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7. TITHONIAN BENTHIC FORAMINIFERS FROM HOLE 901A[1]

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ABSTRACT

Dark gray laminated silty claystones (Unit II) drilled at Site 901 contain Tithonian benthic foraminifer assemblages that indicate a neritic depositional environment and probably dysaerobic bottom-water conditions. Three benthic foraminifer zones are distinguished within Unit II. The upper part of the unit is dominated by *Spirillina polygyrata,* contains *Globospirillina* spp. (Samples 149-901A-3R-1, 10-12 cm, to 149-901A-3R-1, 75-77 cm) and is interpreted as late Tithonian. Samples 149-901A-3R-1, 87-89 cm, to 149-901A-6R-1, 74-76 cm, contain *Epistomina uhligi* and *Lingulina franconica* and are probably early Tithonian. The early Tithonian *Neobulimina atlantica* Zone is characterized by the occurrence of the zonal marker and *Epistomina uhligi* and reaches from Sample 149-901A-6R-1, 128-130 cm, to the base of the drilled-sequence. The sediments and benthic foraminiferal assemblage characteristics of the Tithonian-aged sequence in Hole 901A are unknown elsewhere in the Atlantic and may represent deposition in a marginal shelf basin with increased terrigenous and organic flux.

INTRODUCTION

Upper Jurassic sediments have been found at DSDP Sites 4,5,99, 100, 105, 111, 367, 391, 401, 416, 534, 544-547 and ODP Site 639 in the North Atlantic (Luterbacher, 1972; Kuznetsova and Seibold, 1978; Sliter, 1980; Gradstein, 1983; Riegraf and Luterbacher, 1989). A formal lithostratigraphic subdivision of Upper Jurassic sediments in the western North Atlantic was proposed by Jansa et al. (1979). These authors included Upper Jurassic sedimentation in their Cat Gap Formation, which is characterized by reddish brown and greenish gray clayey limestone interbedded with reddish calcareous claystone. Microfossil assemblages suggest a bathyal environment (Luterbacher, 1972; Oertli, 1972; Riegraf and Luterbacher, 1989) and foraminifer assemblages are often dominated by agglutinated species (Riegraf and Luterbacher, 1989).

Attempts toward a formal benthic foraminifer zonation of these sediments have been made by Moullade (1984) and Riegraf and Luterbacher (1989). The samples obtained from Hole 901A (Fig. 1) have generally low numbers of benthic foraminifers. They do not provide precise delineations of first and last occurrences, making any zonation tentative. However, finding a similar succession of taxa as Riegraf and Luterbacher (1989), we were encouraged to use their zonation scheme and herein provide a threefold subdivision of the presumably Tithonian Unit II in Hole 901 A.

Despite their rare occurrence, many of the benthic foraminifers from Hole 901A show unusually good preservation and thus a number of species, unknown from the Late Jurassic or only known from poorly preserved specimens in onshore sections, are documented in this paper.

METHODS

Samples of varying sizes (Table 1) were processed for study of benthic foraminifers. Because of the very unconsolidated nature of the sediments, the samples were only wet-sieved through a 63-um (#230 mesh) screen and the residue was dried. Foraminifer residues were examined using a binocular microscope with at least ×40 magnification. In all cases the complete residue was picked for benthic foraminifers. Data are reported only in numbers/sample because of the generally low numbers of benthic foraminifers. The total numbers of both planktonic foraminifers and ostracodes present in each sample is also reported.

Raw sediment samples were carefully examined for possible downhole contamination and carefully cleaned before processing. To further try to eliminate the possible problem of contamination, our initial results were double checked by washing additional samples. Some samples were washed at Dalhousie University, others at Kiel University to confirm that there was no laboratory contamination.

BIOSTRATIGRAPHY

Planktonic Foraminifers

Planktonic foraminifers occur only as rare elements in a few of the samples examined (Table 1). In most cases the small size and poor preservation of the specimens did not allow specific determination. However, a number of reasonably preserved individuals belong to the species *Globuligerina bathoniana* (Pazdrowa) and *Globuligerina oxfordiana* (Grigelis), both ranging from the Bajocian to the early Valanginian (Stam, 1986).

Benthic Foraminifers

The lower part (Cores 7R and 6R) of Hole 901A is characterized by the rare occurrence of *Neobulimina atlantica.* This species has been used in the zonation of Riegraf and Luterbacher (1989) as an index species of the late Kimmeridgian to early Tithonian *N. atlantica* zone. This zone roughly corresponds to the *Epistomina uhligi* zone of Moullade (1984). We observed the marker species of this zone in Core 7R-1, 30-32 cm, and in various samples of Core 5R. The last occurrence of typical individuals of *Epistomina uhligi* is observed in Core 3R-1, 87-89 cm. A third biostratigraphic marker, used for defining Kimmeridgian to early Turonian sediments, is *Lingulina franconica,* which was observed in two samples from Core 5R (5R-1, 142-144 cm, and 5R-2, 4-6 cm). Together these markers suggest a late Kimmeridgian to early Tithonian age for the lower part of Hole 901A (Cores 7R to the base of Core 3R). No characteristic marker

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species are observed in our samples from Core 3R-1, 75-77 cm, to 3R-1, 10-12 cm. However, the assemblage composition (dominance of *Spirillina polygyrata, Trocholina,* and *Nodobacularia*) is almost identical to Cores 5R to 7R. Moullade (1984) defines a late Tithonian to Berriasian *Globospirillina neocomiana* zone, which is defined by the first occurrence of the marker species and the last appearance of *Epistomina uhligi.* We found in samples from Cores 5R and 3R some poorly preserved specimens of spirillinids with a covered umbilical area, which may represent early forms of *Globospirillina,* but the poor preservation and small size of these specimens did not allow unquestionable identification. In Table 1 these forms are included in *Spirillina* spp. Late Tithonian age is most probable for this core (Fig. 2). A Tithonian age for these sediments is supported by the calcareous nannofossil results (de Kaenel and Bergen, this volume).

