

## 22. BOLBOFORMA FROM LEG 105, LABRADOR SEA AND BAFFIN BAY, AND THE CHRONOSTRATIGRAPHY OF BOLBOFORMA IN THE NORTH ATLANTIC<sup>1</sup>

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### INTRODUCTION

The genus *Bolboforma*, first described by Daniels and Spiegler (1974), is a problematic group of calcareous microfossils. *Bolboforma* is most probably a planktonic cyst (Rögl and Hochuli, 1976) having protozoan or algal affinities (Poag and Karowe, 1986). Its known distribution at present suggests that various species may have potential for becoming good stratigraphic indicators. *Bolboforma* also may be useful in areas where other calcareous planktonic microfossils are poorly preserved, i.e., the North Sea, the Norwegian-Greenland Sea, and Baffin Bay. This report summarizes the known occurrences of *Bolboforma* in the North Atlantic and correlates them with a standard geochronology (Berggren et al., 1985a, 1985b). In addition, further occurrences of *Bolboforma* are reported from Sites 645, 646, and 647 (Fig. 1).

### MATERIALS AND METHODS

Samples from Sites 645, 646, and 647 were dried at 60°C, boiled in a dilute solution of Calgon, and then washed on a 63 µm sieve. The residues were dried and examined with a binocular microscope.

Information for Figures 2 and 3 was interpolated from existing reports (Echols, 1985; King, 1983; Müller et al., 1985; Murray, 1979, 1984, 1987; Poag and Karowe, 1986) and correlated to the Berggren time scale (Berggren et al., 1985a, 1985b). For DSDP Sites 403, 404, 406, 552, 553, 554, 555, 119, 606, 609B, 610, 611C, and 400A, depth in meters below seafloor was determined for each sample, and the sedimentation-rate curve from the site chapters was used to determine the age in Ma. This age was then plotted for each occurrence. COST B-2, COST B-3, ASP15, and ASP22 data were compiled for DSDP Sites 106, 604, and 612 from Poag and Karowe (1986). Occurrences of *Bolboforma* could not be correlated with standard nannofossil zones for DSDP Sites 348, 400, 550, and the North Sea wells (King, 1983); thus, ranges given are approximate ages and are represented in Figures 2 and 3 by dashed lines.

### DATA

*Bolboforma* was found at all three Leg 105 sites. *Bolboforma irregularis* Daniels and Spiegler is present in Hole 647A from the Labrador Sea in Samples 105-647A-28R-4, 91-98 cm, and 105-647A-30R-3, 110-112 cm. *Bolboforma metzmacheri* (Clodius) is present in Hole 646B, also at the Labrador Sea, in Sample 105-646B-74X-4, 10-12 cm. The species also occurs sporadically in Hole 645E at Baffin Bay from Section 105-645E-36R, CC down to Section 105-645E-50R, CC, where it is most common in Sample 105-645E-38R-6, 127-129 cm. A list of samples that yielded *B. metzmacheri* in Hole 645E follows:

Core/section	Interval (cm)
105-645E-38R-6	127-129
105-645E-38R, CC	
105-645E-44R-2	96-99
105-645R-44R-2	115-117
105-645E-46R-3	95-97
105-645E-48R, CC	
105-645E-48R-2	84-86
105-645E-49R-2,	120-122
105-645E-49R-3	62-64
105-645E-50R-2	84-86
105-645E-50R, CC	
105-645E-53R-3	101-103
105-645E-53R, CC	

*Bolboforma* species A and B, as yet undescribed, were observed in Hole 646B in Samples 105-646B-71X-2, 60-62 cm, and 105-646B-74X-4, 60-62 cm.

