

14. CENOZOIC BIOSTRATIGRAPHY AND PALEOBIOGEOGRAPHY OF THE NORTH ATLANTIC

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GENERAL

The stratigraphic distribution of Cenozoic sediments recovered on Leg 12 is shown in Figure 1. Paleogene sediments were recovered at Sites 111, 112, 116, 117, 118 and 119. Neogene (including Pleistocene) sediments were recovered at all sites (Sites 111 through 119). The general planktonic and benthonic foraminiferal biostratigraphy at each site has been summarized in the text and figures accompanying the site reports. In this section we present a synthesis of the biostratigraphy and paleobiogeography of the North Atlantic based on Leg 12 results. For convenience in the following discussion the North Atlantic includes Sites 111 through 117; the Bay of Biscay includes Sites 118 and 119.

PLANKTONIC FORAMINIFERA

Paleogene

Paleocene was recovered at Sites 117, 118, and 119. The oldest Paleocene recovered was at the bottom of Site 119 (core 40) in which an association of *Globorotalia pseudo-bulloides*, *G. compressa*, *Globigerina triloculinoides*, *G. spiralis* and *Globorotalia angulata* suggest an age of earliest Late Paleocene (top of Zone P2 or the base of Zone P3). Sediments of unequivocal Danian age were not cored on Leg 12.

Keeled globorotaliids (*G. acuta-velascoensis* group) occur in Upper Paleocene sediments at Sites 118 and 119, together with various acarininids. At Site 117 the Upper Paleocene contains small globigerinids referable to *Globigerina triangularis* and *G. velascoensis*, and acarininids (Figure 2).

Eocene sediments were recovered at Sites 111, 112, 117, 118 and 119. Lower Eocene keeled-globorotaliid faunas occur at Sites 111 (Orphan Knoll, Labrador Sea) and 118 (Bay of Biscay). At the latter site, in particular, rich and diverse faunas occur and include, among others *Globorotalia subbotinae*, *G. marginodentata*, *G. aragonensis*, *G. formosa*, *G. formosa gracilis*, *Acarinina soldadoensis*, *A. soldadoensis angulosa*, *A. coalingensis*, *A. pentacamerata*, *Globigerina patagonica* and *Chiloguembelina wilcoxensis*.

In the North Atlantic Middle Eocene sediments were recovered only at Sites 111 and 112 (Labrador Sea). *Acarinina densa*, *Truncorotaloides collectea*, *Globigerina frontosa*, *G. patagonica*, *G. linaperta* and *Pseudohastigerina wilcoxensis* characterize these levels in the Labrador Sea. Approximately equivalent levels in the Bay of Biscay (Site 118) contain similar acarininid faunas but include *Globigerapsis index* and *Globorotalia pseudoscitula* also.

Upper Eocene was cored only in the North Atlantic (Sites 112, 116, ?117). The dominant elements are *Globigerina galavisi* and *Globigerinita unicava* in the Labrador Sea, whereas at Rockall these forms are accompanied by *Globigerina linaperta* and *Globigerapsis index*. (*Globigerapsis index* appears to be a useful guide form in the Upper Eocene of high latitudes; it is common in the Upper Eocene of New Zealand, as well as in the Upper Eocene of Denmark and the North Sea.) Chiloguembelinids occur sporadically in the Upper Eocene of the North Atlantic and range into the lower part of the Upper Oligocene at several sites.

The Oligocene was cored in the North Atlantic (Sites 112, 116, 117) and the Bay of Biscay (Site 119). The dominant element at these sites is the group of globigerinitids (*Globigerinita dissimilis* and *G. unicava* primarily). Chiloguembelinids occur sporadically in the Lower Oligocene at Sites 116; *Globigerina ampliapertura* occurs in the lower part of the Lower Oligocene at Site 116, and *Globorotalia munda* in the upper part of the Lower Oligocene at Site 112. The association of globigerinitids, chiloguembelinids, *G. munda* and *G. ampliapertura* is useful in a biostratigraphic subdivision of the upper Paleogene of the North Atlantic (see Figure 3).

Although globigerinitids are common in the Upper Oligocene in the North Atlantic (Sites 112, 116 and 117), the occurrence of *Globoquadrina baroemoensis* in the Upper Oligocene at Site 116 heralds the development of the genus as the dominant element in Lower Miocene sediments at this site and its usefulness in biostratigraphic subdivision. Globigerinitids continue as the dominant faunal element in the Upper Oligocene in the Bay of Biscay (Site 119). The absence of globoquadrinids and other characteristic Oligocene forms is attributed to selective solution (which is observed throughout most of the stratigraphic section cored at both Sites 118 and 119). *Globorotalia opima*—a stratigraphically important form—was found at Sites 117 and 119. An interesting fact is that although sediments of appropriate age were cored, the morphologically distinct and stratigraphically important *Globigerina angulituralis* was not found in any of the Upper Oligocene sediments on Leg 12.

A multiple planktonic foraminiferal zonation for the Paleogene of the North Atlantic based on assemblages at Sites 111, 112, 116, and 117 is shown in Figure 2. This zonation scheme is based strictly on assemblages and is essentially biostratigraphic in nature. It is not formally defined here, but presented merely in order to demonstrate an ability to determine approximate positions within a standard time-stratigraphic scale. Approximate correlations of this high latitude zonation scheme with a composite zonation for low (tropical) latitudes is shown in Figure 4.

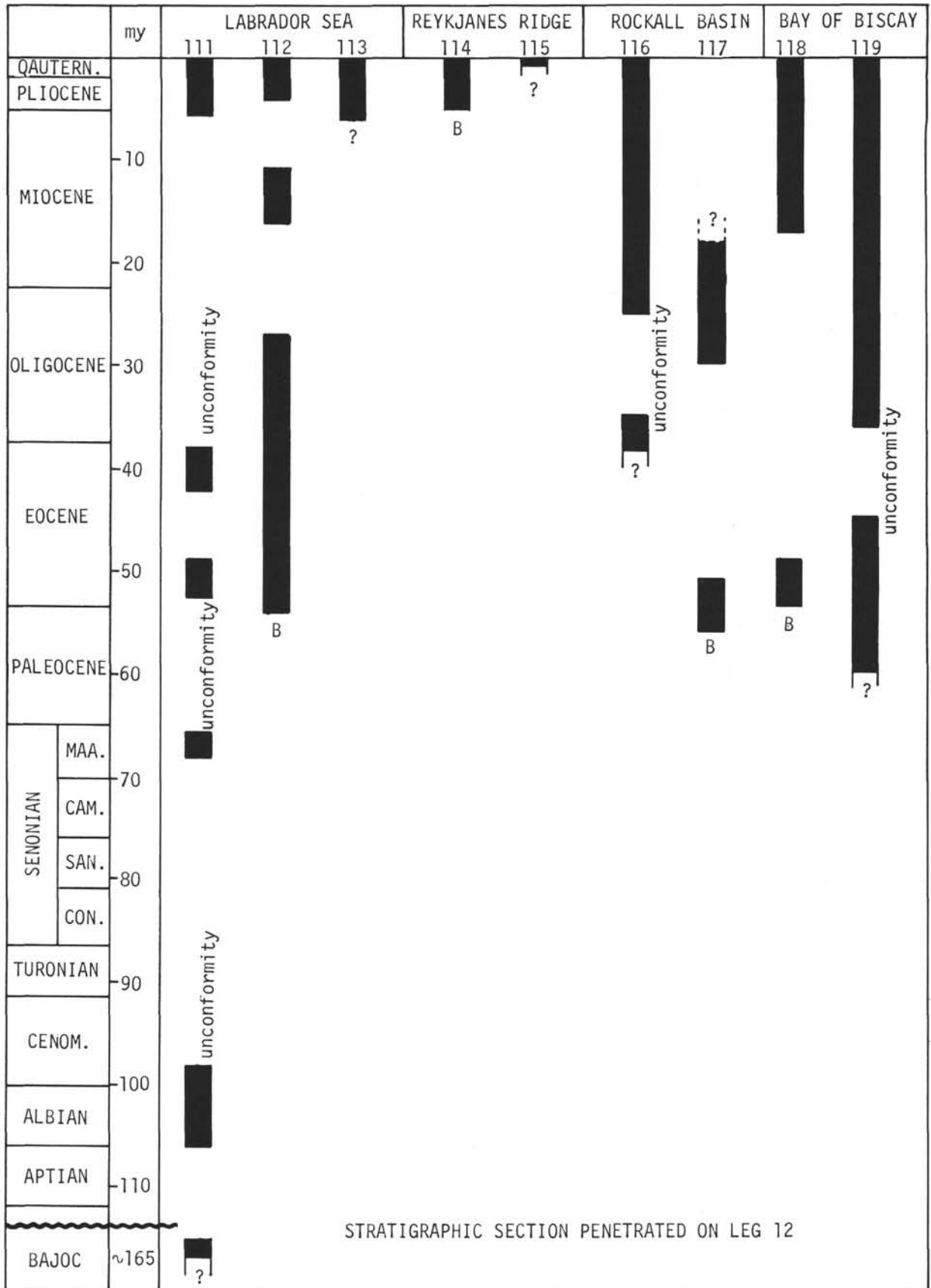


Figure 1. Stratigraphic distribution of sediments cored on Leg 12.

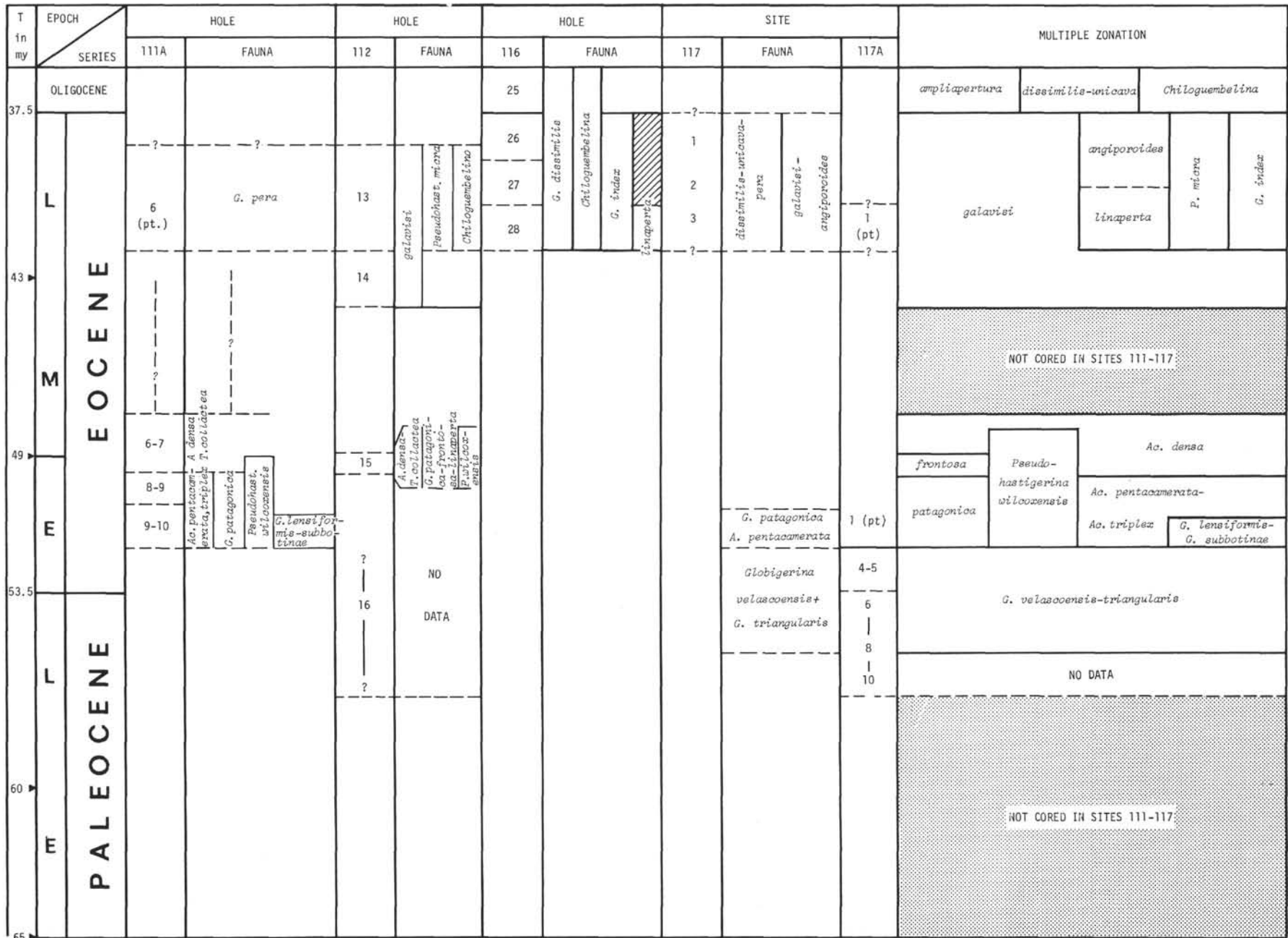


Figure 2. Paleocene-Eocene planktonic foraminiferal biostratigraphy of the North Atlantic (Leg 12).