PALEOECOLOGY

The Tithonian sedimentary facies of Hole 901A is unknown elsewhere in the North Atlantic. Pre-rift sediments drilled on the Galicia Margin during Leg 103 consist of Tithonian and basal Cretaceous shallow-water limestones and dolomites (Boillot, Winterer, Meyer, et al., 1987). In the western North Atlantic, the equivalent formation of the same age (Cat Gap Formation; Jansa et al., 1979) is composed of reddish and greenish gray claystones with calcareous turbidites. The black laminated, silty claystones of Hole 901A contain a distinct but rather uniform benthic foraminifer assemblage, which is different from Tithonian assemblages of the North Atlantic Cat Gap Formation. The dominating species are *Spirillina polygyrata, Spirillina* spp., *Trocholina* spp., nodosariids, lenticulinids, and miliolids (e.g., *Ophthalmidium* and *Nodobacularia*). These forms are characteristic of Late Jurassic and Early Cretaceous Tethyan neritic and upper bathyal assemblages (Riegraf and Luterbacher, 1989). Their occurrence in deep water (lower bathyal to abyssal) assemblages of DSDP sites, (i.e., Site 534; Gradstein, 1983) has been interpreted as an effect of redeposition of shallow-water material (Riegraf and Luterbacher, 1989). A notable feature of the Tithonian benthic foraminifer assemblages from Hole 901A is the absence of deep-water agglutinated foraminifers such as *Hippocrepina, Kalamopsis, Thurammina, Reophax, Ammobaculites* and *Trochammina.*

The benthic foraminifer fauna of Hole 901A includes a number of morphotypes that are comparable to Cretaceous and modern infaunal species which characterize areas of increased organic matter flux to the sea floor. Kaiho (1994) lists the general features of dysoxic benthic foraminifer indicators in the modern ocean. The characteristics of a dysoxic benthic foraminifer assemblage include specimens with small size, a thin wall, flat or elongate-tapered morphotypes, and high-porosity tests (Kaiho, 1994). Generally, the Tithonian fauna identified here fit these criteria. The occurrence of bolivinids and neobuliminids is typical for environments with increased organic flux, and lenticulinids have also been reported from organic-rich, low-oxygen environments (Bernhard, 1986; Kaiho, 1994). Although this is the first report of bolivinids in Late Jurassic sediments, we feel this is not a result of contamination (see methods). The black sediment color and presence of plant debris also indicate low oxygen levels. The peculiar composition of the benthic assemblages is in good agreement with the sedimentary facies of black laminated claystones, indicating a dysaerobic, organic matter-rich sedimentary environment.

The Hole 901A benthic foraminifer assemblages thus most probably represent authochthonous neritic faunas of a dysaerobic (oxygen minimum zone?) environment. Oxygen-related morphogroup patterns of benthic foraminifers have been successfully applied to other Jurassic deposits (Tyszka, 1993). The location of Site 901 is at the edge of a tilted fault block, probably close to the Late Jurassic shelf margin. Similar sediments at the edge of tilted fault blocks may have been the source for redeposited shallow-water faunas in other North Atlantic abyssal sites.

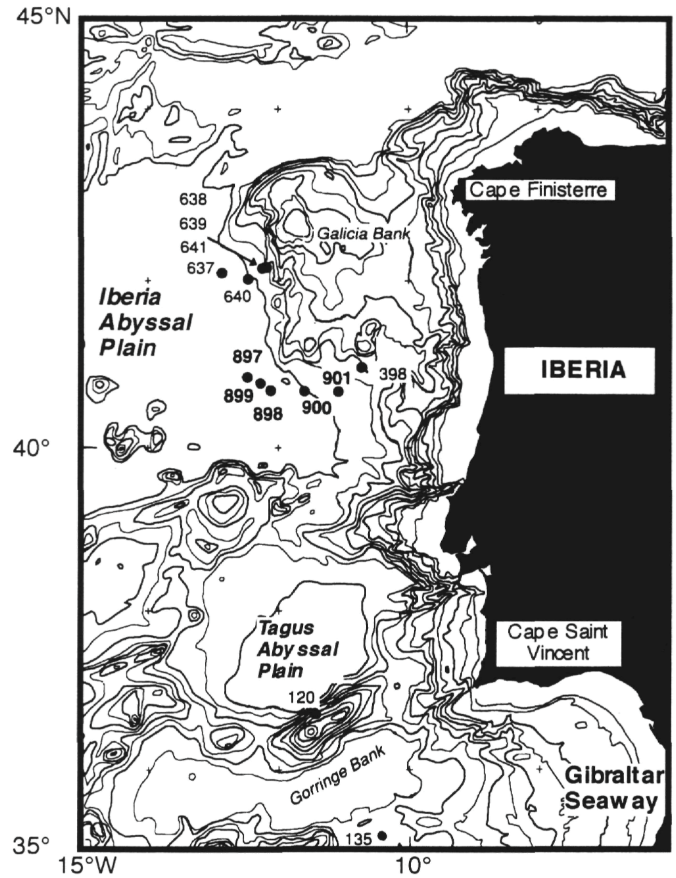

Figure 1. Location of Site 901, other sites drilled during Leg 149, and nearby previously drilled DSDP and ODP Holes.

CONCLUSIONS

Site 901 represents a unique possibility for the study of a diagenetically little-altered Tithonian neritic benthic foraminifer assemblage. This assemblage lacks bathyal-abyssal agglutinated foraminifers, which are a common component of other Tithonian deposits of the Cat Gap Formation (e.g., Gradstein, 1983).

The unconsolidated black shales may represent deposition in a Tithonian oxygen minimum zone off the Iberian margin. Infaunal morphotypes of calcareous benthic foraminifers that are characteristic of modern marginal shelf basins with high organic carbon flux rates and dysaerobic bottom-water conditions (such as *Bolivina*) are, to our knowledge, observed for the first time in Upper Jurassic sediments in the Atlantic.

HOLE 901A SPECIES REFERENCE LIST

Tithonian Benthic Foraminifers

Bolivina aff. *liasica* (Terquem, 1858)
(Plate 3, Figs. 13, 14)

aff. *Textularia liasica* Terquem, 1858, p. 634, pl. 4, figs. 12a, b.
aff. *Textularia metensis* Terquem, 1858, p. 635, pl. 4, figs. 13a, b.
aff. *Bolivina liasica* (Terquem) Norling, 1968, p. 11-13, pl. 9, text-figs. 2-3.