### DISCUSSION

Little is known about the chronostratigraphy of different species of *Bolboforma* in the North Atlantic. What is known from the literature is summarized in Figures 2 and 3. Here, we applied a standard biochronological framework, the Berggren time scale (Berggren et al., 1985a, 1985b), to all reported occurrences of species in DSDP sites from the North Atlantic, as well as those from ODP Leg 105. For each citation in the literature, we determined the age and zonal assignment from either the sediment-rate curve of the respective DSDP site chapters or from analogous time charts in reports by King (1983), Müller et al. (1985), and Poag and Karowe (1986). Stratigraphic ranges of *Bolboforma* species that could not be correlated with standard nannofossil zones are reported according to our estimates. Thus, our charts present standardized systematic ranges of the North Atlantic species of *Bolboforma* (Figs. 2 and 3).

From Figures 2 and 3, one can see that many species have long ranges, but most species occur in the Miocene. From the limited data available, we found that the geographic distribution of the genus as well as the occurrence of several species is widespread in the Miocene. *Bolboforma aculeata* Daniels and Spiegler has the most restricted range in the North Atlantic and may be useful for determining the upper Miocene. *Bolboforma costata* Murray appears to be restricted to upper Pliocene. With the growing knowledge of distribution of these taxa, further studies may eventually lead to a zonation based on *Bolboforma*.

Because of their small size, species of *Bolboforma* are often found in muddy sediments and may be preferentially concentrated in high-latitude, contourite drift deposits (Murray, 1984). *Bolboforma metzmacheri* (Clodius) was found in Hole 646B just below seismic reflector R3 (Srivastava, Arthur, et al., 1987). Kaminski et al. (this volume) interpreted this seismic horizon to represent the initiation of the Denmark Straits overflow from

<sup>1</sup> Srivastava, S. P., Arthur, M. A., Clement, B., et al., 1989. *Proc. ODP, Sci. Results*, 105: College Station, TX (Ocean Drilling Program).

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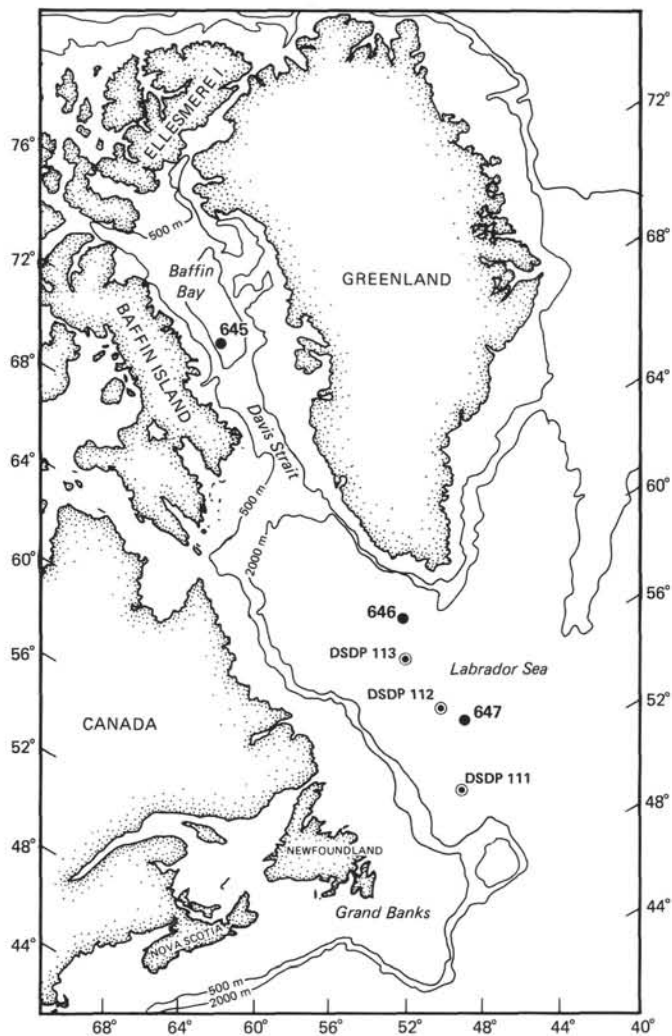