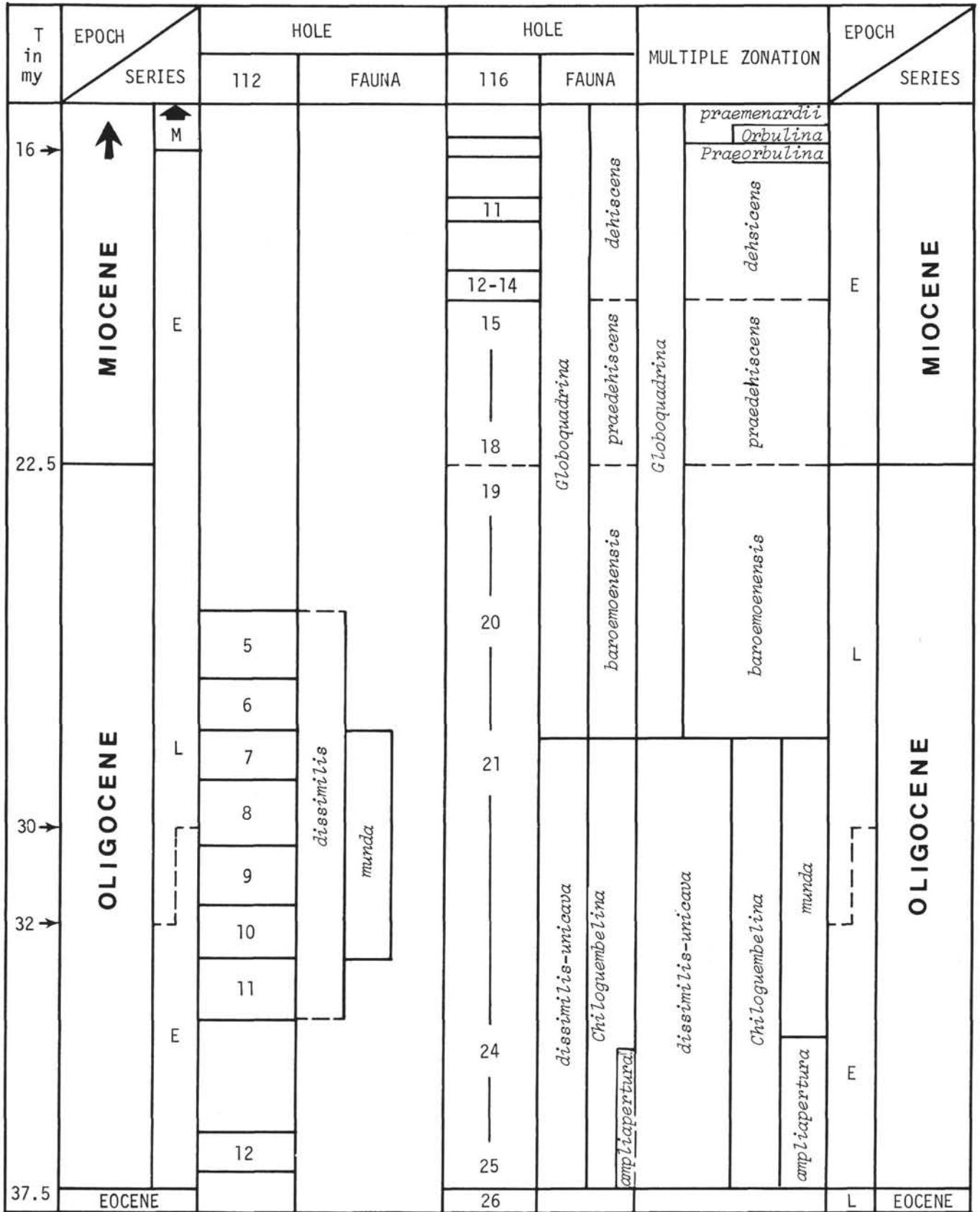


Figure 3. Oligocene-Lower Miocene planktonic foraminiferal biostratigraphy of the North Atlantic (Leg 12).

T IN M.Y.	EPOCH		AGE		PLANKTONIC FORAMINIFERAL ZONATION				
	SERIES	STAGE	TROPICAL REGIONS		NORTH ATLANTIC				
			COMPOSITE: BLOW (1969; BOLLI (1957); BERGGREN (1969)		BERGGREN (THIS PAPER)				
	E	MIOCENE	AQUITANIAN	N4	<i>G. quadrilobatus</i> <i>primordius</i> / <i>G. (Turbo.) kugleri</i> P-R-Z		<i>praedehisens</i>		
25	L	OLIGOCENE	CHATTIAN	P22	<i>G. angulisetuariae</i> P-R-Z		<i>dicloquadria</i>	<i>barcoenensis</i>	
				P21	<i>G. angulisetuariae</i> / <i>G. (Trabertalia) opima opima</i> C-R-Z				
30			E	RUPELIAN	P20	<i>G. ampliapertura</i> P-R-Z		<i>disarmis - unitana</i>	<i>Chilomenella</i>
35				LATTORFIAN	P19	<i>G. sellii</i> / <i>P. barbadoensis</i> C-R-Z			
	L	EOCENE	BARTONIAN	P17	<i>G. gortanii</i> / <i>G. (T.) centralis</i> P-R-Z		<i>galaviei</i>	<i>angiporoidea</i>	Pseudo. GI. index
40				PRIABONIAN	P16	<i>C. inflata</i> T-R-Z			
			P15	<i>G. mexicana</i> P-R-Z		<i>linaperta</i>		<i>miora</i>	
45			LUTETIAN	P14	<i>T. rohrri</i> - <i>G. howei</i> P-R-Z				
	M	Eocene	LUTETIAN	P13	<i>O. bockmanni</i> T-R-Z		NOT CORED ON LEG 12		
				P12	<i>G. leimeri</i> P-R-Z		NOT CORED ON LEG 12		
				P11	<i>G. kugleri</i> P-R-Z		NOT CORED ON LEG 12		
				P10	<i>H. aragonensis</i> P-R-Z		NOT CORED ON LEG 12		
50	E	Eocene	YPRESIAN				<i>frontosa</i>	Pseudo- <i>hastigerina</i>	<i>Ac. pentacoerata</i>
							<i>patagonica</i>		
	L	PALEOCENE	THANETIAN	P6	b	<i>G. subbotinae</i> / <i>A. wilcozensis</i> P-R-Z		<i>Ac. triangularis</i>	NO DATA
				a	<i>G. velascoensis</i> / <i>G. subbotinae</i> C-R-Z				
55				P5	<i>G. velascoensis</i> P-R-Z				
				P4	<i>G. pseudomenardii</i> T-R-Z				
	E	DANIAN	DANIAN	P3	<i>G. pusilla</i> - <i>G. angulata</i> C-R-Z		NOT CORED ON LEG 12		
60				P2	<i>G. uoinata</i> - <i>G. spiralis</i> C-R-Z		NOT CORED ON LEG 12		
65				P1	C	<i>subjergensis</i> P-R-Z	<i>compressa</i>		NOT CORED ON LEG 12
	B	<i>trionetans-praeaeorialis</i>		NOT CORED ON LEG 12					
	A	<i>trilooulinoidea</i>		NOT CORED ON LEG 12					
							<i>ebulloidea</i>	NOT CORED ON LEG 12	

Figure 4. Correlation of Paleogene high and low latitude planktonic foraminiferal biostratigraphic zonation schemes.

Neogene

Neogene sediments were cored at all sites on Leg 12. (In this writer's concept, Neogene includes Miocene–Pleistocene, the Pleistocene including sediments to the present day.) Representative sections of the Miocene were cored in the North Atlantic (Site 116) and the Bay of Biscay (Sites 118 and 119). Questionable or extremely small amounts of Miocene sediments were recovered at Sites 111, 113 and 114.

The Lower Miocene at Site 116 is characterized by globoquadrinids (*G. praedehiscens* to *G. dehiscens*) (Figure 3). Globigerinitids (*G. dissimilis* and *G. unicava*) occur commonly at both Sites 116 and 119. Their presence at Site 119 is probably due to their greater resistivity to solution than other planktonic foraminifera. At Site 116 *Sphaeroidinellopsis seminulina* is particularly common in the upper part of the Lower Miocene (Burdigalian; approximately equivalent to Zone N7).

The *Orbulina* Datum, one of the most important datum levels in the Cenozoic, was cored at Site 116 (Core 116A-10). In this core the evolutionary bioseries leading from *Globigerinoides sicana* to *Praeorbulina glomerosa* to *Orbulina suturalis* has been found (see Plate 4) and provides a valuable reference point in the stratigraphy of this site.

Representative Middle and Upper Miocene sediments were cored at Sites 116, 118 and 119. Questionable or minor amounts of Upper Miocene sediment were cored at Sites 111, 112, 113 and 114. At the latter sites the planktonic foraminiferal faunas are extremely poor in the lower part of the stratigraphic section recovered and it is not possible to determine with any degree of certainty whether these levels are of late Miocene or early Pliocene age. One of the significant paleontologic discoveries of Leg 12 was the discovery that the *Globorotalia miozea* group can be used for Middle–Late Miocene biostratigraphic subdivision. This group appears to consist of *Globorotalia praemenardii*, *G. miozea* and *G. conoidea*. These forms succeed each other at Site 116. *G. praemenardii* is common in samples dated as equivalent to Zones N9-10. It is replaced above in a stratigraphic interval correlated approximately with Zones N12-13 (Serravallian) by *G. miozea*. *Globorotalia conoidea* replaces *G. miozea* within a stratigraphic interval correlated approximately with the Serravallian/Tortonian boundary (that is, Middle/Upper Miocene).

A distinctive feature of the Middle Miocene at Sites 112 and 116 is the common occurrence of large, robust forms referred here to *Globigerina praebulloides* (Figure 5). *Globigerina nepenthes* was found in the Middle Miocene at Sites 112 and 116 as well. It occurs as a relatively common form in the Lower Pliocene at Site 111. At Site 118, *Globorotalia miozea* also occurs in the Middle Miocene in association with *G. fohsi* (Core 8). It occurs in association with *Praeorbulina glomerata circularis* and *Orbulina universa* in Core 10. Thus the Middle Miocene planktonic foraminiferal faunas are rather similar at Sites 116 and 118.

Several features characterize the Upper Miocene. In the North Atlantic, forms assigned to *Globorotalia acostaensis-humerosa* dominate Upper Miocene assemblages at Site 116 (Figure 5). The development of *Globigerina bulloides* from *G. praebulloides* is observed at Site 116 in sediments correlated with Zone N16, and *Globigerina apertura* occurs in

the Upper Miocene also at Sites 116 and 118. A distinctive form—*Globigerina atlantica*—appears for the first time at about the Middle/Upper Miocene boundary at Site 116. This form is dextrally coiled and present in small numbers in Upper Miocene sediments in the North Atlantic sites, but is sinistrally coiled and becomes the dominant element in the Pliocene at all North Atlantic sites. It is discussed in further detail below.

The Pliocene and Pleistocene were cored at all sites on Leg 12 with the exception of Site 117 (Figure 5). In a general way it would appear that the sequential appearance of *Globorotalia puncticulata*, *G. crassaformis* and *G. inflata* can be used for biostratigraphic subdivision of the Pliocene in the North Atlantic. *Globorotalia puncticulata* was not observed in pre-Pliocene levels and appears to be a useful marker for the Lower Pliocene. *Globorotalia inflata* appears at about the level coincident with the first glacially-rafted sediments, together with *Globigerina pachyderma*.

The dominant species in all North Atlantic Pliocene sites is *Globigerina atlantica*. In some instances this form occurs essentially alone to the exclusion of all planktonic species; more commonly it occurs associated with *Globigerina bulloides*, *Globorotalia crassaformis*, *G. inflata*, *G. scitula*, *G. hirsuta* and *Orbulina universa*. It is replaced gradually in the Late Pliocene by *Globigerina pachyderma* (which appears with the first glacially-rafted sediments). However, it disappears at the Pliocene/Pleistocene boundary (as determined by the extinction of *Discoaster brouweri*), and would appear to be a useful addition to the multiple criteria which now serve to determine this boundary in various parts of the world ocean. Although some forms assigned to *G. atlantica* bear a superficial morphologic resemblance to *G. pachyderma*, the two forms are quite distinct. *Globigerina atlantica* exhibits a wider range of morphologic variation, is consistently larger and has a thicker-walled test than *G. pachyderma*. Extreme variants of *G. atlantica* develop an extra-umbilical aperture and bear a resemblance to *Globorotalia humerosa*. It is probable that *G. atlantica* has been described in publications on Mediterranean stratigraphy under different names. The significant fact here is that this is a morphologically and stratigraphically distinct form, which appears near the base of the Tortonian and ranges to the Pliocene/Pleistocene boundary. It appears to change coiling direction (dextral to sinistral) at or near the Miocene/Pliocene boundary. Sinistrally coiled populations are indicative of a Pliocene age; the association of *G. atlantica* with other forms (such as, *G. puncticulata*, *G. inflata*, *G. pachyderma*) can be used in distinguishing approximate stratigraphic positions within the Pliocene (Figure 5).