According to Loeblich and Tappan (1988) the genus *Bolivina* first appears in the Maastrichtian. However, *Bolivina liasica* (Terquem) from the Liassic of central Europe probably belongs to the same genus (Norling, 1968). We checked specimens of *B. liasica* from the Pliensbachian of northern Germany (well Zielen Zl, 1600 m), which morphologically resemble our specimens

Table 1. Absolute counts of benthic and planktonic foraminifers in samples from Hole 901A.

149-901A- Core, section, interval (cm): Sample volume:	3R-1, 10–12 7 cm³	3R-1, 20–22 7cm³	3R-1, 40–42 10 cm³	3R-1, 60–62 8 cm³	3R-1, 75–77 10 cm³	3R-1, 87–89 8 cm³	5R-1, 50–52 7 cm³	5R-1, 73–75 10 cm³	5R-1, 99–101 8 cm³	5R-1, 125–127 8 cm³	5R-1, 139–141 8 cm³	5R-1, 142–144 8 cm³	5R-1, 144–148 20 cm³
Bolivina aff. *liasica*												2	1
Dentalina debilis							1						
Dentalina seorsa (fragments)	1	1											
Dentalina-Marginulina group		3	5	1			1			4		3	8
Eoguttulina aff. *liassica*			1										
Epistomina spp.	1	3	1	1								4	
Epistomina uhligi						1	2	8		1	1		18
Frondicularia spp.		2											
Glomospira charoides													
Glomospira irregularis											1		
Glomospira variabilis	1	1	4	1				2	2	3	3	1	9
Lagena ex gr. *hauteriviana*					1	1			1			4	1
Lagena ex gr. *ovata*										2	1		
Lagena ex gr. *sulcata*	1							1					
Lenticulina muensteri													
Lenticulina quenstedti		1		1									
Lenticulina sp. A	1	3						3			1	2	1
Lingulina franconica												1	1
Marginulinopsis phragmites					2								
Neobulimina atlantica													
Nodobacularia bulbifera		16	9		1			3		1	1	5	14
Nodosaria raphanistriformis		2								1		1	
Ophthalmidium oxfordianum		7	2					2		4	4	3	15
Ophthalmidium rotula		2	3					1				1	8
Paleogaudryina magharaensis												1	
Planularia sp. A								1					
Saracenaria spp.		9	5		1			1		3		1	10
Spirillina polygyrata	5	44	28	5	10	1	12		19	73	29	35	99
Trocholina (?) spp.		13	3	1	1		3	2		7	2	11	35
Vaginulina cf. *jurassica*		1	1									1	
Vaginulina manubrium	1		1	1				1					1
Planktic foraminifers					8	2			2		3	31	2
Ostracodes		6	18					1	4	11		5	17
	Spirillina polygyrata					*Epistomina uhligi* and *Lingulina franconica*							
	late Tithonian					middle-early Tithonian							

149-901A- Core, section, interval (cm): Sample volume:	5R-2, 4–6 10 cm³	5R-2, 4–8 20 cm³	5R-2, 15–17 7 cm³	5R-CC 10 cm³	6R-1, 8–10 8 cm³	6R-1, 8–12 20 cm³	6R-1, 25–27 8 cm³	6R-1, 74–76 10 cm³	6R-1, 98–100 9 cm³	6R-1, 128–130 10 cm³	7R-1, 16–18 8 cm³	7R-1, 30–32 10 cm³	7R-1, 37–39 10 cm³
Bolivina aff. *liasica*	2	1			1	1							
Dentalina debilis													
Dentalina seorsa (fragments)												4	
Dentalina-Marginulina group	2	3				4							2
Eoguttulina aff. *liassica*		2				1							
Epistomina spp.	4				1							2	
Epistomina uhligi		4		1		1						7	
Frondicularia spp.													
Glomospira charoides	1							1				2	
Glomospira irregularis													1
Glomospira variabilis	1	9	1		2	11						5	
Lagena ex gr. *hauteriviana*								1		1		2	
Lagena ex gr. *ovata*													
Lagena ex gr. *sulcata*						4							
Lenticulina muensteri										1			
Lenticulina quenstedti	1		1				1						
Lenticulina sp. A	3	1		1				1	4	1		11	1
Lingulina franconica	1	2				2							
Marginulinopsis phragmites						1							
Neobulimina atlantica									2	1		1	
Nodobacularia bulbifera	4	20		1		1				3			
Nodosaria raphanistriformis					1	1						2	
Ophthalmidium oxfordianum	3	23				8							
Ophthalmidium rotula		3										1	
Paleogaudryina magharaensis	1	2				2				2			
Planularia sp. A													
Saracenaria spp.	2	5				12				3		1	
Spirillina polygyrata	13	54	10	4	10	86	1	2	1	21	3	19	
Trocholina (?) spp.	5	18	2	1		10				5	1	2	
Vaginulina cf. *jurassica*				1						1			
Vaginulina manubrium												1	
Planktic foraminifers	1				7	4					1	3	
Ostracodes	4	4		1									
	Epistomina uhligi and *Lingulina franconica* (continued).								*Neobulimina atlantica*				
	middle-early Tithonian (continued).								early Tithonian				

from Hole 901 A. The only difference is the absence of pores in the Liassic specimens, which may be an effect of diagenetic alteration. However, Terquem in his original drawing of *B. liasica* indicated pores on his specimens and thus the evolutionary history of the genus *Bolivina* may extend back to the Early Jurassic.

Dentalina debilis (Berthelin, 1880)
(Plate 2, Fig. 5)

Marginulina debilis Berthelin, 1880, p. 35, pl. 26, fig. 28.
Dentalina debilis (Berthelin). Riegraf and Luterbacher, 1989, p. 1029, pl. 3, figs. 9-15.

Dentalina seorsa Schwager, 1865
(Plate 2, Fig. 7)

Dentalina seorsa Schwager, 1865, p. 95, 102, pl. 2, fig. 23, pl. 3, fig. 4.
Dentalina seorsa Schwager. Luterbacher, 1972, pl. 2, fig. 33.

Dentalina-Marginulina group
(Plate 2, Figs. 1-4)

We include all elongated morphotypes of the genera *Dentalina* and *Marginulina* with a very small initial spiral part in this group.

