10. BIOSTRATIGRAPHIC VALUE OF BOLBOFORMA, LEG 81, ROCKALL PLATEAU¹

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ABSTRACT

Six previously known species of the incertae sedis genus Bolboforma (aculeata, clodiusi, intermedia, laevis, metzmacheri, and reticulata) are recorded from the bathyal Miocene sediments of Sites 552-555. Three species extend into the early Pliocene (B. clodiusi, metzmacheri, and reticulata). Two new species are described: danielsi from the middle Miocene and costata from the early Pliocene. Bolboforma is especially common in contourite deposits.

INTRODUCTION

The genus Bolboforma Von Daniels and Spiegler (1974) was erected to include problematic microfossils from the Tertiary of Germany. Such microfossils have subsequently been recorded from Belgium (Willems, 1976), Poland (Odrzywolska-Bienkova, 1976), the Mediterranean (Bizon et al., 1977), the North Atlantic (Molinsky in Rögl and Hochuli, 1976; Murray, 1979), and off Antarctica (Rögl and Hochuli, 1976). The present chapter records further occurrences in bathyal sediments from the North Atlantic.

MATERIALS AND METHODS

Samples were collected during the drilling at Sites 552 to 555 off Rockall Plateau on Leg 81 of the Deep Sea Drilling Project. Soft chalks were processed without drying, but many were oven dried and then soaked in water or dilute calgon before being washed on a 230mesh (63-µm) sieve. The residue was dried and then split on a 125mesh (125- μ m) sieve; only the fraction >125 μ m was examined. Benthic foraminifers were the primary objective of the study, but Bolboforma species were picked from those samples in which they occurred. No counts were made, but samples were subjectively grouped into present (P) and common (C) categories.

RESULTS

The occurrence of *Bolboforma* is recorded in Table 1. Site 555 has by far the richest occurrences, and these are confined to lithologic Unit II: foraminifer-nannofossil ooze and biosiliceous foraminifer-nannofossil ooze (Fig. 1). Bolboforma first appears in small numbers in the middle Miocene, Zone NN6 (Sample 555-23,CC). From 20,CC to 12,CC the genus is common, the dominant species being B. clodiusi, B. intermedia, and B. laevis; of these the only consistently dominant form is B. clodiusi. Two further common levels are at 9,CC and 8,CC in the late Miocene, Zone NN11. Thereafter, Bolboforma is present in low abundance up to Zone NN12, above which it was not found.

In Hole 553A the occurrences range from early Miocene (NN1) to late Miocene (NN9-11) in lithologic Units III, IIb, and IIa. These are nannofossil foraminiferal chalk, glauconitic nannofossil foraminiferal chalk, and nannofossil foraminiferal oozes or chalks, respectively. The common occurrences are of middle and late Miocene age (Zones NN6-8, and 9-11, Fig. 1).

Hole 552A yielded Bolboforma in lithologic Units IIa and IIb of early Miocene to early late Pliocene age (NN7, 10-16); only in the middle Miocene (NN7), however, are they common. The sediment is foraminifernannofossil or nannofossil-foraminifer ooze and chalk throughout, with glauconite present in Unit IIb (Fig. 1).

The deepest hole, Hole 554, has common Bolboforma throughout the middle to late Miocene in lithologic Unit II (nannofossil-foraminifer or foraminifer-nannofossil oozes). The dominant species are B. clodiusi, B. intermedia, B. metzmacheri, and B. reticulata (Fig. 1).

Bolboforma occurs in some samples studied from Site 119 in the Bay of Biscay (Table 1). The middle and late Miocene sediments are firm nannofossil clays, and species recorded are B. clodiusi and B. laevis (Table 2).