The case of Orphan Knoll in the Labrador Sea (Site 111) is rather distinct in regards to late Neogene biostratigraphy. Latest Miocene and Pliocene (about .05 to 2.8 million years) are compressed into little over a meter of sediment at about 146 meters in a glauconitic ooze facies. A rich tropical-subtropical planktonic foraminiferal fauna has been recorded from this interval. This is overlain (with a transitional interval of about 15 centimeters) by glacially-rafted sands, silts and clays. The extinction of several stratigraphically important forms (*Globorotalia multicamerata*, *Globoquadrina altispira*, *Sphaeroidinellopsis seminulina*, *S. subdehiscens*) within this transitional interval and of various

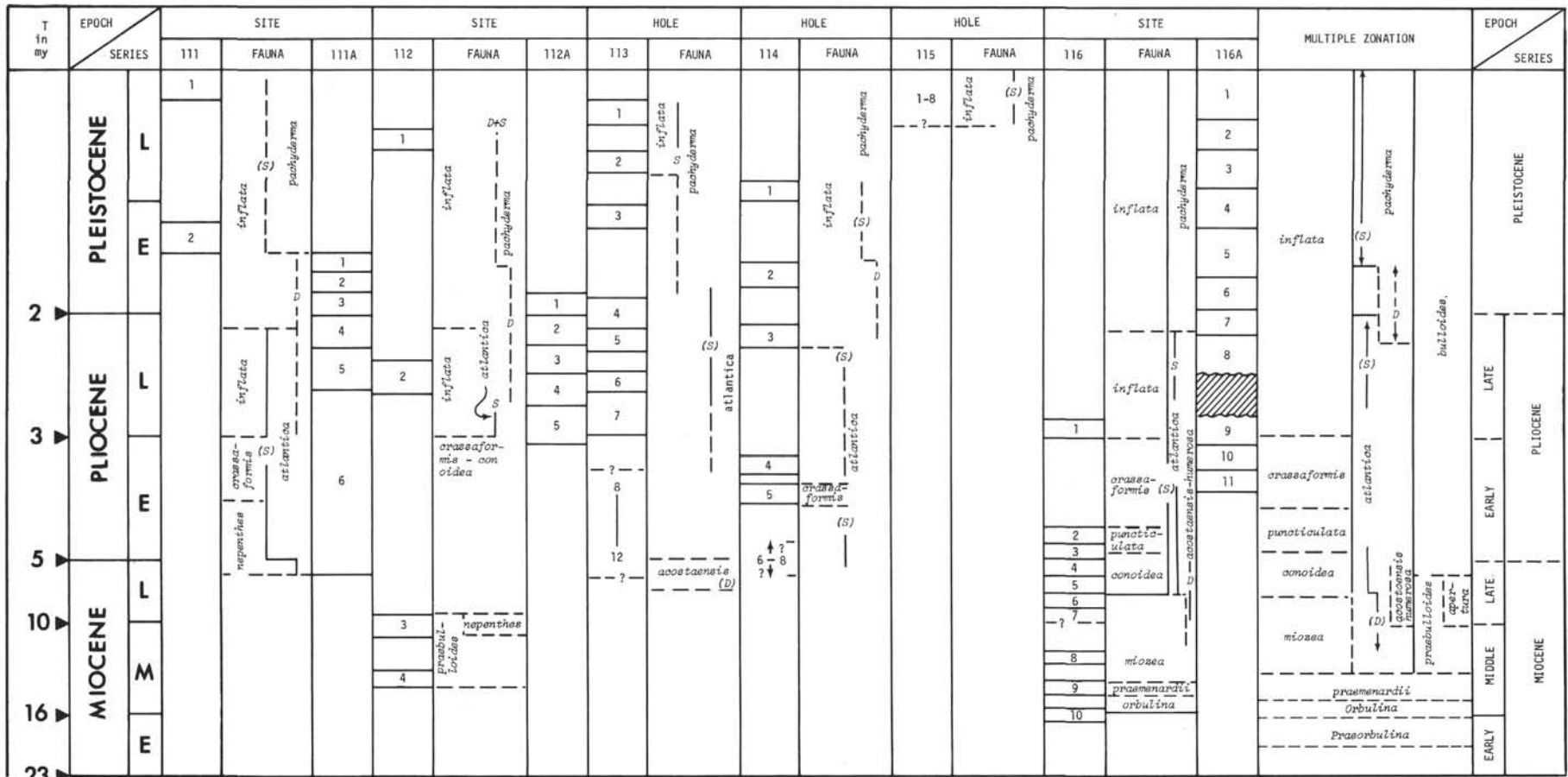


Figure 5. Neogene planktonic foraminiferal biostratigraphy of the North Atlantic (Leg 12).

other species (*Globoquadrina dehiscens*, *Globigerina nepenthes*) at lower levels makes it possible to estimate the age of the various levels within this short interval based on known relationships with paleomagnetic stratigraphy elsewhere. The results, calculated in various ways, are internally consistent, and, an age of 3 million years has been estimated for the level of the first ice-rafted detritus.

There is a marked diminution in the planktonic foraminiferal fauna through the transitional interval, a response no doubt to the relatively rapid cooling of the sea at that time. *Globigerina atlantica*—a common form in the pre-glacial levels—becomes the dominant form in the glacial sediments and occurs together with *Globigerina bulloides* *G. pachyderma* and *Globorotalia inflata*.

Similar conditions were observed at site 112 near the central part of the Labrador Sea, about 360 kilometers northeast of Site 111. Although the stratigraphic sequence cored at Site 112 is not as extensive as at Site 111 (because of different rates of sedimentation), the pre-glacial/glacial boundary was cored and a marked decrease in fauna was observed across this boundary. In contrast to Site 111, the pre-glacial fauna at Site 112 contained fewer tropical-subtropical species and a correspondingly greater proportion of temperate forms.

The Pleistocene was cored at all North Atlantic sites (with the exception of Site 117) and in the Bay of Biscay. In the North Atlantic *Globigerina pachyderma*, *G. bulloides*, and *Globorotalia inflata* are the dominant forms. A broad trend has been observed in *Globigerina pachyderma*: the species tends to be predominantly dextrally coiled in the Lower Pleistocene and sinistrally coiled in the Upper Pleistocene. This is probably a reflection of the intensification of glaciation in the Upper Pleistocene. *Globorotalia truncatulinoides* occurs as an accessory form at some sites in the North Atlantic (111, 115, 116) and the Bay of Biscay (118, 119), but does not occur in quantities sufficient for stratigraphic utility.

A comparison of the biostratigraphically important Neogene planktonic foraminiferal assemblages encountered on Leg 12 is shown in Figure 5. A multiple zonation scheme based upon these assemblages is shown on the right side of this figure. As in the case of the multiple zonation proposed for the Paleogene of the North Atlantic above, this scheme is strictly biostratigraphic in nature and is, thus, not formally defined here. It is presented mainly as a guide to aiding stratigraphers in recognizing approximate levels within the standard time-stratigraphic scale at high latitudes in the North Atlantic. An approximate correlation of this multiple zonation scheme with a zonation based primarily upon tropical (low latitude) assemblages is shown in Figure 6.

Globigerina atlantica spec. nov.

Derivatio nominis: from its abundant occurrence in the North Atlantic sediments cored on Leg 12.

Diagnosis: A 4-5 chambered globigerinid characterized by a relatively coarse granular surface, large apertural variability and, during the Pliocene, by pronounced sinistral coiling.

Description: The adult test is average sized to large for the genus, coiled in a tight low-trochospire with 4-5 chambers gradually increasing in size in the final whorl. The

final chamber, usually the fifth, is often diminutive and caplike, extending in some instances down over the umbilicus. The test outline is broadly oval and the peripheral margin strongly lobulate. The intercameral sutures on the umbilical side are radial to slightly curved and distinctly incised. The primary aperture is a relatively low, narrow opening above the umbilicus but in some specimens it extends laterally towards, but not up to, the peripheral margin. An apertural lip is generally absent, the distal margin of the apertural region being developed as a thickened rim with spines being developed up to the edge; in rare instances a flanging lip is developed, particularly between the last two chambers. The calcareous wall is thick, and the test surface is densely covered with bluntly pointed spines giving the test a distinctly "granular" appearance. Within the umbilical region the spines are longer and sharper and somewhat less dense in their spacing.

The species is consistently sinistrally coiled in the Pliocene, whereas pre-Pliocene forms exhibit a preference for dextral coiling.

Remarks: This species is the dominant globigerinid and, indeed, the dominant planktonic foraminifer in most Pliocene samples in the North Atlantic encountered on Leg 12. In some instances it constitutes over 90% of the total planktonic foraminiferal fauna. It exhibits a preference for dextral coiling in the late Miocene but exhibits a pronounced sinistral coiling pattern in the Pliocene (over 95%) up to its extinction at the Pliocene/Pleistocene boundary.

This species is markedly similar to *Globoquadrina dutertrei*; it differs, however, in its consistently tighter coiling (and consequently narrower, smaller umbilicus), the greater variability of its aperture and in the "granular" test texture. This "granular" test texture is reminiscent of similar morphology developed in some forms of the genus *Acarinina* in the Paleogene. Indeed, the general test shape, outline and morphology of *Globigerina atlantica* is strongly similar to that developed in *Acarinina mckannai* and *A. pentacamerata* (= *A. gravelli*) during the late Paleocene and early Eocene.

Globigerina atlantica also exhibits a general similarity to *Globigerina pachyderma* but can be distinguished by consistent size differences, in addition to discrete morphologic differences. *G. pachyderma* makes its initial appearance in all North Atlantic cores coincident with the first evidence of glaciation (ice-rafted detritus) and the two species are the dominant forms in upper Pliocene samples of the North Atlantic.

The present species may be related to the "*Globorotalia*" *humerosa*–*Globoquadrina dutertrei* group but at the present time it is not possible to discern definite kinship or phylogenetic trends in this highly complex and variable group. It would appear that this species has been recorded in the late Neogene of the Mediterranean region by Italian workers, but a more thorough comparison of actual specimens from this region must be made before this can be confirmed.

Globigerina atlantica has been recorded from sites 111, 112, 113, 114, 116 and 118 of Leg 12.

Holotype: The holotype specimen (plate 2, fig. 8) is from sample 116A-8-CC (late Pliocene).

T in my	EPOCH		AGE		PLANKTONIC FORAMINIFERAL ZONATION										
	SERIES		STAGE		TROPICAL REGIONS		NORTH ATLANTIC								
					BLOW (1969)		BERGGREN (1971)								
2	L	PLEISTOCENE	CALABRIAN	N23	G. calida/ S. dehiscens excavata G. truncatulinoides	inflata	pachyderma	bulloides							
	E			N22	P-R-Z										
5	L	PLIOCENE	ASTIAN	N21	G. tosaensis tenuitheco	crassaformis	puncticulata	bulloides							
	E		PIACENZIAN	N20	G. multicamerata P. obliquiloculata										
			ZANCLIAN	N19	S. dehiscens G. altispira P-R-A										
			N18	G. tumida S. subdehiscens paenedehiscens P-R-Z											
10.5	L	MIOCENE	MESSINIAN	N17	G. tumida plesiotumda C-R-Z	conoidea	atlantica (S)	acostaensis - numerosa (D)	bulloides						
			TORTONIAN	N16	G. (Turbo.) acostaensis G. merotumida P-R-Z										
				SERRAVALLIAN	N15					G. (Turbo.) continua C-R-Z					
					N14					G. nepenthes/ G. (T.) siokensis P-R-Z					
			N13		S. subdehiscens- G. druryi P-R-Z										
			N12		G. fohsi Group										
			LANGHIAN	N11	Q. suturalis-G (Turbo) peripheroronda P-R-Z					praeemendii					
				N10	G. sicanus-G. insueta P-F-Z										
			16	E	BURDIGALIAN					N9	G. insueta-G. quadrilobatus trilobus P-R-Z	Orbulina	Praeorbulina	dehiscens	Globoquadrina
										N8	G. insueta-G. quadrilobatus trilobus P-R-Z				
N7	G. insueta- G. dissimilis C-R-Z														
N6	G. insueta- G. dissimilis C-R-Z														
22.5	L	OLIGOCENE	CHATTIAN	P22	G. angulisuturalis P-R-Z	baroemoenensis	Globoquadrina								
			AQUITANIAN	N5	G. dehiscens praedehiscens- G. dehiscens P-R-Z										
	E	AQUITANIAN	N4	G. quadrilobatus primordius/ G. (Turbo.) kugleri P-R-Z	praedehiscens	Globoquadrina									
			N4	G. quadrilobatus primordius/ G. (Turbo.) kugleri P-R-Z											

Figure 6. Correlation of Neogene high and low latitude planktonic foraminiferal biostratigraphic zonation schemes.

Stratigraphic Range: *Globigerina atlantica* has been observed from the late Miocene to late Pliocene (Zone N16-N21) in the North Atlantic. Sporadic and questionable occurrences in middle Miocene (Serravallian) samples—Zones N14-N15—have been observed.

BENTHONIC FORAMINIFERA

General

Benthonic foraminifera comprise one of the more interesting components of the fossil faunas encountered on

Leg 12. Because the sites drilled on Leg 12 ranged from 1050 to 4900 meters in water depth, and because some of them have undergone a history of sinking from relatively shallow depths to abyssal depths the benthonic foraminiferal faunas encountered on Leg 12 are of interest from the stratigraphic and paleobiogeographic point of view, and from the purely paleontologic-taxonomic point of view. In the section below we shall discuss the nature of the Cenozoic benthonic foraminiferal assemblages encountered on Leg 12, dividing the discussion into Paleogene and Neogene as above.

Paleogene

Paleocene and Lower Eocene benthonic foraminiferal assemblages were recovered at Site 117. The Late Paleocene assemblages contain, among others, *Anomalina acuta*, *Anomalinoides danica*, *Gavelinella neelyi*, *Cibicidoides propria*, *C. hercegovinensis*, *Osangularia pteromphalia*, *Lenticulina midwayensis*, *Vaginulina longiforma* and *Karrerria fallax*. This faunal assemblage exhibits strong similarity with those described from the Midway Formation of Texas, the Hornerstown-Vincetown sequence of New Jersey, the Paleocene of Denmark and Sweden and Poland, as well as equivalent levels in the Mediterranean region (North Africa and Italy). The assemblage is characteristic of continental shelf conditions in which the water depth probably did not exceed 200 meters.

In the Lower Eocene of Site 117, such forms as *Anomalinoides grosserugosa*, *Cibicidoides sulzensis*, *Lenticulina decorata*, *L. alatolimbata* appear—forms which are well-known from the Lower Eocene of western Europe.

Lower and Middle Eocene assemblages were encountered at Site 111. Among the benthonic foraminifera are: *Anomalina acuta*, *A. praespissiformis*, *Anomalinoides grosserugosa*, *Osangularia pteromphalia*, *Cibicidoides hercegovinensis*, *C. acutimargo*, *Vaginulinopsis decorata*, *Gaudryina* sp. cf. *G. hiltermanni*, *Oridorsalis ecuadorensis*, *Nuttallides truempyi*, *Bulimina grata* and various stilostomellids and pleurostomellids. This assemblage contains several elements characteristic of the Eocene of the Caribbean and European regions. In particular *Nuttallides truempyi* is a widespread form in deep-water facies in the Caribbean region. On Leg 12, it was found in the Eocene of the Labrador Sea (Sites 111 and 112) and the Bay of Biscay (Sites 118 and 119). Indeed, the association of *Nuttallides truempyi* and various stilostomellids and pleurostomellids (and a relatively rich planktonic foraminiferal fauna) indicate that Orphan Knoll lay at considerable depth by the Early Eocene (comparable to its present depth perhaps: 1800 meters).

