

## 22. MID-CRETACEOUS PLANKTONIC FORAMINIFERAL BIOSTRATIGRAPHY OFF CENTRAL MOROCCO, DEEP SEA DRILLING PROJECT LEG 79, SITES 545 AND 547<sup>1</sup>

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### ABSTRACT

Sites 545 and 547 collectively penetrated 629 m of mid-Cretaceous strata (upper Aptian to upper Cenomanian) off central Morocco during Leg 79 of the Deep Sea Drilling Project. Site 545, at the base of the steep Mazagan Escarpment, records a virtually complete succession of hemipelagic sediments of early late Aptian to middle Cenomanian age. Minor faunal recycling occurred throughout much of the upper Aptian to middle Albian part of the sequence (Cores 55 through 41), reflecting bottom currents along the Mazagan Escarpment. This may be related to the strong upwelling régime and high surface water productivity over Site 545 during the latest Aptian through middle Albian. The upwelling system ceased rather abruptly in this area in late middle Albian time. Recycling of older strata by bottom currents also ceased in the late middle Albian and resulted in a slower average accumulation rate in the upper Albian to middle Cenomanian section of Site 545 (Cores 40 through 28). However, intervals of pebbly claystone conglomerates in Cores 40 and 34 record sporadic instability in the slope adjacent to Site 545. Site 547, located only about 15 km seaward, is situated in a small sub-basin adjacent to the basement block drilled by Site 544. It contains an expanded upper Albian to upper Cenomanian sequence as a result of the numerous conglomeratic intervals throughout much of the section. In contrast to Site 545, the conglomerates were not derived from older strata cropping out on the Mazagan Escarpment; rather, they originated penecontemporaneously from a local unstable slope.

A detailed biostratigraphic framework based on planktonic foraminifers is established for the mid-Cretaceous sections of Sites 545 and 547 and a new composite zonal scheme is proposed for the early late Aptian through early late Cenomanian interval. Fifty-five species are recognized and illustrated.

### INTRODUCTION

DSDP Sites 545 and 547 recovered a virtually complete succession of strata of early late Aptian to early late Cenomanian age off central Morocco during Leg 79 of the Deep Sea Drilling Project (Figs 1–4). Planktonic foraminifers are abundant, diverse, and generally well preserved throughout the section, permitting a detailed biostratigraphic framework to be established.

The mid-Cretaceous section is predominantly composed of nannofossil claystones with subordinate pebbly claystone intervals, particularly common in the Site 547 sequence (Figs. 5, 6). Redeposition is a characteristic feature of the continental margin off central Morocco from Early Jurassic through Late Tertiary times. Although Site 547 contains abundant conglomeratic intervals, faunal reworking is not an obvious problem. However, at Site 545, at the base of the Mazagan Escarpment, extended ranges of several late Aptian planktonic foraminiferal taxa suggest that faunal mixing is common in the upper Aptian through middle Albian part of the sequence and may be associated with upwelling-related bottom currents.

#### Site 545

The mid-Cretaceous section of Site 545 is 278.7 m thick and ranges in age from early late Aptian (*Globigerinelloides ferreolensis* Zone) to middle Cenomanian

(*Rotalipora reicheli* Zone). The lower 113 m (Cores 45 through 56) is dominated by greenish gray nannofossil claystone with subordinate clayey nannofossil chalks. A pervasive fabric of microfaulting and microfolding characterizes this part of the section. A fault mélange zone occurs in the lowermost part of Core 55 and upper part of Core 56. The upper 166 m (Cores 28 through 44) is composed of grayish green and grayish olive green nannofossil-bearing clay/claystone and clayey nannofossil chalks. Two intervals of intraclastic clayey conglomerates and pebbly or cobbly mudstones occur in Cores 34 and 40. The only representation of the widespread mid-Cretaceous black shale facies occurs in two thin, finely laminated, olive black claystone intervals in Sections 545-42-1, 2 and 545-43-7. The hemipelagic sediments accumulated at an average rate of 20 m/m.y. for the upper Aptian to middle Albian part of the sequence (Cores 41 through 56) and at an average rate of 11 m/m.y. for the upper Albian to middle Cenomanian (Cores 28 through 40).

The mid-Cretaceous is unconformably bounded by lower Miocene radiolarian-bearing nannofossil chalk above and by Upper Jurassic shallow-water dolomitized limestone below (see site chapter, this volume).

#### Site 547

The mid-Cretaceous section of Site 547 (Holes 547A and 547B) is 350.4 meters thick and ranges in age from late middle Albian (*Ticinella praeticinensis* Zone) to early late Cenomanian (*Rotalipora cushmani* Zone). The dominant lithology is dark greenish gray, grayish olive green, and grayish green nannofossil-bearing claystone with subordinate amounts of pebbly-cobbly claystone and mud-

<sup>1</sup> Hinz, K., Winterer, E. L., et al., *Init. Repts. DSDP, 79*: Washington (U.S. Govt. Printing Office).

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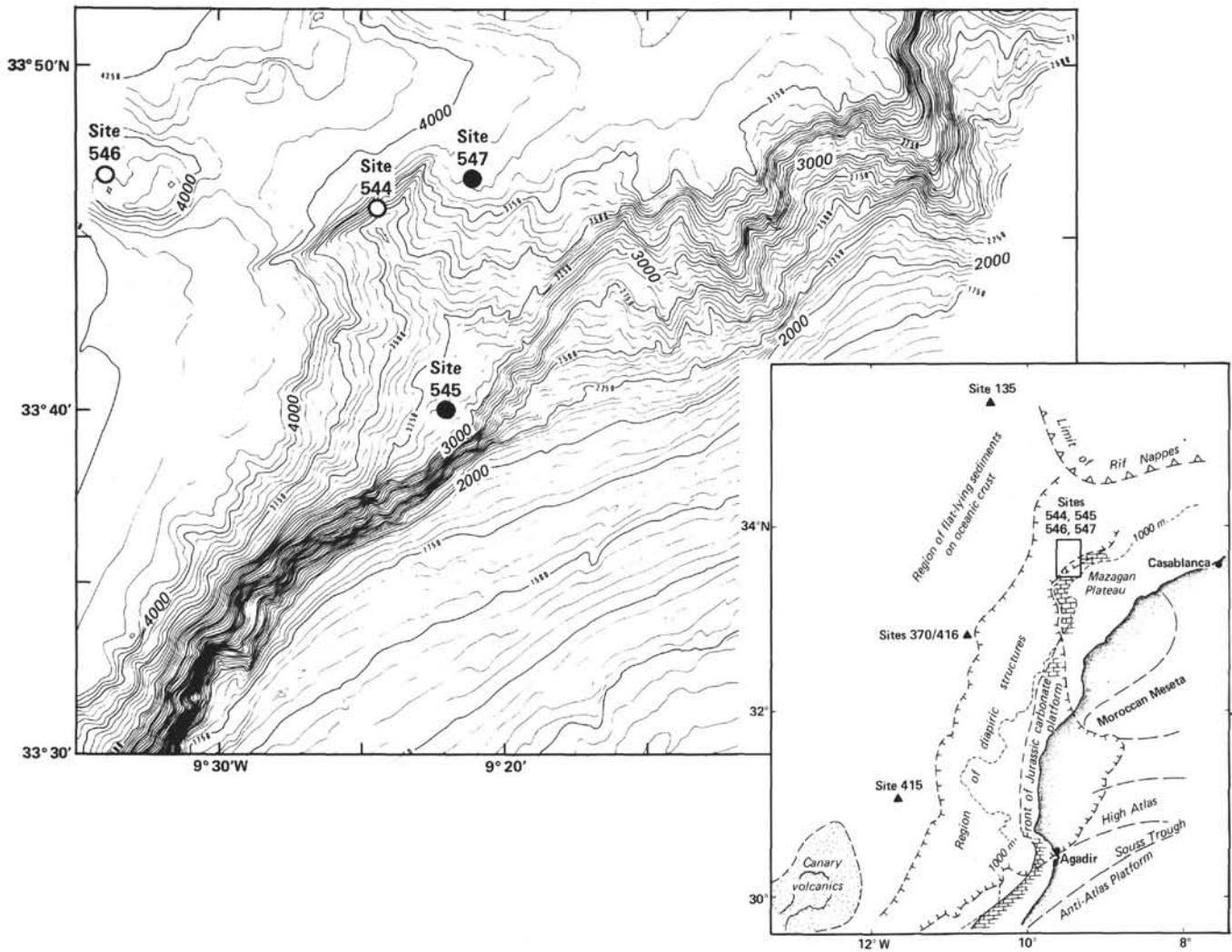


Figure 1. Map showing the regional setting of the Mazagan Plateau and location of sites drilled during Leg 79.

stone. The Site 547 conglomeratic intervals are considerably more frequent and thicker than those of Site 545 and may explain the higher sediment accumulation rates at Site 547; these averaged greater than 30 m/m.y.

This sequence is unconformably bounded by Campanian clayey nannofossil and foraminiferal-nannofossil chinks above, and by a very thin Neocomian section which caps an earliest Cretaceous to Jurassic carbonate section below.

#### TECTONIC SETTING AND FAUNAL RECYCLING

Site 545 was drilled at the foot of the steep Mazagan Escarpment in a water depth of 3150 m (Figs. 2, 3). In the Late Jurassic, Site 545 was situated in the shallow-water environment of a carbonate platform, but during the latest Jurassic and Early Cretaceous carbonate accumulation could not keep pace with subsidence. Differential subsidence along listric normal faults resulted in the formation of the Mazagan Escarpment at the seaward edge of the broad Mazagan Plateau. By mid-Cretaceous time, Site 545 had probably attained middle to upper bathyal depths at the base of the steepening escarpment.

Extended ranges of several late Aptian planktonic foraminiferal species suggest that continuous recycling of penecontemporaneous and older faunas occurred throughout the upper Aptian to middle Albian interval (Cores 41 through 55). These taxa include *Globigerinelloides blowi* s.l., *G. aptiense*, *G. algerianus*, and *Hedbergella* aff. *sigali*. Regardless of this faunal mixing, a normal foraminiferal succession occurs throughout the section. The redeposited sediment and fauna probably originated from the Mazagan Escarpment. The lack of conglomerate beds suggests that bottom current scour may be responsible for the faunal mixing, although slumping of semilithified sediments also occurred. Bottom current erosion and entrainment of sediment is reflected in the higher accumulation rates in the upper Aptian to middle Albian part of the sequence compared with the overlying upper Albian to middle Cenomanian strata.

A minor erosional unconformity represented by pebbly claystone conglomerates is present in the lower part of Core 545-40, probably within the late Albian *Biticinella breggiensis* Zone. Core 40 contains numerous conglomerates throughout and, near the top, a thin pebble bed in 545-40-1, 8–10 cm, contains a mixed late Albian

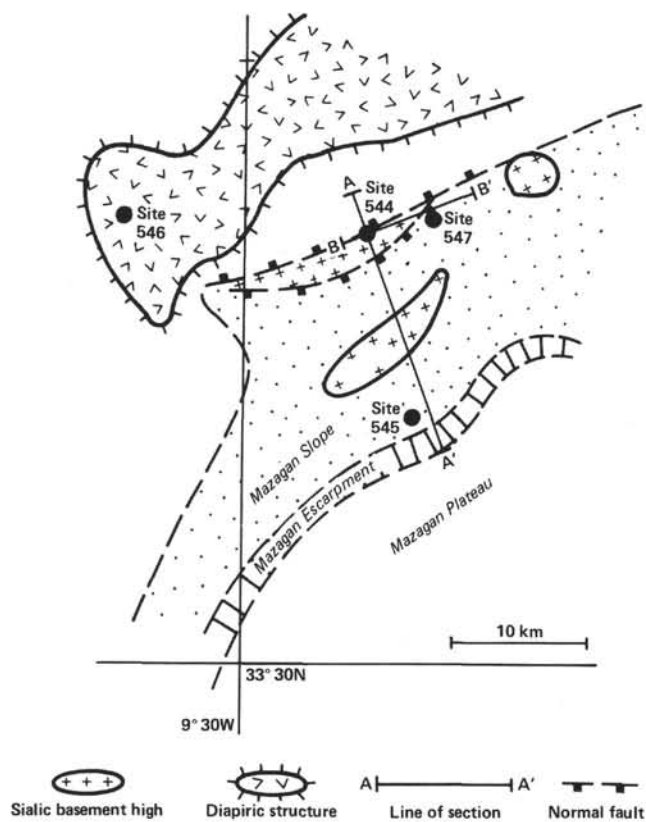


Figure 2. Mazagan Escarpment area, showing sites drilled during Leg 79, location of lines of cross sections, and major geologic features.

and latest Albian fauna (*B. breggiensis* and *Planomali-na praebuxtorfi-buxtorfi* zones). This is overlain by a normal succession of the *B. breggiensis* Zone, the *P. praebuxtorfi* Subzone and the *Rotalipora appenninica* Subzone (Table 1, later). It appears that the pebble bed at the top of Section 545-40-1 represents a period of erosion in the latest Albian (*P. praebuxtorfi-buxtorfi* Zone) during which a slump block containing a normal succession of late Albian zones slid onto the site. The slumped

block contains the portion of the sequence that had been eroded from the site earlier, resulting in a virtually complete upper Albian section.

Another conglomeratic interval in Core 545-34 (lower Cenomanian) contains clasts of upper Aptian strata as evidenced by planktonic foraminifers (Table 1, later). The clasts probably originated from the Mazagan Escarpment.

Site 547 is situated in a small sub-basin on the flank of a structural basement high (Figs. 2, 4). It was drilled in a water depth of 3940 m. During Early Jurassic rifting, Site 547 subsided rapidly and nodular limestones were deposited in a basinal environment. These were followed by deposition of sandy breccias and finally, during the Late Jurassic, by deposition of pelagic carbonates on a progressively deepening platform slope (Steiger and Jansa, this volume). This area continued to subside during the Early Cretaceous and by the mid-Cretaceous had probably reached middle bathyal depths.

In contrast to Site 545, the mid-Cretaceous section at Site 547 (middle Albian to upper Cenomanian) contains frequent and thicker conglomeratic intervals. However, planktonic foraminiferal evidence suggests that most of the redeposition is penecontemporaneous, and foraminiferal ranges do not extend upward beyond their expected extinction datums as they do in the upper Aptian to middle Albian section of Site 545. The lack of recycled older faunas suggests that the conglomerate beds were not derived from the Mazagan Escarpment some 15-20 km away, but were derived locally.

#### UPWELLING OFF THE MAZAGAN PLATEAU

There is strong evidence from Site 545 of significant upwelling and associated fertile surface waters off central Morocco during latest Aptian through middle Albian time. This is primarily indicated by the accumulation of siliceous skeletons (radiolarians and sponge spicules) and their presence as the dominant biotic elements from the upper part of Core 50 through the lower part of Core 41 (Fig. 7). Because the oceans are undersaturated with respect to silica, preservation of siliceous skeletons is enhanced in the sedimentary record during periods of

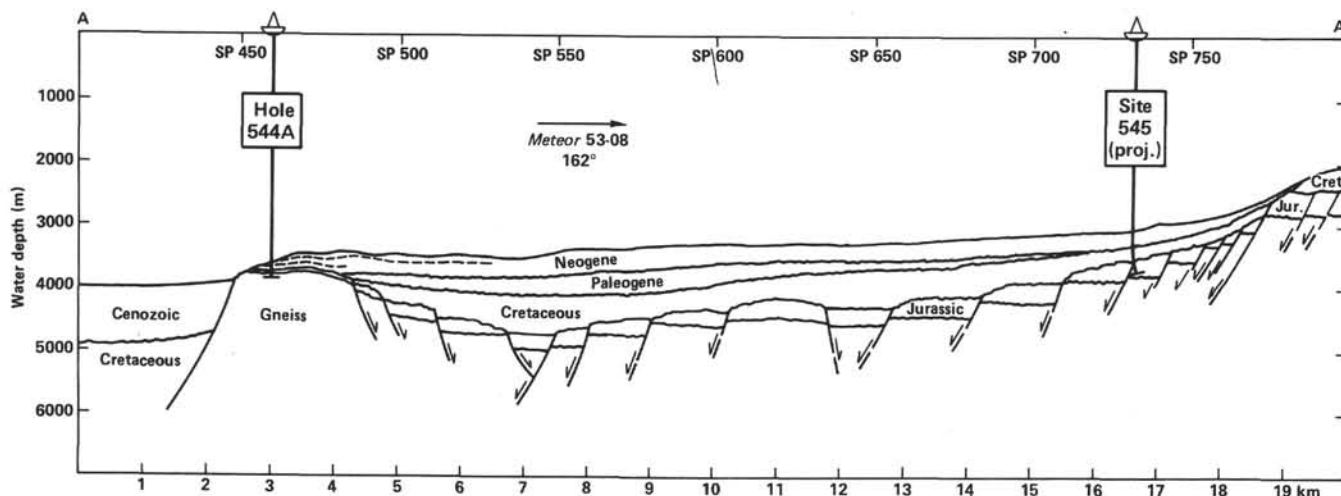


Figure 3. Geologic cross section along *Meteor* seismic profile 53-08, through Sites 544 and 545 (projected into line).

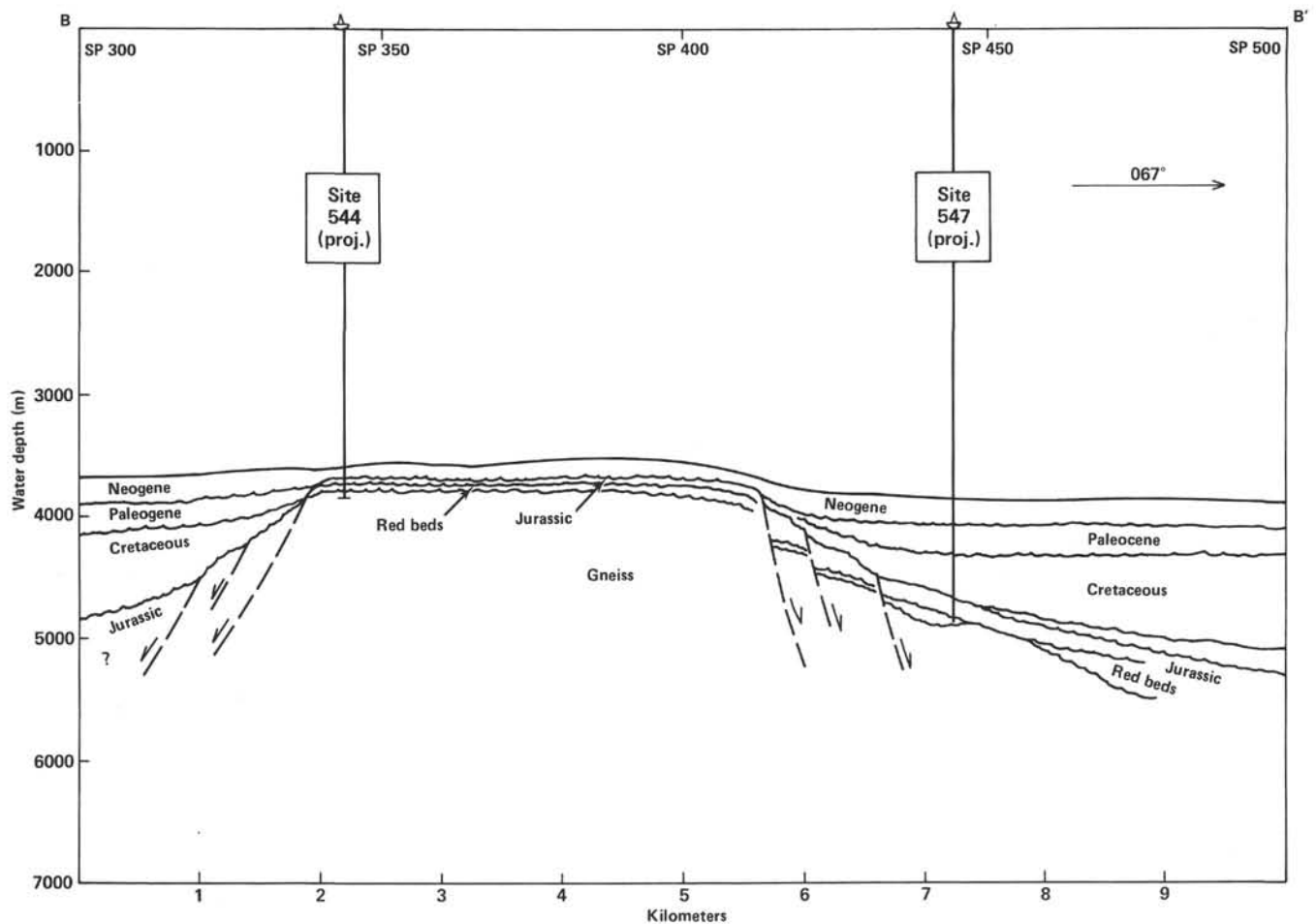


Figure 4. Geologic cross section along *Meteor* seismic profile 53-10, through Sites 544 and 547 (projected into line).

greater surface water productivity and net accumulation of silica at the seafloor. Therefore, the preservation of significant amounts of siliceous skeletons in the ancient record is indicative of upwelling of nutrient-rich deep water and high biologic productivity (see discussions by Berger, 1970; Diester-Haass, 1978). Other evidence supporting upwelling is the sharp increase in benthic foraminifers relative to planktonic forms, the drop in planktonic foraminiferal diversity, and the increase in fish debris (Fig. 7). The upwelling probably occurred over the outer Mazagan Plateau and upper Mazagan Escarpment, adjacent to Site 545.

Development of this upwelling system over Site 545 shows the first minor pulses of radiolarians in Cores 55, 54, and 53 with a greater pulse through Cores 52 and 51. Then beginning in the upper part of Core 50, both radiolarians and sponge spicules significantly increase. From there, the proportion of radiolarians to planktonic foraminifers and spicules to benthic foraminifers steadily increases as these siliceous components dominate the assemblages in the  $>63 \mu\text{m}$  fraction through the lower part of Core 41. The abundances of radiolarians and sponge spicules drop off sharply in Section 545-41-3 and are virtually absent above the minor erosional hiatus in the lowermost part of Core 40.

Foraminiferal assemblages were notably affected by the upwelling regime. Foraminifers in general have their lowest proportion, relative to other biota, in the  $>63 \mu\text{m}$  fraction for the interval from Core 47 through the lower part of Core 41. The planktonic to benthic ratio steadily decreases from Cores 55 through 48. Then in Core 47 there is a sharp drop in the proportion of planktonics to benthics (Fig. 7; compare with data from Site 547, Fig. 8). In fertile regions along the present Northwest African margin, Diester-Haass (1978) also noted that benthic foraminifers showed a greater increase in abundance relative to planktonic forms. In the mid-Cretaceous at Site 545, several environmental factors may contribute to this trend. One such factor may be dissolution of planktonic foraminifers, either as they fell through the water column or reacted with interstitial waters in the bottom sediments. It has been shown that the present-day calcite compensation depth (CCD) commonly rises under regions where fertility is greater (Berger, 1970; Diester-Haass, 1978); however, benthic foraminiferal assemblages clearly indicate that Site 545 was well above the lysocline in the mid-Cretaceous. Selective dissolution of planktonic taxa may be partially responsible for the drop in simple diversity (Fig. 7) and/or the exclusion of such planktonic species as *Ticinella roberti* s.l., *T. primula*,

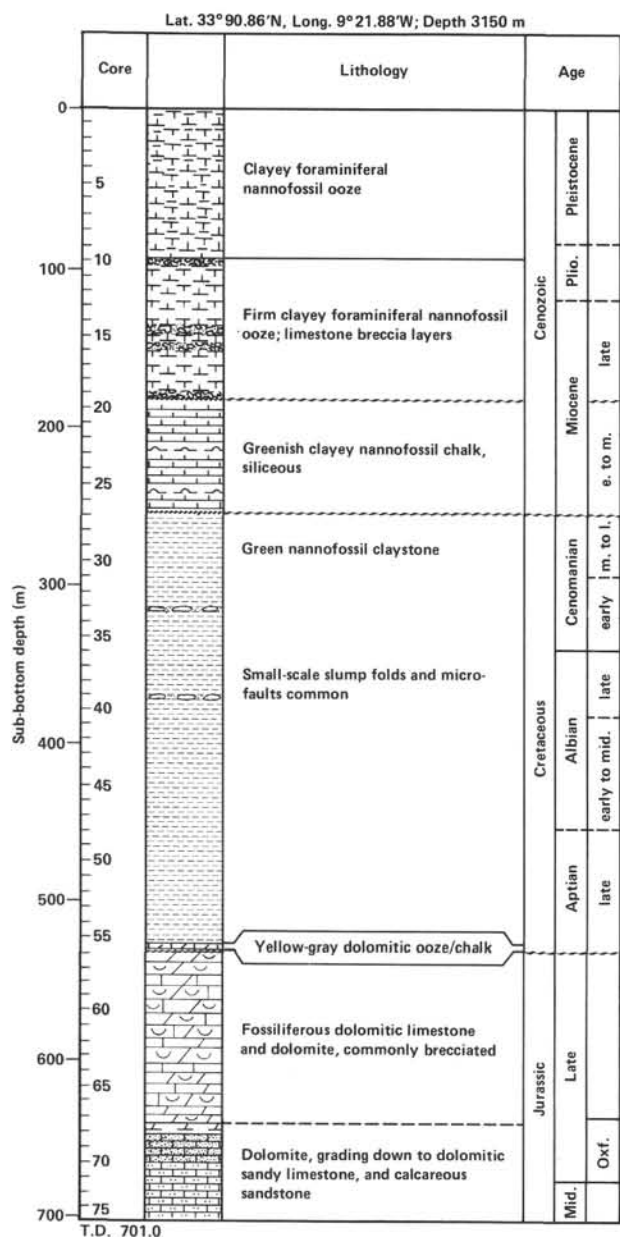


Figure 5. Lithologic column drilled at Site 545.

and *T. praeticinensis* (especially in Cores 43 through 41), although it is difficult to imagine that such apparently robust taxa were more susceptible to dissolution than *Hedbergella delrioensis*.