Eoguttulina aff. *liassica* (Strickland, 1846)
(Plate 3, Fig. 15)

aff. *Polymorphina liassica* Strickland, 1846, p. 31, fig. b.
aff. *Eoguttulina liassica* (Strickland). Groiss, 1967, p. 49, pl. 4, fig. 179 (with synonymy).

Epistomina spp.
(Plate 3, Fig. 9)

Small trochospiral forms that were recrystallized and specific determination was impossible.

Epistomina uhligi Mjatliuk, 1953
(Plate 3, Figs. 8, 10-12)

Epistomina uhligi Mjatliuk, 1953, p. 219, pl. 2, figs. 5a, b.
Brotzenia sp. aff. *B. uhligi* (Mjatliuk). Luterbacher, 1972, pl. 4, figs. 14-16.
Epistomina aff. *E. uhligi* Mjatliuk. Gradstein, 1983, p. 554, pl. 4, figs. 1-5.
Epistomina uhligi Mjatliuk. Riegraf and Luterbacher, 1989, p. 1037, pl. 4, figs. 24-26.

Frondicularia spp.
(Plate 2, Fig. 11)

Two fragments of *Frondicularia* spp. were found in Sample 901A-3R-1, 20-22 cm.

Glomospira charoides (Jones and Parker, 1860)

Trochammina squamata Jones and Parker var. *charoides* Jones and Parker, 1860, p. 304.

Glomospira irregularis (Grzybowski, 1898)

Ammodiscus irregularis Grzybowski, 1898, p. 285, pl. 11, figs. 2-3.
Glomospira irregularis (Grzybowski). Riegraf and Luterbacher, 1989, p. 1019, pl. l, fig. 11.

Glomospira variabilis (Kübler and Zwingli, 1870)
(Plate l, Figs. 4, 5)

Cornuspira variabilis Kübler and Zwingli, 1870, p. 33, pl. 4, fig. 4b.
Glomospira variabilis (Kübler and Zwingli). Luterbacher, 1972, pl. 1, figs. 4-6.

Glomospira sp. Luterbacher, 1972, pl. 2, fig. 7.
Glomospira variabilis (Kübler and Zwingli). Riegraf and Luterbacher, 1989, p. 1019, pl. l, fig. 10.

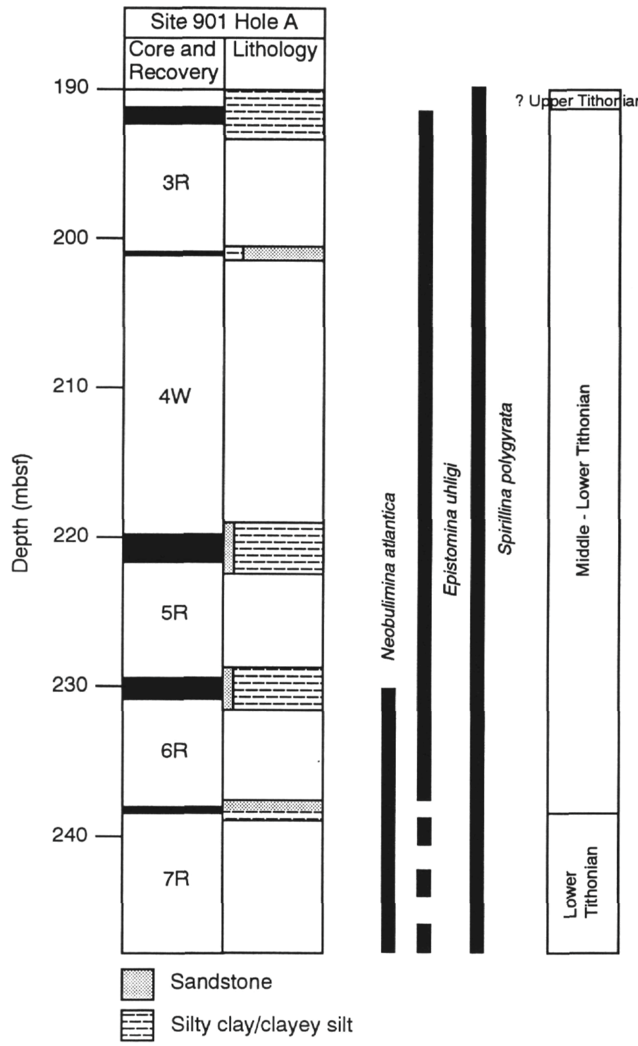

Figure 2. Core recovery and lithology for Hole 901 A. Because of the low core recovery, the lithology is not continuous. Ranges of biostratigraphic marker species are also shown.

Our specimens are characterized by thin, smooth, glassy walls and a mode of coiling which strongly resembles *Glomospira serpens* (Grzybowski). A similar specimen is figured by Riegraf and Luterbacher (1989) on pl. 1, fig. 10.

Lagena ex gr. *hauteriviana* Bartenstein and Brand, 1951

Lagena hauteriviana Bartenstein and Brand, 1951, p. 317, pl. 10, figs. 277, 278.
ex gr. *Lagena hauteriviana hauteriviana* Bartenstein and Brand. Sliter, 1980, pl. 8, figs. 1,2.

We include all small smooth lagenids in this group.

Lagena ex gr. *ovata* (Terquem, 1858)

Oolina ovata Terquem, 1858, p. 586, pl. 1, figs. 2a-c.
ex gr. *Lagena laevis* (Montagu). Sliter, 1980, pl. 8, figs. 3, 4.
ex gr. *Lagena* sp. cf. *L. meridionalis* Wiesner. Sliter, 1980, pl. 8, fig. 5.
ex gr. *Lagena ovata* (Terquem). Sliter, 1980, pl. 8, fig. 6.

Lagena ex gr. *sulcata* (Walker and Jacob, 1798)
(Plate 2, Fig. 6)

Serpula (Lagena) sulcata Walker and Jacob, 1798, p. 634.
Lagena sulcata (Walker and Jacob). Sliter, 1980, pl. 8, figs. 8-10.

We lump all striate, unichambered lagenids in this group.

Lenticulina muensteri Roemer, 1839
(Plate 2, Fig. 12)

Lenticulina muensteri Roemer, 1839, p. 48, pl. 20, fig. 29.
Lenticulina muensteri Roemer. Luterbacher, 1972, pl. 3, figs. 11, 12.

