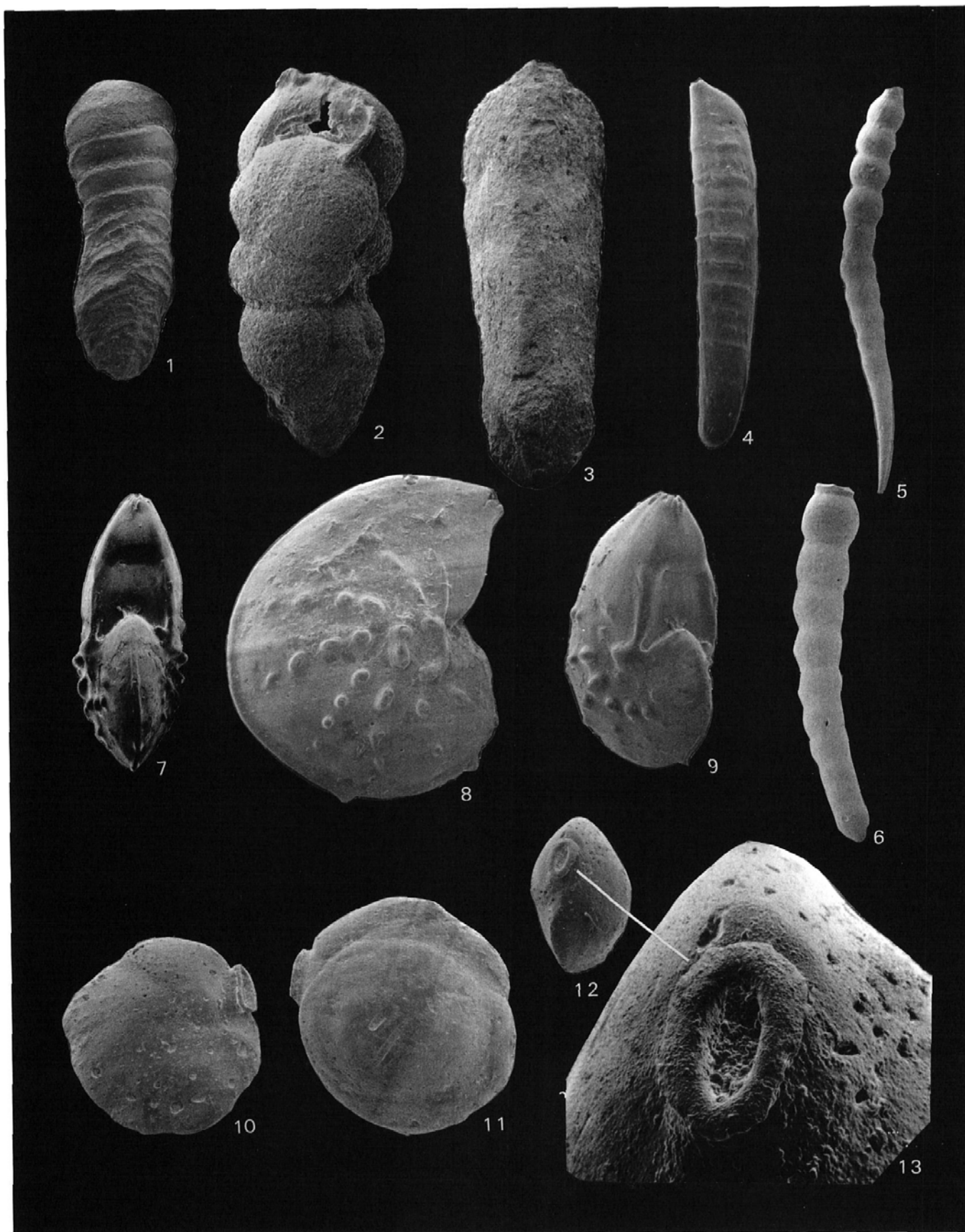
*Eponides alabamensis* CUSHMAN and MCGLAMERY, 1938, p. 110, pl. 27, fig. 2.

**Remarks:** This species, described originally from the Chickasawhay Marl Member of the Byram Marl Formation, from Chocktaw Bluff, Alabama, is distinguished by the five to six chambers in the adult

## PLATE 1

Explanation of sample nomenclature: Deep Sea Drilling Project, Leg 12, Hole 117/core no./section no.—interval in cm. from top of core. CC = core catcher sample.