The decrease in diversity and exclusion of specialized planktonic taxa may also result from upwelled cool, nutrient-rich bottom water. Butt (1982) proposed that the production of cherts and phosphates, and the interbedded deposits containing assemblages of radiolarians and nonkeeled planktonic foraminifers during the early Turonian of Morocco signalled the occurrence of major coastal upwelling of cold water masses (Antarctic Current). Butt interpreted the low-diversity, high-density hedbergellid fauna as representing a cool-water assemblage. However, this interpretation for the early Turonian must be considered in light of the dearth of keeled plankton-

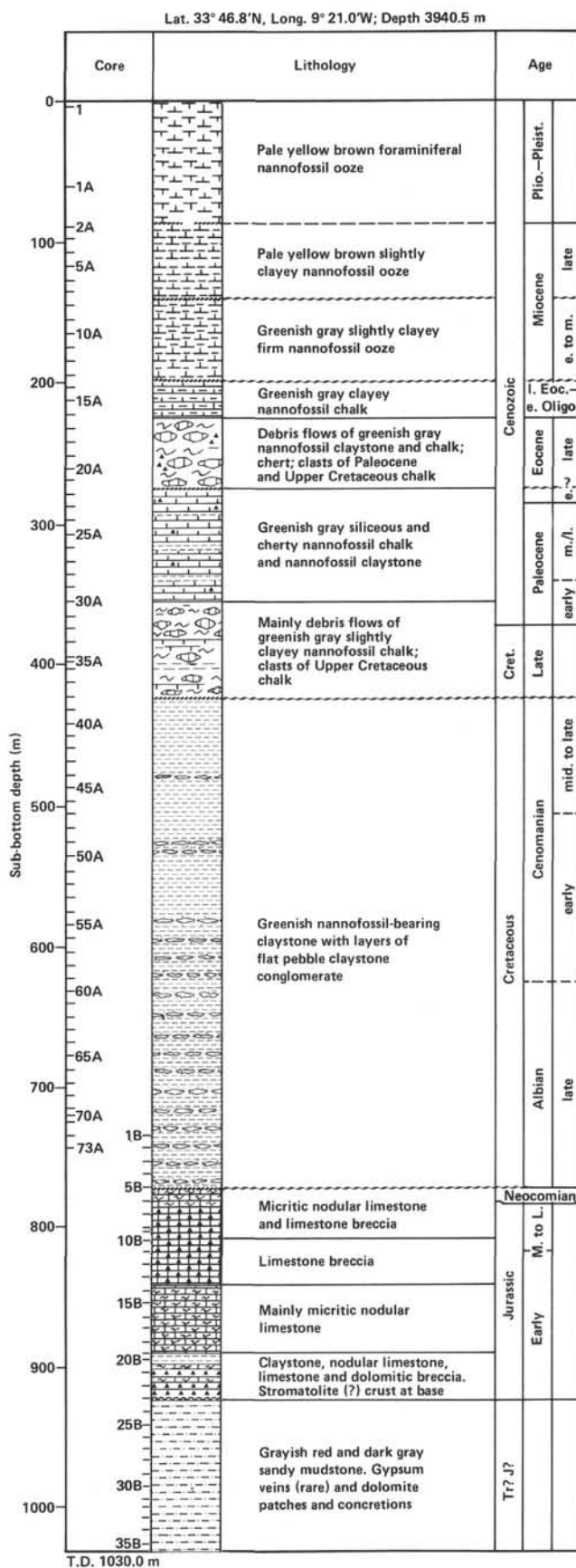


Figure 6. Lithologic column drilled at Site 547.

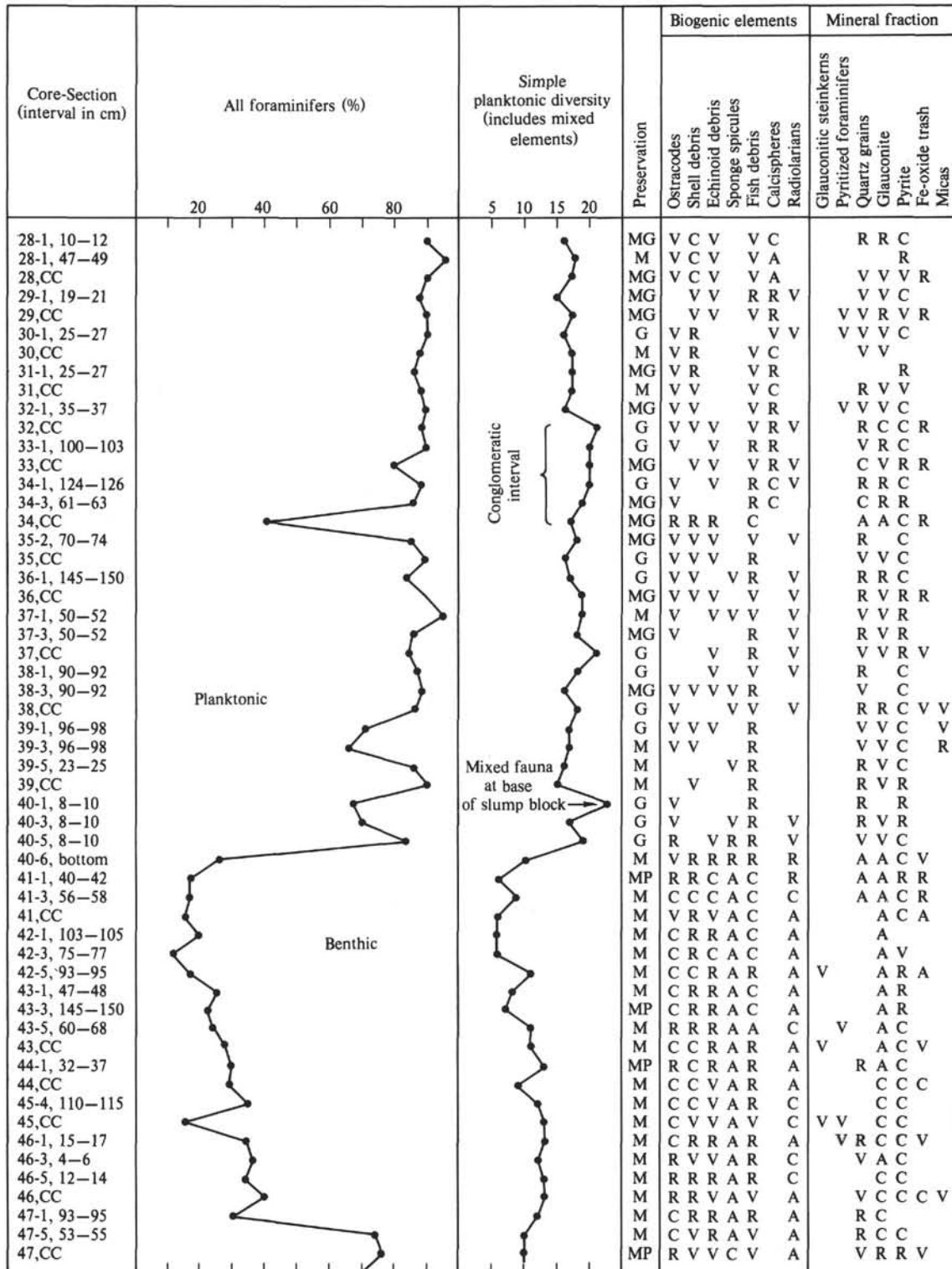


Figure 7. Distribution and character of selected biogenic and lithologic components at Site 545. Relative abundance of planktonic and benthic foraminifers based on counts of 300 specimens from the >63 μm fraction. Simple planktonic diversity includes mixed elements. Foraminiferal preservation: G = good, MG = moderately good, M = moderate, MP = moderately poor, P = poor. Relative abundances of other biogenic and mineral components based on proportion relative to foraminifers (P + B): 25% = abundant, 5-25% = common, 1-5% = rare, 1% very rare.

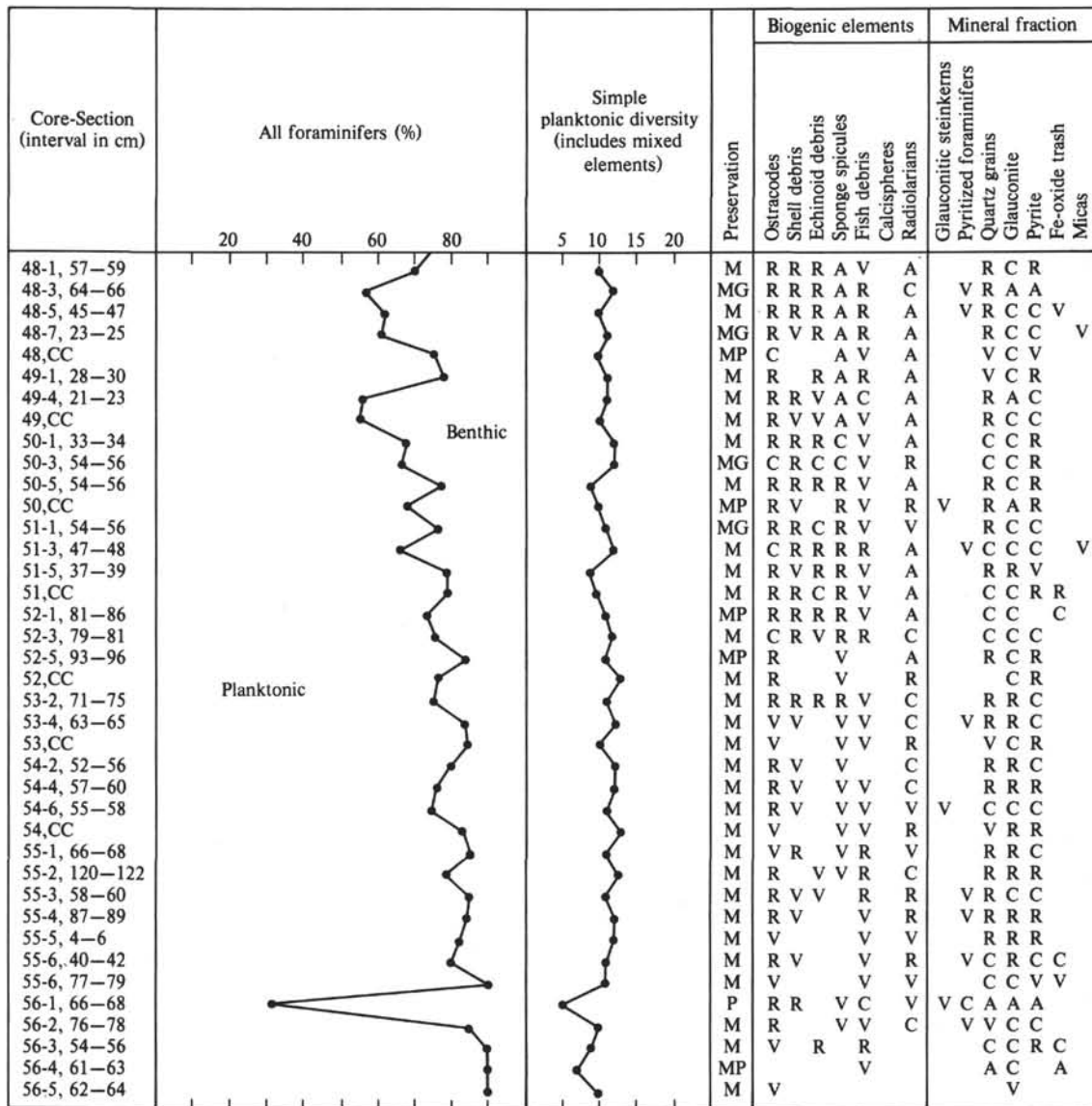


Figure 7. (Continued).

ics at this time after the disappearance of the late Cenomanian keeled assemblages of *Rotalipora* and *Praeglobotruncana*, ("zone à grandes globigérines"; Van Hinte, 1976) and the radiation of the marginotruncanids during the middle and late Turonian (see Robaszynski and Caron, 1979). The middle Albian records a similar period of low-diversity faunas composed of simpler forms which preceded a radiation of specialized, morphologically advanced taxa in the late Albian. The suggestion of cool bottom waters bears importantly on the paleoceanography of the Atlantic Ocean, especially its thermal gradient and the potential source of such cold bottom waters.

The Aptian-Albian and Cenomanian-Turonian Oceanic Anoxic Events (OAE) of Arthur and Schlanger (1979) corresponded to times of rising sea levels (Fig. 9). These were also times of upwelling along the Northwest African continental margin and of low-diversity (oligotaxic) planktonic foraminiferal assemblages dominated by sim-

ple morphologic forms. Wonders (1980) noted the correspondence between OAE's and the evolution and faunal turnovers of Tethyan planktonic foraminifers. He proposed two models to explain how the ecological niche of the deep-dwelling, specialized planktonic foraminifers may disappear: either by absence of the thermocline whereby vertical mixing of the surface waters expands to much greater depths, or anoxic conditions in the deeper waters.

An intensified oxygen minimum zone off central Morocco during the latest Aptian and early Albian is probably responsible for the loss of *Planomalina cheniourensis*, the earliest keeled planktonic foraminifer, and a simultaneous disappearance of several other planktonic taxa favoring the simpler morphologic forms. The vertical expansion of the oxygen minimum zone peaked during the middle Albian (Cores 545-43 to 545-41), when all species of *Ticinella* disappeared from the planktonic foraminiferal populations and oxygen-poor water im-

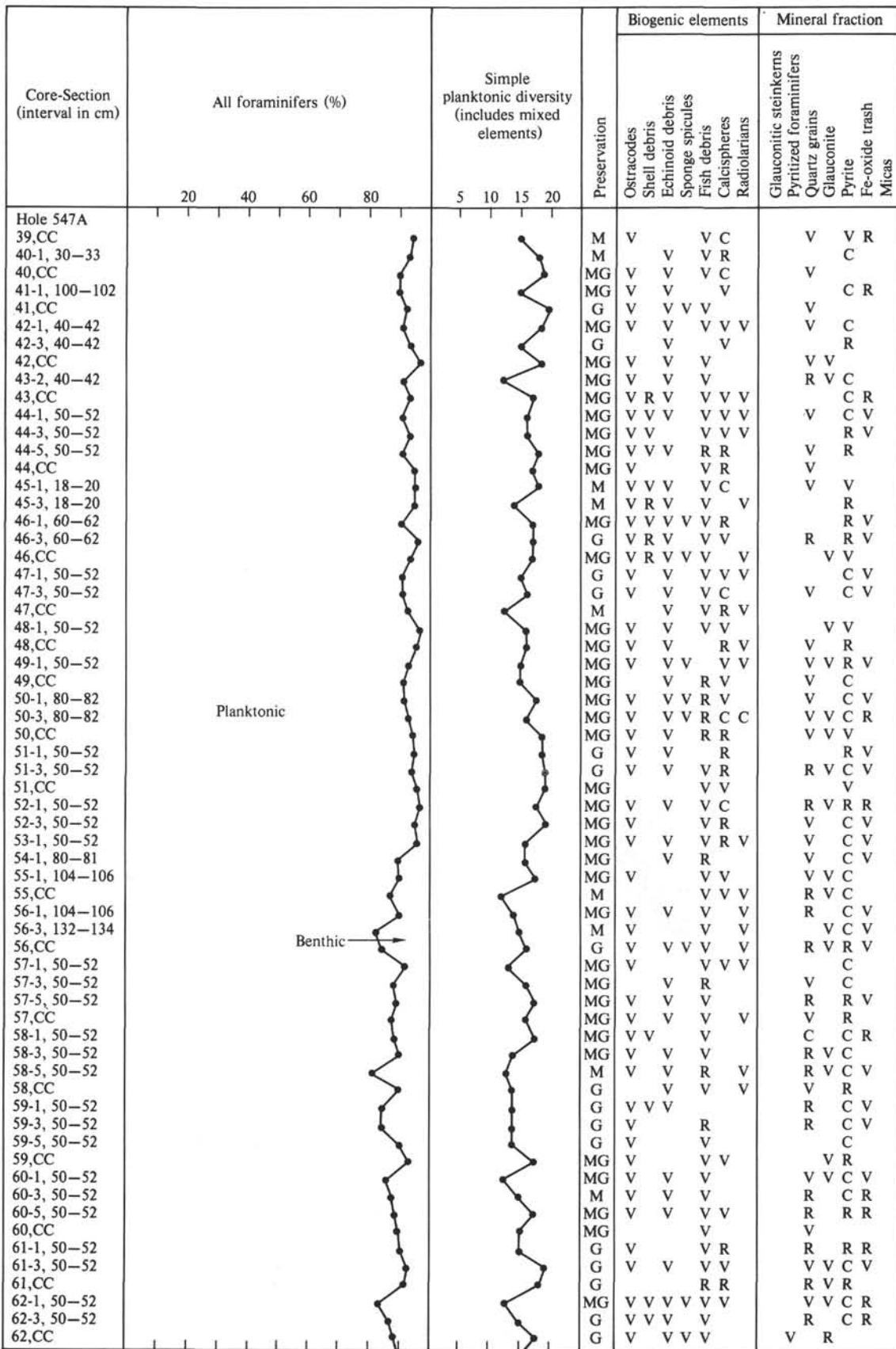


Figure 8. Distribution and character of selected biogenic and lithologic components at Site 547. Explanation as for Figure 7.



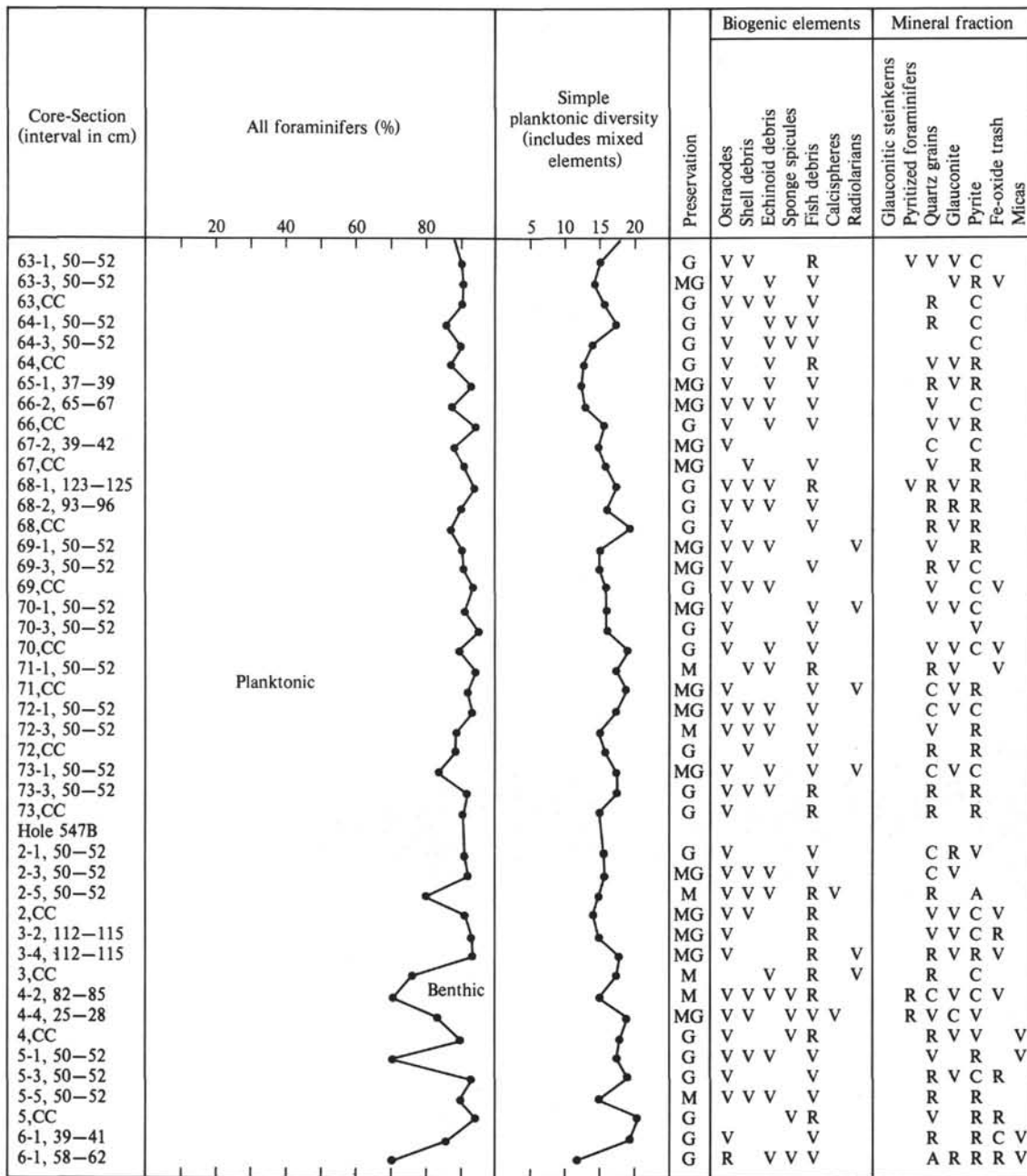


Figure 8. (Continued).

pinged on the seafloor in the vicinity of Site 545, as recorded by the deposition of thin, organic-carbon-rich, black shales.

Upwelling over Site 545 ended rather abruptly in the early late Albian with a simultaneous reduction in the oxygen minimum zone. This is indicated by the sharp decline and eventual loss of siliceous skeletons in the lower part of Core 40, the significant increase in planktonic foraminiferal diversity and preservation, and a return to normal upper-bathyal planktonic/benthic ratio values (Fig. 7). Although Sites 545 and 547 only lie some 15 km apart, there is no record of this upwelling event in the middle Albian sample from Site 547 (Fig. 8).

**BIOSTRATIGRAPHY**

The zonal scheme adapted here for the early late Aptian through early late Cenomanian interval (Fig. 10) is based on that of van Hinte (1976) among others. The only new addition to previous schemes is the *Planomalina cheniourensis* Subzone in the latest Aptian.

Correlation of the mid-Cretaceous sections of Sites 545 and 547 is summarized in Figure 11. A continuous stratigraphic sequence of early late Aptian through middle Albian age is present at Site 545. This interval is absent at Site 547, although a very thin sliver of ?upper middle Albian is present beneath a minor hiatus that oc-

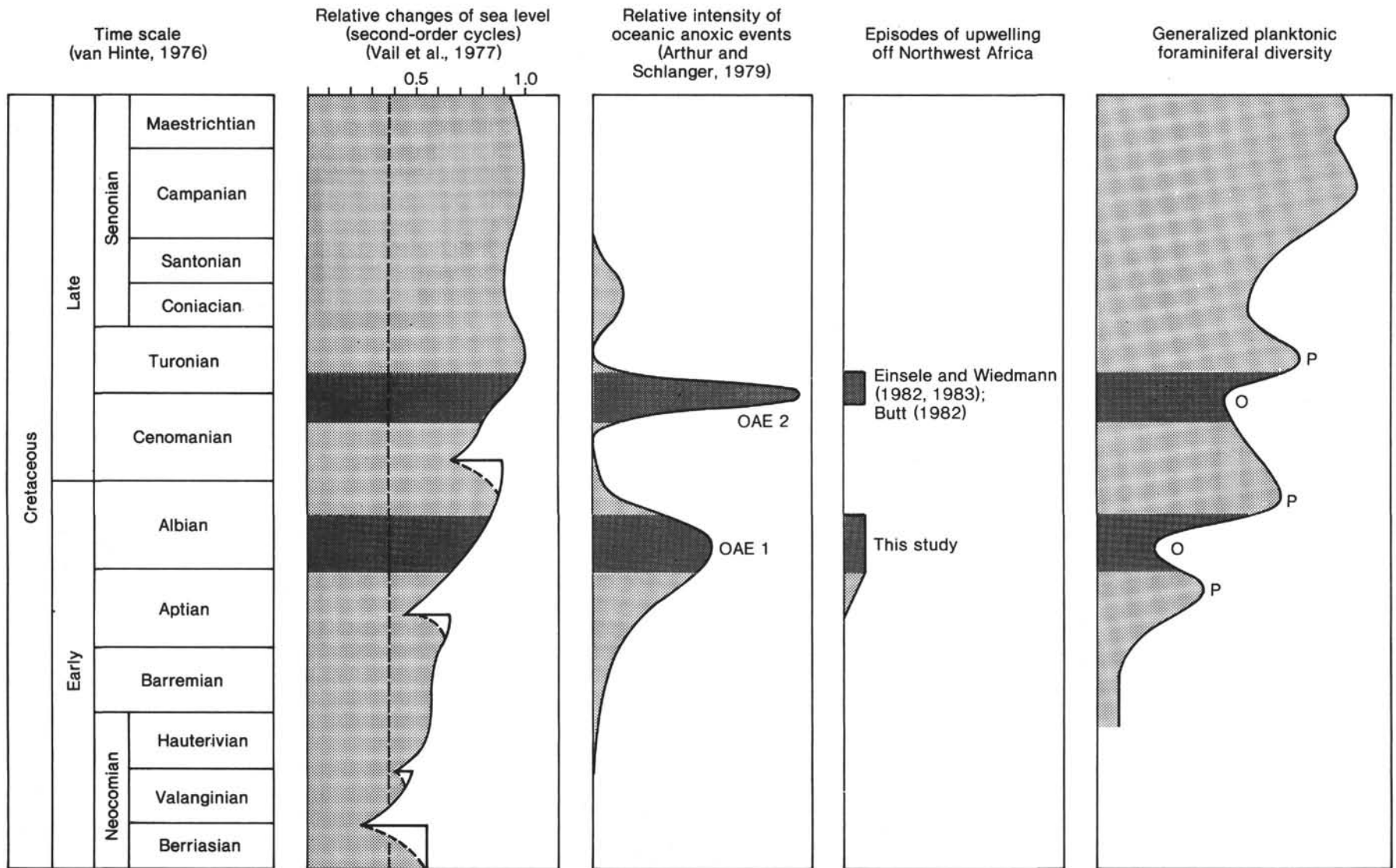


Figure 9. Correlation of global sea level changes, oceanic anoxic events, episodes of upwelling of Northwest Africa, and diversity trends in planktonic foraminifers. O = oligotaxitic; P = polytaxitic.