Eocene benthonic foraminiferal faunas were also encountered at Sites 112 and 116. In the case of the former, a relatively diverse agglutinated fauna characterizes the ?Upper Paleocene-Lower, Middle and Upper Eocene interval. Forms referable to the following genera have been observed: *Cyclamina*, *Glomospira*, *Ammodiscus*, *Bolivinospis*, *Rhabdammina*, *Cribrostomoides* and *Haplophragmoides*. In addition various calcareous forms occur sporadically: *Osangularia pteromphalia*, *Oridorsalis ecuadorensis*, *Nuttallides truempyi*, *Cibicidoides* sp. and various siphonodoriids and stilostomellids. The association indicates that Site 112 lay at bathyal depths in the Eocene.

The Upper Eocene at Site 116 is characterized by an abundance of *Osangularis mexicana*; also present are *Oridorsalis ecuadorensis*, *Cibicidoides perlucida*, and various cibicidids and siphonodoriids.

Eocene benthonic foraminiferal faunas in the Bay of Biscay (Sites 118 and 119) are characterized by a relatively high diversity. Among the forms recorded from the Lower-Middle Eocene are: *Cibicidoides havanensis*, *C. trinitatis*, *C. martinicensis*, *Oridorsalis ecuadorensis*, *Alabamina dissonata*, *Bulimina grata*, *Nuttallides truempyi*, *Pleurostomella naranjoensis*, *P. beirigi*, *Karrerriella chapapontensis*, *Nodosarella mappa*, *N. subnodosa*, *Stilostomella*

verneuili, *S. paucistriata*, and *Gaudryina* sp. cf. *G. hiltermanni*. This assemblage shows a strong affinity with those described from the Caribbean-Antilles region, in particular, the Barbados section. The faunal association, together with the evidence of solution effects on the planktonic foraminiferal fauna, indicates that the Bay of Biscay abyssal plain lay at great depths in the Eocene, probably comparable to its present depth.

Representative Oligocene benthonic foraminiferal faunas were encountered at Sites 116 and 117 (North Atlantic), and Site 119 (Bay of Biscay).

In the Rockall area the characteristic Oligocene benthonic foraminifera include: *i.a.l.*, *Heterolepa mexicana*, *Cibicidoides perlucida*, *C. trincherasensis*, *Anomalinoides pompilioides*, *Anomalina alazanensis*, *Vulvulina jarvisi*, *Uvigerina mexicana* and *Siphonina tenuicarinata*. The latter form is one of the dominant forms in Oligocene and Lower Miocene assemblages at Site 116 and at some levels is almost the only benthonic form present. This assemblage shows strong affinities with those recorded from the Oligocene of the Caribbean and Mediterranean regions and is indicative of middle-upper bathyal depths (about 300 to 600 meters).

The Oligocene at Site 119 (Bay of Biscay) is characterized by an abyssal assemblage including, among others, *Cibicidoides grimsdalei*, *C. martinicensis*, *Anomalina alazanensis*, *Anomalinoides semicibrata*, *Vulvulina jarvisi*, *Stilostomella abyssorum*, *Ellipsoglandulina multicostata*, *Stilostomella subspinosa*, *S. verneuili*, *Nodosarella subnodosa*, *N. mappa*, and various pleurostomellids and cassidulinids. The fauna exhibits a marked affinity with those in the Oligocene of Barbados. The similar association here in what must have been abyssal depths during the Eocene-Oligocene and Early Miocene strongly supports the idea that the Barbados section was also deposited at similar depths.

Neogene

Representative Miocene benthonic foraminiferal assemblages were encountered at Site 116 (North Atlantic), and Sites 118 and 119 (Bay of Biscay).

The Lower Miocene assemblages at Site 116 are essentially the same as those which occur in the Oligocene. Along with the forms mentioned above, *Planulina renzi* and *Anomalinoides pompilioides* are characteristic of the Lower Miocene here. The Lower Miocene assemblages at Site 119 are essentially the same as those which occur in the Oligocene. *Anomalinoides pompilioides*, *A. semicibrata*, *Cibicidoides trincherasensis*, *C. grimsdalei*, *Gyroidina complanata*, various stilostomellids and cassidulinids are the most persistent forms.

In the Middle Miocene a change is seen in the benthonic foraminiferal faunas at Site 116 (North Atlantic), and Sites 118 and 119 (Bay of Biscay). Preliminary analysis of the material at hand suggests that the living bathyal-abyssal benthonic foraminiferal faunas developed in the Middle Miocene about 15 million years ago. Characteristic forms found in the North Atlantic sites (111 through 116) which range from the Middle Miocene to the present include:

<i>Cibicidoides robertsoniana</i>	<i>Planulina bradii</i>
<i>Cibicidoides pseudoungeriana</i>	<i>Planulina wuellerstorfi</i>
<i>Melonis pompilioides</i>	<i>Planulina ariminensis</i>

<i>Melonis barleeanum</i>	<i>Pyrgo murrhyna</i>
<i>Gyroidina neosoldanii</i>	<i>Pyrgo lucernula</i>
<i>Bulimina marginata</i>	<i>Karriella bradyi</i>
<i>Eponides tener</i>	<i>Eggerella bradyi</i>
<i>Eponides umbonatus</i>	<i>Anomalinoidea globulosa</i>
<i>Laticarinina halophora</i>	<i>Anomalinoidea cicatricosa</i>
<i>Uvigerina peregrina</i>	<i>Sigmoilopsis schlumbergeri</i>
<i>Uvigerina hollicki</i>	

Most of these forms occur in the Middle Miocene–Pleistocene of the Bay of Biscay sites (118, 119). An additional element not recorded in the North Atlantic sites is *Epistominella exigua*. The greater depth of water of the Bay of Biscay sites is reflected in their larger proportion of stilostomellids and pleurostomellids in comparison to the North Atlantic sites.

The references used in identifying the benthonic foraminiferal faunas on Leg 12 are listed at the conclusion of this chapter.

ACKNOWLEDGMENTS

The planktonic foraminifera in Plates 1-5 were photographed by Kenichi Harada, W.H.O.I., on a JEOLCO JSM-U3 scanning electron microscope. All benthonic foraminifera with the exception of those listed below were photographed by Francis Saffon, of the Paleontological Laboratory of the Societ  National des P troles Aquitaine (S.N.P.A.), Pau, France using a Cambridge Stereoscan. I should also like to thank Jane Aubert for her aid in preparing these specimens for study and in the assembly of the plates. Kenichi Harada, W.H.O.I., photographed the following benthonic specimens using a JEOLCO JSM-U3 scanning electron microscope: Plate 7, Figures 1-5; Plate 8, Figures 8-18; Plate 9, Figure 10; Plate 10; Plate 11, Figures 17-20.

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PLATE 1

All specimens are from Site 111

- Figures 1-4 *Globigerina atlantica* Berggren spec. nov. 12-111A-6-2, 121.5-122.5 cm, 1: X45; 2-4: X71; Late Pliocene.
- Figure 5 *Globigerina atlantica* Berggren spec. nov. 12-111A-6-3, 29-30 cm. X74; Early Pliocene.
- Figure 6 *Globigerina atlantica* Berggren spec. nov. 12-111A-6-3, 39-40 cm. X74; Early Pliocene.
- Figure 7 *Globigerina atlantica* Berggren spec. nov. 12-111A-6-3, 68.5-69.5 cm. X75; Early Pliocene.
- Figure 8 *Globigerina nepenthes* Todd. 12-111A-6-3, top. X73; Early Pliocene.
- Figure 9 *Globigerinoides conglobata* (Brady). 12-111A-6-2, 121.5-122.5 cm. X44; Late Pliocene.
- Figure 10 *Globorotalia miocenica* Palmer. 12-111A-6-3, 29-30 cm. X66; Early Pliocene.
- Figures 11, 12 *Globorotalia miocenica* Palmer. 12-111A-6-3, 17-18 cm. X77; Early Pliocene.
- Figures 13, 14 *Globorotalia margaritae* Bolli. 12-111A-6-3, 7-8 cm. X73; Early Pliocene.
- Figures 15-17 *Globorotalia crassula* Cushman and Stewart. 12-111A-6-2, 121.5-122.5 cm. X63; Late Pliocene.
- Figures 18, 19 *Globorotalia tumida* (Brady). 12-111A-6-3, 29-30 cm. X54; Early Pliocene.

PLATE 1

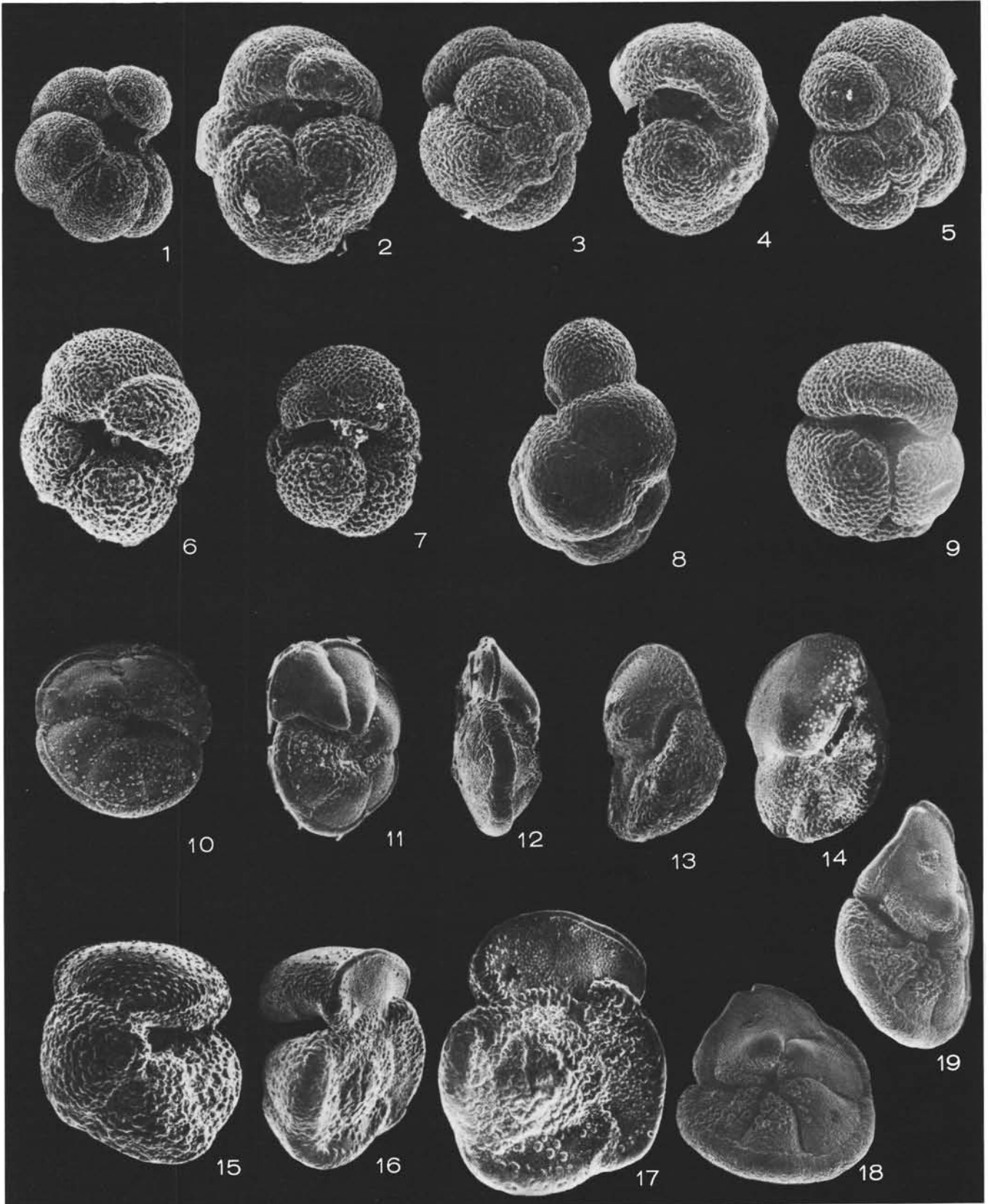


PLATE 2

Top row: all specimens from Site 113; all others from Site 116

- Figures 1-4 *Globigerina pachyderma* (Ehrenberg). 12-113-2-3, 99-102 cm. X95; Early Pleistocene; Figure 2 is same specimen as Figure 1, tilted to aperture.
- Figures 5-8 *Globigerina atlantica* Berggren spec. nov. 12-116A-8, CC. 5 and 7: X50; 6: X60; 8 holotype: X72; Late Pliocene.
- Figures 9-12 *Globorotalia humerosa* Takayanagi and Saito. 12-116-7-0, bottom. 9 and 10: X110; 11: X78; 12: X97; Middle-Late Miocene.
- Figures 13, 14 *Globorotalia acostaensis* Blow. 12-116-4, CC. 13: X91; 14: X80; Late Pliocene.
- Figures 15, 16 *Globorotalia continua* Blow. 12-116-7-1, 138-141 cm. X140; Middle-Late Miocene.
- Figures 17, 18 *Globigerina* sp. 12-116-5-5, 140-143 cm. X72; Late Miocene.