Lenticulina quenstedti (Gümbel, 1862)
(Plate 2, Figs. 15, 16)

Cristellaria quenstedti Gümbel, 1862, p. 226, pl. 4, figs. 2a, b.
Lenticulina quenstedti (Gümbel). Luterbacher, 1972, pl. 3, figs. 1, 2.
Lenticulina sp. ex gr. *L. quenstedti* (Gümbel); close to "*Cristellaria osnaburgensis*" in Brückmann 1904. Luterbacher, 1972, pl. 3, figs. 3-6.
Lenticulina quenstedti (Gümbel). Riegraf and Luterbacher, 1989, p. 1032, pl. 3, figs. 29-35.

Lenticulina sp. A
(Plate 2, Figs. 13, 14)

Small, smooth lenticulinids that have not been specifically determined.

Lingulina franconica (Gümbel, 1862)
(Plate 2, Fig. 9)

Frondicularia franconica Gümbel, 1862, p. 219, pl. 3, figs. 13a-c.
Lingulina franconica Gümbel. Seibold and Seibold, 1955, p. 119, pl. 13, fig. 8, text-fig. 3e.
Lingulina franconica Gümbel. Riegraf and Luterbacher, 1989, p. 1029, pl. 3, figs. 16-20.

Marginulinopsis phragmites Loeblich and Tappan, 1950
(Plate 3, Figs. 6, 7)

Marginulinopsis phragmites Loeblich and Tappan, 1950, p. 9, pl. 1, figs. 22, 23, text-fig. 1.
Marginulinopsis phragmites Loeblich and Tappan. Riegraf and Luterbacher, 1989, p. 1033, pl. 4, fig. 10.

Neobulimina atlantica Gradstein, 1983
(Plate 3, Figs. 16-18)

Neobulimina atlantica Gradstein, 1983, p. 554, pl. 3, figs. 1-12.
Neobulimina atlantica Gradstein. Riegraf and Luterbacher, 1989, pl. 4, figs. 27-35.

Nodobacularia bulbifera Paalzow, 1932
(Plate 1, Figs. 12, 13)

Nodobacularia bulbifera Paalzow, 1932, p. 96, pl. 5, figs. 4-6.
Nodobacularia bulbifera Paalzow. Riegraf and Luterbacher, 1989, p. 1027, pl. 2, figs. 22-24.

Nodosaria raphanistriformis (Gümbel, 1862)
(Plate 2, Fig. 8)

Dentalina raphanistriformis Gümbel, 1862, p. 219, pl. 3, figs. 12a, b.
Nodosaria raphanistriformis (Gümbel). Seibold and Seibold, 1955, p. 117, fig. 5a.
Nodosaria raphanistriformis (Gümbel). Luterbacher, 1972, pl. 2, fig. 29.
Nodosaria raphanistriformis (Gümbel). Riegraf and Luterbacher, 1989, p. 1028, pl. 3, fig. 3.

Ophthalmidium oxfordianum (Deecke, 1886)
(Plate l, Figs. 14-16)

Trocholina oxfordiana Deecke, 1886, pl. 1, figs. 32, 32a.
Ophthalmidium milioliniformis (Paalzow). Luterbacher, 1972, pl. 2, figs. 11, 12.
Ophthalmidium milioliniformis (Paalzow). Gradstein, 1983, pl. 4, figs. 11-13.
Ophthalmidium oxfordianum (Deecke). Riegraf and Luterbacher, 1989, p. 1027, pl, 2, figs. 25-27.

Ophthalmidium rotula Lalicker, 1950
(Plate l, Figs. 17-20)

Ophthalmidium rotula Lalicker, 1950, p. 11, pl. 1, figs. 3a, b.
Ophthalmidium carinatum Kübler and Zwingli. Luterbacher, 1972, pl. 2, figs. 18, 19.
Ophthalmidium sp. cf. *O. carinatum* Kübler and Zwingli. Sliter, 1980, pl. 5, figs. 10, 12.
Ophthalmidium rotula Lalicker.- Riegraf and Luterbacher, 1989, p. 1027, pl. 2, figs. 28-33.

Paleogaudryina magharaensis Said and Barakat, 1958
(Plate 1, Fig. 10)

Paleogaudryina magharaensis Said and Barakat, 1958, p. 243, pl. 3, fig. 42, pl. 4, figs. 33, 36.
Paleogaudryina magharaensis Said and Barakat. Riegraf and Luterbacher, 1989, p. 1026, pl. 2, figs. 9-11.

Planularia sp. A

A single specimen in Sample 901A-5R-1, 73-75 cm.

Saracenaria spp.
(Plate 2, Figs. 18-21; Plate 3, Figs. 2-4)

We observed a broad variability in the intensity of the carinate margins. Only a morphometric study based on more than a few specimens could show whether this is intraspecific variability or if several species are present. At the present stage we did not attempt to determine these forms specifically.

Spirillina polygyrata Gümbel, 1862
(Plate 1, Figs. 1-3)

Spirillina polygyrata Gümbel, 1862, p. 214, pl. 4, figs, lla-c.
Spirillina elongata Bielecka and Pozaryski, 1954, p. 67, pl. 10, figs. 53a, b.
Spirillina polygyrata Gümbel. Seibold and Seibold, 1955, p. 124-125, text-figs. 5f-h.
Spirillina tenuissima Gümbel. Seibold and Seibold, 1955, p. 125-126, text-fig. 5n.
Spirillina elongata Bielecka and Pozaryski. Sliter, 1980, pl. 15, figs. 1, 2.
Spirillina minima Schacko. Sliter, 1980, p. 15, figs. 3, 4.
Spirillina polygyrata Gümbel. Riegraf and Luterbacher, 1989, p. 1028, pl. 2, figs. 36-38, pl. 3, figs. 1-2.

Spirillina polygyrata is the most common species in our material from Hole 901 A.

Trocholina? spp.
(Plate 1, Figs. 6-9)

? *Rotalia turbinella* Gümbel, 1862; p. 230, pl. 4, figs. l0a, b.
?*Paalzowella turbinella* Gümbel. Seibold and Seibold, 1955, p. 126, pl. 13, fig. 12, text-figs. 5i-m.
?*Paalzowella turbinella* Gümbel. Riegraf and Luterbacher, 1989, p. 1026, pl. 2, fig. 21.