		Sigal, 1966	Premoli Silva and Boersma, 1977 Moullade, 1974	Pessagno, 1967 Longoria, 1974 Longoria and Gamper, 1977	van Hinte, 1976	Wonders, 1980	Robaszynski et al., 1979	Pflaumann and Čepek, 1982	This study		
Cenomanian	late		<i>alpina</i>	<i>Rotalipora cushmani</i> — <i>greenhornensis</i>	<i>R. cushmani</i>	<i>cushmani</i>	<i>W. archeocretacea</i>		<i>W. archeocretacea</i>		
	middle		<i>greenhornensis</i>				<i>Rotalipora cushmani</i>	<i>Rotalipora cushmani</i>	<i>Rotalipora cushmani</i>		
	early		<i>cushmani</i>		<i>R. gandolfii</i> — <i>R. reicheli</i>		<i>Rotalipora reicheli</i>		<i>R. reicheli</i>		
Albian	Vraconian	à <i>appenninica</i> (part)	<i>moliniensis</i>	<i>Thalmaninella ticinensis</i>	<i>P. buxtorfi</i> — <i>R. appenninica</i>	<i>appenninica</i>	<i>Rotalipora appenninica</i>	<i>Rotalipora appenninica</i>	<i>Planomalina praebuxtorfi</i> — <i>buxtorfi</i>	<i>R. appenninica</i>	
		à <i>Rotalipores (ticinensis)</i>	<i>buxtorfi</i>		<i>R. ticinensis</i> — <i>P. buxtorfi</i>	<i>appenninica</i> — <i>buxtorfi</i> <i>ticinensis</i> — <i>buxtorfi</i>				<i>P. praebuxtorfi</i>	
	late	à <i>Rotalipores (ticinensis)</i>	<i>breggiensis</i>	<i>ticinensis</i>	<i>T. breggiensis</i>	<i>B. breggiensis</i>	<i>ticinensis</i>	<i>R. ticinensis</i> — <i>subticinensis</i>	<i>Rotalipora ticinensis</i>	<i>Biticinella breggiensis</i>	<i>R. ticinensis</i>
			<i>praeticinensis</i>				<i>subticinensis</i>		<i>Ticinella breggiensis</i>		<i>R. subticinensis</i>
	middle	à <i>washitensis</i> — <i>roberti</i> , sans <i>Rotalipores</i>	<i>rischi</i>	<i>T. primula</i>	<i>T. primula</i>	<i>T. praeticinensis</i>	<i>Ticinella</i> (part)		<i>Ticinella primula</i>	<i>Ticinella praeticinensis</i>	
			<i>subnodosa</i>	<i>T. bejaouaensis</i>	<i>T. bejaouaensis</i> — <i>Gl. gyroidinaeformis</i> — <i>T. primula</i>				<i>Ticinella roberti</i>	<i>T. primula</i>	
	early	à <i>Hedbergella</i> , sans <i>Globigerinelloides</i>	<i>avec roberti</i>		<i>T. bejaouaensis</i> — <i>Gl. gyroidinaeformis</i>	<i>T. bejaouaensis</i> — <i>Gl. gyroidinaeformis</i>			<i>Ticinella bejaouaensis</i>	<i>T. roberti</i> s.l.	<i>Globigerinelloides gyroidinaeformis</i>
	<i>sans roberti</i>		<i>bejaouaensis</i>	<i>H. trocoidea</i>	<i>Gl. ferreolensis</i> — <i>T. bejaouaensis</i>	<i>Hedbergella trocoidea</i>			<i>P. cheniouensis</i>		
	Aptian	Clans	à <i>Globigerinelloides</i>	<i>algerianus</i>	<i>Gl. algerianus</i>	<i>Gl. algerianus</i>			<i>Hedbergella trocoidea</i>	<i>Hedbergella trocoidea</i>	
				<i>ferreolensis</i>	<i>Gl. ferreolensis</i>	<i>Gl. ferreolensis</i>			<i>Globigerinelloides algerianus</i>	<i>G. algerianus</i>	
Gargasian		à <i>Schackoines</i> (part)	<i>cabri</i> (part)	<i>Leupoldina cabri</i>	<i>Schackoina cabri</i>			<i>Gl. ferreolensis</i>	<i>G. ferreolensis</i>		
							<i>L. cabri</i>	<i>Schackoina cabri</i> (part)			

Figure 10. Comparison of previous late Aptian–late Cenomanian zonal schemes with scheme developed for the mid-Cretaceous of DSDP Sites 545 and 547. Geochronologic framework based on van Hinte (1976).

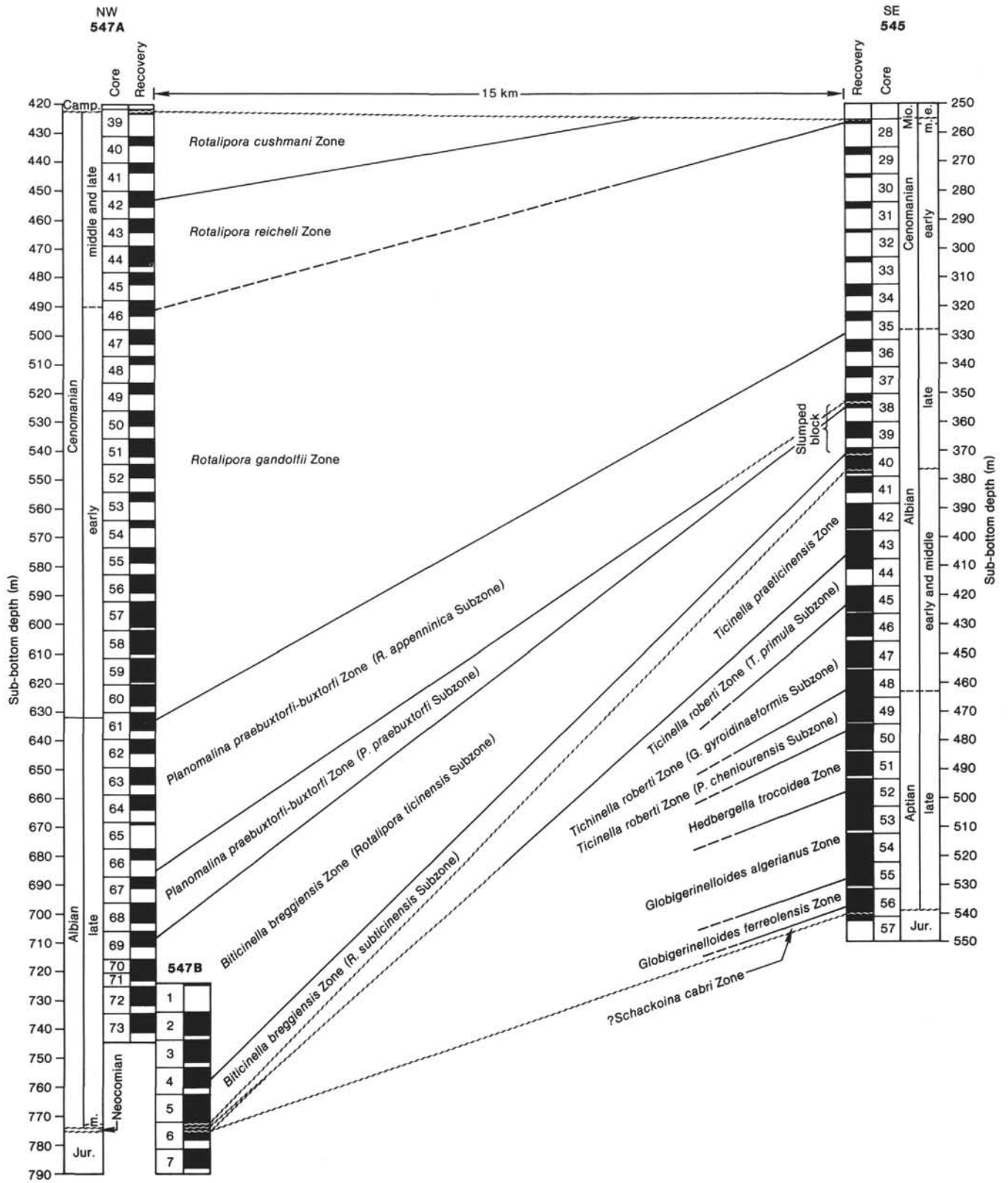


Figure 11. Biostratigraphic correlation between the mid-Cretaceous of DSDP Sites 545 and 547.

curs between the middle and upper Albian of both sites. Above the diastem, a continuous section of late Albian through early late Cenomanian age at Site 547 contrasts with the thinner, less-complete section of Site 545. Capping the mid-Cretaceous at both sites is a widespread unconformity that is responsible for the paucity of Upper Cretaceous sequences around the North Atlantic (see discussion by Lancelot and Winterer, 1980).

#### *Schackoina cabri* Zone

The equivalent of the *Schackoina cabri* Zone may be represented by the lower two samples from Site 545. Although the index species is absent, the presence of a single specimen of *Globigerinelloides* cf. *saundersi* (Bolli) and the absence of *G. ferreolensis* (Moullade) suggests a latest early Aptian age.

#### *Globigerinelloides ferreolensis* Zone

**Definition.** Interval from the first occurrence of *G. ferreolensis* (Moullade) to the first appearance of *G. algerianus* Cushman and ten Dam.

**Age.** Early late Aptian.

**Diagnostic taxa.** *G. ferreolensis*, *G. blowi* s.l. (Bolli), *G. aptiense* Longoria, *Hedbergella delrioensis* (Carsey), *H. aff. sigali* Moullade, *H. aff. trocoidea* (Gandolfi), *H. sp. 1*, and *Gubkinella graysonensis* (Tappan).

**Distribution.** 545-56-2, 76–78 cm to 545-55-6, 40–42 cm.

#### *Globigerinelloides algerianus* Zone

**Definition.** Interval representing the total range of *G. algerianus* Cushman and ten Dam.

**Age.** Late Aptian.

**Diagnostic taxa.** *G. algerianus*, *G. ferreolensis* (Moullade), *G. aptiense* Longoria, *G. blowi* s.l. (Bolli), *G. barri* (Bolli, Loeblich and Tappan), *Hedbergella trocoidea* (Gandolfi), *H. aff. trocoidea*, *H. delrioensis* (Carsey), *H. aff. sigali* Moullade, *H. sp. 1*, and *Gubkinella graysonensis* (Tappan).

**Distribution.** 545-55-5, 4–6 cm to 545-52-5, 93–96 cm.

#### *Hedbergella trocoidea* Zone

**Definition.** Interval from the last occurrence of *G. algerianus* Cushman and ten Dam to the first appearance of *Ticinella roberti* s.l. (Gandolfi).

**Age.** Late Aptian.

**Diagnostic taxa.** *Hedbergella trocoidea*, (Gandolfi) *H. gorbachikae* Longoria, *H. delrioensis* (Carsey), *Globigerinelloides aptiense* Longoria, *G. blowi* s.l. (Bolli), and *Gubkinella graysonensis* (Tappan).

**Distribution.** 545-52-3, 79–81 cm to 545-50-3, 54–56 cm.

#### *Ticinella roberti* Zone

**Definition.** Interval from the first occurrence of *T. roberti* s.l. (Gandolfi) to the first occurrence of *T. praeticinensis* Sigal. Three subzones are recognized.

**Age.** Latest Aptian to middle Albian.

**Distribution.** 545-50-1, 33–34 cm to 545-44, CC.

#### *Planomalina cheniourensis* Subzone

**Definition.** Interval from the first appearance of *Ticinella roberti* (Gandolfi) to the last occurrence of *P. cheniourensis* (Sigal).

**Age.** Latest Aptian.

**Diagnostic taxa.** *P. cheniourensis*, *T. roberti*, *Hedbergella trocoidea* (Gandolfi), *H. delrioensis* (Carsey), and *Gubkinella graysonensis* (Tappan).

**Distribution.** 545-50-1, 33–34 cm to 545-48-7, 23–25 cm.

#### *Globigerinelloides gyroidinaeformis* Subzone

**Definition.** Interval from the last occurrence of *Planomalina cheniourensis* (Sigal) to the first appearance of *Ticinella primula* Luterbacher.

**Age.** Early Albian.

**Diagnostic taxa.** *G. gyroidinaeformis*, *T. roberti* (Gandolfi), *Hedbergella trocoidea* (Gandolfi), *H. cf. rischi* Moullade, and *H. delrioensis* (Carsey).

**Distribution.** 545-48-5, 45–47 cm to 545-45, CC.

#### *Ticinella primula* Subzone

**Definition.** Interval from the first appearance of *T. primula* Luterbacher to the first occurrence of *T. praeticinensis* Sigal.

**Age.** Early middle Albian.

**Diagnostic taxa.** *T. primula*, *T. roberti* (Gandolfi), *Globigerinelloides gyroidinaeformis* Moullade, *Hedbergella cf. rischi* Moullade, and *H. delrioensis* (Carsey).

**Distribution.** 545-45-4, 110–115 cm to 545-44, CC.

#### *Ticinella praeticinensis* Zone

**Definition.** Interval from the first occurrence of *T. praeticinensis* Sigal to the first appearance of *Biticinella breggiensis* (Gandolfi).

**Age.** Late middle Albian.

**Diagnostic taxa.** *T. praeticinensis*, *T. primula* Luterbacher, *T. roberti* (Gandolfi), *Globigerinelloides gyroidinaeformis* Moullade, *Hedbergella cf. rischi* Moullade, and *H. delrioensis* (Carsey).

**Distribution.** 545-44-1, 32–37 cm to 545-43-1, 47–48 cm. An interval of undifferentiated *T. praeticinensis* and *Biticinella breggiensis* Zones occurs from 545-42-5, 93–95 cm to 545-40-6 (bottom). A single sample from 547B-6-1, 58–62 cm is probably equivalent to the *T. praeticinensis* Zone.

#### *Biticinella breggiensis* Zone

**Definition.** Interval from the first appearance of *B. breggiensis* (Gandolfi) to the first occurrence of *Planomalina praebuxtorfi* Wonders. Two subzones are recognized.

**Age.** Early late Albian.

**Distribution.** 545-40-5, 8–10 cm to 545-38, CC and 547B-6-1, 39–41 cm to 547A-69-3, 50–52 cm.

#### *Rotalipora subticinensis* Subzone

**Definition.** Interval from the first appearance of *Biticinella breggiensis* (Gandolfi) to the last occurrence of *R. subticinensis* (Gandolfi).

**Age.** Early late Albian.

**Diagnostic taxa.** *R. subticinensis*, *R. ticinensis* (Gandolfi), *Ticinella primula* Luterbacher, *T. raynaudi* s.l. Sigal, *T. madecassiana* Sigal, *T. roberti* (Gandolfi), *Globigerinelloides bentonensis* (Morrow), *G. ultramicrus* (Subbotina), *Clavihedbergella subcretacea* (Tappan), *C. moremani* (Cushman), *C. simplex* (Morrow), *Hedbergella delrioensis* (Carsey), *H. planispira* (Tappan), and *H. simplicissima* (Magné and Sigal).

**Distribution.** 545-40-5, 8–10 cm to 545-40-3, 8–10 cm and 547B-6-1, 39–41 cm to 547B-4-4, 25–28 cm.

#### *Rotalipora ticinensis* Subzone

**Definition.** Interval from the last occurrence of *R. subticinensis* (Gandolfi) to the first occurrence of *Planomalina praebuxtorfi* Wonders.

**Age.** Late Albian.

**Diagnostic taxa.** Characterized by the same basic taxa as in the *Ticinella subticinensis* Subzone but with the addition of *R. praebalernaensis* Sigal as a diagnostic taxon.

**Distribution.** 545-39, CC to 545-38, CC and 547B-4-2, 82–85 cm to 547A-69-3, 50–52 cm.

#### *Planomalina praebuxtorfi-buxtorfi* Zone

**Definition.** Interval from the first occurrence of *P. praebuxtorfi* Wonders to the last occurrence of *P. buxtorfi* (Gandolfi). Two subzones are recognized.

**Age.** Latest Albian (Vraconian).

**Distribution.** 545-38-3, 90–92 cm to 545-36-1, 145–150 cm and 547A-69-1, 50–52 cm to 547A-61-3, 50–52 cm.

#### *Planomalina praebuxtorfi* Subzone

**Definition.** Interval representing the total range of *P. praebuxtorfi* Wonders.

**Age.** Early Vraconian.

**Diagnostic taxa.** *P. praebuxtorfi*, *P. buxtorfi* (Gandolfi), *Rotalipora appenninica* (Renz), *R. praebalernaensis* Sigal, *Ticinella madecassiana* Sigal, *Globigerinelloides bentonensis* (Morrow), *G. ultramicrus* (Subbotina), *Hedbergella paradubia* (Sigal), *H. simplicissima* (Magné and Sigal), *H. delrioensis* (Carsey), *H. planispira* (Tappan), and *Clavihedbergella simplex* (Morrow).

**Distribution.** 545-38-3, 90–92 cm and 547A-69-1, 50–52 cm to 547A-67-2, 39–42 cm.

#### *Rotalipora appenninica* Subzone

**Definition.** Interval from the last occurrence of *Planomalina praebuxtorfi* Wonders to the last occurrence of *P. buxtorfi* (Gandolfi).

**Age.** Latest Albian.

**Diagnostic taxa.** The assemblages are essentially the same as in the *Planomalina praebuxtorfi* Subzone but important additions include *Rotalipora gandolfii* Luterbacher and Premoli Silva, *Praeglobotruncana delrioensis* (Plummer), *P. stephani* (Gandolfi), *Hedbergella libyca* Barr, *Heterohelix moremani* (Cushman), *Guembeltria cenomana* (Keller), and *Schackoina* spp., whereas *Ticinella madecassiana* Sigal and *Rotalipora praebalernaensis* Sigal drop out of the fauna.

**Distribution.** 545-38-1, 90–92 cm to 545-36-1, 145–150 cm and 547A-66, CC to 547A-61-3, 50–52 cm.

#### *Rotalipora gandolfii* Zone

**Definition.** Interval from the last occurrence of *Planomalina buxtorfi* (Gandolfi) to the first appearance of *R. reicheli* (Mornod).

**Age.** Early Cenomanian.

**Diagnostic taxa.** *Hedbergella libyca* Barr is important in the lower part whereas *R. micheli* (Sacal and Debourle), *R. aff. cushmani* (Morrow) and *R. greenhornensis* (Morrow) become important in the mid and upper parts of the *R. gandolfii* Zone. Taxa that range throughout the zone include *R. gandolfii* (Luterbacher and Premoli Silva), *R. appenninica* (Renz), *Praeglobotruncana delrioensis* (Plummer), *P. stephani* (Gandolfi), *Globigerinelloides bentonensis* (Morrow), *G. ultramicrus* (Subbotina), *Clavihedbergella simplex* (Morrow), *Hedbergella delrioensis* (Carsey), *H. planispira* (Tappan), *Heterohelix moremani* (Cushman), *Guembeltria cenomana* (Keller), and *Schackoina* spp.

**Distribution.** 545-35, CC to 545-28, CC and 547A-61-1, 50–52 cm to approximately 547A-46-3, 60–62 cm, based on correlation with calcareous nannofossil data (Wiegand, this vol.)

#### *Rotalipora reicheli* Zone

**Definition.** Interval from the first appearance of *R. reicheli* (Mornod) to the first appearance of *R. cushmani* (Morrow).

**Age.** Middle Cenomanian.

**Discussion.** Because *R. reicheli* is absent in the Site 547 samples, the base of the *R. reicheli* Zone is correlated with the base of the *Cruciellipsis chiasta* Subzone (*Lithraphidites acutum* Zone), (Wiegand, this vol.), which roughly corresponds with the first appearance of *R. reicheli* at Site 545.

**Diagnostic taxa.** Composition of the assemblages as for the upper part of the *R. gandolfii* Zone with the important addition of the index species and the loss of *R. appenninica* (Renz).

**Distribution.** 545-28-1, 47–49 cm to 545-28-1, 10–12 cm and approximately 547A-46-1, 60–62 cm to 547A-42-3, 40–42 cm.

#### *Rotalipora cushmani* Zone

**Definition.** Interval representing the total range of *R. cushmani* (Morrow). Only the lowermost part of this zone was recovered at Site 547.

**Age.** Late Cenomanian.

**Diagnostic taxa.** *R. cushmani*, *R. greenhornensis* (Morrow), *Praeglobotruncana delrioensis* (Plummer), *P. stephani* (Gandolfi), *Globigerinelloides bentonensis* (Morrow), *G. ultramicrus* (Subbotina), *Clavihedbergella simplex* (Morrow), *Hedbergella delrioensis* (Carsey), *H. planispira* (Tappan), *Heterohelix moremani* (Cushman), *Guembeltria cenomana* (Keller), and *Schackoina* spp.

**Distribution.** 547A-42-1, 40–42 cm to 547A-39, CC.

#### TAXONOMIC NOTES

All species encountered in this study are presented below. Synonymies are limited to the original reference plus one or two additional references whose synonymy lists and species concepts are followed here. Brief discussions are included, where appropriate, to review literature controversies and explain how the author differentiates one form

from morphologically similar or related forms. For detailed descriptions the reader is referred to the references listed in the synonymies. Planktonic foraminiferal distributions through the mid-Cretaceous sections of DSDP Sites 545 and 547 are shown in Tables 1 and 2.

***Gubkinella graysonensis* (Tappan)**

(Pl. 1, Figs. 2-3)

*Globigerina graysonensis* Tappan, 1940, p. 122, pl. 19, figs. 15-17.  
*Gubkinella graysonensis* (Tappan). Longoria, 1974, p. 50, pl. 1, figs. 1-12.

**Occurrence.** This distinctive species is particularly common in the uppermost Aptian to mid Albian of Site 545 but also occurs throughout the upper Albian and Cenomanian.

***Guembeltria cenomana* (Keller)**

(Pl. 11, Fig. 12)

*Guembelina cenomana* Keller, 1935, pp. 547-548, pl. 2, figs. 13, 14.  
Masters, 1977, pp. 481-482, pl. 27, figs. 1, 3.

**Occurrence.** Rare to common in the upper Albian and lower Cenomanian of Sites 545 and 547 (*Planomalina praebuxtorfi-buxtorfi* Zone to *Rotalipora gandolfii* Zone).

***Heterohelix moremani* (Cushman)**

(Pl. 10, Fig. 12)

*Guembelina moremani* Cushman, 1938, p. 10, pl. 2, figs. 1a-3.  
*Heterohelix moremani* (Cushman). Pessagno, 1967, p. 260-261, pl. 48, figs. 10, 11; pl. 89, figs. 1-2.

**Occurrence.** Rare to common from the uppermost Albian (*Planomalina praebuxtorfi-buxtorfi* Zone) through Cenomanian of Sites 545 and 547.

***Globigerinelloides algerianus* Cushman and ten Dam**

(Pl. 2, Figs. 5-8)

*Globigerinelloides algeriana* Cushman and ten Dam, 1948, p. 42, pl. 8, figs. 4-6.

*Globigerinelloides algerianus* Cushman and ten Dam. Longoria, 1974, pp. 77-79, pl. 6, figs. 1-18.

**Discussion.** This distinctive species demonstrates considerable morphologic variability especially in breadth (thickness) of the test and the degree to which the test becomes evolute. Stratigraphically older specimens tend to be gradational with *G. ferreolensis* (Moullade).

**Occurrence.** Rare throughout the upper Aptian *G. algerianus* Zone of Site 545. Recycled specimens occur sporadically as high as the lower Cenomanian.

***Globigerinelloides aptiense* Longoria**

(Pl. 1, Figs. 9-11)

*Globigerinelloides aptiense* Longoria, 1974, pp. 79-80, pl. 4, figs. 9, 10; pl. 8, figs. 4-6, 17, 18.

**Discussion.** *G. aptiense*, as reported here, extends through a much longer range than originally described by Longoria. This observation may, however, be an artifact of recycling. *G. aptiense* differs from *G. ferreolensis* (Moullade) in having 5-6 1/2 chambers in the final whorl rather than 7 to 9.

**Occurrence.** A common species in the upper Aptian to lowermost Albian (*G. ferreolensis* Zone to lower *Ticinella roberti* s.l. Zone), then becoming rare into the middle Albian of Site 545.

***Globigerinelloides barri* (Bolli, Loeblich, and Tappan)**

(Pl. 2, Figs. 1-4)

*Biglobigerinella barri* Bolli, Loeblich, and Tappan, 1957, p. 25, pl. 1, figs. 13-18.

*Globigerinelloides barri* (Bolli, Loeblich, and Tappan). Longoria, 1974, pp. 80-82, pl. 4, figs. 1-3, 8, 14; pl. 5, figs. 9-16; pl. 27, fig. 19.

**Discussion.** *G. barri* differs from both *G. ferreolensis* (Moullade) and *G. algerianus* Cushman and ten Dam in being circular in outline rather than elliptical and having a broader (thicker) test.