Figure 1. Generalized bathymetry of the Labrador Sea-Baffin Bay region showing exploratory wells, DSDP sites, and Leg 105 Sites 645, 646, and 647.

the Norwegian-Greenland Sea, which corresponds to an increase in sedimentation rates at the site. This implies that preservation is not limited to sediment types but in some way reflects paleoenvironmental controls. *Bolboforma* is probably a planktonic cyst (Rögl and Hochuli, 1976). Such cysts are produced during periods of ecological adversity; they are usually deposited in shallow and deep basins and seem to prefer cool water (latitudes higher than 25° to 35°), according to their known regional distribution. If periods of adversely low surface-water temperatures are the controlling influences, then abundance and diversity might be highest in high latitudes.

*Bolboforma* species are very resistant to dissolution, as indicated by their excellent preservation in samples that contain strongly etched and broken planktonic foraminifers (i.e., as in DSDP Cores 550-17 and 550-18). In Hole 645E and in Norwegian-Greenland Sea Cores 348-27 and 348-30, these species are the only preserved calcareous microfossils (Müller et al., 1980). Because planktonic foraminifer preservation in the Miocene of Site 645 was poor, *Bolboforma* may be the only key for correlating this site with the North Atlantic. In addition, the temporal occurrences of *Bolboforma metzmacheri* (Clodius) in the North Sea and Baffin Bay areas may be causally related. This could imply either concurrent geographic development of populations

or advection of specimens by a proto-West Greenland current into Baffin Bay.

#### TAXONOMY

##### *Bolboforma* sp. A, Pl. 1, Fig. 2.

**Description.** Monocamerate. Test is ornamented with well-defined, subcontinuous, flat-bladed ridges arranged radially around the aperture. Small perpendicular secondary ridges connect the radial ridges. Aperture is circular and produced on a small neck.

**Occurrence.** Upper Miocene, Zone NN11.

**Type locality.** Labrador Sea, ODP Site 646.

##### *Bolboforma* sp. B, Pl. 1, Fig. 3.

**Description.** Test is small, monocamerate, and has a slightly flattened aboral end. Ornamentation consists of closely spaced, nonbifurcating spines located on irregular ridges. Ridges are interconnected in a quasireticulate pattern. Aperture is circular, well-defined, and at the end of a produced neck. Neck is smooth.

**Occurrence.** Upper Miocene, Zone NN11.

**Type locality.** Labrador Sea, ODP Site 646.

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#### REFERENCES

- Berggren, W. A., Kent, D. V., and Flynn, J. J., 1985a. Paleogene geochronology and chronostratigraphy. In Snelling, N. J. (Ed.), *The Chronology of the Geological Record*: London (Blackwell Scientific Publications), Geol. Soc. London Mem. 10:141-195.
- Berggren, W. A., Kent, D. V., Van Couvering, J. A., 1985b. Neogene geochronology and chronostratigraphy. In Snelling, N. J. (Ed.), *The Chronology of the Geological Record*: London (Blackwell Scientific Publications), Geol. Soc. London Mem. 10:211-259.
- Echols, D. J., 1985. "*Bolboforma*": a Miocene algae(?) of possible biostratigraphic and paleoclimatic value. In Bougault, H., Cande, S. C., et al., *Init. Repts. DSDP, 82*: Washington (U.S. Govt. Printing Office), 605-610.
- King, C., 1983. Cainozoic micropaleontological biostratigraphy of the North Sea. *Rept. Inst. Geol. Sci.*, 82(7).
- Müller, C., Spiegler, D., and Pastouret, L., 1985. The genus *Bolboforma* Daniels and Europe. In de Graciansky, P.C., Poag, C. W., et al., *Init. Repts. DSDP, 80*(Pt. 1): Washington (U.S. Govt. Printing Office), 669-675.
- Murray, J. W., 1979. Cenozoic biostratigraphy and paleoecology of Sites 403 to 406 based on the foraminifers. In Montadert, L., Roberts, D. G., et al., *Init. Repts. DSDP, 48*: Washington (U.S. Govt. Printing Office), 415-430.
- Murray, J. W., 1984. Biostratigraphic value of *Bolboforma*, Leg 81, Rockall Plateau. In Roberts, D. G., Schnitker, D., et al., *Init. Repts. DSDP, 81*: Washington (U.S. Govt. Printing Office), 535-539.
- Murray, J. W., 1987. *Bolboforma* from North Atlantic sites, Deep Sea Drilling Project Leg 94. In Ruddiman, W. F., Kidd, R. B., Thomas, E., et al., *Init. Repts. DSDP, 94*: Washington (U.S. Govt. Printing Office), 813-814.
- Poag, C. W., and Karowe, A. L., 1986. Stratigraphic potential of *Bolboforma* significantly increased by new finds in the North Atlantic and South Pacific. *Palios*, 1:162-171.
- Rögl, F., and Hochuli, P., 1976. The occurrence of *Bolboforma*, a probable algal cyst, in the antarctic Miocene of DSDP Leg 35. In Hollister, C. D., Craddock, C., et al., *Init. Repts. DSDP, 35*: Washington (U.S. Govt. Printing Office), 713-719.