DISCUSSION

In their original descriptions of Bolboforma species, Daniels and Spiegler (1974) gave the overall size range as 120–170 μ m in diameter. Although the upper size limit is exceeded in the Rockall material, many of the specimens are less than 150 μ m in size. The choice of sieve used in sample preparation is therefore of paramount importance. In this study, a $125-\mu m$ sieve was used, but many authors use a 150-µm sieve and must therefore lose most of the Bolboforma. This may account for the relatively few records to date. Bolboforma is most probably a planktonic cyst (Rögl and Hochuli, 1976) and such cysts are produced during periods of ecological adversity. All records are from high latitudes, but that from Biscay at 45°N has the lowest diversity. If periods of adversely low temperature of surface waters are the controlling influence, then abundance and diversity might be highest in high latitudes. Bolboforma might be truly absent from tropical regions. Further careful study is needed to confirm this hypothesis.

Because of their small size, Bolboforma species are found mainly in muddy sediments, and they may be preferentially concentrated in nannofossil-rich contourite deposits.

From the limited data available (Table 3), the occurrence of the genus in the Miocene is seen to be wide-

¹ Roberts, D. G., Schnitker, D., et al., Init. Repts. DSDP, 81: Washington (U.S. Govt. Printing Office). ² Address: Department of Geology, University of Exeter, Exeter, England.

Table 1.	Occurrence	of Bolbof	orma at Sites
552-5	555 off Rocka	all Plateau.	and Site 119,
Bay o	of Biscay.		

	aculeata	clodiusi	costata	danielsi	intermedia	laevis	metzmacheri	reticulata
Sample	B. (B. 6	B. 6	B. c	B. 1	B. I	B. 1	B. /
552-6,CC		Р					Р	
552A-12,CC							P	
552A-14,CC		Р	Ρ					
552A-18,CC		Р					Ρ	Ρ
552A-26,CC						P		P
552A-28,CC							Р	
552A-30,CC	Ρ	Р						
552A-32,CC						P		
552A-34,CC		Ρ			C		Ρ	
552A-35,CC	Ρ	P		Ρ	C	cf.	Ρ	
552A-36-3, 100							Ρ	
552A-36,CC							Ρ	
553A-4,CC	Р					С	Ρ	
553A-5,CC		Ρ				С		
553A-6,CC	Ρ	Ρ			Ρ	Ρ	С	
553A-7,CC		Ρ		С			Ρ	
553A-8,CC							P	
554-6,CC						Ρ		С
554-7,CC		Ρ						
554-8,CC		Ρ						
554A-1-1, 70								Р
554A-1,CC				Ρ				
554A-2-2, 3				P				
554A-2,CC		С				Ρ		
554A-3-3, 80	Ρ	Ρ			C	P		Ρ
554A-3,CC		С				Ρ	С	
555-3,CC		Ρ					Ρ	Ρ
555-4,CC		P						
555-5,CC					Ρ			С
555-6,CC		Р			P	Р		
555-7.CC	P	C					Ρ	
555-8,CC		C			C	P	Р	
555-9,CC	Р	P					C	
555-10.CC		Ρ			Ρ	Ρ	Ρ	Р
555-11.CC		P			P		P	
555-12,CC					C			
555-13,CC					C	P		
555-14.CC	P	C			P	P		
555-15.CC	Ρ	C			С	Ρ		
555-16,CC		C			P	Ρ		
555-17.CC		C				C		
555-18.CC		C					Ρ	
555-19.CC		P		P		C	P	
555-20,CC		P		C		ॅ	P	Р
555-21,CC		P				Р	P	1
555-23.CC		P				P	P	Р
119-4-1, 57						P	2	-
119-4-1, 141						P		
119-4-2.4						P		
119-4-2, 127						C		
119-5-1 20		C				č		
119-5-1, 117		P				C		
,								

Note: P = present; C = common.

spread and so too is the occurrence of several of the species.

The original study from Germany showed a distribution in time through the Oligocene and Miocene (Daniels and Spiegler, 1974). All subsequent records have been of Miocene occurrences: Antarctica, early Miocene (N6-N7 = NN3-NN4; Rögl and Hochuli, 1976); Belgium, late Miocene (Willems, 1976); Poland (Odrzywolska-Bienkova, 1976); Rockall, late Miocene (N16-N18 = NN9-NN12; Murray, 1979). The results presented here extend the range into the Pliocene (Fig. 1, Table 3). A comparison of the Rockall sites (Fig. 1) shows that individual species have different ranges at different sites. The total ranges are summarized in Table 3, and from this it can be seen that although *Bolboforma* species are of value in identifying the Miocene and early Pliocene, they are not of value as fine biostratigraphic markers. Daniels and Spiegler (1974) found that the abundance of individual species in the Miocene of Germany is stratigraphically useful. This may be true on a local scale, but such a pattern is not evident in the Rockall material.