**Occurrence.** A rare species at Site 545, where it is restricted to the upper Aptian *G. algerianus* Zone.

***Globigerinelloides bentonensis* (Morrow)**

(Pl. 10, Figs. 5-11)

*Anomalina bentonensis* Morrow, 1934, p. 201, pl. 30, fig. 4.

*Planomalina caseyi* Bolli, Loeblich, and Tappan, 1957, p. 24, pl. 1, figs. 4-5.

*Globigerinelloides eaglefordensis* (Moreman). Loeblich and Tappan, 1961, p. 268, pl. 2, figs. 3-7.

*Globigerinelloides bentonensis* (Morrow). Eicher and Worstell, 1970, p. 297, pl. 8, figs. 17, 19; pl. 9, fig. 3.

*Globigerinelloides cushmani* (Tappan). Masters, 1977, p. 408, pl. 10, fig. 4; pl. 11, figs. 1-2.

**Discussion.** *G. bentonensis* (Morrow) is a common component of the Cenomanian planktonic assemblages from the Western Interior, U.S.A., where it was first described. Typical specimens are illustrated by Eicher and Worstell (1970). The specimens illustrated by Bolli, Loeblich, and Tappan (1957) and described as *Planomalina caseyi* are identical to *G. bentonensis* from the type locality in Kansas. Small specimens can be confused with *G. ultramicrus* (Subbotina). However, *G. bentonensis* includes larger forms with more inflated and more rapidly increasing chambers.

**Occurrence.** Rare specimens referable to *G. bentonensis* are first observed in the middle to upper Albian of Site 545. A common species throughout the upper Albian and Cenomanian of Sites 545 and 547.

***Globigerinelloides blowi* s.l. (Bolli)**

(Pl. 1, Figs. 4-8)

*Planomalina blowi* Bolli, 1959, p. 260, pl. 20, figs. 2, 3.

*Planomalina maridalensis* Bolli, 1959, p. 261, pl. 20, figs. 4-6.

*Globigerinella duboisi* Chevalier, 1961, p. 33, pl. 1, figs. 14-18.

*Globigerinella gottisi* Chevalier, 1961, pp. 33-34, pl. 1, figs. 9-11, 13 (not fig. 12).

*Globigerinelloides blowi* (Bolli). Masters, 1977, pp. 406-408, pl. 11, fig. 3.

**Discussion.** A somewhat variable species group with 4 to 5 chambers in the final whorl. There appears to be a continuous range of variation in chamber shape and width from ovoid to subspherical shapes representing the *G. blowi/maridalensis* (Bolli) morphotype suite to subclavate (elongate) shapes representing the *G. duboisi/gottisi* (Chevalier) morphotype suite.

**Occurrence.** Particularly common in the upper Aptian of Site 545, then becomes rare in the lower and middle Albian (to within the *Ticinella praeticinensis* Zone). These latter occurrence may be recycled.

***Globigerinelloides ferreolensis* (Moullade)**

(Pl. 2, Figs. 9-12)

*Biticinella ferreolensis* Moullade, 1961, p. 14, pl. 1, figs. 1-5.

*Globigerinelloides ferreolensis* (Moullade). Longoria, 1974, pp. 84-85, pl. 5, figs. 7, 8; pl. 8, figs. 1-3, 8-15; pl. 14, figs. 7-8; pl. 27, figs. 3, 5, 12.

**Discussion.** *G. ferreolensis* is distinguished from *G. aptiense* Longoria in having 7-9 chambers in the final whorl rather than 5-6 1/2.

**Occurrence.** Typically a rare but persistent species through the upper Aptian of Site 545 (*G. ferreolensis* Zone through *Hedbergella trocoidea* Zone and occasionally present in the lower *Ticinella roberti* s.l. Zone).

***Globigerinelloides gyroidinaeformis* Moullade**

(Pl. 7, Figs. 7-8)

"*Globigerinelloides*" *gyroidinaeformis* Moullade, 1966, pp. 128-129, pl. 9, figs. 16-22.

**Occurrence.** This robust species is rare in the lower and middle Albian of Site 545 (*G. gyroidinaeformis* Subzone to *Ticinella praeticinensis* Zone).

***Globigerinelloides saundersi* (Bolli)**

*Planomalina saundersi* Bolli, 1959, p. 262, pl. 20, figs. 9-11.

*Globigerinelloides saundersi* (Bolli). Longoria, 1974, p. 88, pl. 3, figs. 2, 6-12; pl. 9, figs. 8, 9.





44,CC	A	R	C	C	R	C	V	V	V	V	R	?								<i>T. primula</i> Subzone
45-4, 110-115	A	R	R	C	R	R	C	V	V	R	R	V	V	R	R	?				<i>Globigerinelloides gyroidinaeformis</i> Subzone
45,CC	A	V	R	R	C	R	R	R	R	R	V	V	V	R	R	R				
46-1, 15-17	A	R	R	C	C	R	R	R	R	R	V	?	V	R	R	R				<i>Ticinella roberti</i> Zone
46-3, 4-6	A	R	R	R	C	R	R	R	R	R	V	?	V	R	R	R				
46-5, 12-14	A	V	R	R	V	C	R	C	R	R	R			R	R	R				<i>Planomalina cheniourensis</i> Subzone
46,CC	A	V	R	R	V	R	R	R	R	V	V	V	V	R	R	R				
47-1, 93-95	A	V	R	R	R	R	R	C	R	R	V	V	V	R	R	R				<i>Ticinella roberti</i> Zone
47-5, 53-55	A	V	R	V	C	R	R	A	R	R	V	V	V	R	R	R				
47,CC	A	V	V	R	R	R	R	A	R	R	V	V	V	R	R	R				<i>Planomalina cheniourensis</i> Subzone
48-1, 57-59	A	V	R	R	R	R	C	R	R	R	V	V	V	R	R	R				
48-3, 64-66	A	V	R	R	V	R	C	C	C	R	V	R	V	R	R	R				<i>Ticinella roberti</i> Zone
48-5, 45-47	A	V	R	R	C	R	R	A	C	R	V	R	V	R	R	R				
48-7, 23-25	A	V	R	R	C	R	R	A	C	R	V	V	V	R	R	R				<i>Planomalina cheniourensis</i> Subzone
48,CC	A	V	R	R	V	R	C	C	R	R	V	V	V	R	R	R				
49-1, 28-30	A	R	V	R	R	C	R	A	C	R	V	V	V	R	R	R				<i>Planomalina cheniourensis</i> Subzone
49-4, 21-23	A	V	R	C	R	C	R	A	C	R	V	V	V	R	R	R				
49,CC	A	R	V	R	V	C	R	A	C	R	V	V	V	R	R	R				<i>Planomalina cheniourensis</i> Subzone
50-1, 33-34	A	V	R	R	R	C	R	A	C	R	V	V	V	R	R	R				
50-3, 54-56	C	R	R	V	C	V	V	A	C	V	V	V	V	R	R	R				<i>Hedbergella trocoidea</i> Zone
50-5, 54-56	C	V	R	R	C	R	R	A	C	R	V	V	V	R	R	R				
50,CC	A	R	V	V	R	R	R	R	C	R	V	V	V	R	R	R				<i>Hedbergella trocoidea</i> Zone
51-1, 54-56	C	V	V	R	C	R	V	A	C	V	V	V	V	R	R	R				
51-3, 47-48	A	V	R	R	C	R	V	A	C	V	V	V	V	R	R	R				<i>Hedbergella trocoidea</i> Zone
51-5, 37-39	A	V	R	R	C	C	R	A	C	V	V	V	V	R	R	R				
51,CC	A	R	R	R	R	C	R	C	R	V	V	V	V	R	R	R				<i>Hedbergella trocoidea</i> Zone
52-1, 81-86	A	R	R	R	C	C	V	A	C	V	V	V	V	R	R	R				
52-3, 79-81	A	V	R	R	R	C	V	A	C	R	V	V	V	R	R	R				<i>Hedbergella trocoidea</i> Zone
52-5, 93-96	C	V	R	R	R	R	A	C	R	V	R	R	R	R	R	R				
52,CC	C	V	V	V	R	C	R	A	C	R	V	R	R	R	R	R				<i>Globigerinelloides algerianus</i> Zone
53-2, 71-75	A	R	V	V	C	C	R	A	C	R	V	R	R	R	R	R				
53-4, 63-65	A	V	V	V	C	R	R	A	C	R	V	V	V	R	R	R				<i>Globigerinelloides algerianus</i> Zone
53,CC	A	V	R	R	C	R	A	R	R	V	V	R	R	R	R	R				
54-2, 52-56	A	V	R	R	R	C	R	A	C	R	V	V	V	R	R	R				<i>Globigerinelloides algerianus</i> Zone
54-4, 57-60	A	V	R	R	R	C	R	C	C	R	V	V	V	R	R	R				
54-6, 55-58	A	V	V	R	C	R	C	C	V	V	V	V	V	R	R	R				<i>Globigerinelloides algerianus</i> Zone
54,CC	A	V	R	V	V	C	R	R	C	R	V	V	V	R	R	R				
55-1, 66-68	A	R	R	R	V	R	R	C	C	V	V	V	V	R	R	R				<i>Globigerinelloides algerianus</i> Zone
55-2, 120-122	A	V	R	R	R	R	R	R	C	V	V	V	V	R	R	R				
55-3, 58-60	A	R	V	R	R	R	R	R	C	V	V	V	V	R	R	R				<i>Globigerinelloides algerianus</i> Zone
55-4, 87-89	A	V	R	R	R	C	C	C	C	V	V	V	V	R	R	R				
55-5, 4-6	A	R	R	R	V	R	C	C	C	R	R	V	V	R	R	R				<i>Globigerinelloides algerianus</i> Zone
55-6, 40-42	A	R	R	R	R	R	R	R	V	V	cf.			R	R	R				
55-6, 77-79	A	V	R	V	V	C	R	R	R	R	R	cf.		R	R	R				<i>Globigerinelloides algerianus</i> Zone
56-1, 66-68	C	R	R	R	R	R	A	A	A	A				R	R	R				
56-2, 76-78	A	V	C	R	R	C	R	V	R	R	V			R	R	R				<i>Globigerinelloides algerianus</i> Zone
56-3, 54-56	A	R	R	R	V	C	R	R	R	R	V			R	R	R				
56-4, 61-63	A	R	R	R	C	R	R	R	C	V				R	R	R				<i>?Schackoina cabri</i> Zone
56-5, 62-64	A	V	C	R	V	R	C	R	R	C				R	R	R				

Note: Based on 300-specimen counts of the fraction  $>63 \mu\text{m}$ . 25% = abundant (A), 5-25% = common (C), 1-5% = rare (R), 1% = very rare (V).



58-5, 50-52	A A R	R	R	C	R	V	V	V	V	V	V	V	V	V			
58,CC	A A R	R	R	C	R	V	V	V	V	V	V	V	V	V			
59-1, 50-52	A C R	V	V	C	R	V	V	V	V	V	V	V	V	V			
59-3, 50-52	A C R	V	V	C	R	V	V	V	V	V	V	V	V	V			
59-5, 50-52	A A R	V	V	C	R	V	V	V	V	R	V	V	V	V			
59,CC	A A R	V	V	C	R	V	V	V	V	R	V	V	V	V			
60-1, 50-52	A C R	R	R	C	C	V	V	V	R	V	V	V	V	V			
60-3, 50-52	A A R	V	V	C	R	V	V	V	R	V	V	V	V	V			
60-5, 50-52	A A R	V	R	C	R	V	V	V	R	V	V	V	V	V			
60,CC	A A R	V	R	R	R	V	V	V	R	V	V	V	V	V			
61-1, 50-52	A A R	R	R	C	R	R	V	V	C	V	V	V	V	V			
61-3, 50-52	A A R	R	R	R	R	R	V	V	R	V	V	V	V	V			
61,CC	A A R	R	R	R	R	V	V	V	R	V	V	V	V	V			
62-1, 50-52	A C R	R	R	C	R	V	V	V	C	V	V	V	V	V			
62-3, 50-52	A C R	V	R	C	R	C	V	V	V	V	V	V	V	V			
62,CC	A A C	R	R	C	R	V	V	V	V	V	V	V	V	V			
63-1, 50-52	A C R	V	R	V	V	V	V	V	V	V	V	V	V	V			
63-3, 50-52	A A R	V	V	C	C	V	V	V	R	V	V	V	V	V			
63,CC	A A R	R	R	C	C	R	V	V	V	V	V	V	V	V			
64-1, 50-52	A A R	R	R	C	C	R	R	V	V	V	V	V	V	V			
64-3, 50-52	A A R	R	R	C	C	R	V	V	V	V	V	V	V	V			
64,CC	A A R	R	R	C	C	C	V	V	V	V	V	V	V	V			
65-1, 37-39	A A R	R	V	C	C	C	V	V	V	V	V	V	V	V			
66-2, 65-67	A C R	R	V	C	R	R	V	V	R	V	V	V	V	V			
66,CC	A C R	V	V	C	C	R	V	V	R	V	V	V	V	V			
67-2, 39-42	A C R	R	?	C	C	R	V	V	V	R	V	V	V	V			
67,CC	A C R	V	V	C	?	C	?	V	V	C	V	V	V	V			
68-1, 123-125	A A R	V	R	V	V	V	V	V	?	R	R	V	V	V			
68-2, 93-96	A C R	V	V	V	V	V	V	V	V	R	V	V	V	V			
68,CC	A C R	V	R	V	V	V	V	V	V	R	V	V	V	V			
69-1, 50-52	A A R	R	R	C	V	C	R	V	V	R	V	V	V	V			
69-3, 50-52	A A R	V	V	C	V	C	R	V	V	V	V	V	V	V			
69,CC	A A R	R	V	C	C	R	V	V	V	V	V	V	V	V			
70-1, 50-52	A A R	R	V	C	C	C	V	V	V	V	V	V	V	V			
70-3, 50-52	A A R	V	V	C	V	C	R	V	V	V	V	V	V	V			
70,CC	A A R	V	R	V	C	V	C	V	V	V	V	V	V	V			
71-1, 50-52	A A R	V	R	C	V	C	R	V	V	V	V	V	V	V			
71,CC	A A R	V	R	C	V	R	C	V	V	V	V	V	V	V			
72-1, 50-52	A A R	V	R	C	V	C	C	V	V	V	V	V	V	V			
72-3, 50-52	A A R	R	V	C	V	C	R	?	V	V	V	V	V	V			
72,CC	A A R	R	V	C	V	C	R	V	V	V	V	V	V	V			
73-1, 50-52	A A R	V	R	V	V	V	V	V	V	V	V	V	V	V			
73-3, 50-52	A A R	V	V	V	V	V	V	V	V	V	V	V	V	V			
73,CC	A A R	V	R	V	V	V	V	V	V	V	V	V	V	V			
Hole 547B																	
2-1, 50-52	A C C	V	R	R	V	V	V	V	V	V	V	V	V	V			
2-3, 50-52	A A R	V	V	R	V	V	V	V	V	V	V	V	V	V			
2-5, 50-52	A A C	V	V	V	V	V	V	V	V	V	V	V	V	V			
2,CC	A C R	V	R	V	V	V	V	V	V	V	V	V	V	V			
3-2, 112-115	A A C	R	V	V	V	V	V	V	V	R	V	V	V	V			
3-4, 112-115	A A R	V	V	V	V	V	V	V	V	V	V	V	V	V			
3,CC	A A R	V	R	V	V	V	V	V	V	V	V	V	V	V			
4-2, 82-85	A A R	V	R	V	V	V	V	V	V	R	V	V	V	V			
4-4, 25-28	A C R	V	R	V	V	V	V	V	V	V	V	V	V	V			
4,CC	A A C	V	V	V	V	V	V	V	V	V	V	V	V	V			
5-1, 50-52	A A C	V	R	V	V	V	V	V	V	R	V	V	V	V			
5-3, 50-52	A A R	?	V	V	V	V	V	V	V	V	V	V	V	V			
5-5, 50-52	A A R	V	V	V	V	V	V	V	V	R	V	V	V	V			
5,CC	A A R	V	V	V	R	V	V	V	V	R	V	V	V	V			
6-1, 39-41	A A C	V	R	R	V	V	V	V	V	V	V	V	V	V			
6-1, 58-62	A A R R R	R	R	V	V	V	V	V	V	V	V	V	V	V			

Note: Based on 300-specimen counts of the fraction >63  $\mu\text{m}$ . 25% = abundant (A), 5-25% = common (C), 1-5% = rare (R), 1% = very rare (V).

*Planomalina*  
*praebuxtorfi*—  
*buxtorfi*  
Zone

*Planomalina*  
*praebuxtorfi*  
Subzone

*Biticinella*  
*breggiensis*  
Zone

*Rotalipora*  
*ticinensis*  
Subzone

*Rotalipora*  
*subticinensis*  
Subzone

*Ticinella*  
*praeticinensis* Zone?

**Occurrence.** A single specimen is recorded from 545-56-4, 61-63 cm (?lower Aptian).

***Globigerinelloides ultramicrus* (Subbotina)**  
(Pl. 11, Figs. 10-11)

*Globigerinella ultramicra* Subbotina, 1949, p. 33, pl. 2, figs. 17, 18.  
*Globigerinelloides caseyi* (Boll, Loeblich, and Tappan). Eicher and Worstell, 1970, p. 297, pl. 8, figs. 11, 15, 16.

*Globigerinelloides ultramicra* (Subbotina). Masters, 1977, p. 413, pl. 12, figs. 3-5.

**Discussion.** This species is distinguished by its small, compressed test. It superficially resembles *Hedbergella planispira* (Tappan) and specimens typically have to be flipped over to confirm its planispiral, biumbilicate form.

**Occurrence.** A common taxon throughout the upper Albian and Cenomanian of Sites 545 and 547.

***Planomalina buxtorfi* (Gandolfi)**  
(Pl. 10, Figs. 3-4)

*Planulina buxtorfi* Gandolfi, 1942, p. 103, pl. 3, fig. 7; pl. 5, figs. 3-6; pl. 6, figs. 1-3; pl. 8, fig. 8; pl. 9, fig. 2; pl. 12, fig. 2; pl. 13, figs. 13, 15.

*Planomalina buxtorfi* (Gandolfi). Wonders, 1975, pp. 91-92, pl. 1, fig. 4; text-figs. 3a-4b.

**Occurrence.** The range of *P. buxtorfi* defines the uppermost zone of the Albian.

***Planomalina cheniourensis* (Sigal)**  
(Pl. 4, Figs. 1-4)

*Planulina cheniourensis* Sigal, 1952, p. 21, pl. 17.

*Planomalina cheniourensis* (Sigal). Moullade, 1966, pp. 130-131, text-fig. 3. Dupeuble, 1979, pl. 2, figs. 10, 11.

**Discussion.** This species basically differs from *Globigerinelloides algerianus* Cushman and ten Dam in possessing a keel along much of its periphery. Some specimens are similar in appearance to the unrelated late Albian *Planomalina buxtorfi* (Gandolfi) (see discussion by Moullade, 1966).

**Occurrence.** In the present study, *P. cheniourensis* is restricted to the *P. cheniourensis* Subzone (uppermost Aptian) of Site 545 although some workers recognize an earlier first occurrence whereas others recognize a range into the early Albian.

***Planomalina praebuxtorfi* Wonders**  
(Pl. 10, Figs. 1-2)

*Planomalina praebuxtorfi* Wonders, 1975, pp. 90-91, pl. 1, figs. 1a-c, 2a-c; text-fig. 4: 2a, b.

**Discussion.** The *Globigerinelloides caseyi* (= *G. bentonensis*)-*Planomalina buxtorfi* lineage proposed by Wonders (1975) is beautifully represented in the Leg 79 material. A transitional specimen between *G. bentonensis* (Morrow) and *P. praebuxtorfi* is illustrated on Pl. 10, Figs. 5-6.

**Occurrence.** *P. praebuxtorfi* is confined to the lowermost *P. praebuxtorfi-buxtorfi* Zone (*P. praebuxtorfi* Subzone, upper Albian).

***Schackoina bicornis* Reichel**  
(Pl. 9, Figs. 10-11)

*Schackoina cenomana bicornis* Reichel, 1948, pp. 401-402, text-figs. 4a-g, 6(4), 7(4), 8b, 9a-g, 10(6, 8).

*Schackoina bicornis* Reichel. Masters, 1977, pp. 429-430, pl. 15, figs. 3-4.

**Occurrence.** A rare species in the upper Albian (*Planomalina praebuxtorfi-buxtorfi* Zone) and Cenomanian of Sites 545 and 547.

***Schackoina cenomana* (Schacko)**  
(Pl. 9, Figs. 5, 9)

*Siderolina cenomana* Schacko, 1897, p. 166, pl. 4, figs. 3-5.

*Schackoina cenomana* (Schacko). Masters, 1977, pp. 430-432, pl. 16, figs. 1-2.

**Occurrence.** A persistent taxon from the upper Albian (*Planomalina praebuxtorfi-buxtorfi* Zone) through the Cenomanian.

***Schackoina moliniensis* Reichel**  
(Pl. 9, Fig. 13)

*Schackoina moliniensis* Reichel, 1948, pp. 402, 404; text-figs. 5a-d, 6(5), 7(5), 8c, 10(13).

*Schackoina moliniensis* Reichel. Masters, 1977, p. 434, pl. 17, fig. 1. Caron, 1978, pl. 8, figs. 10-11.

**Occurrence.** A rare species in the upper Albian (*Planomalina praebuxtorfi-buxtorfi* Zone) and Cenomanian of Sites 545 and 547.

***Schackoina multispinata* (Cushman and Wickenden)**  
(Pl. 9, Fig. 12)

*Hantkenina multispinata* Cushman and Wickenden, 1930, pp. 40-43, pl. 6, figs. 4-6 (not 4a-c).

*Schackoina multispinata* (Cushman and Wickenden). Masters, 1977, pp. 434-435, pl. 16, figs. 4, 6; pl. 17, fig. 2.

**Occurrence.** Persistent from the *Planomalina praebuxtorfi-buxtorfi* Zone (late Albian) through the Cenomanian.

***Hedbergella delrioensis* (Carsey)**  
(Pl. 1, Fig. 12; Pl. 9, Figs. 1-4, 8)

*Globigerina cretacea* d'Orbigny var. *delrioensis* Carsey, 1926, p. 43.

*Globigerina infracretacea* Glaessner, 1937, p. 28, text-fig. 1.

*Hedbergella delrioensis* (Carsey). Loeblich and Tappan, 1961, p. 275, pl. 2, figs. 11-13.

**Discussion.** *H. delrioensis* is a moderately variable species characterized by its flat or nearly flat dorsal side and 4-1/2-5-1/2 chambers in the final whorl. Variation is represented by the degree of chamber enlargement as added to the whorl, development of an apertural lip, and surface texture; the late Albian-Cenomanian specimens tend to be slightly larger and more pustulose whereas the late Aptian-middle Albian specimens tend to be smoother, smaller, and possess a less pronounced apertural lip. Such variability can probably be explained as ecophenotypic, and a consistent differentiation between *H. delrioensis* and Aptian-Albian *H. infracretacea* (Glaessner) could not be established in this study. Hermes (1969) has suggested that *H. infracretacea* may actually be a chronosubspecies of *H. delrioensis*.

**Occurrence.** *H. delrioensis* is the most abundant and persistent species throughout the upper Aptian-Cenomanian of Sites 545 and 547.

***Hedbergella gorbachikae* Longoria**  
(Pl. 4, Figs. 9-11)

*Hedbergella gorbachikae* Longoria, 1974, p. 56, pl. 15, figs. 1-16.

**Occurrence.** A rare species in the upper Aptian to middle Albian (*Globigerinelloides ferreolensis* Zone to *Ticinella praeticinensis* Zone) of Site 545.

***Hedbergella libyca* Barr**  
(Pl. 11, Figs. 5-9)

*Hedbergella libyca* Barr, 1972, p. 14, pl. 10, figs. 10a-c. Miles and Orr, 1980, pp. 798-799, pl. 2, figs. 4-5.

*Hedbergella costellata* Saint-Marc. Caron, 1978, p. 658, pl. 4, figs. 1-3, 8-9.

**Discussion.** This species was widely distributed around the Atlantic and Tethys during the late Albian and earliest Cenomanian. It has significant biostratigraphic, and perhaps environmental, value. *H. costellata* Saint-Marc (1973) was described from neritic deposits of Lebanon and determined to be of middle Cenomanian age. Further work may prove *H. costellata* to be synonymous with *H. libyca*. Based on the Atlantic and Libyan occurrences of *H. libyca*, its range is from the *Planomalina praebuxtorfi-buxtorfi* Zone (late Albian) to within the early part of the *Rotalipora gandolfii* Zone (earliest Cenomanian).

***Hedbergella paradubia* (Sigal)**  
(Pl. 11, Figs. 1-4)

*Globigerina paradubia* Sigal, 1952, p. 28, text-fig. 28.

*Hedbergella brittonensis* Loeblich and Tappan, 1961, pp. 274-275, pl. 4, figs. 1-8.

*Globigerina paradubia* Sigal. Masters, 1977, p. 467, pl. 23, figs. 2-4; pl. 24, fig. 1.

**Discussion.** A somewhat variable species with 5 or 6 chambers in the final whorl and moderately low to high trochospire. Differs from *H. planispira* (Tappan) in being larger, having a higher trochospire, deeply depressed sutures, and deep umbilicus. Lower-spined forms with 5 chambers are distinguished from *H. delrioensis* (Carsey) by their less-rapid increase in chamber size.

**Occurrence.** First appears in the upper part of the *Biticinella breggiensis* Zone and remains a persistent taxon throughout the upper Albian and Cenomanian of Sites 545 and 547.