PLATE 2

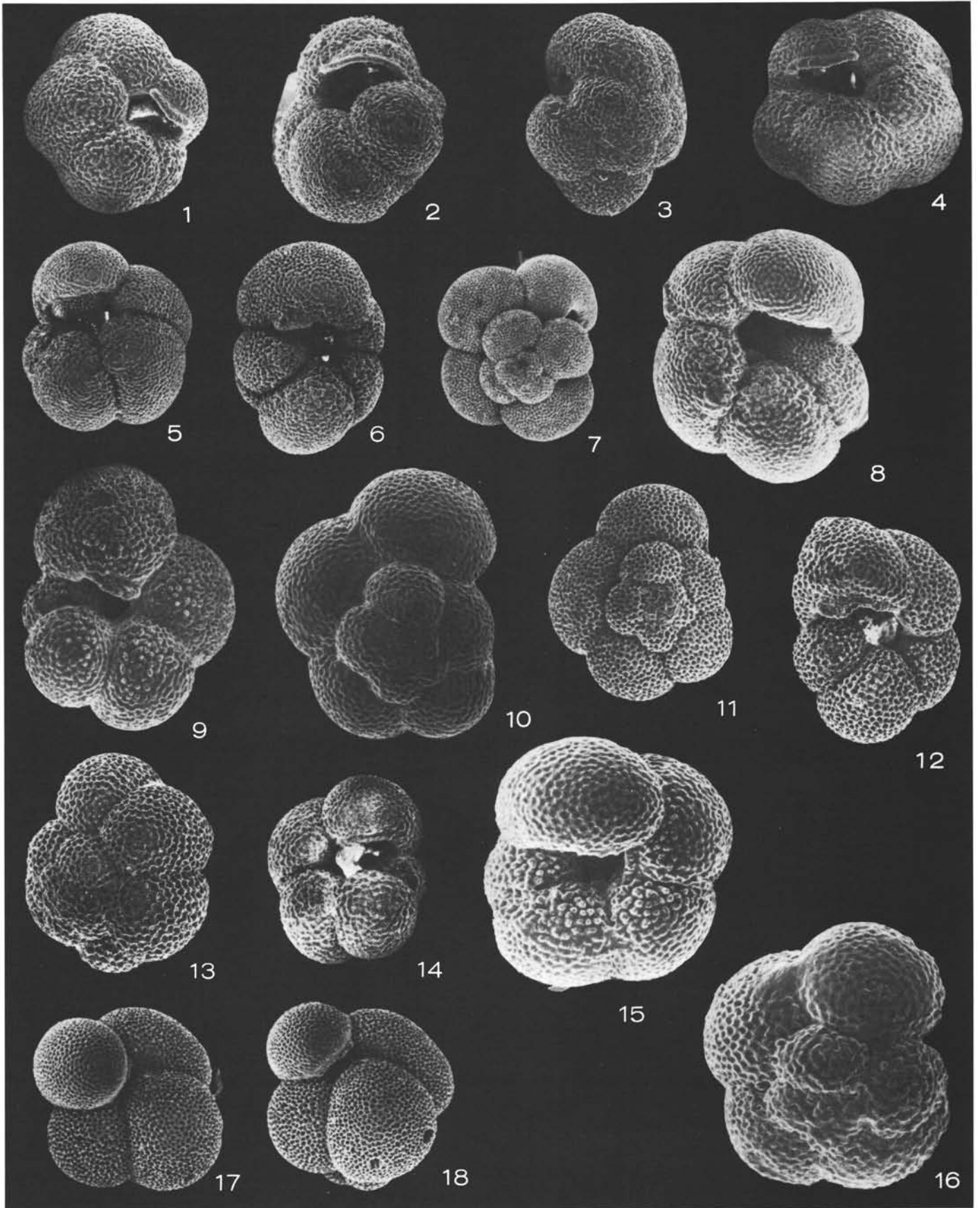


PLATE 3

All specimens from Site 116

- Figures 1, 2 *Globigerina nepenthes* Todd. 12-116-7-1, 138-141 cm. X140; Middle-Late Miocene. Figure 2 is same specimen as Figure 1, tilted to show aperture.
- Figure 3 *Globigerina apertura* Cushman. 12-116-5-0, bottom, X134; Late Miocene.
- Figure 4 *Globigerina zealandica* Hornibrook. 12-116-9, CC. X100; Middle Miocene.
- Figure 5 *Globigerina praebulloides* Blow. 12-116-10, CC. X84; Early/Middle Miocene.
- Figures 6-8 *Globorotalia conoidea* Walters. 12-116-2, CC. 6: X112; 7: X99; 8: X72; Early Pliocene.
- Figures 9, 10 *Globorotalia praemenardii* Cushman and Stainforth. 12-116-9-2, 141-144 cm. 9: X83; 10: X52; Middle Miocene.
- Figures 11, 12 *Globorotalia birnageae* Blow. 12-116-12-4, 124-127 cm. X95; Early Miocene.
- Figures 13, 14 *Globoquadrina praedehiscens* Blow. 12-116-16-4, 136-137 cm. X65; Early Miocene; same specimen rotated to show aperture.
- Figure 15, 16 *Globigerinita dissimilis* (Cushman and Stainforth). 12-116-23-0, bottom. X90; Early Oligocene.

PLATE 3

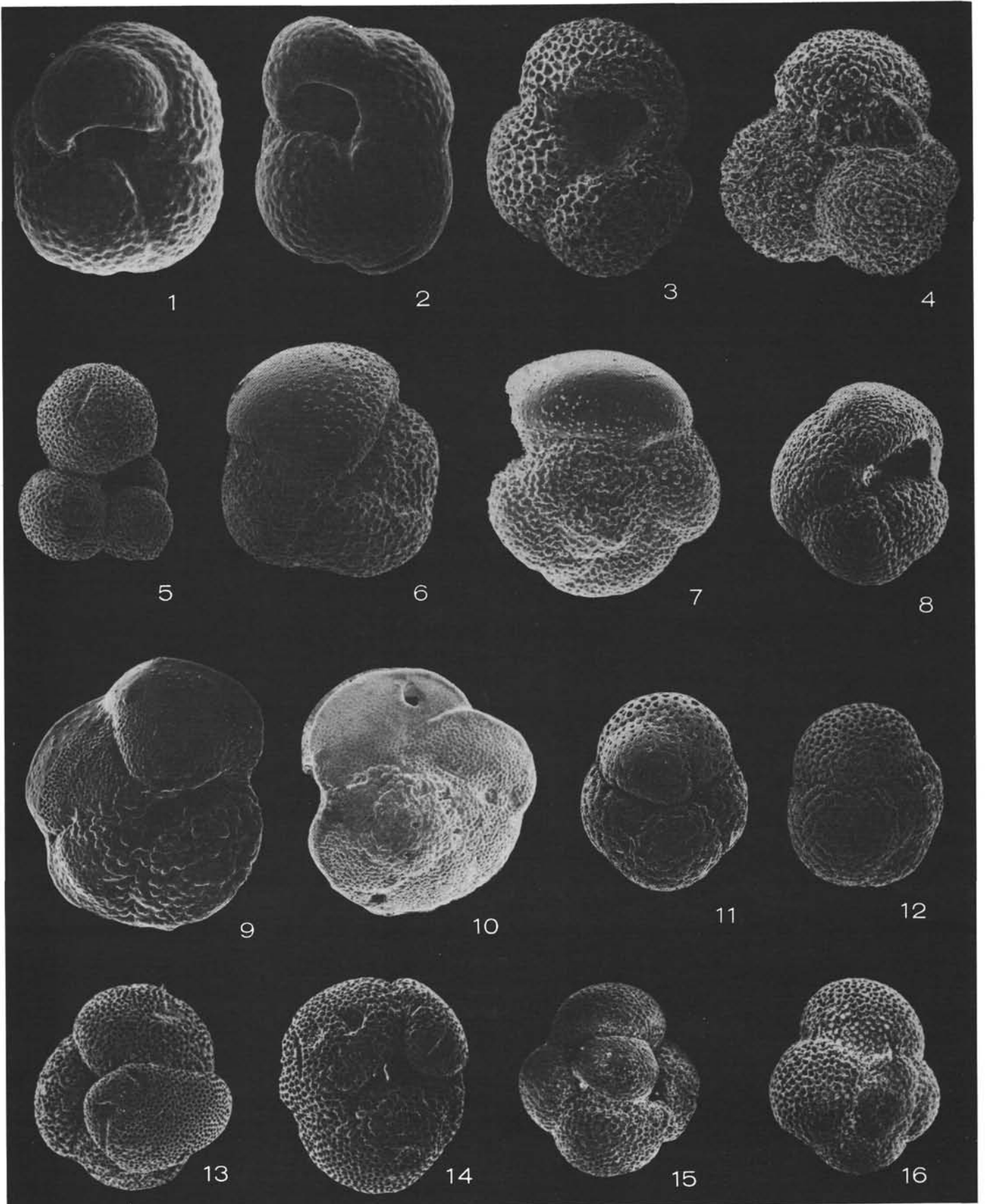


PLATE 4

All specimens from Site 116

- Figure 1 Bilobate form generally referred to *Biorbulina bilobata* (d'Orbigny). 12-116-10-3, 62-63 cm. X98; Early/Middle Miocene.
- Figure 2 *Globigerinoides sicana* (di Stefani). 12-116-10-5, 137-140 cm. X95; Early Miocene.
- Figure 3 *Praeorbulina glomerosa curva* Blow. 12-116-10-2, 63-65 cm. X99; Early Miocene.
- Figure 4 *Praeorbulina glomerosa glomerosa* Blow. 12-116-10-2, 135-136 cm. X118; Middle Miocene.
- Figure 5 *Praeorbulina glomerosa circularis* Blow. 12-116-10-1, 62-65 cm. X99; Middle Miocene. The sutural apertures are virtually indistinguishable along the sutural margins.
- Figures 6, 7 *Praeorbulina glomerosa circularis* Blow. 12-116-10-1, 87-91 cm. 6: X106; 7: X143; Middle Miocene. Two views of a broken specimen to show interior detail.

PLATE 4

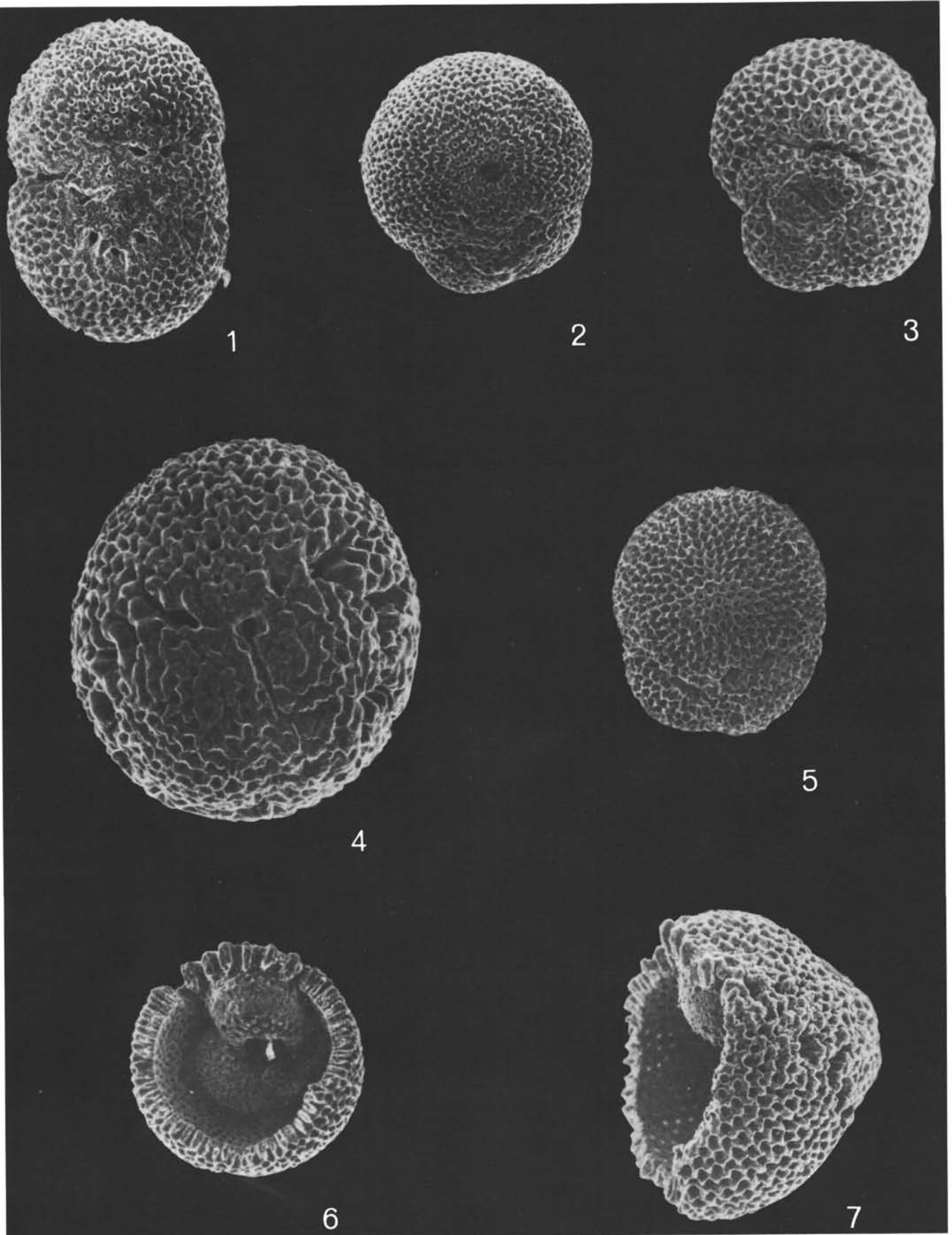


PLATE 5

All specimens from Site 118

- Figures 1, 2 *Globorotalia subbotinae* Morozova. 12-118-14, CC. X99; Early Eocene. Same specimen tilted to show apertural characters.
- Figure 3 *Globorotalia subbotinae* Morozova. 12-118-15-1, 99-100 cm. X95; Early Eocene.
- Figures 4-6 *Globorotalia marginodentata* Subbotina. 12-118-14, CC. X83; Early Eocene.