- |   |   |
|---|---|
| 1 <i>Vulvulina jarvisi</i> Cushman<br>117/1–CC, × 30.                           | 5 <i>Stilostomella gracillima</i> (Cushman and Jarvis)<br>117/1–CC, × 14.   |
| 2 <i>Karreriella subcylindrica</i> (Nuttall)<br>117/1–CC, × 35.                 | 6 <i>Stilostomella verneuili</i> (d'Orbigny)<br>117/1–CC, × 14.   |
| 3 <i>Tritaxia polygonalis</i> (Galloway and Heminway)<br>117A/1/1–42 cm., × 65. | 7–9 <i>Lenticulina subpapillosa</i> (Nuttall)<br>117/1–CC, × 35.  |
| 4 <i>Vaginulinopsis mexicana</i> (Nuttall)<br>117/1–CC, × 14.                   | 10–13 <i>Siphonina advena</i> Cushman<br>10, 12, 13: 1172/3–145–148 cm.; 11: 116/<br>22/2–150 cm.; 10–12, × 65; 13, × 330 |





whorl, strongly oblique sutures on the spiral side and finely papillate umbilical side and discrete costae across the sutures in some specimens. This form is relatively common in the Upper Oligocene at Site 117. Specimens are uniformly broken or corroded and it may be assumed that they have been transported from shallower (inner-middle neritic) depths.

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The SEM micrographs were made by Francis Saffon (S.N.P.A.) using a Cambridge Mark II instrument.

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This is Woods Hole Oceanographic Institution Contribution No. 3638.

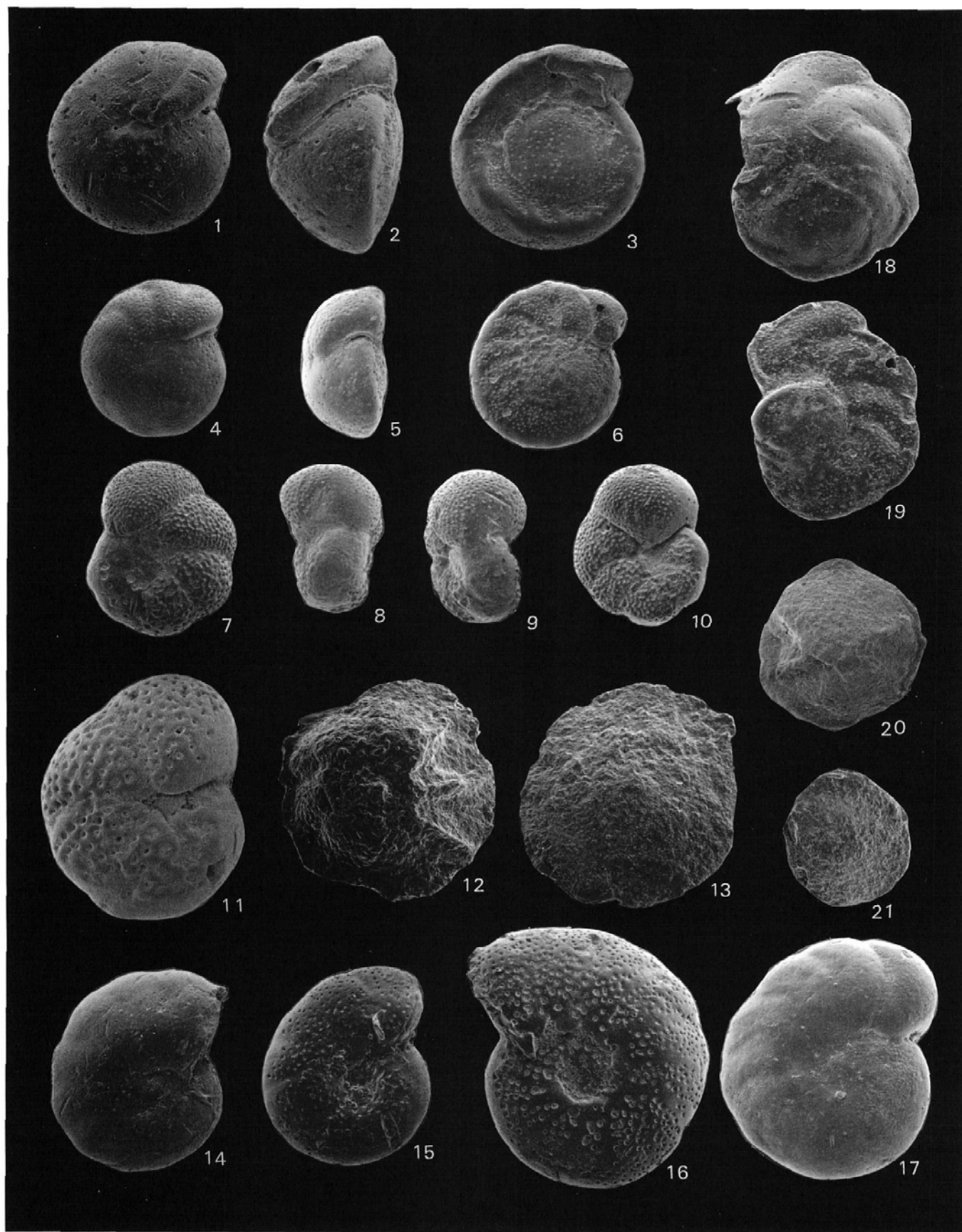
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#### PLATE 2