*Hedbergella planispira* (Tappan)  
(Pl. 9, Figs. 6-7)

*Globigerina planispira* Tappan, 1940, p. 122, pl. 19, fig. 12.

*Hedbergella planispira* (Tappan). Loeblich and Tappan, 1961, p. 276, pl. 5, figs. 4-11.

**Discussion.** This distinctive species is characterized by its small, flat test with 6-7-1/2 chambers in the last whorl. However, specimens from before the late Albian tend to be smaller than the late Albian-Cenomanian forms.

**Occurrence.** A persistent and occasionally abundant species throughout the mid-Cretaceous of Sites 545 and 547.

*Hedbergella cf. rischi* Moullade  
(Pl. 7, Figs. 11-12)

*Hedbergella* (*Hedbergella*) aff. *infracretacea* (Glaessner). Moullade, 1966, pp. 89-90, pl. 8, figs. 6-9 (not figs. 10-16).

*Hedbergella rischi* Moullade, 1974, p. 1816.

**Discussion.** The middle Albian sediments of Site 545 contain a 6-chambered species which is similar to *Hedbergella* sp. 1 of the upper Aptian section; however, several million years probably separate their ranges. *H. cf. rischi* differs from *H. delrioensis* (Carsey) in possessing 6 rather than 5 chambers and lacks the small size and circular outline of *H. planispira* (Tappan).

**Occurrence.** Ranges from the *Ticinella primula* Subzone to the *Ticinella praeticinensis* Zone (middle Albian) of Site 545.

*Hedbergella aff. sigali* Moullade  
(Pl. 1, Fig. 1)

*Hedbergella* (*Hedbergella*) *sigali* Moullade, 1966, p. 87, pl. 7, figs. 20-25.

**Discussion.** *H. sigali* has typically been reported from Barremian through early Aptian age strata (*H. sigali* to *Globigerinelloides blowi* zones). However, similar forms persistently range through the middle Albian of Site 545, and these may actually be recycled.

**Occurrence.** Persistent but rare through the upper Aptian to ?upper Albian of Site 545 (*G. ferreolensis* Subzone to the ?*Biticinella breggiensis* Zone).

*Hedbergella simplicissima* (Magné and Sigal)  
(Pl. 8, Figs. 5-6)

*Hastigerinella simplicissima* Magné and Sigal, 1954, in Cheylan et al., pp. 487-488, pl. 14, figs. 11a-c.

*Hedbergella amabilis* Loeblich and Tappan, 1961, p. 274, pl. 3, figs. 1a-7b, 9. (not figs. 8, 10).

*Hedbergella simplicissima* (Magné and Sigal). Sliter, 1980, pl. 18, figs. 7-10.

**Occurrence.** Rare to common throughout the upper Albian and Cenomanian.

*Hedbergella trocoidea* (Gandolfi)  
(Pl. 3, Figs. 1-4)

*Anomalina lorneiiana* (d'Orbigny) var. *trocoidea* Gandolfi, 1942, p. 99, pl. 2, figs. 1a-c; pl. 4, figs. 2-3; pl. 13, figs. 2a-b, 5a-b.

*Hedbergella trocoidea* (Gandolfi). Longoria, 1974, p. 69, pl. 17, figs. 1-16; pl. 18, figs. 3-5.

**Discussion.** *H. trocoidea* is distinguished from the early forms of *Ticinella roberti* s.l. (Gandolfi) by possessing embracing chambers, fewer chambers in the final whorl, and a closed umbilicus.

**Occurrence.** This distinctive species first appears in the late Aptian *Globigerinelloides algerianus* Zone and ranges through the middle Albian *Ticinella primula* Subzone (*T. roberti* s.l. Zone).

*Hedbergella aff. trocoidea* (Gandolfi)  
(Pl. 3, Figs. 5-10)

**Discussion.** This group basically differs from true *H. trocoidea* (Gandolfi) in having fewer chambers; 5 to 6 rather than 7 to 8. Earlier forms, particularly of the *Globigerinelloides ferreolensis* and *G. algerianus* zones, are also smaller than later forms and closely resemble early Aptian *H. excelsa* Longoria. *H. aff. trocoidea* essentially differs from *H. excelsa* in being larger; it is possible that *H. excelsa* represents an ancestor of the *H. trocoidea* stock. *H. aff. trocoidea* differs from *H. hispaniae* Longoria in having a moderate trochospire rather than flat dorsal side. Some specimens of *H. aff. trocoidea* appear gradational with *Hedbergella* sp. 1.

**Occurrence.** A fairly common and persistent species from the upper Aptian to the middle Albian of Site 545 (*G. ferreolensis* Zone to *Ticinella praeticinensis* Zone).

*Hedbergella* sp. 1  
(Pl. 4, Figs. 5-8, 12)

**Description.** Test medium-sized, chambers increase fairly rapidly in size as added with 6 chambers in the final whorl. Possesses a moderately wide and deep umbilicus. Aperture bordered by lip. Dorsally flat to slightly convex.

**Discussion.** This form is similar to *H. planispira* (Tappan) but lacks the characteristic circular outline and smaller size of that taxon. Differs from *H. delrioensis* (Carsey) in possessing 6 rather than 5 chambers in the final whorl and differs from *H. occulta* Longoria in lacking "deeply incised" sutures on the umbilical side. *Hedbergella* sp. 1 differs from *H. aff. trocoidea* in being flat dorsally, having an open umbilicus and chambers that increase more rapidly in size as added, although transitional specimens are common.

**Occurrence.** A persistent species in the upper Aptian of Site 545 (*Globigerinelloides ferreolensis* Zone through *H. trocoidea* Zone).

*Hedbergella* sp. 2  
(Pl. 17, Figs. 8-11)

*Hedbergella* sp. Sliter, 1980, p. 369, pl. 18, figs. 11-14.

**Description.** Test medium sized with 4-1/2-5 chambers in the final whorl. Inflated, globular chambers that increase in size very rapidly as added, causing an unusual, pseudo-enrolled coiling. On some specimens, aperture extends around to the spiral side of the test.

**Occurrence.** This unique taxon is restricted to a short stratigraphic interval in the lower upper Cenomanian (*Rotalipora cushmani* Zone) of Site 547.

*Loeblichella* spp.  
(Pl. 3, Figs. 11-12)

**Discussion.** Rare specimens referable to the genus *Loeblichella* occur sporadically through the upper Aptian-Albian successions of Sites 545 and 547.

*Clavihedbergella moremani* (Cushman)  
(Pl. 8, Fig. 11-12)

*Hastigerinella moremani* Cushman, 1931, p. 86, pl. 11, figs. 1a-c (not 2, 3).

*Clavihedbergella moremani* (Cushman). Loeblich and Tappan, 1961, p. 279, pl. 5, figs. 12-16.

**Discussion.** This distinctive taxon of the upper Albian (*Biticinella breggiensis* Zone) of Sites 545 and 547 is tentatively assigned to *C. moremani*. This species was originally described from the upper Cenomanian Eagle Ford Shale of Texas. A similar form, *C. pentagonalis* (Reichel), was described from the upper Albian of the Breggia Gorge section, Switzerland (level 26 of Gandolfi, 1942). This latter taxon is characterized by its bulbous chamber protuberances (see discussion by Luterbacher and Premoli Silva, 1962), a feature not noted in the original description of *C. moremani*. However, Loeblich and Tappan (1961) illustrate several specimens from the Eagle Ford Group (upper Cenomanian) with such bulbous chambers. Because of the limited stratigraphic occurrence of this taxon in the Leg 79 material, the possibility exists that *C. moremani* and *C. pentagonalis* are unrelated homeomorphs, but until more information is available regarding their ranges, synonymy is assumed and the senior *C. moremani* is utilized.

**Occurrence.** A rare but persistent taxon through the upper Albian of Site 545 and 547.

*Claviedbergella simplex* (Morrow)  
(Pl. 8, Figs. 7–8)

*Hastigerinella simplex* Morrow, 1934, pp. 198–199, pl. 30, fig. 6.  
*Claviedbergella simplex* (Morrow). Masters, 1977, pp. 443–445, pl. 19, figs. 1–3.

**Discussion.** *C. simplex* has not previously been reported from early and middle Albian age strata. The older occurrences from Site 545 may actually be recycled homeomorphic claviedbergellids from the Aptian, particularly the lower Aptian.

**Occurrence.** A persistent taxon throughout the upper Albian and Cenomanian of Sites 545 and 547.

*Claviedbergella subcretacea* (Tappan)  
(Pl. 8, Figs. 9–10)

*Hastigerinella subcretacea* Tappan, 1943, pp. 513–514, pl. 83, figs. 4a–c.  
*Hedbergella amabilis* Loeblich and Tappan, 1961, p. 274, pl. 3, figs. 8a–c, 10a, b (not 1a–7b, 9).

*Claviedbergella subcretacea* (Tappan). Masters, 1977, pp. 445–446, pl. 19, figs. 4–6.

**Discussion.** *C. subcretacea* is distinguished from *C. simplex* (Morrow) by possessing 6–6 1/2 chambers in the final whorl rather than 4–5.

**Occurrence.** A characteristic species of the lower *Biticinella breggiensis* Zone (upper Albian) of Sites 545 and 547.

*Praeglobotruncana delrioensis* (Plummer)  
(Pl. 12, Figs. 1–8)

*Globorotalia delrioensis* Plummer, 1931, pp. 199–200, pl. 13, figs. 2a–c.  
*Praeglobotruncana delrioensis* (Plummer). Loeblich and Tappan, 1961, p. 280, pl. 6, figs. 9–12.

**Occurrence.** A characteristic species of the upper Albian (*Planomalina praebuxtorfi-buxtorfi* Zone) through Cenomanian of Sites 545 and 547.

*Praeglobotruncana stephani* (Gandolfi)  
(Pl. 12, Figs. 9–12)

*Globotruncana stephani* Gandolfi, 1942, pp. 130–133, pl. 3, figs. 4, 5; pl. 4, figs. 36, 37, 41–44; pl. 6, fig. 4 (part); pl. 9, figs. 5, 8, pl. 14, fig. 2.

*Praeglobotruncana stephani* (Gandolfi). Loeblich and Tappan, 1961, p. 284, pl. 6, figs. 1–8.

**Occurrence.** Persistent throughout the upper Albian (*Planomalina praebuxtorfi-buxtorfi* Zone) and Cenomanian of Sites 545 and 547.

*Biticinella breggiensis* (Gandolfi)  
(Pl. 8, Figs. 1–2)

*Anomalina breggiensis* Gandolfi, 1942, pp. 102–103, pl. 3, figs. 6a–c; pl. 5, fig. 3; pl. 9, fig. 1; pl. 13, figs. 7a–8b; text-figs. 34 (1–4).  
*Biticinella breggiensis* (Gandolfi). Caron and Luterbacher, 1969, p. 25, pl. 7, figs. 4a–c.

**Occurrence.** Primarily restricted to the upper Albian *B. breggiensis* Zone although questionable specimens of *B. breggiensis* occur in the upper middle Albian *Ticinella praeticinensis* Zone of Site 545.

*Ticinella madecassiana* Sigal  
(Pl. 6, Figs. 7–12)

*Ticinella madecassiana* Sigal, 1966, pp. 197–198, pl. 3, figs. 7a–10b.

**Discussion.** *T. madecassiana* is distinguished from *T. primula* Luterbacher by possessing fewer chambers (5–6) and a narrower umbilicus. Ventrally, many specimens superficially resemble *Globigerinelloides bentonensis* (Morrow) in chamber shape and arrangement. *T. madecassiana* has a tendency toward pseudoplanispiral coiling that adds to its possible confusion with *G. bentonensis*. *T. caronae* Longoria and Gamper (1977; p. 212, pl. 1, figs. 1–3 and 13–15) may be synonymous with *T. madecassiana*. The specimens tentatively identified as *Hedbergella* sp. aff. *infracretacea* by Moullade (1966, pl. 8, figs. 10–12, 14–16; not figs. 6–9) also resemble *T. madecassiana*.

**Occurrence.** A characteristic species throughout the *Biticinella breggiensis* and lower *Planomalina praebuxtorfi-buxtorfi* zones (upper Albian) of Sites 545 and 547.

*Ticinella primula* Luterbacher  
(Pl. 6, Figs. 1–6)

*Ticinella primula* Luterbacher, in Renz et al., 1963, pp. 1083–1086, text-fig. 4. Sigal, 1966, pp. 198–199, pl. 3, figs. 11–14; pl. 4, figs. 1–9.

**Discussion.** *T. primula* is a variable species with 6-1/2–8 chambers in the final whorl. The size of the accessory apertures varies considerably. As observed by other workers, there is a tendency towards pseudoplanispiral coiling in larger specimens (Pl. 6, Figs. 5). It is distinguished from *T. roberti* s.l. (Gandolfi) by its less embracing chambers, a peripheral outline that is elliptical rather than circular, and flatter dorsoconvexity. *T. primula* differs from *T. raynaudi* s.l. Sigal by its less elongate chambers, and is distinguished from *T. madecassiana* Sigal by its more numerous chambers, looser coiling, and wider umbilicus.

**Occurrence.** A characteristic taxon from the middle Albian *T. primula* Subzone through the upper Albian *Biticinella breggiensis* Zone.

*Ticinella praeticinensis* Sigal  
(Pl. 13, Figs. 9–10)

*Ticinella praeticinensis* Sigal, 1966, pp. 195–196, pl. 2, figs. 3–8; pl. 3, figs. 1–6.

**Discussion.** Specimens transitional with *T. roberti* s.l. (Gandolfi) are present in the lower part of the *T. praeticinensis* Zone at Site 545. However, both species “disappear” in the upper part of that zone because of environmental exclusion/dissolution. *T. praeticinensis* is similar to *Rotalipora praebalernaensis* Sigal and maybe its direct ancestor; however, the development of a true keel in the latter species distinguishes the two forms.

**Occurrence.** Rare specimens present in the *Ticinella praeticinensis* Zone (upper middle Albian) with additional occurrences into the upper Albian of Sites 545 and 547.

*Ticinella raynaudi* s.l. Sigal  
(Pl. 7, Figs. 1–4; Pl. 8, Figs. 3–4)

*Ticinella raynaudi* var. *raynaudi* Sigal, 1966, pp. 201–202, pl. 5, fig. 10; pl. 6, figs. 1–5; var. *digitalis* Sigal, 1966, p. 202, pl. 6, figs. 6–8; var. *aperta* Sigal, 1966, pp. 202–203, pl. 6, figs. 11–13.

**Discussion.** The *T. raynaudi* group is differentiated from other species of *Ticinella* in possessing more elongate chambers. Although recognizing a true distinction between *T. raynaudi* s.l. and other ticinellids, the author finds it difficult to recognize all three varieties of *T. raynaudi*. The one most easily recognized is *T. raynaudi digitalis*. The varieties *raynaudi* and, particularly, *aperta* appear to be transitional with *T. primula* Luterbacher. *T. raynaudi* s.l. is, however, a biostratigraphically useful species group.

**Occurrence.** A characteristic species of the upper Albian *Biticinella breggiensis* Zone of Sites 545 and 547.

*Ticinella roberti* s.l. (Gandolfi)  
(Pl. 5, Figs. 1–12)

*Anomalina roberti* Gandolfi, 1942, pp. 100–101, fig. 22; pl. 2, fig. 2; pl. 4, figs. 5–7; pl. 13, figs. 3, 6.

*Ticinella roberti* (Gandolfi) var. *bejaouaensis* Sigal, 1966, p. 207, pl. 5, figs. 5–9.

*Ticinella roberti* (Gandolfi). Hermes, 1969, pp. 35–40, 42–43, pl. 1, figs. 1–3; pl. 2, figs. 28–47; pl. 3, figs. 56–60.

**Discussion.** Sigal (1966) differentiated the variety *T. roberti bejaouaensis* from *T. roberti* s.s. based on more chambers in the last whorl (averaging 9) and a more open umbilicus. To the contrary, Longoria (1974) notes that *T. bejaouaensis* differs from *T. roberti* in having a smaller umbilicus. Based on the material from this study it is difficult to recognize any distinct differences between *T. roberti* and *T. bejaouaensis*. In trying to assess the true biostratigraphic significance of the *T. roberti* group, it becomes evident from the literature that discrepancies exist between various workers concerning the ranges of “*T. roberti*” and “*T. bejaouaensis*” (see discussion by Hermes, 1969). For example, Sigal (1966) reports a range for *T. roberti* of latest Aptian (Clansayesian) to within the Vraconian (latest Albian) and a concurrent range for *T. bejaouaensis* to within the middle Albian. Other workers (Risch, 1971; Longoria, 1974; Moullade, 1974) report two distinct, nonoverlapping ranges; *T. bejaouaensis* representing a late Aptian–early Albian form and *T. roberti* present only in the late Albi-

an. These latter observations imply that the two forms are homeomorphic and unrelated species. This possibility cannot be confirmed nor denied in the present study because of the environmental exclusions/dissolution observed in the middle Albian of Site 545. However, at Site 545 *T. roberti* s.l. has an overlapping range with *T. praeticinensis* Sigal, a species long thought to represent the transition from *T. roberti* to the *Rotalipora subticinensis* (Gandolfi)-*R. ticinensis* (Gandolfi) lineage (Gandolfi, 1942; Hermes, 1969).

**Occurrence.** A persistent taxon from the latest Aptian (*T. roberti* s.l. Zone) through late Albian (*Biticinella breggiensis* Zone). A stratigraphic gap occurs in the middle Albian (*T. praeticinensis* and ?lower *Biticinella breggiensis* zones) of Site 545.

***Rotalipora appenninica* (Renz)**  
(Pl. 14, Figs. 1-12)

*Globotruncana appenninica* Renz, 1936, p. 14, fig. 2; var. *alpha* Gandolfi, 1942, p. 117, text-figs. 40a-c.

*Rotalipora appenninica appenninica* (Renz). Luterbacher and Premoli Silva, 1962, pp. 266-268, pl. 19, figs. 1, 2; pl. 20, figs. 1-4; pl. 21, figs. 1-4.

*Rotalipora appenninica* (Renz). Caron and Luterbacher, 1969, p. 26, pl. 8, fig. 8. Robaszynski and Caron, 1979, p. 59, 64; pl. 4, figs. 1a-3c; pl. 5, figs. 1a-3c.

**Discussion.** Early specimens tend to have a less strongly developed peripheral keel. *R. appenninica* is generally flatter than *R. gandolfii* Luterbacher and Premoli Silva and lacks the periumbilical flanges of the latter species. *R. appenninica* differs from *R. aff. cushmani* in lacking elongate sutural supplementary apertures and having a narrower umbilicus. A transitional specimen between *R. appenninica* and *R. aff. cushmani* is illustrated on Plate 14, Figures 1-3.

**Occurrence.** A characteristic and persistent species from the *Planomalina praebuxtorfi-buxtorfi* Zone through the *Rotalipora gandolfii* Zone (upper Albian to middle Cenomanian) of Sites 545 and 547.

***Rotalipora cushmani* (Morrow)**

*Globorotalia cushmani* Morrow, 1934, p. 199, pl. 31, figs. 2, 4.

*Rotalipora cushmani* (Morrow). Loeblich and Tappan, 1961, pp. 297-298, pl. 8, figs. 1-10.

*Rotalipora cushmani* (Morrow). Robaszynski and Caron, 1979, p. 69, 74; pl. 7, figs. 1a-c; pl. 8, figs. 1a-2c.

**Discussion.** *R. cushmani* is characterized by its triangular-shaped chambers on the umbilical side, wide umbilicus, sutural secondary apertures, and inflated chambers on both the ventral and dorsal sides. The lack of inflation, particularly on the dorsal side, serves to distinguish *R. aff. cushmani* from *R. cushmani*.

**Occurrence.** Characteristic of the upper Cenomanian (*Rotalipora cushmani* Zone) of Site 547.

***Rotalipora aff. cushmani***  
(Pl. 16, Figs. 1-6)

**Discussion.** *Rotalipora aff. cushmani* is more compressed and lacks the inflation of true *R. cushmani* (Morrow). The chambers on the spiral side are not inflated and dorsal convexity is low. Inflation of the umbilical side is variable. The Let 79 specimens of *R. aff. cushmani* are not equivalent to *R. montsalvensis* (Mornod) because they are less inflated and possess beaded intercameral dorsal sutures. Interestingly, *R. aff. cushmani* appears to have a stratigraphic range consistent with that of *R. montsalvensis* as proposed by Robaszynski and Caron (1979).

**Occurrence.** Ranges from the mid *R. gandolfii* Zone through the *R. reicheli* Zone (late early Cenomanian to middle Cenomanian).

***Rotalipora gandolfii* Luterbacher and Premoli Silva**  
(Pl. 15, Figs. 5-12)

*Globotruncana appenninica* var. *typica* Gandolfi, 1942, pp. 116-123, text-fig. 43 (2, 3); pl. 2, fig. 6; pl. 4, figs. 13, 14; pl. 9, fig. 6; pl. 12, figs. 4-6; pl. 14, figs. 3, 4.

*Rotalipora appenninica gandolfii* Luterbacher and Premoli Silva, 1962, pp. 267-268, pl. 19, fig. 3.

*Rotalipora gandolfii* Luterbacher and Premoli Silva. Caron and Luterbacher, 1969, pp. 26-27, pl. 9, fig. 9. Robaszynski and Caron, 1979, p. 81, 84; pl. 11, figs. 1a-2c.

**Discussion.** *R. gandolfii* tends to be higher ventrally than *R. appenninica* (Renz) and also differs from the latter species in having

periumbilical flanges (umbilical shoulders) on all chambers. *R. gandolfii* lacks the strongly oblique spiral sutures of *R. greenhornensis* (Morrow) and development of raised umbilical sutures (horseshoes).

**Occurrence.** A characteristic species from the uppermost Albian (*Planomalina praebuxtorfi-buxtorfi* Zone) through the lower upper Cenomanian of Sites 545 and 547.

***Rotalipora greenhornensis* (Morrow)**  
(Pl. 15, Figs. 1-4; Pl. 16, Figs. 7-12)

*Globorotalia greenhornensis* Morrow, 1934, p. 199, pl. 31, fig. 1.

*Rotalipora greenhornensis* (Morrow). Loeblich and Tappan, 1961, pp. 299-301, pl. 7, figs. 5-10. Robaszynski and Caron, 1979, p. 85, 90; pl. 12, figs. 1a-2c; pl. 13, figs. 1a-2c.

**Discussion.** The author agrees with Loeblich and Tappan (1961) that *R. globotruncanoides* Sigal and *Thalmaninella brotzeni* Sigal are both synonymous with *R. greenhornensis*. As noted by Eicher and Worstell (1970), this species varies considerably in dorsal convexity. The specimens of this study typically have 6-7-1/2 chambers in the final whorl. *R. greenhornensis* is distinguished from *R. gandolfii* Luterbacher and Premoli Silva by having strongly oblique sutures on the spiral side, a tendency toward a more pronounced asymmetrical test, raised umbilical sutures (horseshoes), and well-developed umbilical supplementary apertures.

**Occurrence.** First appears in the *R. gandolfii* Zone (lower Cenomanian) and ranges into the upper Cenomanian of Sites 545 and 547.

***Rotalipora micheli* (Sacal and Debourle)**  
(Pl. 17, Figs. 3-7)

*Globotruncana (Rotalipora) micheli* Sacal and Debourle, 1957, p. 58, pl. 25, figs. 4, 5, 12.

*Rotalipora micheli* (Sacal and Debourle). Robaszynski and Caron, 1979, p. 91, 94; pl. 14, figs. 1a-3c.

**Discussion.** *Rotalipora marchigiana* (Borsetti), originally described from thin section, may be synonymous with *R. micheli*. *R. micheli* is distinguished from *R. appenninica* (Renz) by its greater inflation on the umbilical side and the presence of adumbilical thickenings which gives the test its distinctive asymmetrical axial profile. *R. micheli* is more inflated ventrally than *R. gandolfii* Luterbacher and Premoli Silva and also lacks the development of true periumbilical flanges as observed in the latter species.

**Occurrence.** Rare from the lower *R. gandolfii* Zone through the *R. reicheli* Zone (lower to middle Cenomanian).

***Rotalipora praebalernaensis* Sigal**  
(Pl. 13, Figs. 4, 8, 11-12)

*Rotalipora praebalernaensis* Sigal, 1969, pp. 635-637, pl. 1, figs. 1-8.

**Discussion.** *R. praebalernaensis* differs from *R. subticinensis* (Gandolfi) in possessing fewer chambers (6-7), in being flatter dorsally, and having a more lobate periphery. *R. praebalernaensis* is distinguished from *R. appenninica* (Renz) by a less well developed peripheral keel and more circular outline.

**Occurrence.** A rare species in the *Biticinella breggiensis* Zone (late Albian).

***Rotalipora reicheli* (Mornod)**  
(Pl. 17, Figs. 1-2)

*Globotruncana appenninica* var. *gamma* Gandolfi, 1942, p. 116.

*Globotruncana (Rotalipora) reicheli* Mornod, 1950, p. 583, fig. 5(4); fig. 6 (1-6); pl. 25, figs. 3-4.

*Rotalipora reicheli* (Mornod). Caron and Luterbacher, 1969, p. 27, pl. 9, fig. 10. Robaszynski and Caron, 1979, p. 99, 106; pl. 16, figs. 1a-c; pl. 17, figs. 1a-c; pl. 18, figs. 1a-2c.

*Rotalipora deeckeii* (Franke). Masters, 1977, pp. 506-508, pl. 32, figs. 1-3.

**Occurrence.** This distinctive taxon is very rare at Sites 545 and 547, apparently restricted to the *R. reicheli* Zone.