PLATE 5

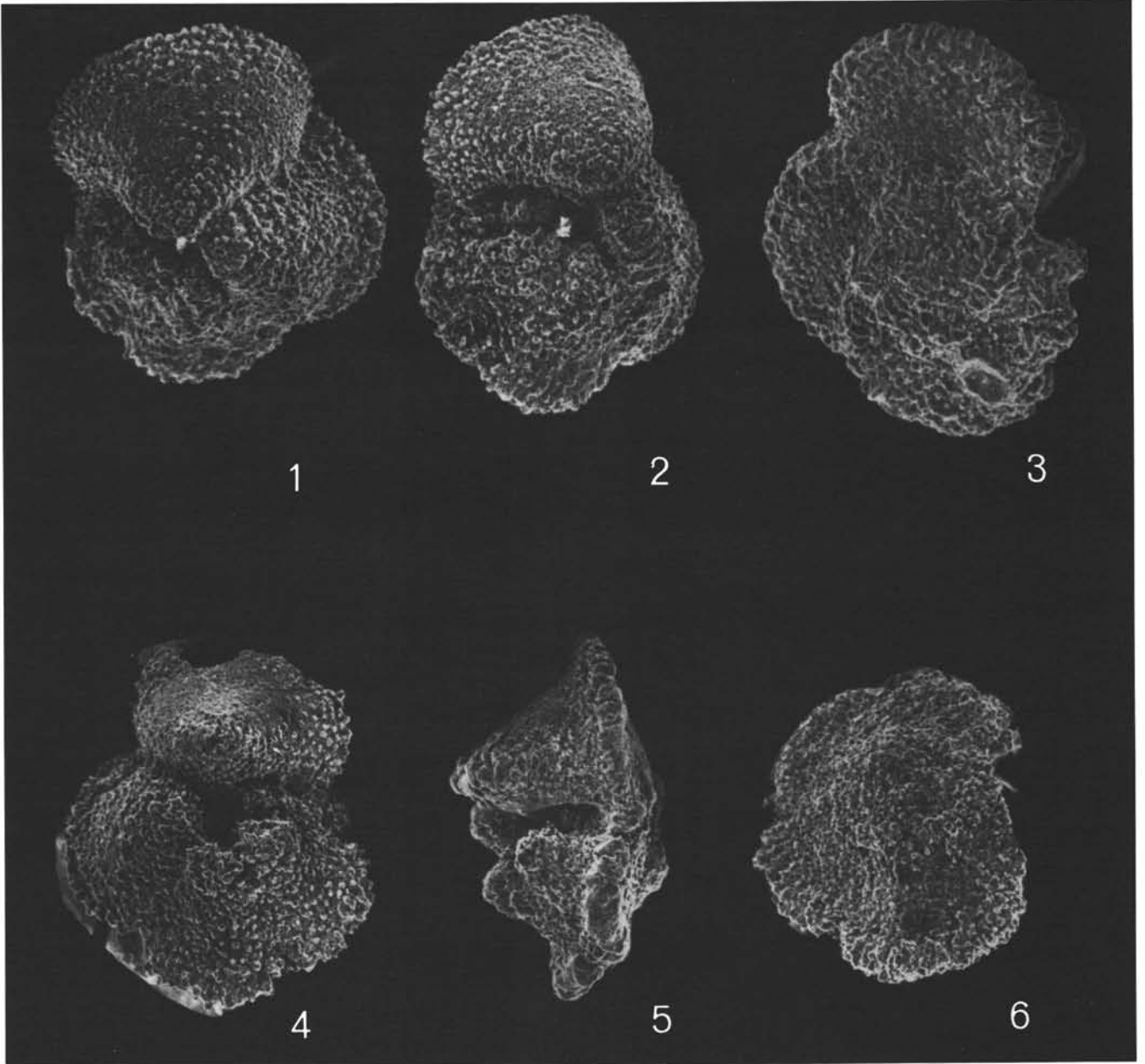


PLATE 6

All specimens are from Site 111

- Figures 1-3 *Neoconorbina* sp. 12-111A-10-4, 148-150 cm. X120; Early Eocene.
- Figure 4 *Stilostomella bradyi* (Cushman). 12-111A-2, CC. X160; Early Pleistocene.
- Figure 5 *Gavelinella limbata* Olsson. 12-111A-8, CC. X168; Early Eocene.
- Figure 6 *Planulina ariminensis* d'Orbigny. 12-111A-7-5, top. X70; Early Eocene.
- Figures 7-9 *Pulsiphonina prima* (Plummer). 12-111A-7, CC. X121; Early Eocene.
- Figures 10-11 *Eponides tener* (Brady). 12-111A-2-3, 137-138 cm. X120; Early Pleistocene.
- Figures 12-14 *Cibicidoides hercegovinensis* (de Witt Puyt). 12-111A-8, CC. 12: X129; 13: X133; 14: X114; Early Eocene.
- Figure 15 *Bulimina notovata* Finaly. 12-111A-2-4, 146-148 cm. X186; Early Pleistocene.
- Figure 16 *Cassidulina subglobosa* Brady. 12-111A-5-5, 144-145 cm. X260; Late Pliocene.
- Figures 17-19 *Gyroidina soldanii* d'Orbigny. 12-111A-2-5, 117-118 cm. X128; Early Pleistocene.
- Figure 20-22 *Uvigerina hollicki* Thalmann. 12-111A-2-4, 146-148 cm. 20 and 22: X80; 21: X66; Early Pleistocene.

PLATE 6

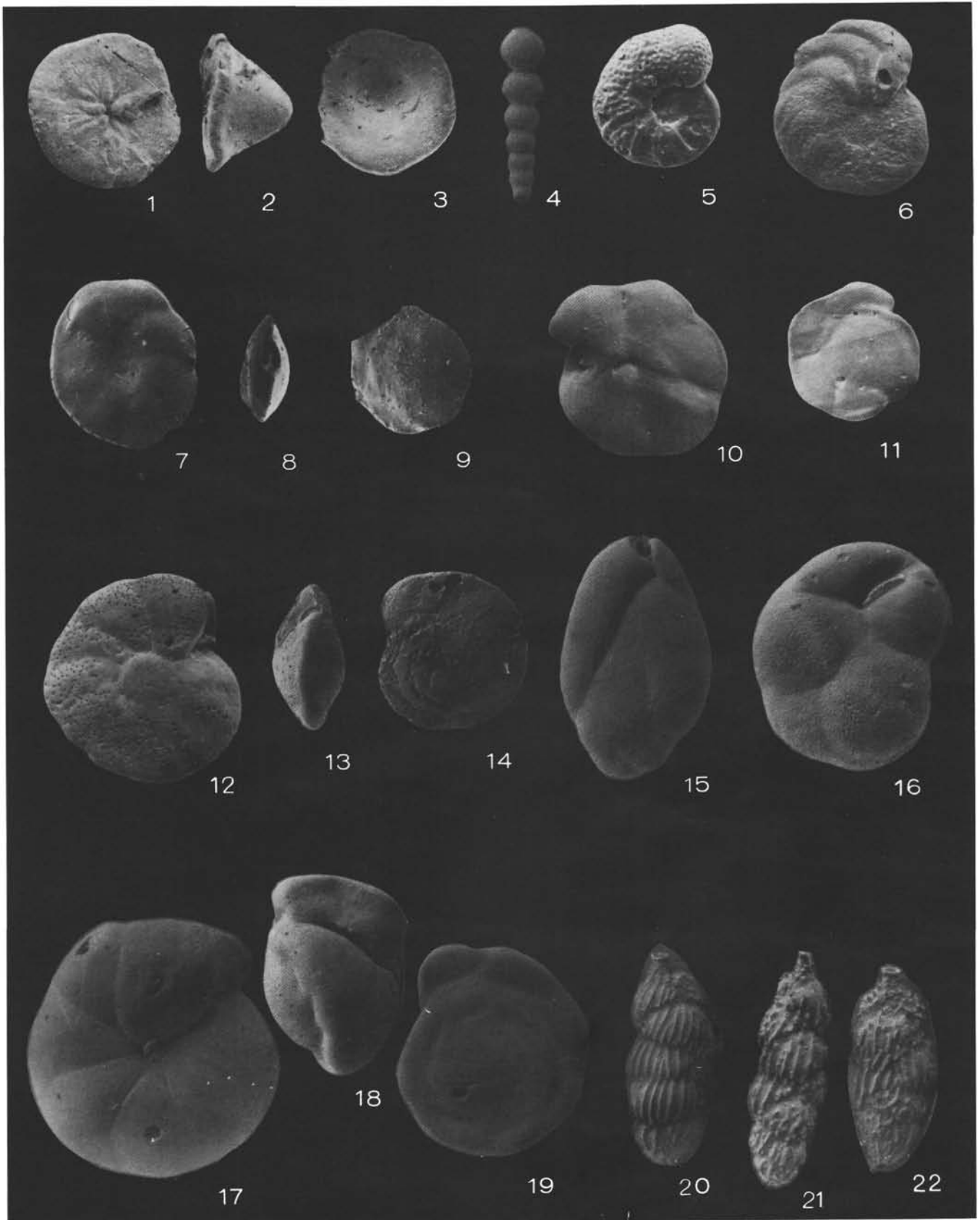


PLATE 7

Figures 1-5 are from Site 111;

Figures 6-11 are from Site 112

Figures 1-4 *Cibicoides pseudougeriana* (Cushman). 12-111A-5-5, 144-145 cm. X40; Late Pliocene.

Figure 5 Benthonic foraminifer (?*Cibicoides pseudougeriana*) with chamber interiors filled with green (?glauconite) mineral; 12-111A-6-2, 126-127 cm. X64; Late Pliocene.

The specimens figured below are from
the same sample: 12-112-14, CC;
Middle Eocene.

Figure 6 *Glomospira* sp.; X125.

Figure 7 *Ammodiscus* sp.; X125.

Figure 8 *Rhabdammina* sp.; X60.

Figure 9 *Bolivinopsis* sp.; X114.

Figure 10 *Cribrostomoides* sp.; X125.

Figure 11 *Cyclammina* sp.; X60.

PLATE 7

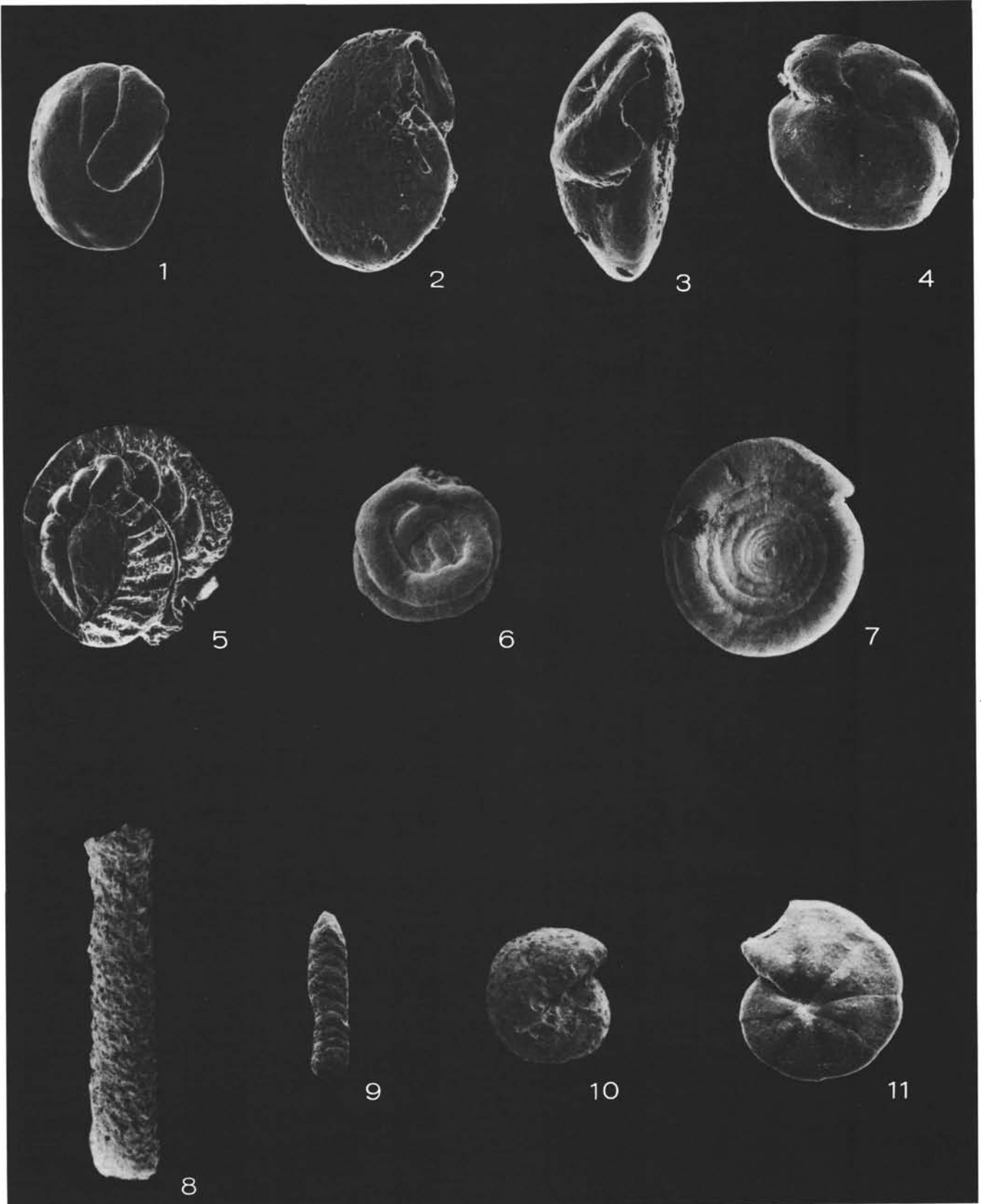


PLATE 8

All specimens are from Site 116

- Figures 1, 2 *Laticarinina halophora* (Stache). 12-116-1, CC. 1: X138; 2: X44; Early Pliocene.
- Figures 3, 4 *Cibicidoides robertsoniana* (Brady). 12-116-3, CC. X133; Early Pliocene.
- Figure 5 *Stilostomelia antillea* (Cushman). 12-116-1-6, 143-145 cm. X137; Early Pliocene.
- Figures 6, 7 *Uvigerina peregrina* d'Orbigny. 12-116-1-4, 141-144 cm. X65; Late Pliocene.
- Figure 8 *Saracenaria italica* de France. 12-116-6-3, 143-146 cm. X24; Middle-Late Miocene.
- Figure 9 *Siphogenerina gaudryinoides* (Lipparini). 12-116-3, CC. X36; Early Pliocene.
- Figures 10, 11 *Uvigerina havanensis* Cushman and Bermudez. 12-116-23-2, 124-127 cm. 10: X49; 11: X75; Early Oligocene.
- Figures 12, 13 *Dorothia* sp. 12-116-6-2, 143-145 cm. 12: X18; 13: X36; Late Miocene. Two views of the same specimen, tilted slightly to show aperture.
- Figures 14-16 *Gyroidina girardana* (Reuss). 12-116-25, CC. X62; Early Oligocene.
- Figures 17, 18 *Gyroidina jarvisi* Cushman and Stainforth. 12-116-12-1, 144-147 cm. 17: X69; 18: X57; Early Miocene.