We lumped all calcareous, trochospiral forms in this group, as the small size and preservation of the specimens made a decision on the internal structure almost impossible. Thus, this group may include representatives of the genera *Paalzowella, Patellinella,* or *Trocholina.* Some of our specimens are morphologically very close to *Paalzowella turbinella.*

Vaginulina cf. *jurassica* (Gümbel, 1862)
(Plate 3, Fig. 5)

cf. *Marginulina jurassica* Gümbel, 1862, p. 222, pl. 3, figs. 21a, b.
cf. *Vaginulina jurassica* (Gümbel). Seibold and Seibold, 1955, p. 120, figs. 5d, e, pl. 13, fig. 15.

Vaginulina cf. *manubrium* (Schwager, 1865)
(Plate 2, Fig. 17; Plate 3, Fig. 1)

Cristellaria manubrium Schwager, 1865, p. 121, pl. 5, fig. 6.

Vaginulina manubrium (Schwager). Riegraf and Luterbacher, 1989, p. 1036, pl. 4, figs. 11,12.

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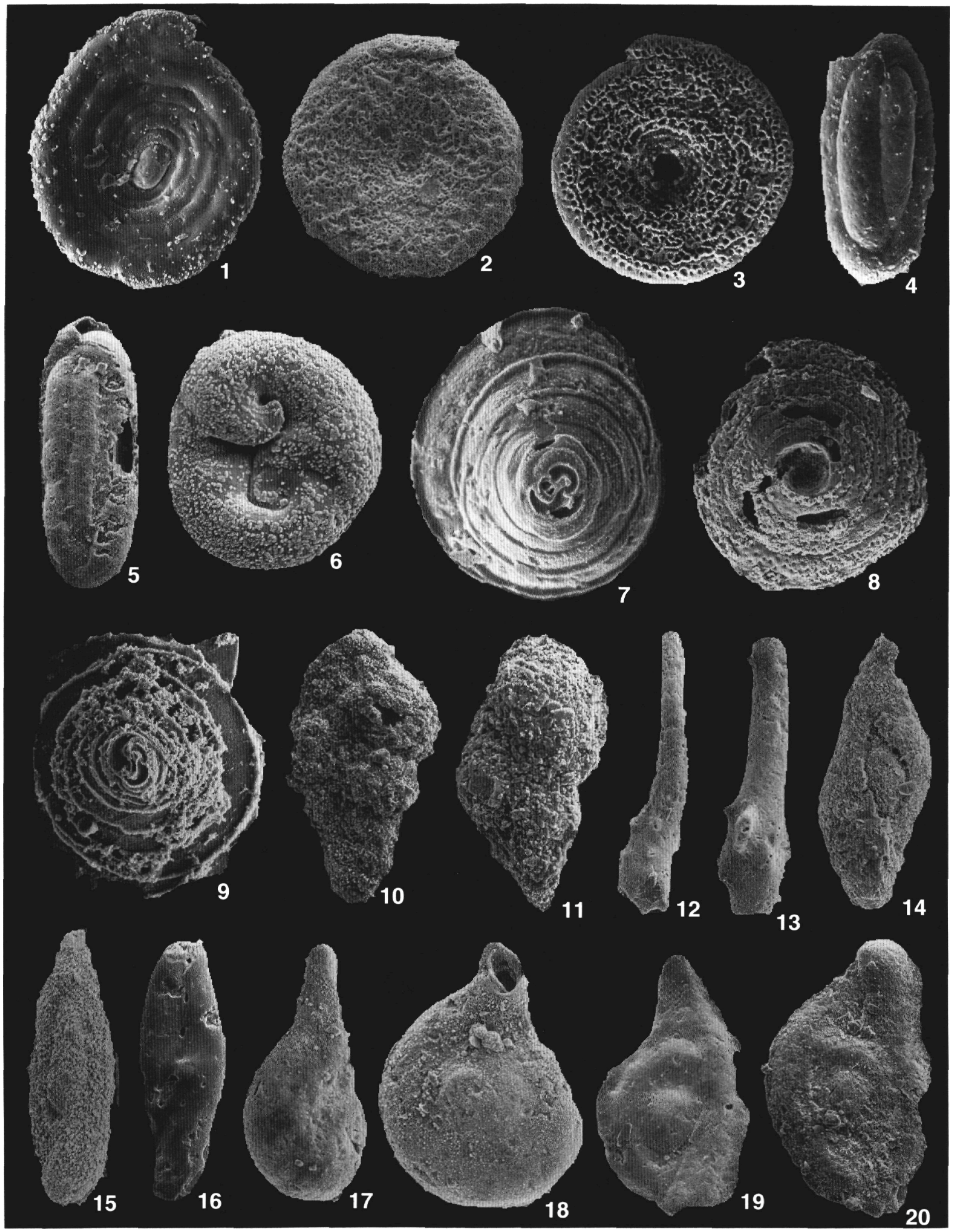

Plate 1. **1.** *Spirillina polygyrata* ×228 (Sample 901A-3R-1, 10-12 cm). **2.** *Spirillina polygyrata* ×165 (Sample 901A-3R-1, 40-42 cm). **3.** *Spirillina polygyrata* ×210 (Sample 901A-3R-1, 20-22 cm). **4.** *Glomospira variabilis* ×184 (Sample 901A-3R-1, 10-12 cm). **5.** *Glomospira variabilis* ×147 (Sample 901A-5R-1, 142-144 cm). **6.** *Trocholina* spp. ×233 Sample (901A-5R-1, 142-144 cm). **7.** *Trocholina* spp. ×287 (Sample 901A-5R-1, 142-144 cm). **8.** *Trocholina* spp. ×229 (Sample 901A-3R-1, 20-22 cm). **9.** *Trocholina* spp. ×257 (Sample 901A-3R-1, 20-22 cm). **10.** *Paleogaudryina magharaensis* ×144 (Sample 901A-6R-1, 128-130 cm). **11.** *Paleogaudryina*? ×209 (Sample 901A-5R-1, 142-144 cm). **12.** *Nodobacularia bulbifera* ×123 (Sample 901A-5R-1, 142-144 cm). **13.** *Atodobacularia bulbifera* ×123 (Sample 901A-5R-1, 142-144 cm). **14.** *Ophthalmidium oxfordianum* ×175 (Sample 901A-3R-1, 40-42 cm). **15.** *Ophthalmidium oxfordianum* ×142 (Sample 901A-3R-1, 40-42 cm). **16.** *Ophthalmidium oxfordianum* ×139 (Sample 901A-3R-1, 20-22 cm). **17.** *Ophthalmidium rotula* ×178 (Sample 901A-3R-1, 40-42 cm). **18.** *Ophthalmidium rotula* ×206 (Sample 901A-3R-1, 40-42 cm). **19.** *Ophthalmidium rotula* ×142 (Sample 901A-5R-1, 142-144 cm). **20.** *Ophthalmidium rotula* ×142 (Sample 901A-3R-1, 40-42 cm).