***Rotalipora subticinensis* (Gandolfi)**  
(Pl. 13, Figs. 5-7)

*Globotruncana ticinensis* var. *alpha* Gandolfi, 1942, p. 114, pl. 2, figs. 4a-c; pl. 8, fig. 3.

*Globotruncana (Thalmaninella) ticinensis subticinensis* Gandolfi, 1957, p. 59, pl. 8, figs. 1a-c.

*Rotalipora subticinensis* (Gandolfi). Robaszynski and Caron, 1979, p. 107, 110; pl. 19, figs. 1a-2d.

**Occurrence.** Restricted to the lower part of the *Biticinella breggiensis* Zone (upper Albian) of Sites 45 and 547.

***Rotalipora ticinensis* (Gandolfi)**  
(Pl. 13, Figs. 1-3)

*Globotruncana ticinensis* typica Gandolfi, 1942, pp. 113-115, text-fig. 39, pl. 2, figs. 3a-c; pl. 5, fig. 2; pl. 8, figs. 4-6.

*Rotalipora ticinensis* (Gandolfi). Robaszynski and Caron, 1979, p. 111, 114; pl. 20, figs. 1a-2b.

**Occurrence.** A characteristic species throughout the *Biticinella breggiensis* and lower *Planomalina praebuxtorfi-buxtorfi* Zones.

**Gen. indet., sp. indet.**  
(Pl. 7, Figs. 5-6, 9-10)

**Description.** Test small, stout. Chambers increase fairly rapidly in size as added, inflated, strongly embracing; 5 chambers in the final whorl. Umbilicus closed. Aperture low, slitlike with thin lip. Low trochospire. Generic assignment uncertain.

**Occurrence.** This distinctive taxon has a short stratigraphic range in late middle or early late Albian age strata of Site 545. It is associated with the interval of lowest planktonic diversity and a presumed harsh ?preservational environment.

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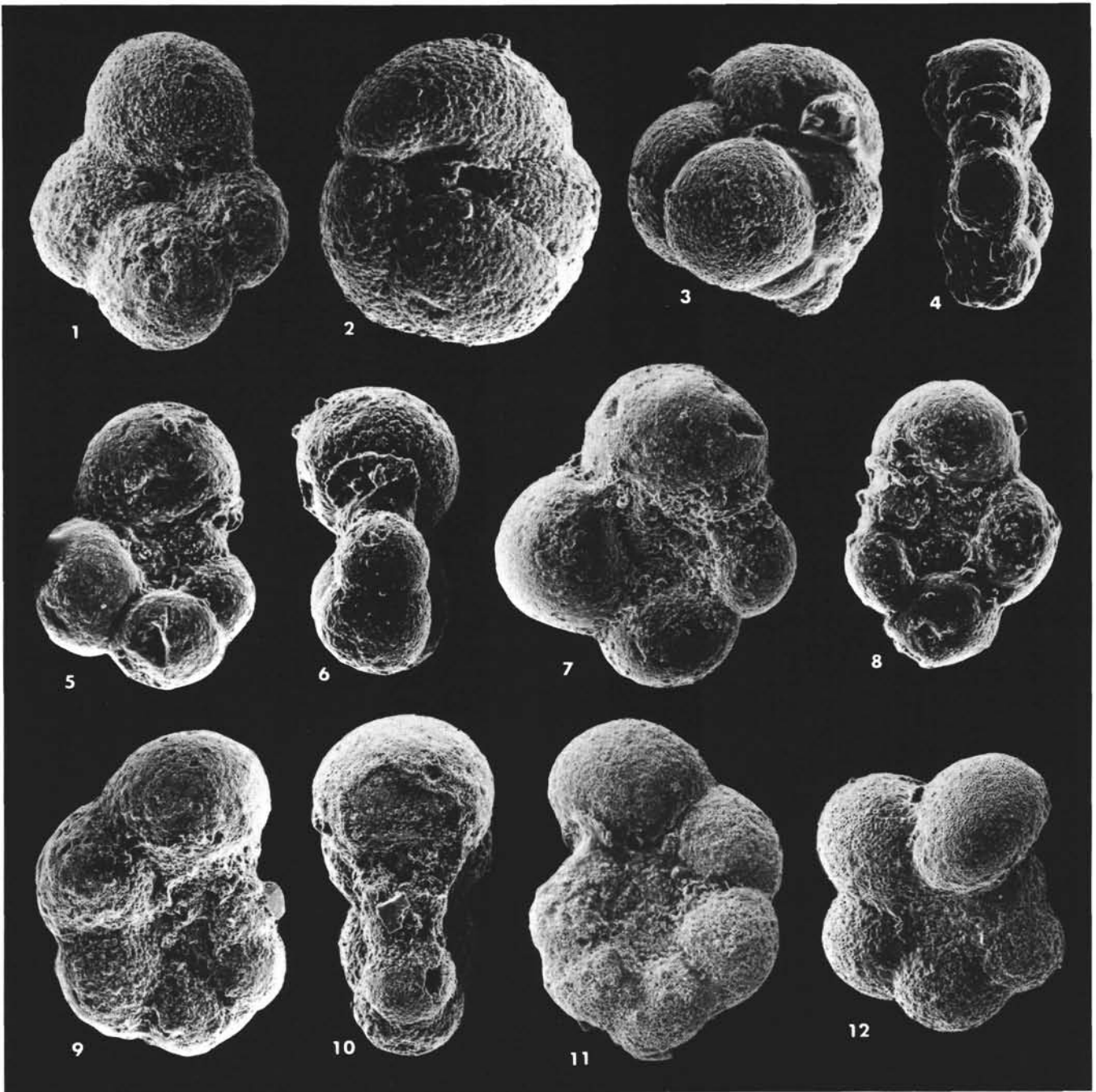


Plate 1. Late Aptian. 1. *Hedbergella* aff. *sigali*, 545-56-5, 62-64 cm (max. diam. 0.14 mm). 2-3. *Gubkinella graysonensis*, (2) 545-44, CC (max. diam. 0.10 mm), (3) 545-54, CC (max. diam. 0.16 mm). 4-8. *Globigerinelloides blowi* s.l., (4-6, 8) 545-54, CC (4, 8, max. diam. 0.15 mm; 5-6, max. diam. 0.12 mm; (7) 545-55-4, 87-89 cm (max. diam. 0.16 mm). 9-11. *Globigerinelloides aptiense*, (9-10) 545-52-1, 81-86 cm (max. diam. 0.21 mm); (11) 545-55-5, 4-6 cm (max. diam. 0.14 mm). 12. *Hedbergella delrioensis*, early form, 545-56-3, 54-56 cm (max. diam. 0.23 mm).

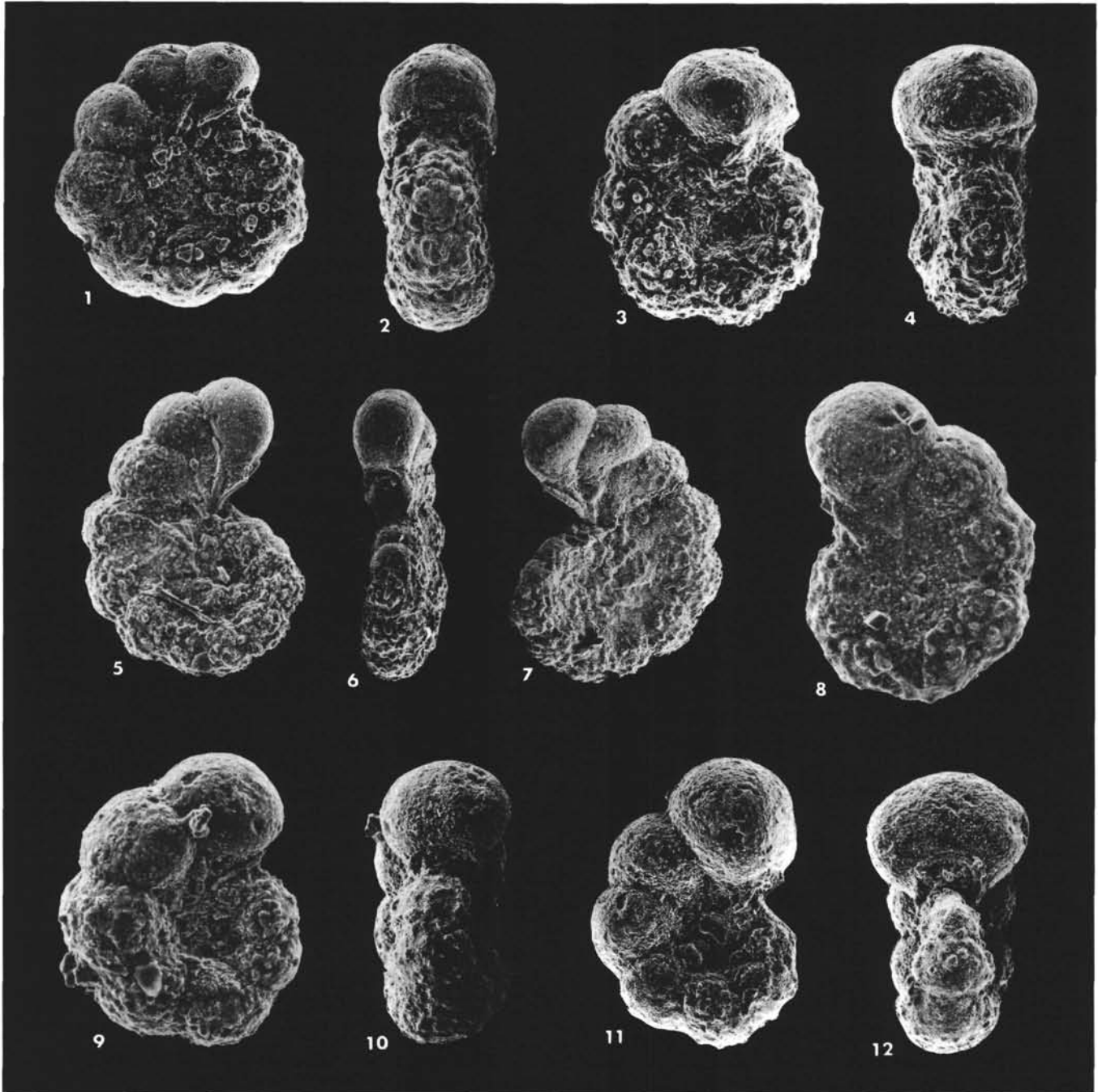


Plate 2. Late Aptian. 1-4. *Globigerinelloides barri*, (1-2) 545-54,CC (max. diam. 0.40 mm), (3-4) 545-52,CC (max. diam. 0.38 mm). 5-8. *Globigerinelloides algerianus*, 545-54,CC, (5-7) max. diam. 0.70 mm, (8) max. diam. 0.30 mm. 9-12. *Globigerinelloides ferreolensis*, 545-54,CC, (9-10) max. diam. 0.30 mm, (11-12) max. diam. 0.30 mm.

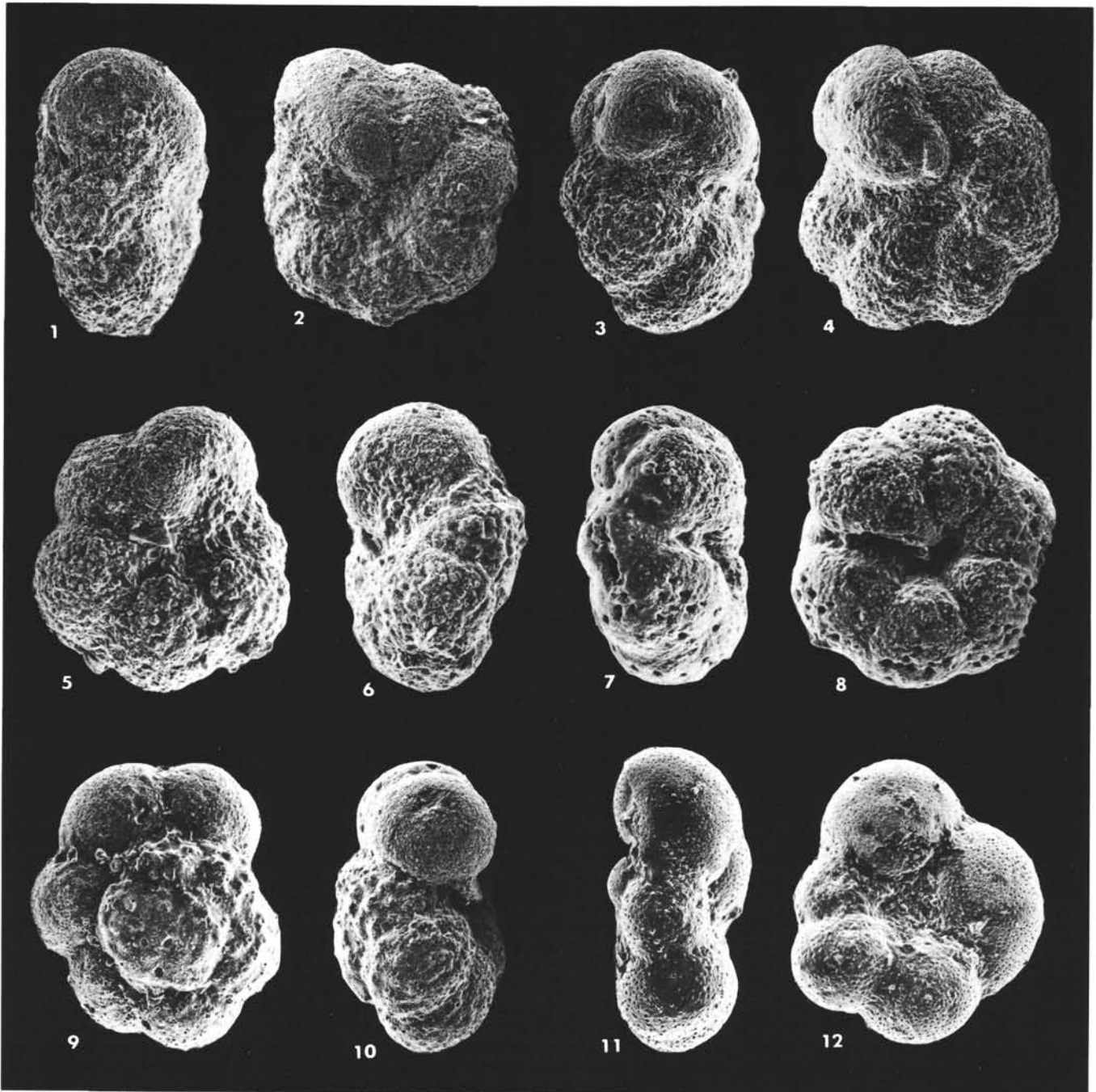


Plate 3. Late Aptian. 1-4. *Hedbergella trocoidea*, (1-2) 545-51, CC (max. diam. 0.37 mm), (3-4) 545-53, CC (max. diam. 0.37 mm). 5-10. *Hedbergella* aff. *trocoidea*, (5-6) 545-54, CC (max. diam. 0.21 mm), (7-8) 545-54-6, 55-58 cm (max. diam. 0.12 mm), (9-10) 545-54-2, 52-56 cm (max. diam. 0.20 mm). 11-12. *Loeblichella* sp., 547A-73, CC (max. diam. 0.27 mm).

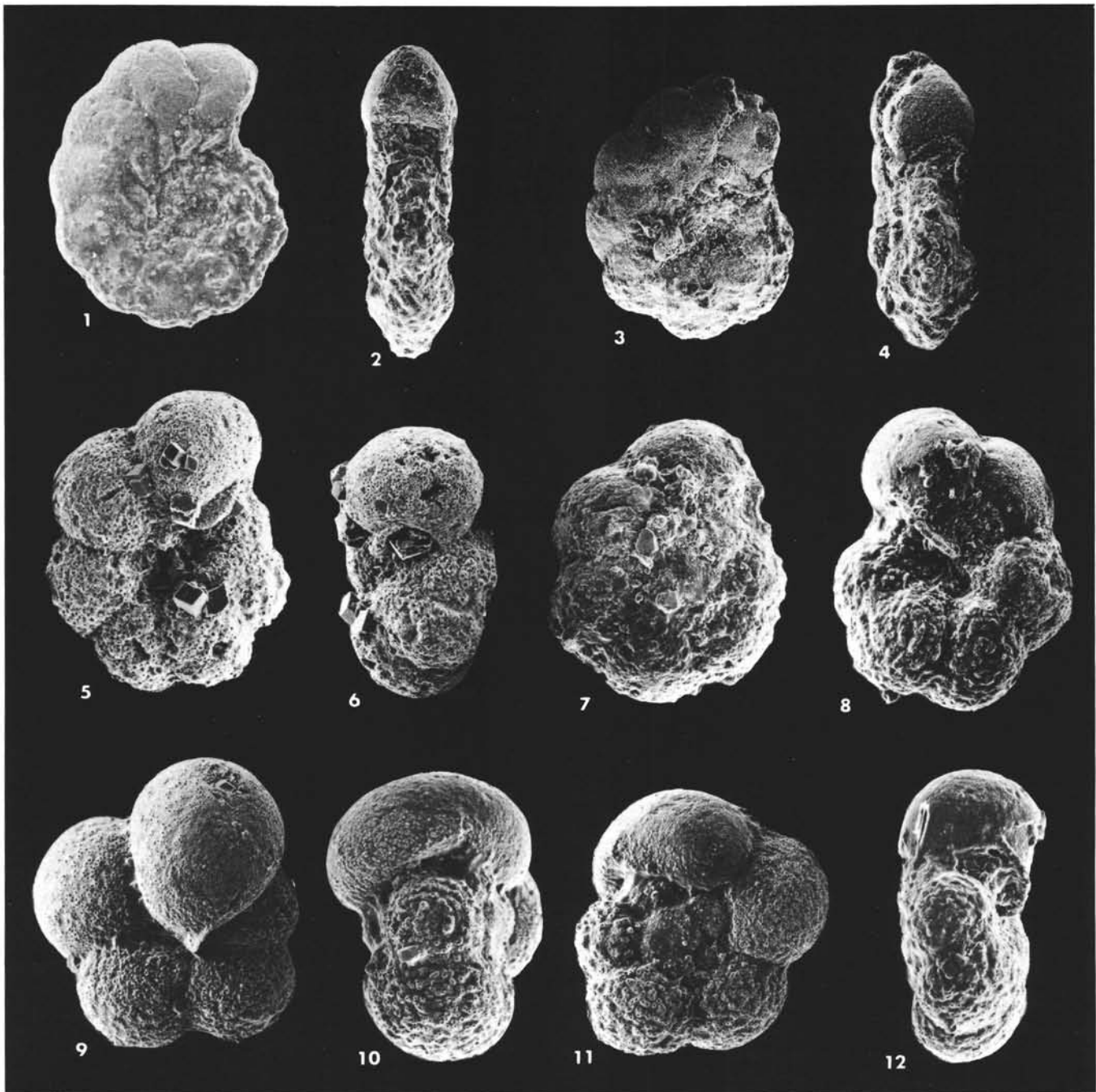


Plate 4. Late Aptian. 1-4. *Planomalina cheniourensis*, (1-2) 545-49,CC (max. diam. 0.48 mm), (3-4) 545-50-1, 33-34 cm (max. diam. 0.40 mm). 5-8, 12. *Hedbergella* sp. 1, (5-6) 545-56-5, 62-64 cm (max. diam. 0.20 mm), (7) 545-54,CC (max. diam. 0.29 mm), (8, 12) 545-53-2, 63-65 (max. diam. 0.21 mm). 9-11. *Hedbergella gorbachikae*, 545-49,CC, (9) max. diam. 0.26 mm, (10-11) max. diam. 0.21 mm.

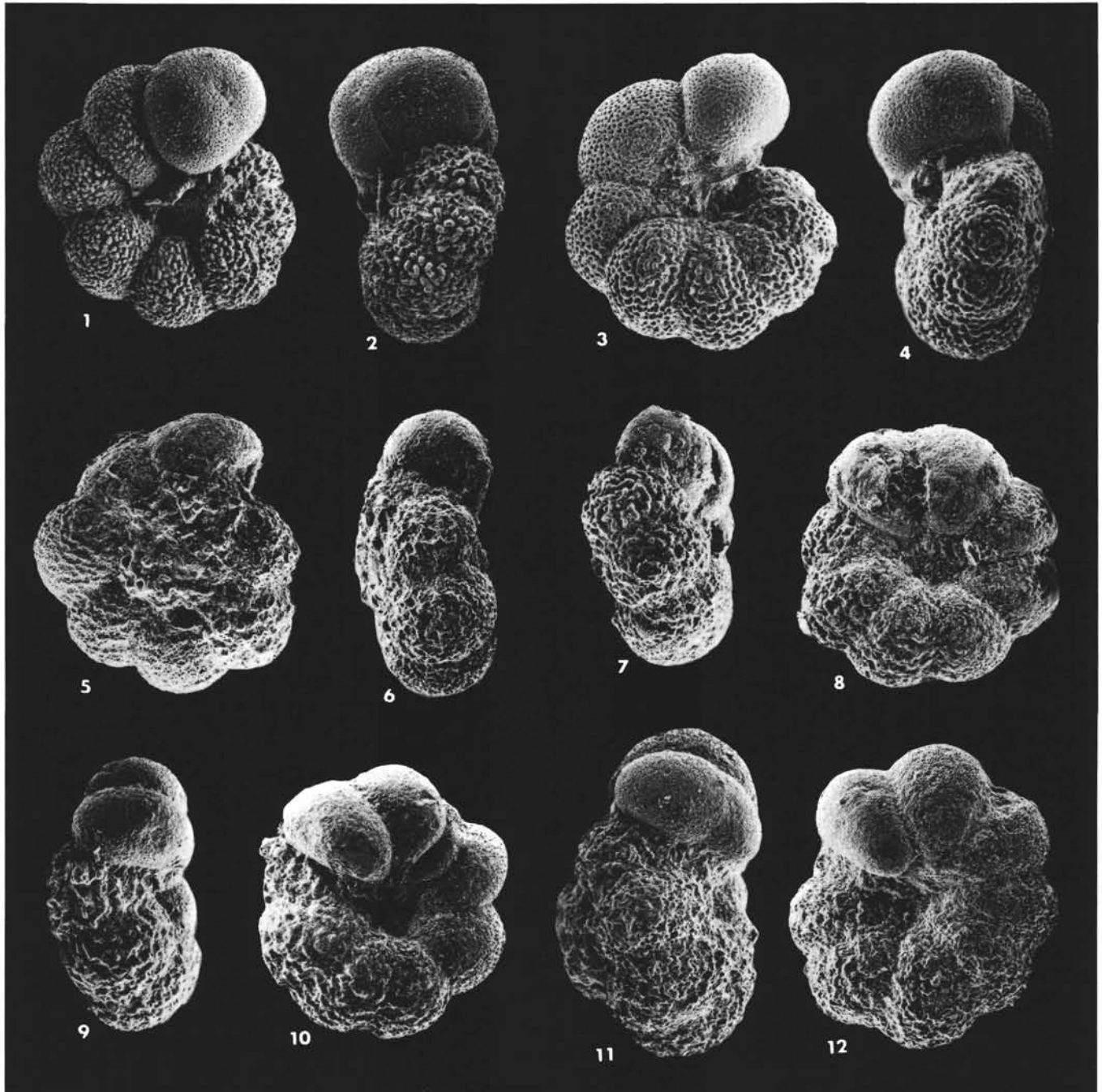


Plate 5. Late Aptian-late Albian. *Ticinella roberti* s.l. 1-2. 545-38,CC (max. diam. 0.38 mm). 3-4. 547A-62,CC (max. diam. 0.34 mm). 5-6. 545-43-3, 145-150 cm (max. diam. 0.44 mm). 7-8. 545-44,CC (max. diam. 0.37 mm). 9-10. 545-46,CC (max. diam. 0.40 mm). 11-12. 545-49,CC (max. diam. 0.40 mm).