PLATE 8

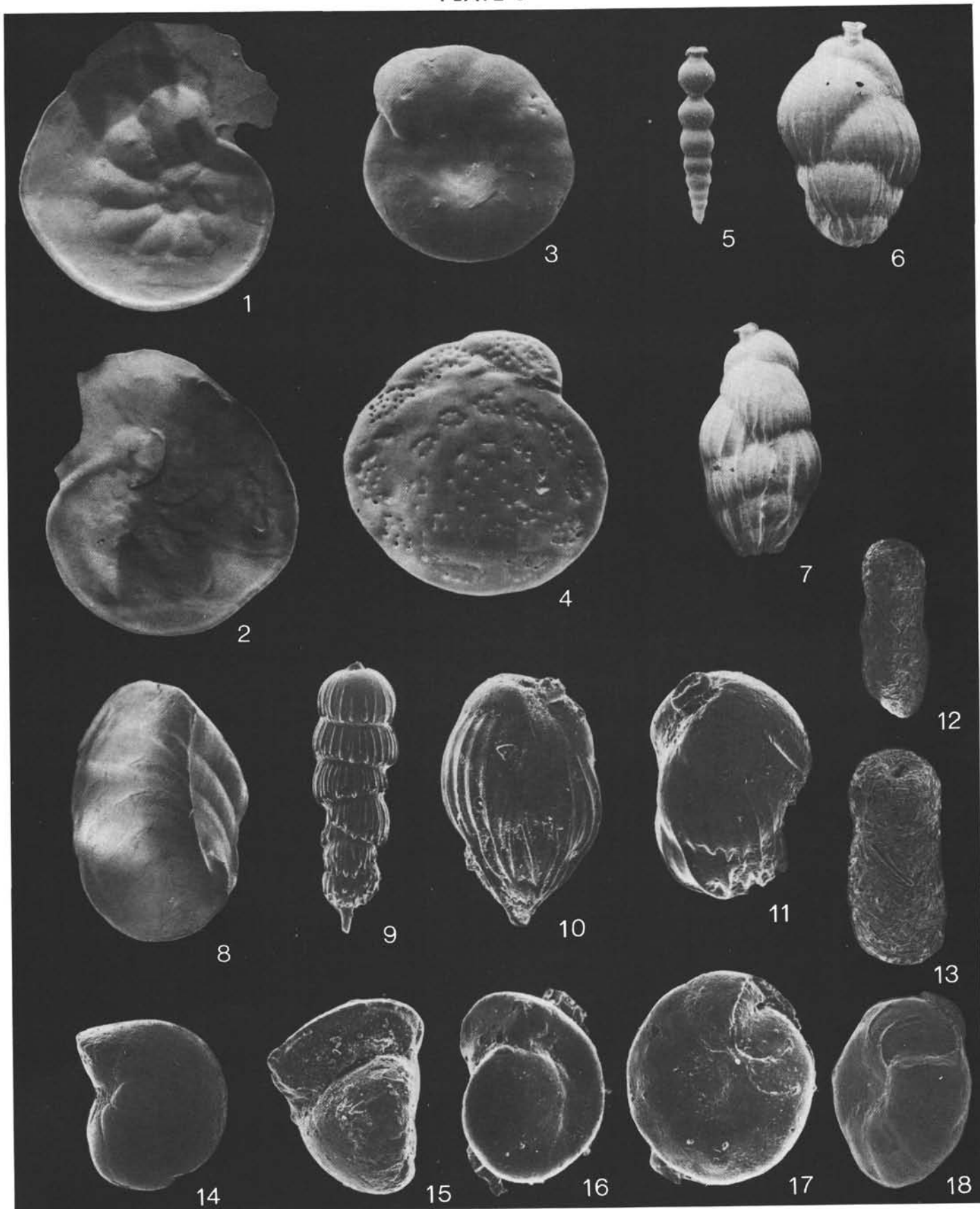


PLATE 9

All specimens are from Site 116

- Figure 1 *Nodosarella* sp. 12-116-1-2, 146-149 cm. X86; Late Pliocene.
- Figure 2 *Dentalina advena* (Cushman). 12-116-1-2, 146-149 cm. X82; Late Pliocene.
- Figures 3, 4 *Planulina bradii* Tolmachoff. 12-116-1-1, 143-146 cm. X80; Late Pliocene.
- Figures 5, 6 *Eponides umbonatus* (Reuss). 12-116-1-1, 143-145 cm. X165; Late Pliocene.
- Figures 7-9 *Anomalinoidea cicatricosa* (Schwager). 12-116-1-1, 143-145 cm. X85, Late Pliocene.
- Figures 10-12 *Cibicidoides kullenbergi* (Parker). 12-116-1, CC; X130. Late Pliocene.
- Figure 13 *Anomalinoidea globulosa* (Chapman and Parr). 12-116-5-0, bottom. X37; Late Miocene.
- Figure 14 *Eggerella bradyi* (Cushman). 12-116-3, CC. X130; Early Pliocene.
- Figure 15 *Sphaeroidina bulloides* d'Orbigny. 12-116-1, CC. X130; Late Pliocene.
- Figure 16 *Uvigerina auberiana* d'Orbigny. 12-116-2-1, 145-147 cm. X130; Early Pliocene.
- Figures 17, 18 *Martinotiella bradyana* (Cushman). 12-116-3, CC. 17: X130; 18: X605; Early Pliocene. Detail of aperture is shown in Figure 18.

PLATE 9

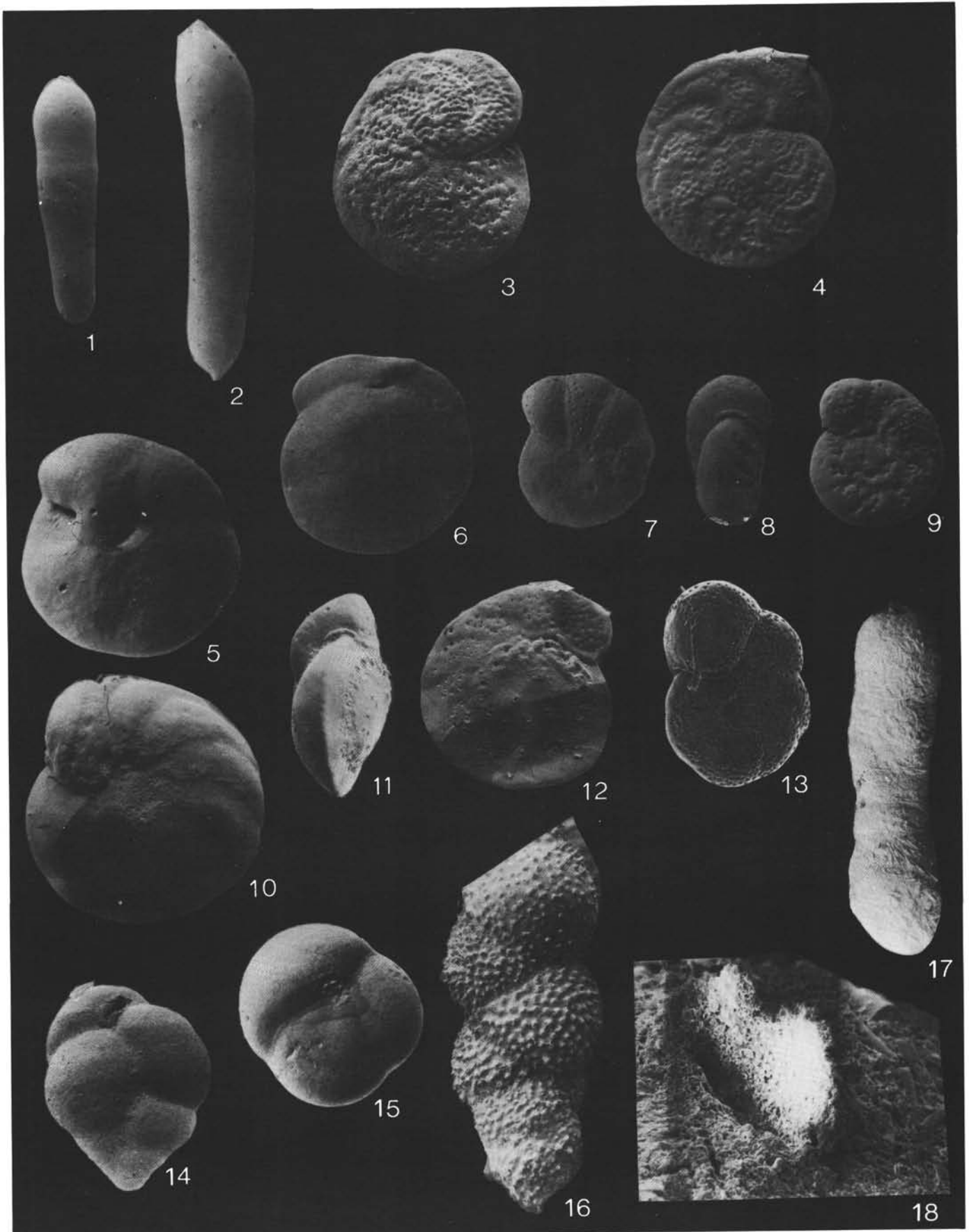


PLATE 10

All specimens are from Site 116

- Figure 1 *Cibicoides trincherasensis* (Bermudez). 12-116-16, CC. X35; Early Miocene.
- Figures 2-4 *Heterolepa mexicana* (Nuttall). 12-116-22, CC. 2 and 4: X50; 3: X60; Early-Late Oligocene.
- Figures 5, 6 *Planulina subtenuissima* (Nuttall). 12-116-10-1, 87-91 cm. 5: X40; 6: X53; Middle Miocene.
- Figures 7, 8 *Planulina renzi* Cushman and Stainforth. 12-116-23-2, 124-127 cm. X60; Early Oligocene.
- Figures 9-11 *Planulina wuellerstorfi* (Schwager). 12-116-8-2, 142-145 cm. 9: X55; 10: X68; 11: X77; Middle Miocene.
- Figures 12, 13 *Siphonina tenuicarinata* Cushman. 12-116-10, CC. 12: X71; 13: X30; Early Miocene.
- Figures 14-17 *Gyroidina complanata* Cushman and Stainforth. 12-116-10, CC. 14: X31; 15: X72; 16: X37; 17: X54; Early Miocene.