- |   |   |
|---|---|
| 1–3 <i>Heterolepa mexicana</i> (Nuttall)<br>1, 2: 117A/1-cc; 3: 117/2/3–145–148 cm.;<br>all × 35. | 12–13 <i>Nuttallides truempyi</i> (Nuttall)<br>116/28-CC, × 65.   |
| 4–6 <i>Cibicidoides trincherasensis</i> (Bermúdez)<br>117/2/3–145–148 cm., × 35.                  | 14–17 <i>Anomalinoidea alazanensis</i> (Nuttall)<br>13, 14: 116/23/1–bottom; 15, 16: 117/2/3–<br>145–148 cm.; all × 65. |
| 7–10 <i>Anomalinoidea</i> sp.<br>117A/1/1–42 cm., × 35.   | 18–19 <i>Cibicidina</i> cf. <i>yazooensis</i> (Cushman)<br>117A/1–40–42 cm., × 65.                                      |
| 11 <i>Anomalinoidea semicribatus</i> (Beckmann)<br>116/22/5–150 cm., × 35.                        | 20–21 <i>Osangularia</i> sp.<br>116/27-CC, × 65.  |



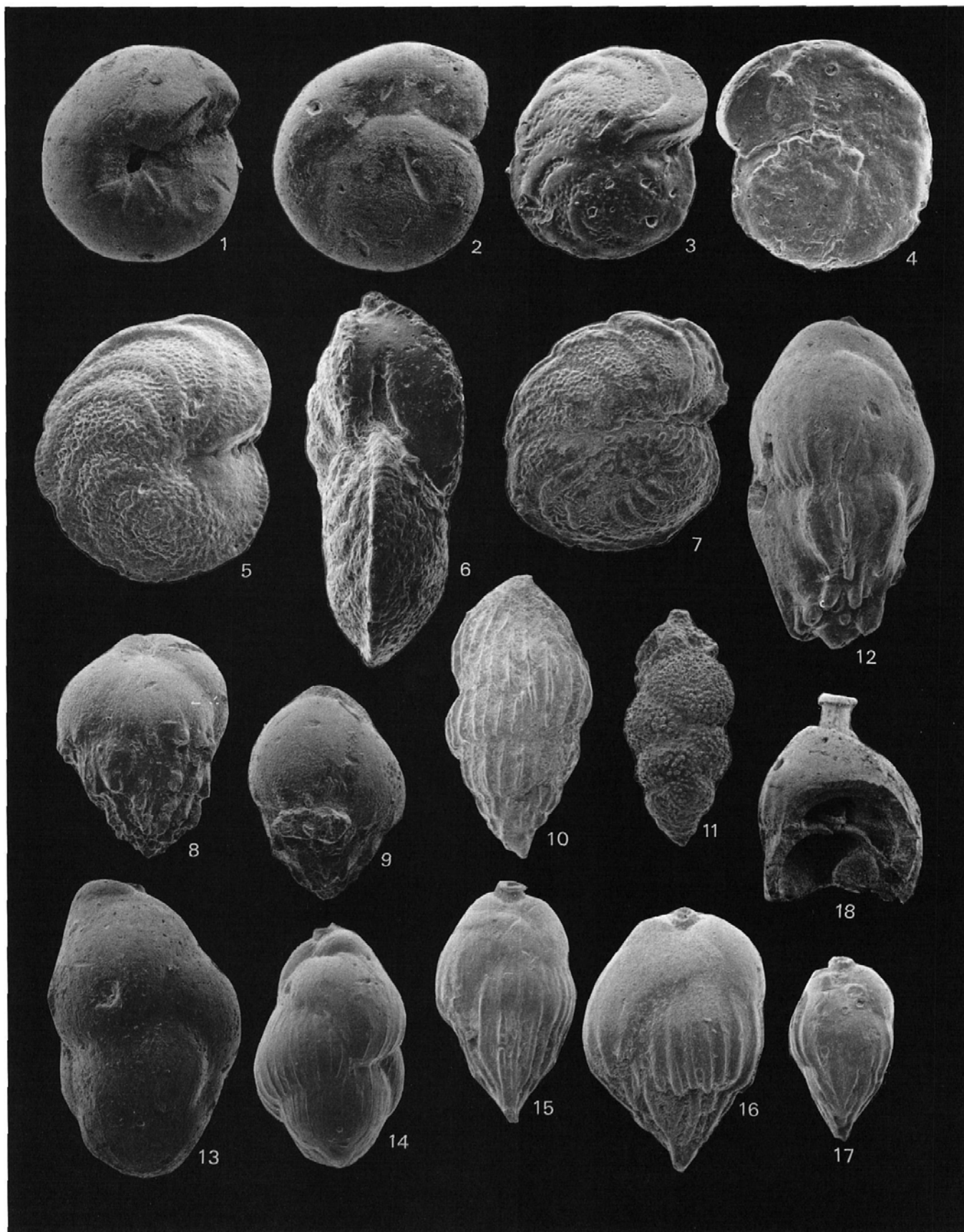


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## PLATE 3

All figures × 65, except as otherwise noted

- |  |   |
|--|---|
| 1–2 <i>Gyroidinoides girardanus</i> (Reuss)<br>116/23/4–150 cm.          | 11 <i>Uvigerina proboscidea</i> Schwager<br>117/2/3–145–148 cm.   |
| 3–4 <i>Planulina marialana</i> Hadley<br>117A/3–CC.                      | 12 <i>Uvigerina gallowayi</i> Cushman<br>117/2/4–146–149 cm.  |
| 5–7 <i>Planulina renzi</i> Cushman and Stainforth<br>117/2/3–145–148 cm. | 13–14 <i>Uvigerina laviculata</i> Coryell and Rivero<br>117/2/3–145–148 cm.                                   |
| 8–9 <i>Bulimina macilenta</i> Cushman and Parker<br>117/2/3–145–148 cm.  | 15–18 <i>Uvigerina eocaena</i> Gümbel<br>16–18: 116/23/2–124–127 cm.; 19: 116/23/<br>1–150 cm.; 16, 18, × 35. |
| 10 <i>Uvigerina havanensis</i> Cushman and Bermúdez<br>116/24–CC.        |   |