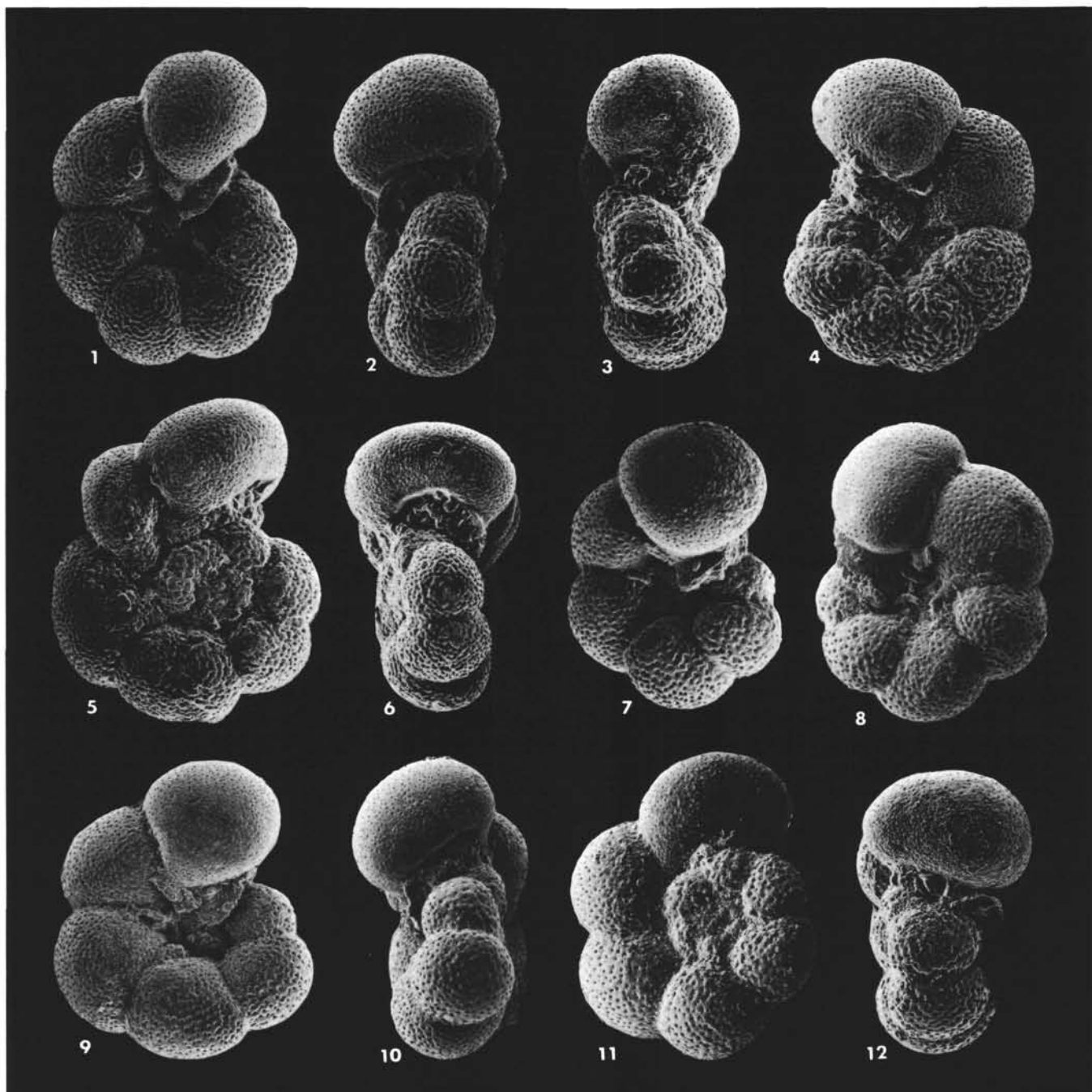


Plate 6. Middle and late Albian. 1-6. *Ticinella primula*, (1-2) 547A-73,CC (max. diam. 0.42 mm), (3-6) 547A-68,CC (3-4, max. diam. 0.38 mm; 5-6, large specimen with pseudo-planispiral coiling, max. diam. 0.45 mm). 7-12. *Ticinella madecassiana*, (7) 547A-73,CC (max. diam. 0.35 mm), (8) 545-39,CC (max. diam. 0.32 mm), (9-10) 547B-5,CC (max. diam. 0.35 mm), (11-12) 547A-73,CC (max. diam. 0.34 mm).

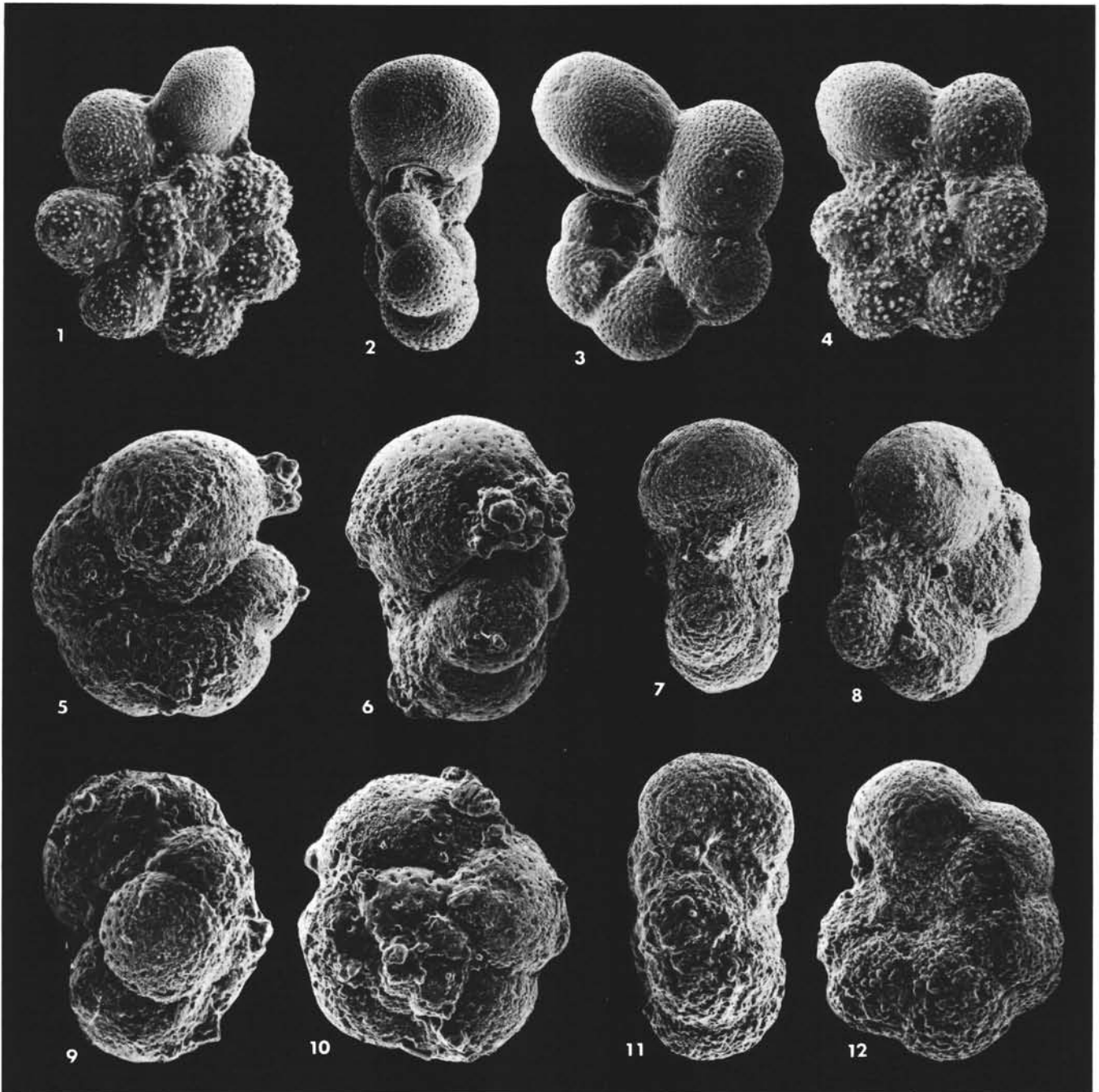


Plate 7. Early to late Albian. 1-4. *Ticinella raynaudi* s.l., (1) 547A-73, CC (max. diam. 0.38 mm), (2-3) 547B-5, CC (max. diam. 0.35 mm), (4) 547B-2, CC (max. diam. 0.31 mm). 5-6. Gen. indet., sp. indet., 545-40-6, bottom (max. diam. 0.16 mm) 7-8. *Globigerinelloides gyroidinaeformis*, 545-47-1, 93-95 cm (max. diam. 0.32 mm). 9-10. Gen. indet., sp. indet., 545-40-6, bottom (max. diam. 0.20 mm). 11-12. *Hedbergella* cf. *rischi*, 545-46-3, 4-6 cm (max. diam. 0.24 mm).



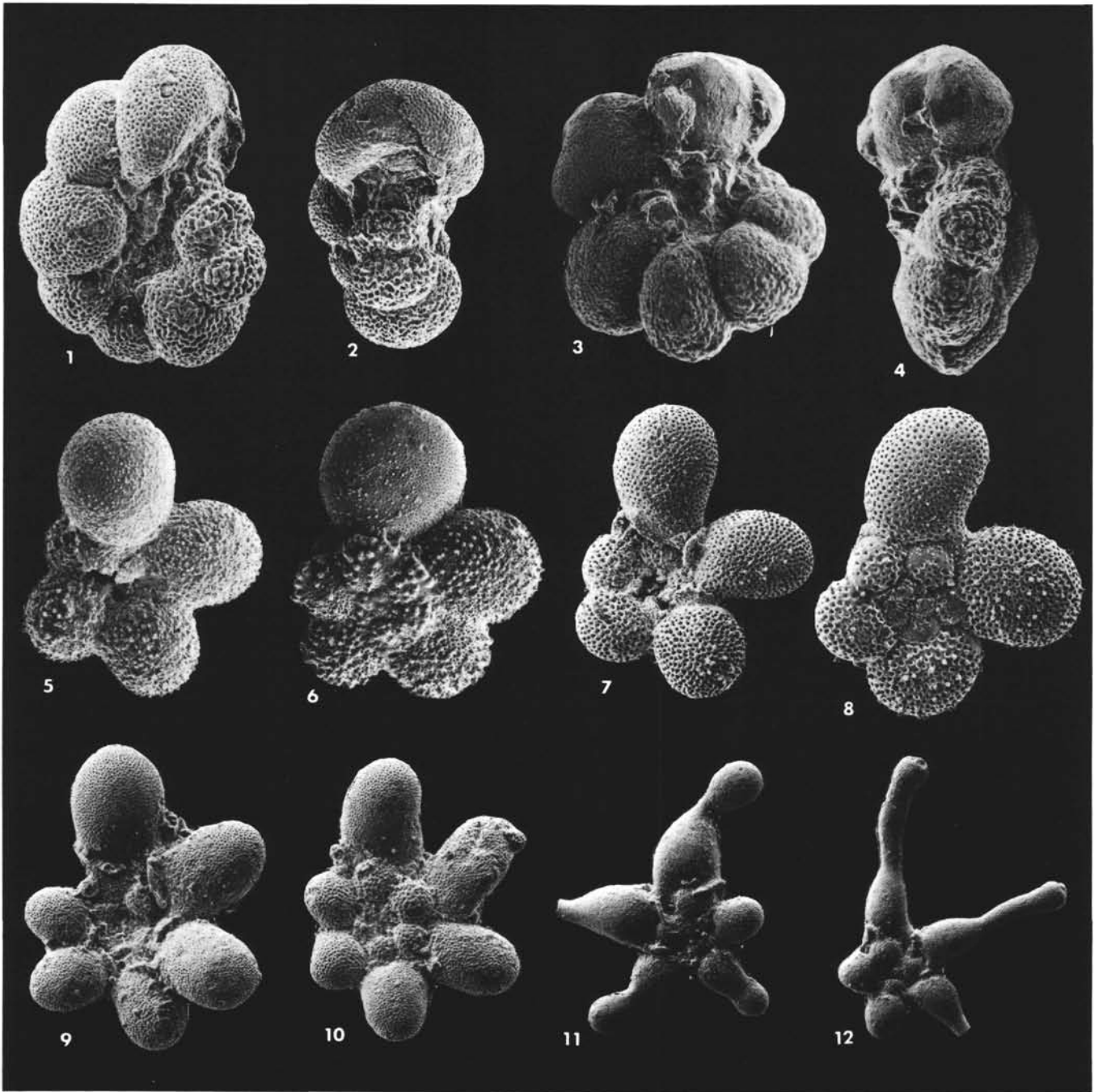


Plate 8. Late Albian, Cenomanian. 1-2. *Biticinella breggiensis*, 547B-5,CC (max. diam. 0.58 mm). 3-4. *Ticinella* cf. *raynaudi* s.l.; note imperforate band in edge view. 547A-66,CC (max. diam. 0.38 mm). 5-6. *Hedbergella simplicissima*, (5) 547A-42,CC (max. diam. 0.32 mm), (6) 547A-52,CC (max. diam. 0.42 mm). 7-8. *Clavihedbergella simplex*, 547A-40,CC, (7) max. diam. 0.26 mm, (8) max. diam. 0.22 mm. 9-10. *Clavihedbergella subcretacea*, 547B-5,CC, (9) max. diam. 0.30 mm, (10) max. diam. 0.28 mm. 11-12. *Clavihedbergella moremani*, 547A-73,CC, (11) max. diam. 0.37 mm, (12) max. diam. 0.43 mm.

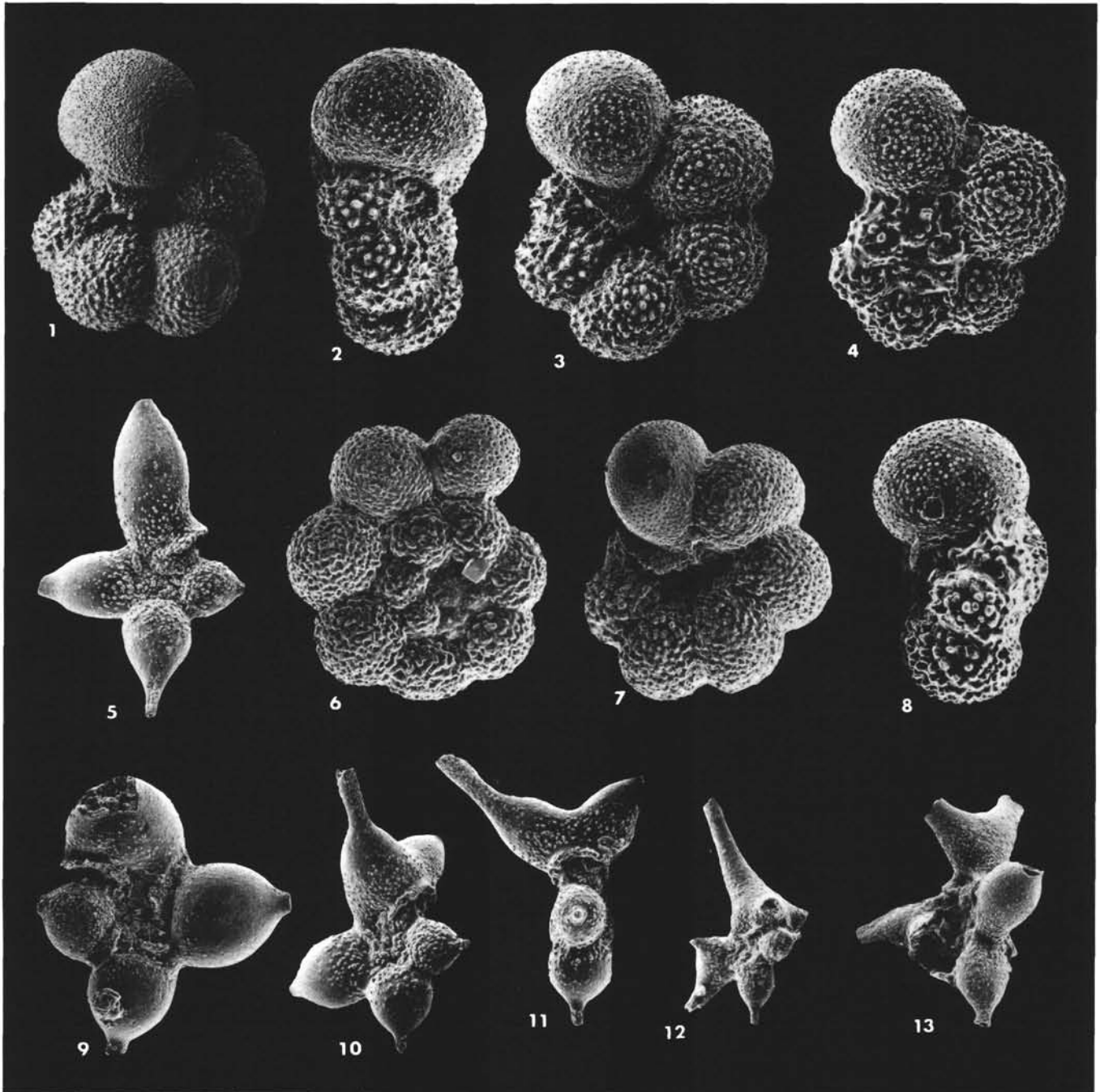


Plate 9. Albian, Cenomanian. 1-4, 8. *Hedbergella delrioensis*, (1-3) 547A-42,CC (1, max. diam. 0.44 mm; 2-3 max. diam. 0.35 mm), (4, 8) 547A-54,CC (max. diam. 0.35 mm). 5. *Schackoina cenomana*, 547A-41,CC (max. diam. 0.32 mm). 6-7. *Hedbergella planispira*, (6) 547A-73,CC (max. diam. 0.24 mm), (7) 547A-42,CC (max. diam. 0.30 mm). 9. *Schackoina cenomana*, 547A-53,CC (max. diam. 0.25 mm). 10-11. *Schackoina bicornis*, 547A-41,CC (max. diam. 0.32 mm). 12. *Schackoina multispinata*, 547A-42,CC (max. diam. 0.40 mm). 13. *Schackoina moliniensis*, 547A-53,CC (max. diam. 0.28 mm).

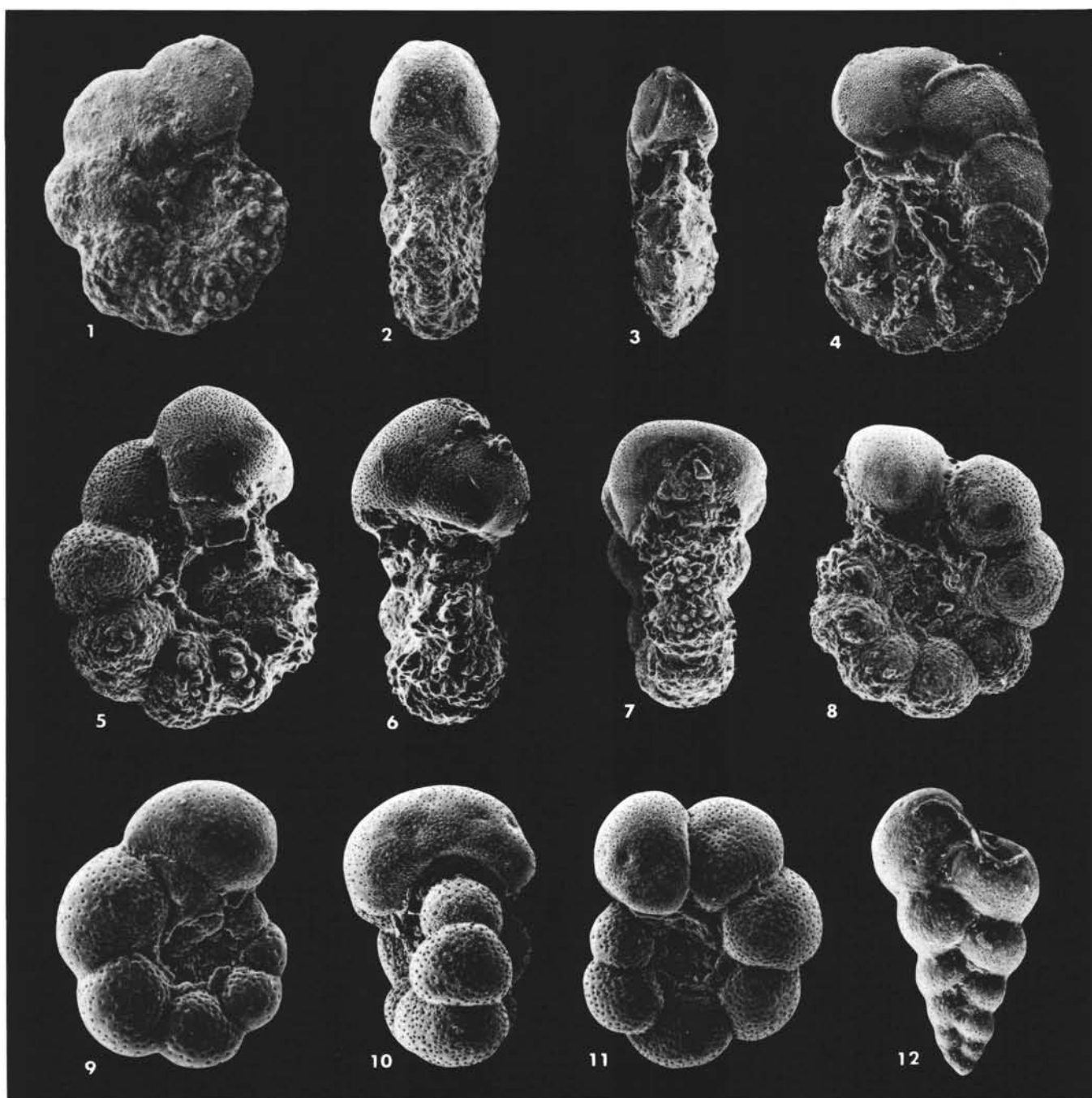


Plate 10. Late Albian, Cenomanian. 1-2. *Planomalina praebuxtorfi*, 547A-67, CC (max. diam. 0.42 mm). 3-4. *Planomalina buxtorfi*, 547A-63, CC (max. diam. 0.54 mm). 5-6. *Globigerinelloides* cf. *bentonensis*, transitional specimen between *G. bentonensis* and *P. praebuxtorfi*; 547A-68, CC (max. diam. 0.44 mm). 7-11. *Globigerinelloides bentonensis*, (7-8) 547A-73, CC (max. diam. 0.38 mm), (9) 547A-60, CC (max. diam. 0.27 mm). (10-11) 547A-51, CC (max. diam. 0.32 mm). 12. *Heterohelix moremani*, 547A-42, CC (max. diam. 0.26 mm).

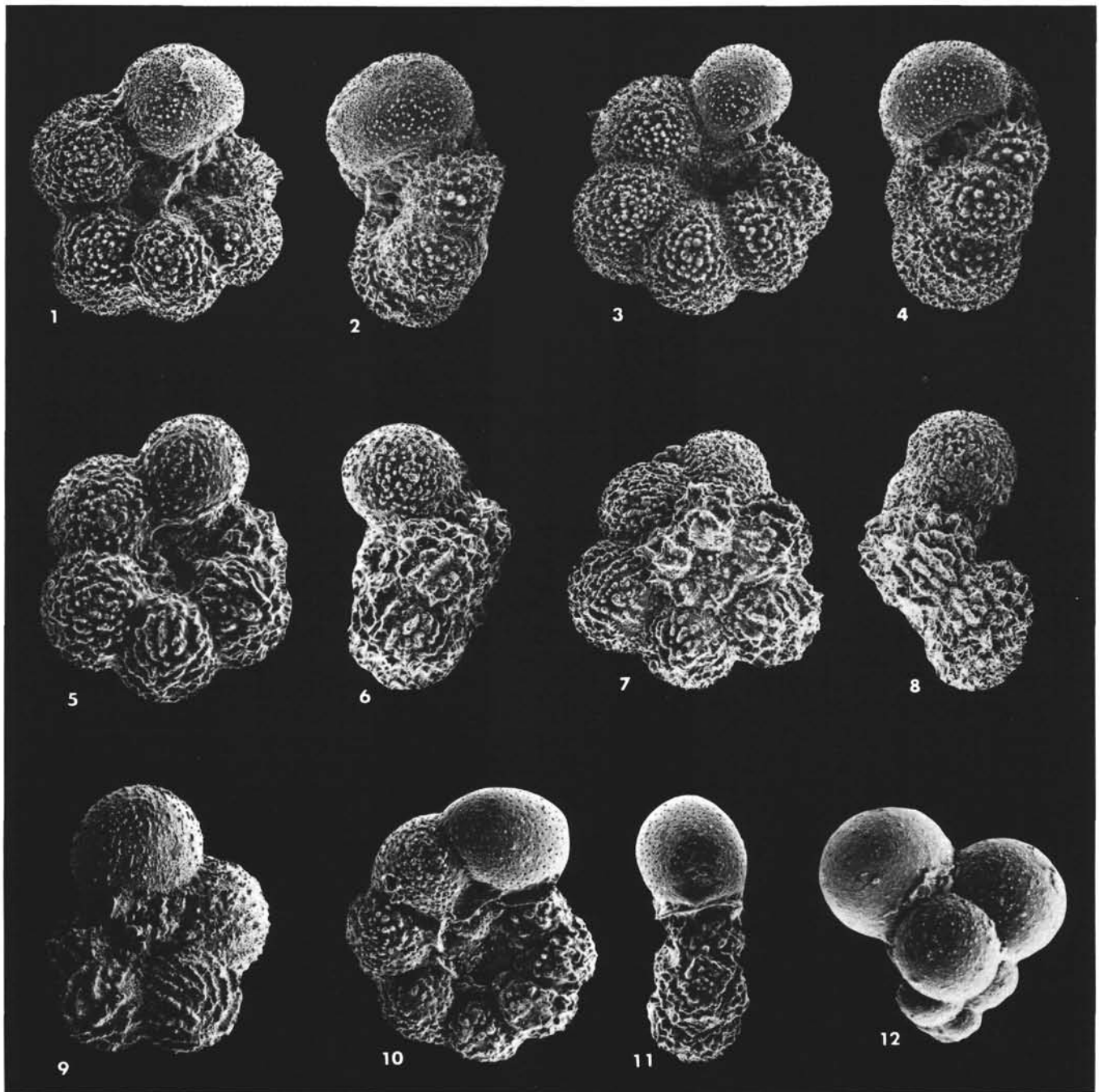


Plate 11. Late Albian, Cenomanian. 1-4. *Hedbergella paradubia*, (1, 2) 547A-53,CC (max. diam. 0.39 mm), (3-4) 547A-40,CC (max. diam. 0.39 mm). 5-9. *Hedbergella libyca*, (5-8) 547A-62,CC (5-6, max. diam. 0.50 mm; 7-8, max. diam. 0.57 mm), (9) 545-40-1, 8-10 cm (max. diam. 0.44 mm). 10-11. *Globigerinelloides ultramicrus*, 547A-42,CC (max. diam. 0.26 mm). 12. *Guembelitria cenomana*, 547A-52,CC (max. diam. 0.15 mm).