PLATE 10

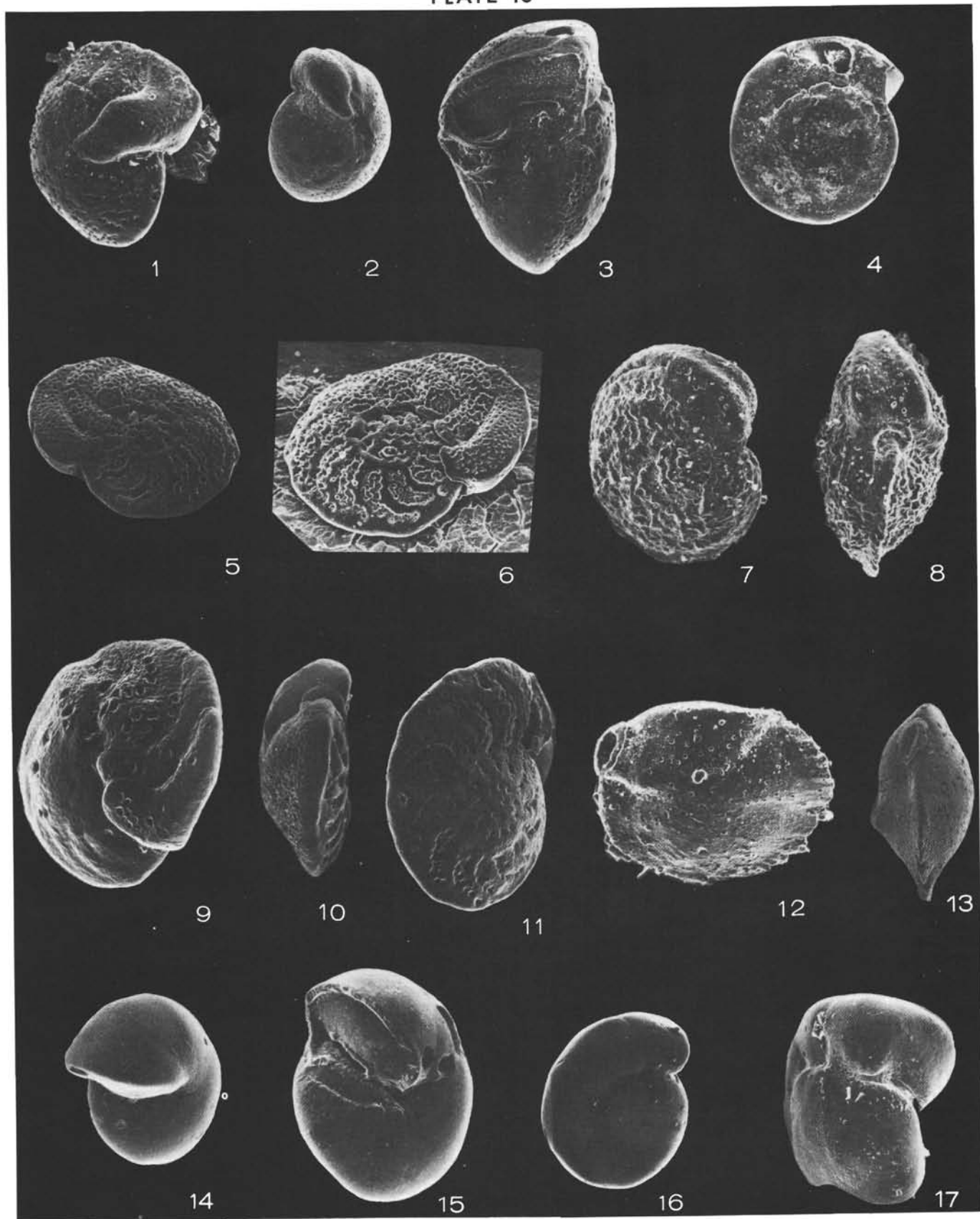


PLATE 11

All specimens are from Site 117

- Figures 1, 2 ?*Bisaccium* sp. 12-117-2, CC. 1: X134; 2: X122;
Oligocene.
- Figure 3 *Anomalina acuta* Plummer. 12-117A-8-1, 4-6 cm.
X120; Late Paleocene.
- Figure 4 *Planulina cocoaensis* Cushman. 12-117-3, CC. X100;
Oligocene.
- Figures 5-8 *Anomalinoides danica* Brotzen. 12-117A-8-1, 4-6 cm.
X120; Late Paleocene.
- Figures 9-11 *Cibicidoides sulzensis* (Hermann). 12-117A-3-3,
142-145 cm. 9 and 10: X120; 11: X96; Early Eocene.
- Figures 12, 13 *Cibicides* sp. cf. *C. praecursorius* (Schwager).
12-117A-7, CC. X120; Late Paleocene.
- Figures 14, 15 *Cibicidoides propria* (Brotzen). 12-117A-4-6, 143-146
cm. X120; Early Eocene.
- Figure 16 *Gravelinella neelyi* (Jennings). 12-117A-7, CC. X120;
Late Paleocene.
- Figures 17-20 *Heterolepa mexicana* (Nuttall). 12-117-2, CC. X30;
Oligocene.

PLATE 11

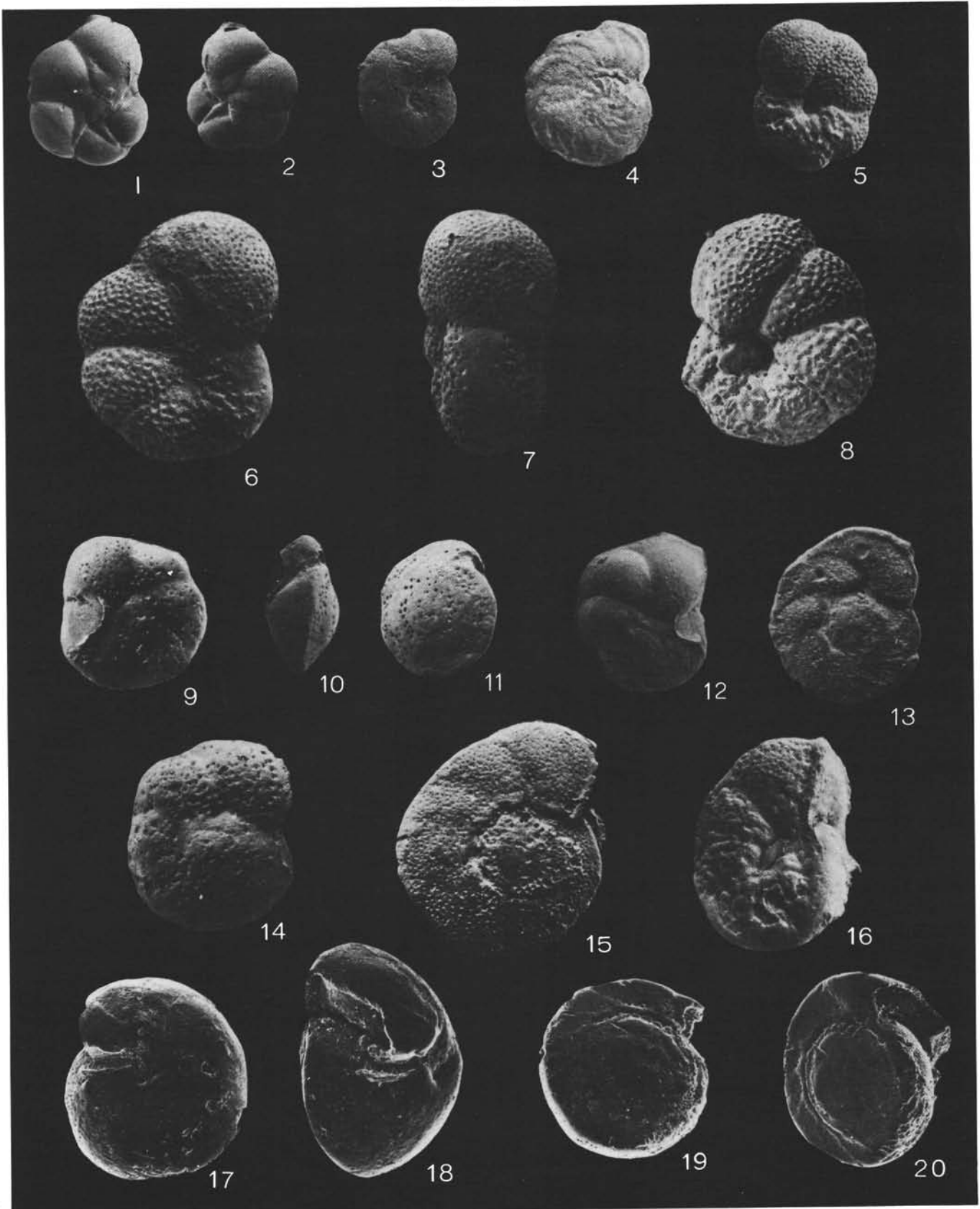


PLATE 12

All specimens are from Site 119 except Figures 1-3 (Site 118)

- Figures 1-3 *Nuttallides treumpei* (Nuttall). 12-118-12, CC. X132; Middle Eocene.
- Figures 4, 5 *Oridorsalis ecuadorensis* (Galloway and Morrey). 12-119-22, CC. X132; Middle Eocene.
- Figures 6-8 *Alabamina dissonata* (Cushman and Renz). 12-119-21, CC. 6 and 8: X130; 7: X260; Middle Eocene.
- Figure 9 *Gyroidina planulata* (Cushman and Renz). 12-119-21, CC. X316; Middle Eocene.
- Figure 10 *Cibicoides cushmani* (Nuttall). 12-119-22, CC. X136; Middle Eocene.
- Figures 11, 12 *Cibicoides grimsdalei* (Nuttall). 12-119-16, CC. X60; Oligocene.
- Figures 13, 14 *Cibicoides* sp. 12-119-16, CC. X25; Oligocene.
- Figures 15, 16 *Cibicoides trincherasensis* (Bermudez). 12-119-16, CC. X41; Oligocene.
- Figures 17, 18 *Anomalinoidea alazanensis* Nuttall. 12-119-16, CC. 17: X71; 18: X64; Oligocene.
- Figures 19, 20 *Vulvulina jarvisi* Cushman. 12-119-21, CC. 19: X110; 20: X275; Middle Eocene.
- Figure 21 *Karrerella bradyi* (Cushman). 12-119-18, CC. X132; Early Oligocene.
- Figure 22 *Plectina cubensis* Cushman and Bermudez. 12-119-21, CC. X66; Middle Eocene.
- Figure 23 *Buliminella grata* Parker and Bermudez. 12-119-22, CC. X144; Middle Eocene.

PLATE 12

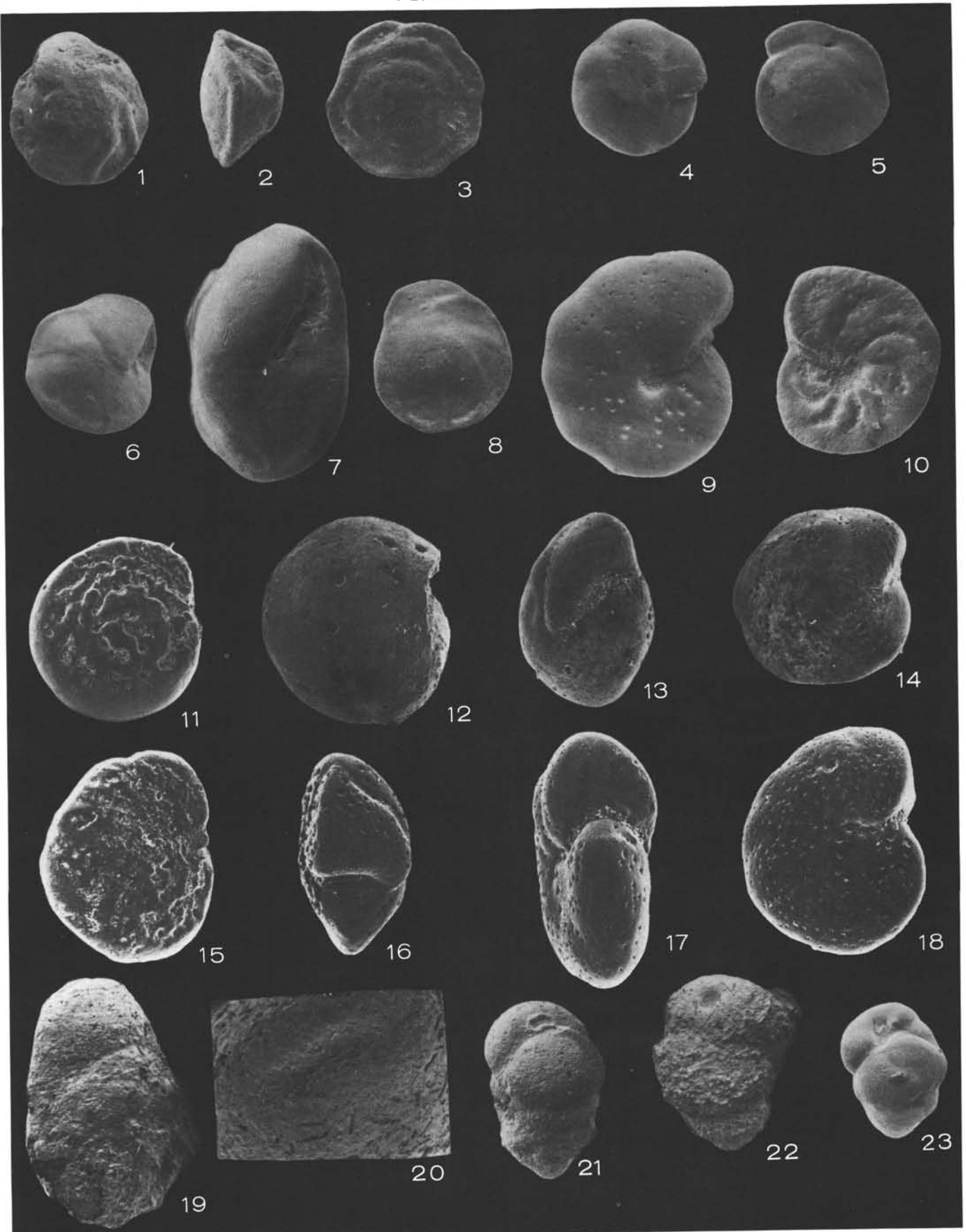


PLATE 13

All specimens are from Site 119

- Figures 1, 2 *Nodosarella subnodosa* (Guppy). 12-119-18, CC. 1: X93; 2: X83; Early Oligocene.
- Figures 3, 4 *Stilostomella nuttalli* Cushman and Jarvis. 12-119-18, CC. 3: X65; 4 (apertural detail): X650; Early Oligocene.
- Figure 5 *Stilostomella aculeata* (Cushman and Renz). 12-119-18, CC. X128; Early Oligocene.
- Figure 6 *Stilostomella nuttalli* Cushman and Jarvis. 12-119-18, CC. X57, Early Oligocene.
- Figure 7 *Stilostomella gracillima* (Cushman and Jarvis). 12-119-21, CC. X60; Middle Eocene.
- Figures 8, 9 *Nodosarella mappa* (Cushman and Jarvis). 12-119-21, CC. 8 (apertural detail): X260; 9: X130; Middle Eocene.
- Figure 10 *Cibicidoides grimsdalei* (Nuttall). 12-119-18, CC. X136; Early Oligocene.
- Figures 11-13 *Anomalina spissformis* Cushman and Stainforth. 12-119-18, CC. X133; Early Oligocene.
- Figures 14-16 *Cibicidoides trinitatis* Beckmann (*non* Nuttall). 12-119-21, CC. 14 and 15: X130; 16: X116; Middle Eocene.
- Figures 17-19 *Cibicidoides martinizensis* (Cushman and Barksdale). 12-119-21, CC. X130; Middle Eocene.

PLATE 13