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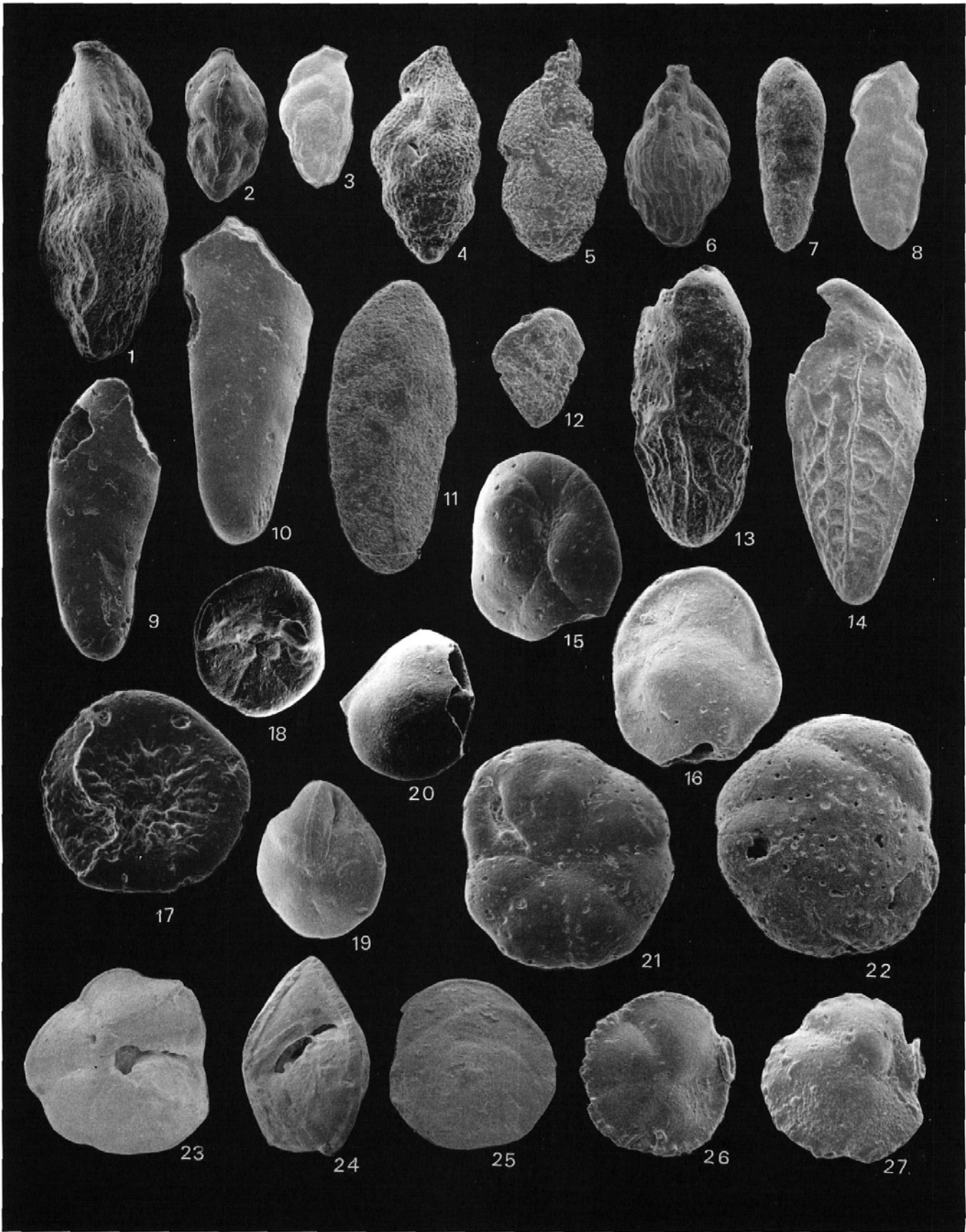
## PLATE 4

Displaced fauna at Site 117 (except 26 and ?27)

All specimens × 135 unless otherwise noted

- |       |  |       |  |
|-------|--|-------|--|
| 1     | <i>Angulogerina halkyardi</i> Cushman and Edwards<br>117A/1/1–40–42 cm.              | 15–16 | <i>Heronallenia</i> sp.<br>117/2/3–145–148 cm.   |
| 2–3   | <i>Angulogerina tenuistriata</i> (Reuss)<br>117/2/4–146–149 cm.                      | 17    | <i>Discorbis</i> sp.<br>117/2/3–145–148 cm.  |
| 4–5   | <i>Uvigerina rugosa</i> d'Orbigny<br>4: 117/2/3–145–148 cm.; 5: 117/2–top.           | 18    | <i>Discorbis</i> sp.<br>117/2/4–146–149 cm.  |
| 6     | <i>Uvigerina</i> sp.<br>117/2/3–145–148 cm.; note double aperture.                   | 19–20 | <i>Alabamina tangentialis</i> (Clodius)<br>117/2/4–146–149 cm.   |
| 7     | <i>Bolivina</i> sp.<br>117/2/3–145–148 cm.   | 21–22 | <i>Svratkina perlata</i> (Andreae)<br>117/2/3–145–148 cm.  |
| 8     | <i>Bolivina</i> sp.<br>117/2/4–146–149 cm.   | 23–25 | <i>Eponides alabamensis</i> Cushman and McGlamery<br>23, 24: 117/2/4–145–149 cm.; 25: 117/3–CC; 23–25, × 65. |
| 9–10  | <i>Bolivina</i> sp.<br>117/2/6–143–146 cm.   | 26    | <i>Siphonina tenuicarinata</i> Cushman<br>117/2/3–145–148 cm.  |
| 11    | <i>Bolivina</i> sp.<br>117/2/3–145–148 cm.   | 27    | <i>Siphonina</i> sp.<br>117/2/4–146–149 cm.  |
| 12    | <i>Bolivina imporcata</i> Cushman and Renz<br>117/2–top.                             |       |  |
| 13–14 | <i>Bolivina fastigia</i> Cushman<br>13: 117/2/4–145–149 cm.; 14: 117/2/6–143–146 cm. |       |  |







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