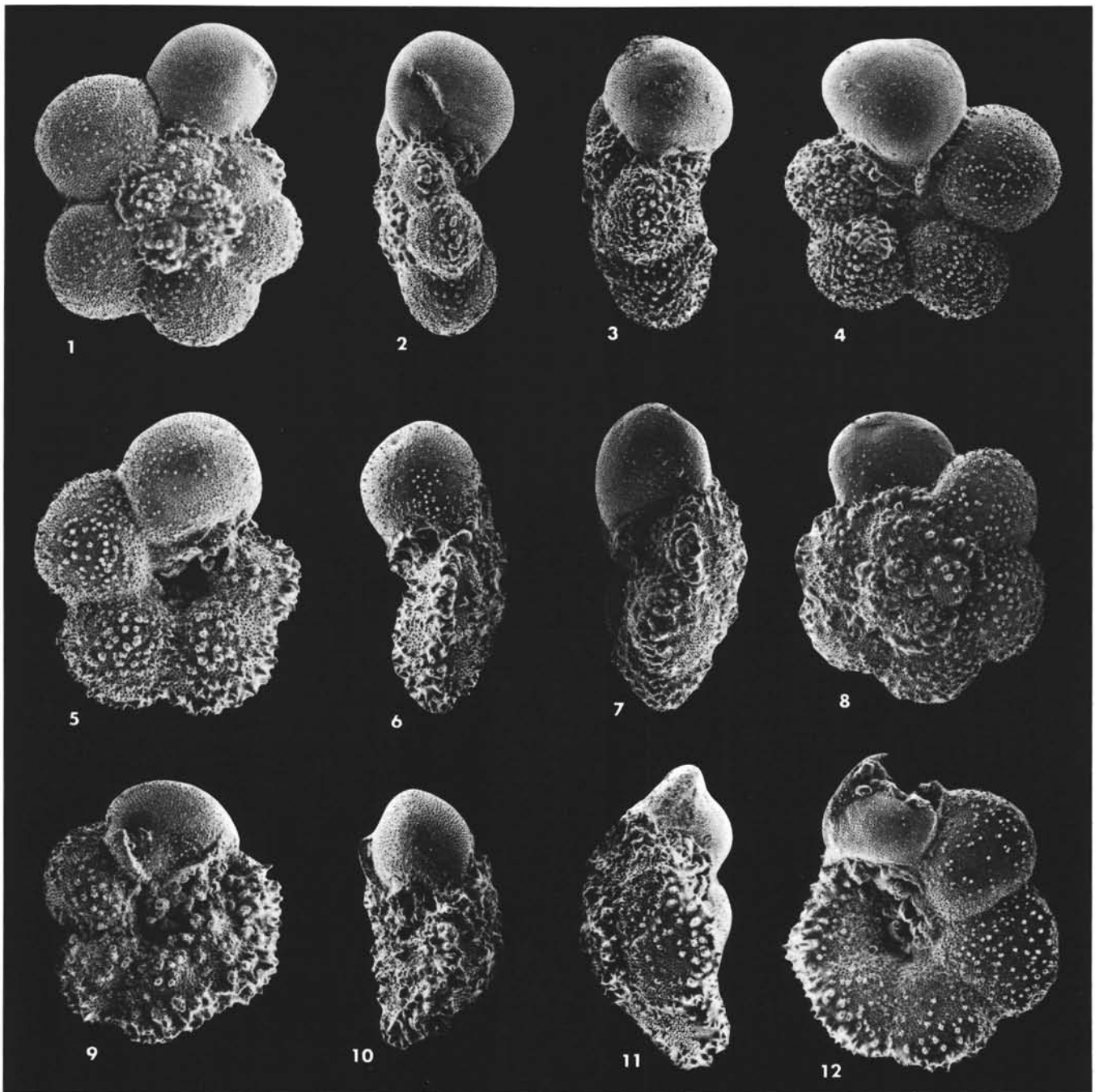


Plate 12. Late Albian-Cenomanian. 1-8. *Praeglobotruncana delrioensis*, (1-4) 547A-51,CC (1-2, max. diam. 0.51 mm; 3-4, max. diam. 0.47 mm), (5-8) 547A-56,CC (5-6, max. diam. 0.39 mm; 7-8, max. diam. 0.56 mm). 9-12. *Praeglobotruncana stephani*, (9-10) 545-40-1, 8-10 cm (max. diam. 0.42 mm), (11-12) 547A-51,CC (max. diam. 0.54 mm).

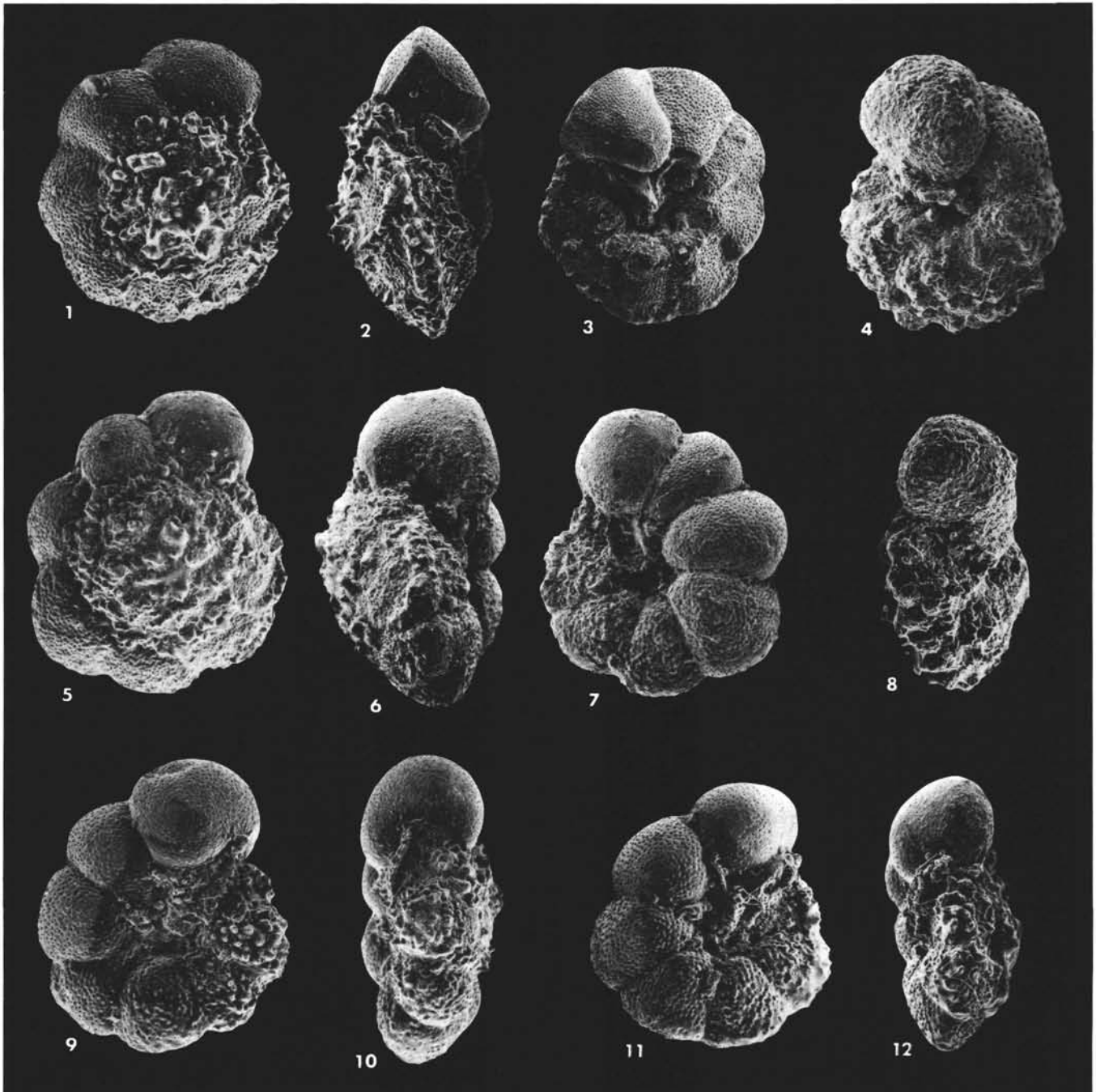


Plate 13. Middle and late Albian. 1-3. *Rotalipora ticinensis*, 547A-69,CC (max. diam. 0.45 mm). 4, 8, 11-12. *Rotalipora praebalernaensis*, (4, 8) 545-40-3, 8-10 cm (max. diam. 0.24 mm), (11-12) 545-39-3, 96-98 cm (max. diam. 0.36 mm). 5-7. *Rotalipora subticinensis*, 547B-4,CC (max. diam. 0.53 mm). 9-10. *Ticinella praeticinensis*, 547B-5,CC (max. diam. 0.43 mm).

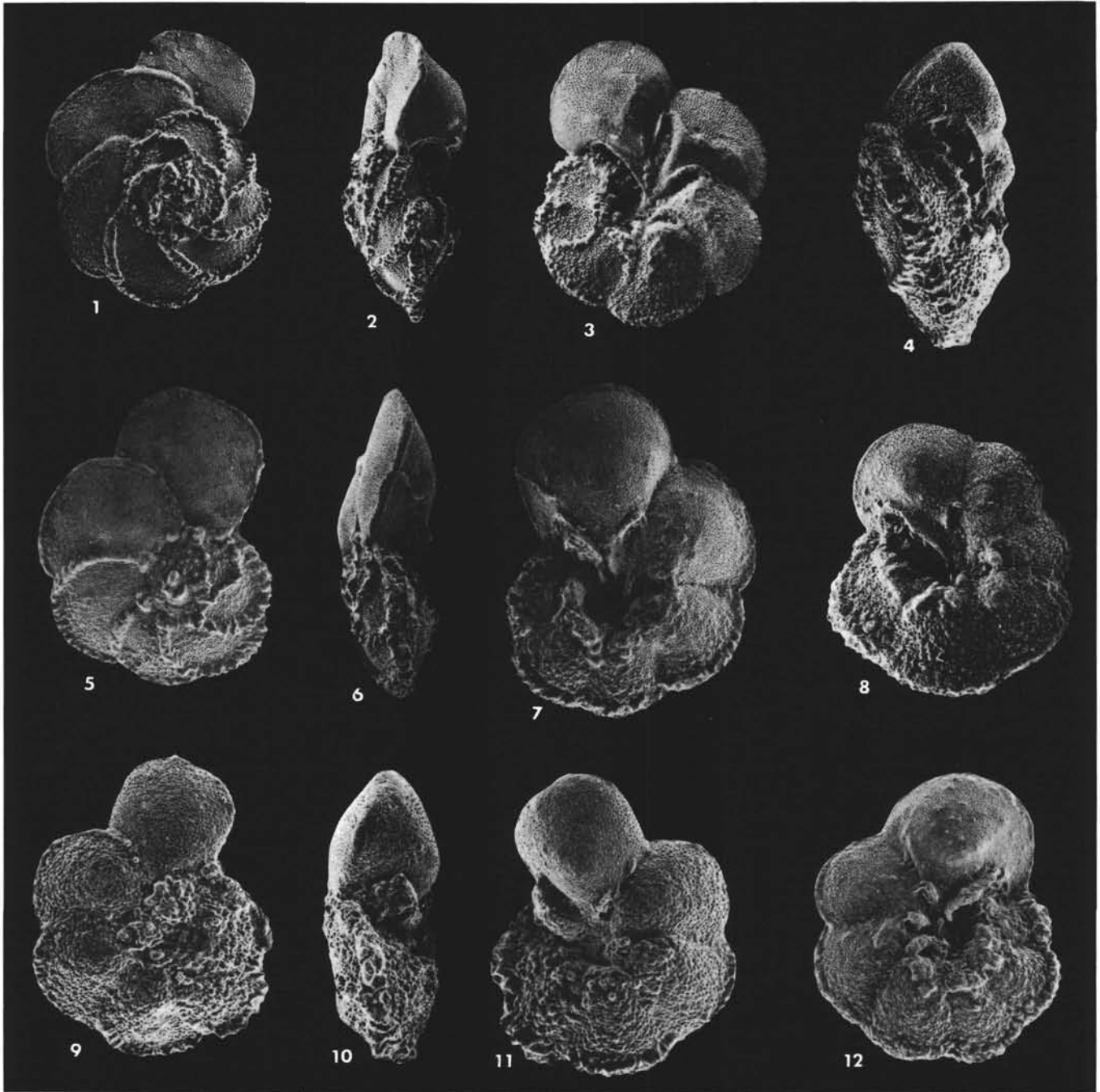


Plate 14. Latest Albian–middle Cenomanian. *Rotalipora appenninica*. 1–3. Later form, specimen becoming transitional with *R. aff. cushmani*; 547A-40, CC (max. diam. 0.67 mm). 4, 8. 545-35, CC (max. diam. 0.40 mm). 5–7, 12. 547A-62, CC (max. diam. 0.55 mm). 9–11. Early form, 547A-69, CC (max. diam. 0.43 mm).

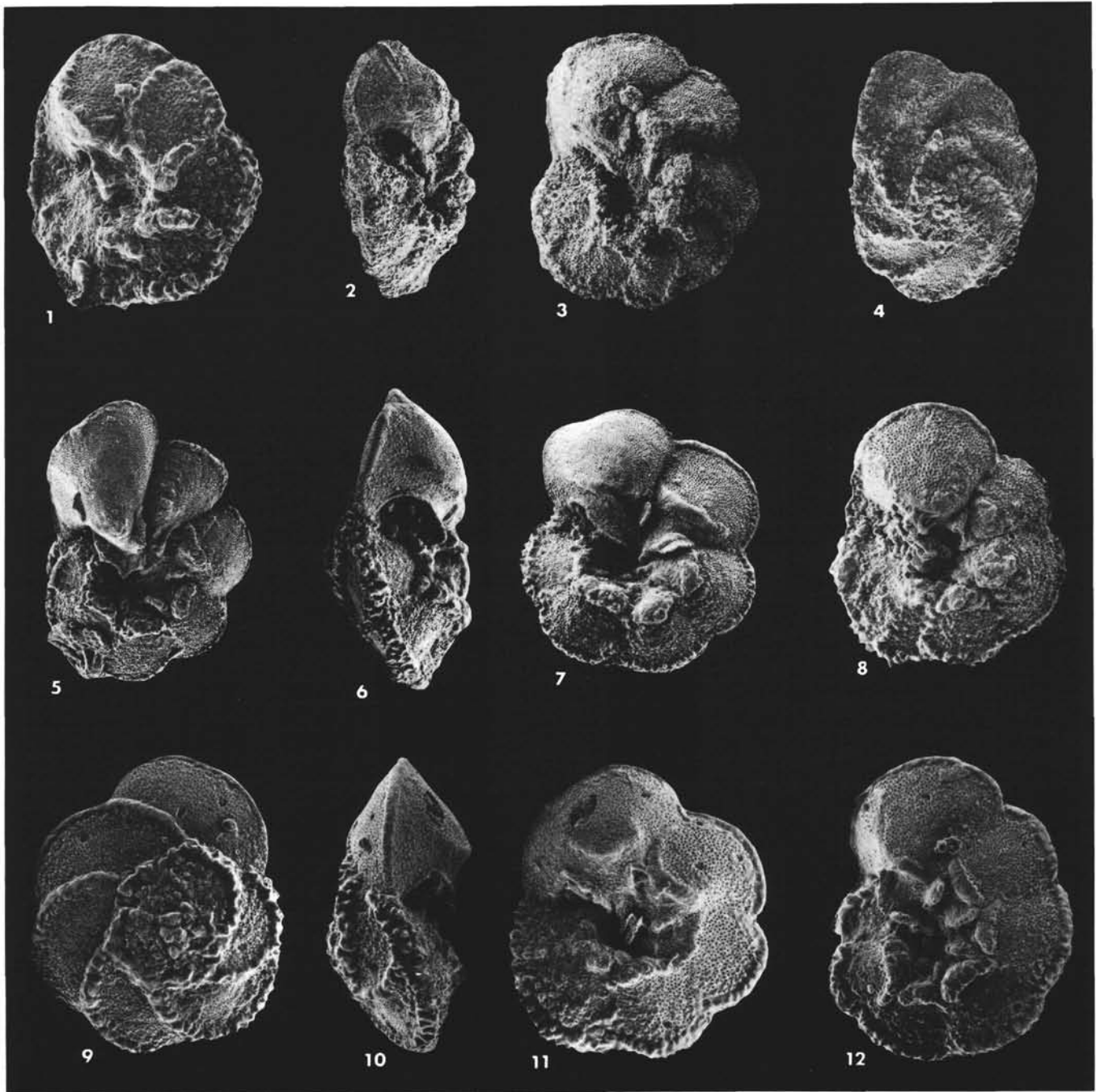


Plate 15. Early and middle Cenomanian. 1-4. *Rotalipora greenhornensis*, (1) 547A-42,CC (max. diam. 0.37 mm), (2-3) 545-31-1, 25-27 cm (max. diam. 0.64 mm), (4) 545-29,CC (max. diam. 0.42 mm). 5-12. *Rotalipora gandolfii*, (5) 547A-44,CC (max. diam. 0.78 mm). (6-7) 545-34,CC (max. diam. 0.58 mm), (8) 545-38-1, 90-92 cm (max. diam. 0.47 mm), (9-12) 547A-53,CC (9-11, max. diam. 0.44 mm; 12, max. diam. 0.46 mm).



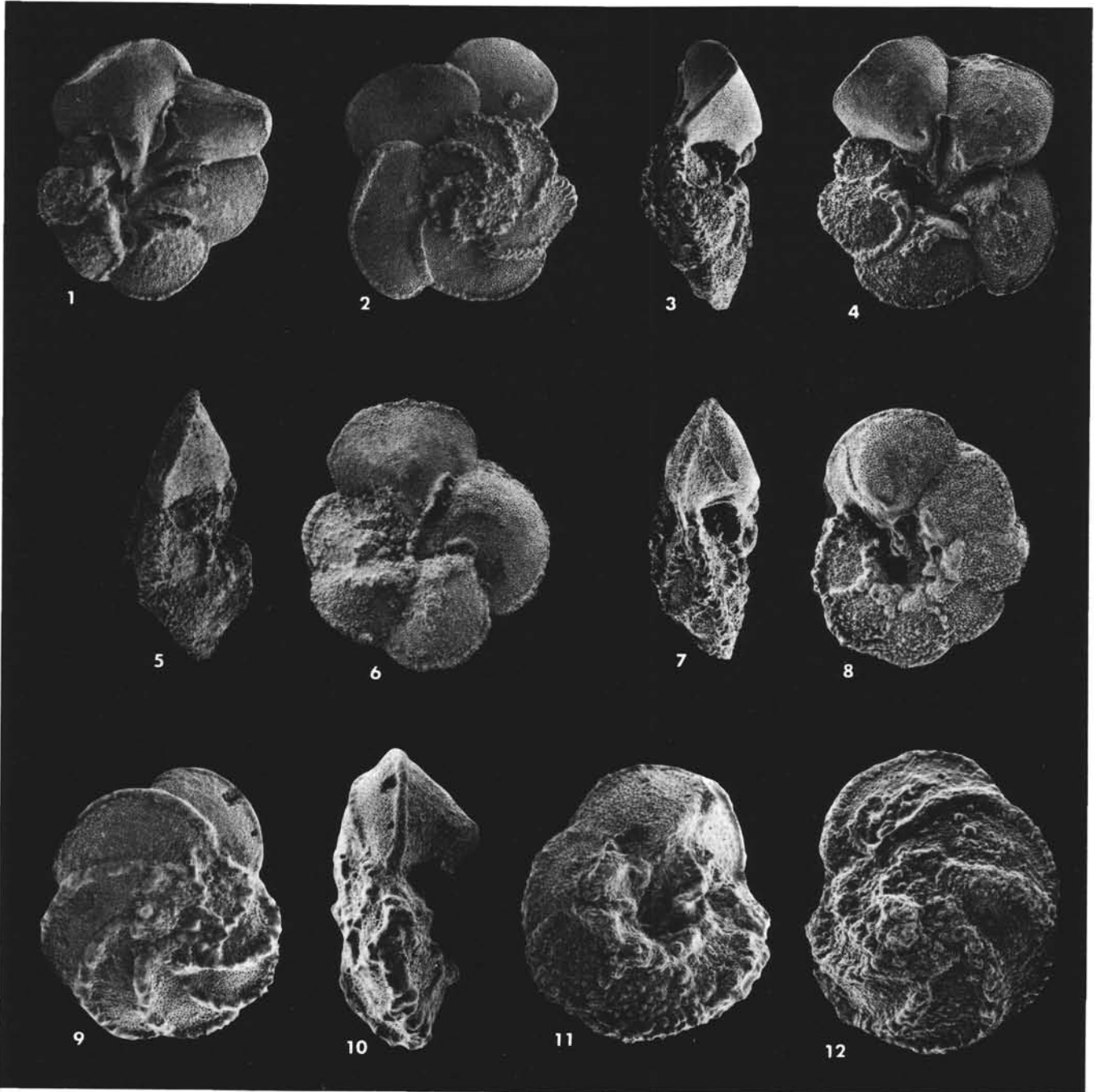


Plate 16. Early and middle Cenomanian. 1-6. *Rotalipora* aff. *cushmani*, (1-4) 547A-40,CC (1-2, max. diam. 0.77 mm; 2-4, max. diam. 0.70 mm), (5-6) 545-31-1, 25-27 cm (max. diam. 0.62 mm). 7-12. *Rotalipora* *greenhornensis*, (7-8) 545-32,CC (max. diam. 0.57 mm), (9-10) 547A-42,CC (max. diam. 0.40 mm), (11-12) 545-33,CC (max. diam. 0.42 mm).

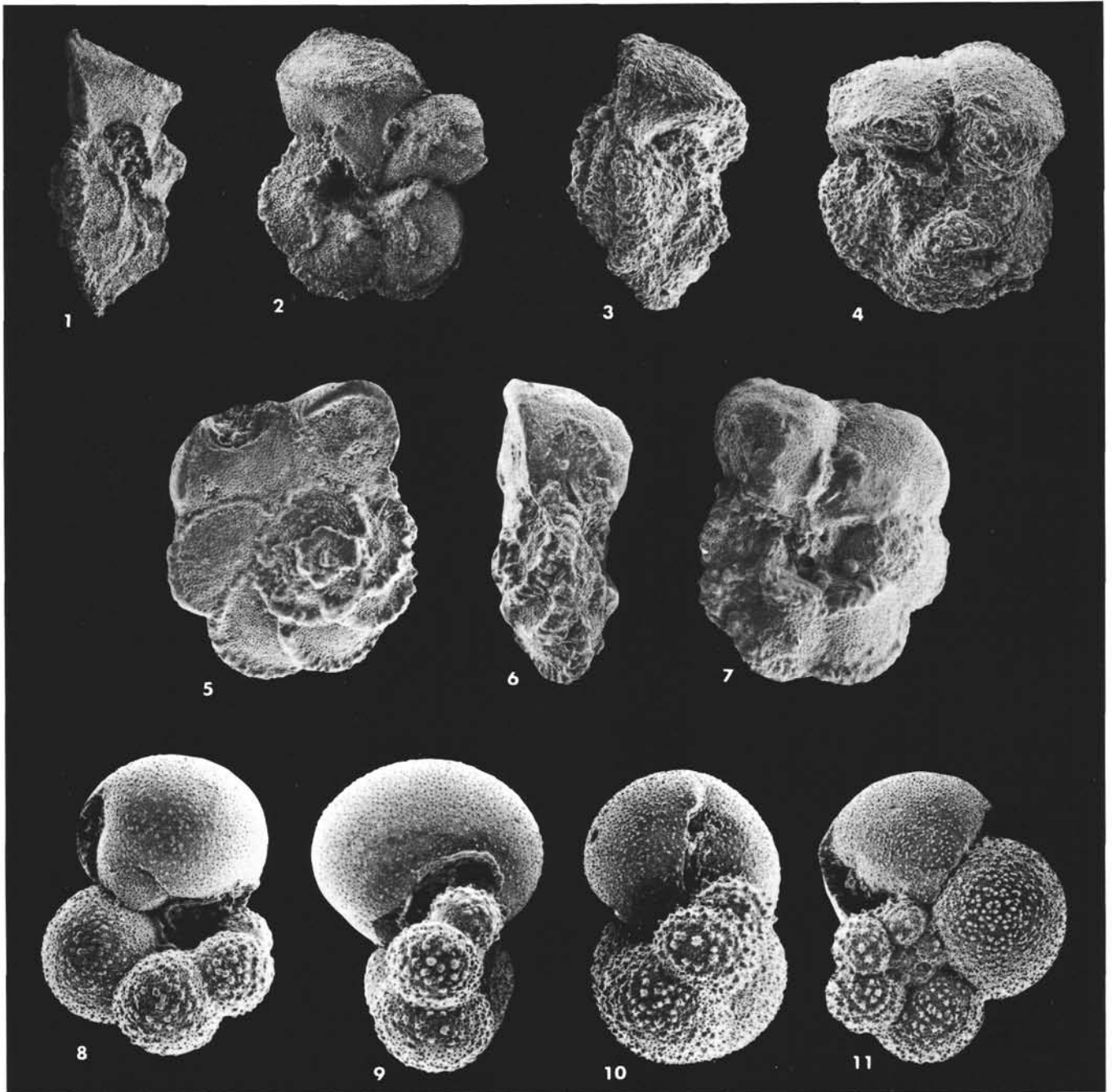


Plate 17. Early and middle Cenomanian. 1-2. *Rotalipora reicheli*, 545-28-1, 47-49 cm (max. diam. 0.70 mm). 3-7. *Rotalipora micheli*, (3-4) 545-31, CC (max. diam. 0.48 mm), (5-7) 547A-59, CC (max. diam. 0.49 mm). 8-11. *Hedbergella* sp. 2, 547A-41, CC, (8-9) max. diam. 0.39 mm, (10-11) max. diam. 0.40 mm.