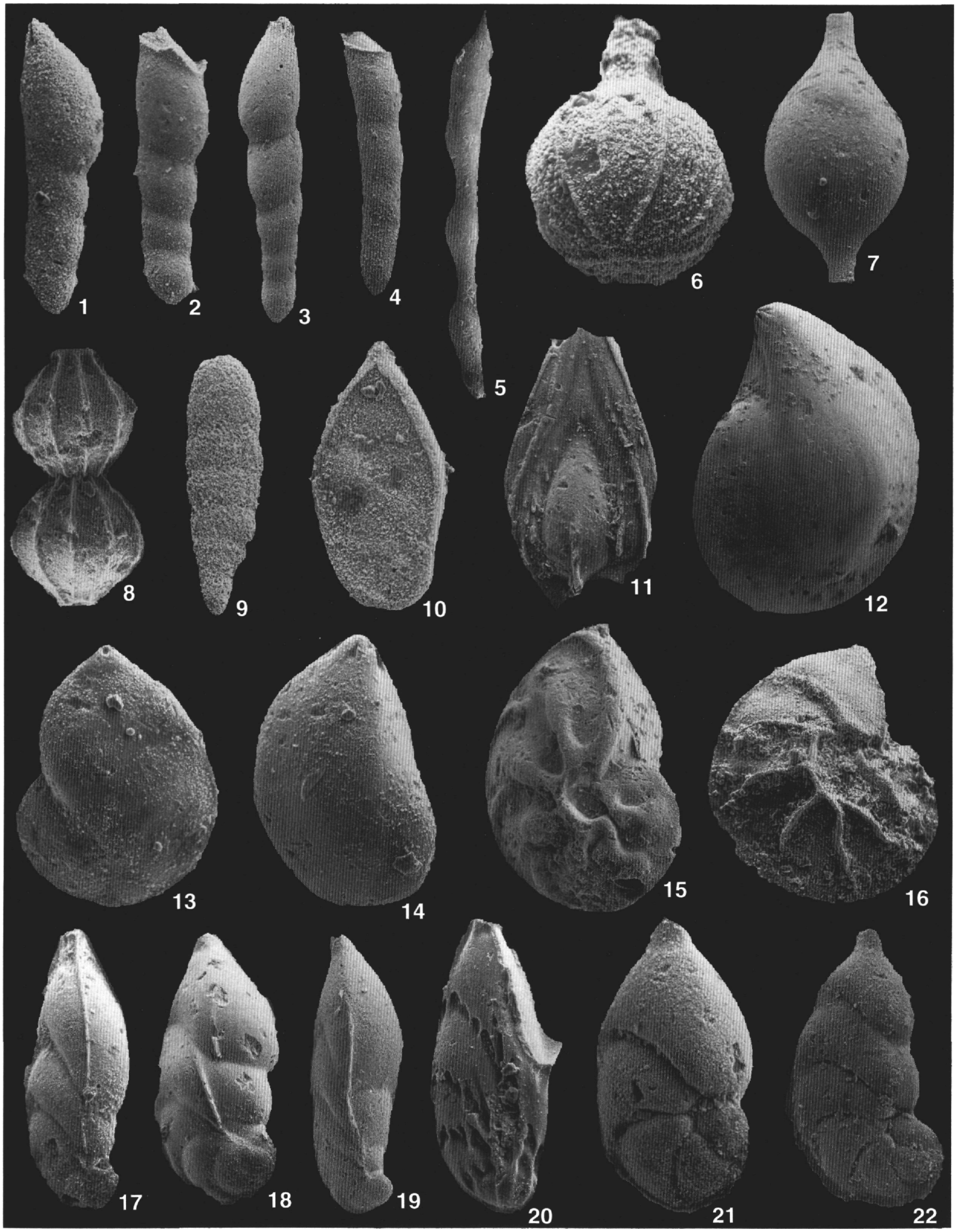

Plate 2. **1.** *Dentalina-Marginulina* group ×159 (Sample 901A-3R-1, 40-42 cm). **2.** *Dentalina-Marginulina* group ×142 (Sample 901A-3R-1, 40-42 cm). **3.** *Dentalina-Marginulina* group ×88 (Sample 901A-3R-1, 40-42 cm). **4.** *Dentalina-Marginulina* group ×I10 (Sample 901A-3R-1, 20-22 cm). **5.** *Dentalina debilis* ×127 (Sample 901A-5R-1, 142-144 cm). **6.** *Lagena* ex gr. *sulcata* ×268 (Sample 901A-3R-1, 10-12 cm). **7.** *Dentalina seorsa* (fragment) ×151 (Sample 901A-3R-1, 20-22 cm). **8.** *Nodosaria raphanistriformis* ×128 (Sample 901A-3R-1, 20-22 cm). **9.** *Lingulina franconica* ×127 (Sample 901A-5R-1, 142-144 cm). **10.** *Vaginulina* spp. ×148 (Sample 901A-6R-1, 128-130 cm). **11.** *Frondicularia* spp. ×134 (Sample 901A-3R-1, 20-22 cm). **12.** *Lenticulina muensteri* ×38 (Sample 901A-6R-1, 128-130 cm). **13.** *Lenticulina* sp. A ×189 (Sample 901A-3R-1, 20-22 cm). **14.** *Lenticulina* sp. A ×148 (Sample 901A-3R-1, 20-22 cm). **15.** *Lenticulina quenstedti* ×105 (Sample 901A-6R-1, 128-130 cm). **16.** *Lenticulina quenstedti* ×l00 (Sample 901A-3R-1, 60-62 cm). **17.** *Vaginulina manubrium* ×I56 (Sample 901A-3R-1, 10-12 cm). **18.** *Saracenaria* spp. ×128 (Sample 901A-3R-1, 20-22 cm). **19.** *Saracenaria* spp. ×128 (Sample 901A-3R-1,40-42 cm). **20.** *Saracenaria* spp. ×172 (Sample 901A-3R-1, 20-22 cm). **21.** *Saracenaria* spp. ×249 (Sample 901A-3R-1, 40-42 cm). **22.** *Vaginulina* cf. *jurassica* ×158 (Sample 901A-6R-1, 128-130 cm).