TAXONOMIC NOTES

Bolboforma was originally described as single chambered (Daniels and Spiegler, 1974), but subsequently two species have been recorded with two chambers (Daniels et al., 1981). All the species recorded here are single chambered.

Bolboforma aculeata Daniels and Spiegler, 1974 (Plate 1, Figs. 1, 2)

The Rockall examples closely resemble the types.

Bolboforma clodiusi Daniels and Spiegler, 1974 (Plate 1, Figs. 3, 4)

The Rockall examples vary from compressed to inflated and vary too in the degree of spinosity. However, this species is distinct from *B. aculeata*, which has fewer, prominent spines. It is thought that no *B. spinosa* have been included in *B. clodiusi*.

Bolboforma intermedia Daniels and Spiegler, 1974 (Plate 1, Figs. 5, 6)

Most of the Rockall specimens are strongly compressed as are the types. Some are relatively large (260 μ m in diameter).

Bolboforma laevis Daniels and Spiegler, 1974 (Plate 1, Figs. 7, 8)

The types are somewhat compressed, smooth forms. Most of the Rockall examples are also of this type, but some are more globular; some have very faint ridges running from the oral to the aboral end, and others have faint polygonal traces, such as those described by Willems (1976).

Bolboforma metzmacheri (Clodius, 1922) (Plate 1, Figs. 9, 10)

This species varies in profile from almost circular to decanter shaped, i.e., having a flat aboral and a conical oral side. Similar variation has been reported by Willems (1976) from the Miocene of Belgium.

Bolboforma reticulata Daniels and Spiegler, 1974 (Plate 1, Figs. 11, 12)

The polygonal ornament is much more strongly developed than in *B. metzmacheri*, so the two species are readily separated.

Bolboforma costata n. sp. (Plate 1, Figs. 16, 17, 21)

Diagnosis. A costate form of Bolboforma.

Description. Shell single-chambered, globular, with short neck at the end of which is a circular aperture. Ornament of five wall-like ribs extending from the base of the neck to the aboral end. Wall glassy in appearance and calcitic. Diameter 140 μ m; length 180 μ m.

Remarks. No previously described species of *Bolboforma* has longitudinal ribs, so this species is quite distinctive. The 24 paratypes show the variability in morphology. The number of ribs ranges from

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Figure 1. Occurrence of Bolboforma in Holes 552A, 553A, 554, 555.

Fable 2. Occurrence o	f Bolboforma	species in	Miocene	deposits.
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Bolboforma species	Poland (Odrzywolska- Bienkowa, 1976)	Germany (Daniels and Spiegler, 1974)	Belgium (Willems, 1976)	Biscay (this chapter)	Mediterranean (Bizon et al., 1977)	Rockall (Murray, 1979)	Rockall (this chapter)	Antarctica (Rögl and Hochuli, 1976)
B. aculeata	-	Р	2 <u></u>	_	-	Р	Р	-
B. armata	-	P	_	$\sim - 1$			-	
B. clodiusi	-	Р	P	P	P	P	P	P
B. intermedia	-	P				P	P	-
B. laevis	-	Р		P	P	Р	Р	P
B. metzmacheri	P	Р	P	-	-	P	Р	
B. reticulata	-	P	P	_	-	-	P	-
B. rotunda	aff.	Р	P					cf.
B. spinosa		P		—				P
B. spiralis	-	Р	P	() — ()		Р	P	
B. danielsi n. sp.	-		-	-		-	Р	