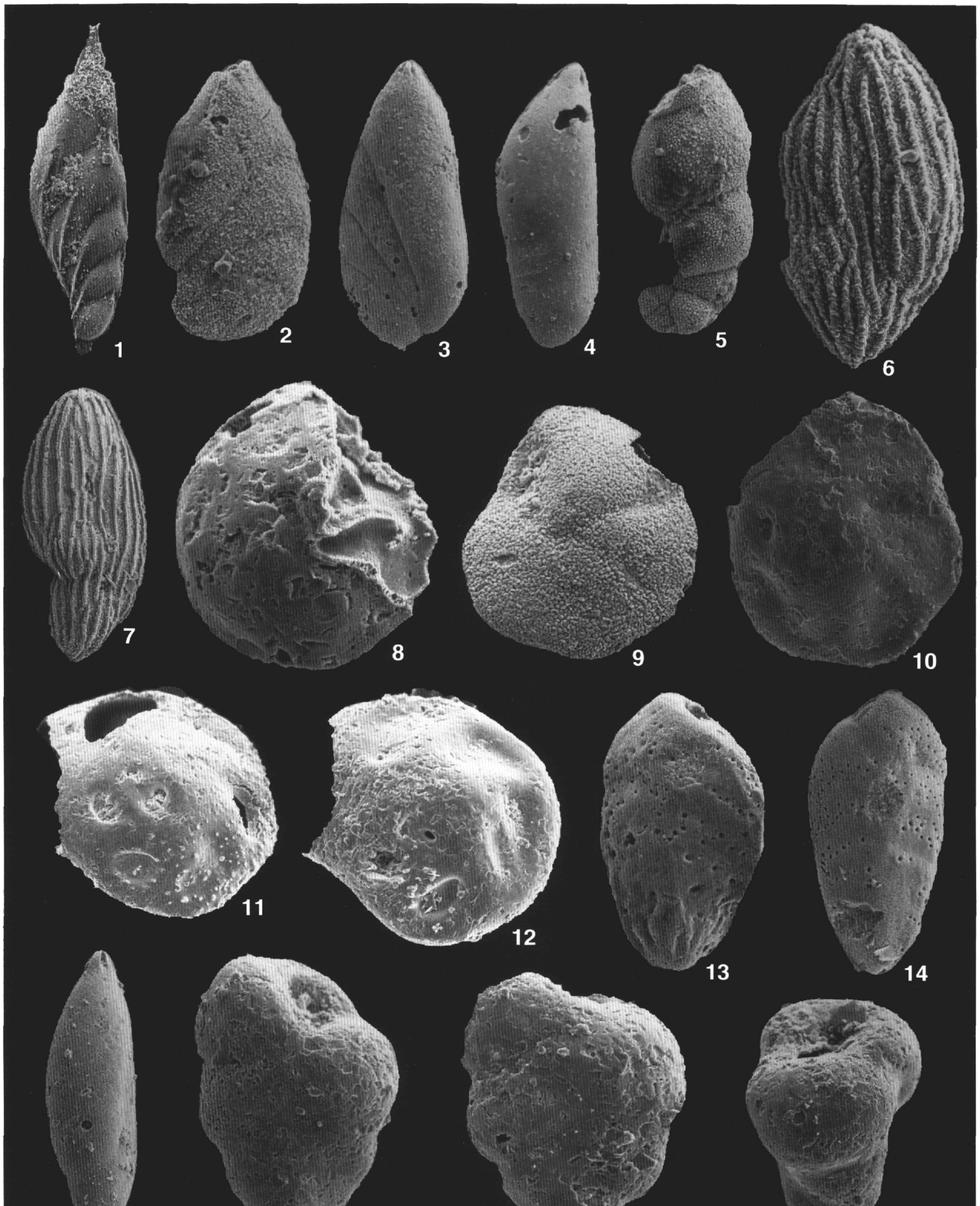

Plate 3. **1.** *Vaginulina manubrium* ×137 (Sample 901A-3R-1, 40-42 cm). **2.** *Saracenaria* spp. ×216 (Sample 901A-6R-1, 128-130 cm). **3.** *Saracenaria* spp. ×127 (Sample 901A-3R-1, 20-22 cm). **4.** *Saracenaria* spp. ×103 (Sample 901A-3R-1, 20-22 cm). **5.** *Vaginulina* cf. *jurassica* ×168 (Sample 901A-3R-1, 40-42 cm). **6.** *Marginulopsis phragmites* ×325 (Sample 901A-3R-1, 75-77 cm). **7.** *Marginulopsis phragmites* ×138 (Sample 901A-3R-1, 75-77 cm). **8.** *Epistomina uhligi* ×351 (Sample 901A-5R-1, 142-144 cm). **9.** *Epistomina* spp. ×217 (Sample 901A-3R-1, 60-62 cm). **10.** *Epistomina uhligi* ×89 (Sample 901A-3R-1, 87-89 cm). **11.** *Epistomina uhligi* ×I13 (Sample 901A-5R-1, 73-75 cm). **12.** *Epistomina uhligi* ×133 (Sample 901A-5R-1, 73-75 cm). **13.** *Bolivina* aff. *liasica* ×253 (Sample 901A-5R-1, 142-144 cm). **14.** *Bolivina* aff. liasica ×216 (Sample 901A-5R-1, 142-144 cm). **15.** *Eoguttulina* aff. *liassica* ×123 (Sample 901A-3R-1, 40-42 cm). **16.** *Neobulimina atlantica* ×162 (Sample 901A-6R-1, 98-100 cm). **17.** *Neobulimina atlantica* ×220 (Sample 901A-6R-1, 98-100 cm). **18.** *Neobulimina atlantica* ×132 (Sample 901A-6R-1, 98-100 cm).