	Nanno- fossil zone	B. aculeata	B. clodiusi	B. intermedia	B. laevis	B. metzmacheri	B. reticulata	B. costata n. sp.	B. danielsi n. sp.
	NN16					x			
and the	NN15		х					х	
early	NN14		Х			X	х		
Phocene	NN13								
	NN12		х		х	х	х		
1	NN11	х	х	х	х	х	х		
late	NN10	X	х	х	х	х	X		
Miocene	NN9	X	х	х	X	X	х		х
	NN8	X	х	х	X	Х	х		х
middle	NN7	x	х	х	X	х	х		X
Miocene	NN6		х		х	X	х		X
	NN5								
early Miocene	NN4								
	NN3								
	NN2								
	NN1								

Table 3. Total range of *Bolboforma* species at Sites 552 to 555.

three to six but most have four or five. Ribs may be low or extend into wall-like outgrowths. They are not always symmetrically distributed. The diameter ranges from 130 to 180 μ m, with an average of 150 μ m; the length ranges from 160 to 220 μ m, with an average of 180 μ m. This species is known from the type area where it occurs in the early Pliocene.

Holotype. P51585. Plate 1, Figs. 17, 21.

Paratypes. P51586-51609. All types deposited in the British Museum (Natural History).

Type locality. Hole 552A, North Atlantic, 56°02.56'N; 23°13.88'W. Sample 552A-14,CC, 67 m below seafloor.

Age. Early Pliocene, NN15 (Backman, this volume).

Bolboforma danielsi n. sp.

(Plate 1, Figs. 13-15, 18-20)

Diagnosis. Bolboforma with a lateral-folded flange.

Description. Shell single chambered: an oblate spheroid, ornamented laterally with a flange which is in the form of three folds. Circular aperture at the end of the neck. Aboral surface smooth. Wall calcitic. Diameter 180 μ m; length 140 μ m. **Remarks.** The sinuous lateral flange makes this species highly distinctive. The diameter of the 24 paratypes ranges from 140–220 μ m, with an average of 180 μ m. The species is known only from the type area where it occurs in the middle Miocene Zones NN6 to 9.

Holotype. P51610. Plate 1, Figs. 18-20.

Paratypes. P51611-51634. All types deposited in the British Museum (Natural History).

Type locality. Site 555, North Atlantic, 56°33.70'N, 20°46.93'W. Sample 555-20, CC, 224 m below the seafloor. Age middle Miocene, NN7-8. (Backman, this volume).

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Plate 1. Species of Bolboforma. 1, 2. B. aculeata Daniels and Spiegler, ×200; (1) side; (2) oral; Sample 553A-6,CC, middle Miocene, NN7-8.
3, 4. B. clodiusi Daniels and Spiegler, ×260; (3) side; (4) oral; Sample 555-5,CC, late Miocene, NN11. 5, 6. B. intermedia Daniels and Spiegler, ×180; (5) oral; (6) side; Sample 552A-34,CC, late Miocene, NN9-10. 7, 8. B. laevis Daniels and Spiegler, ×240; (7) side; (8) oral; Sample 553A-4,CC, late Miocene, NN9-11. 9. B. metzmacheri (Clodius), ×180, side view of compressed form; Sample 555-9,CC, late Miocene, NN11. 10. B. metzmacheri (Clodius), ×200, side view of spherical form; Sample 554A-3,CC, middle Miocene, NN7-8. 11, 12. Bolboforma reticulata Daniels and Spiegler, ×200; (11) oral; (12) side; Sample 555-5,CC, late Miocene, NN11. 13, 14, 15. B. danielsi n. sp., ×200; (13) oral view; (14) side view; (15) aboral view; metatype; Sample 555-20,CC, middle Miocene, NN7-8. 16. B. costata n. sp., ×200, side view; metatype; Sample 552A-14,CC, early Pliocene, NN15. 17, 21. B. costata n. sp., (17) ×220, aboral view; (19) ×230, side view; (20) ×230, oral view; holotype BM (NH) P51585; Sample 552A-14,CC, early Pliocene, NN15. 18, 19, 20. B. daniels n. sp.; (18) ×230, aboral view; (19) ×230, side view; (20) ×230, oral view; holotype, BM (NH) P51610; Sample 555-20,CC, middle Miocene, NN7-8. (Note: Figs. 16-21 are of uncoated type specimens.)