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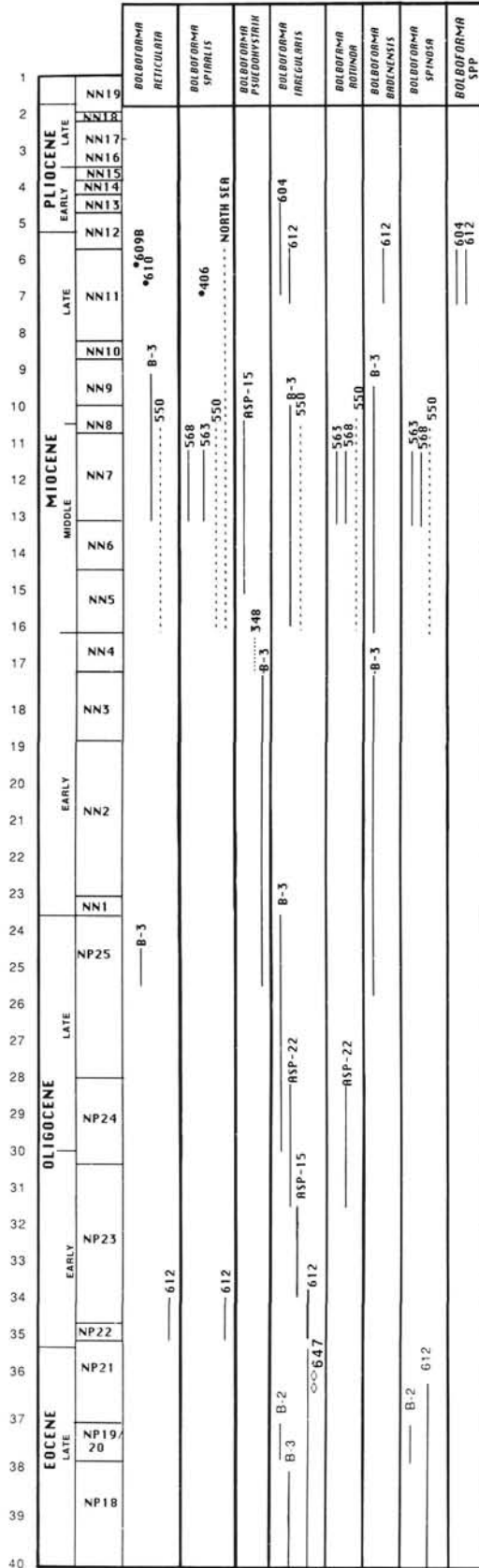


Figure 2. Distribution of Neogene species of *Bolboforma* in the North Atlantic. Dashed lines represent approximate ranges for those species not correlated with the Berggren et al. time scale (1985a, 1985b). Solid lines indicate continuous ranges. Dots are single occurrences.



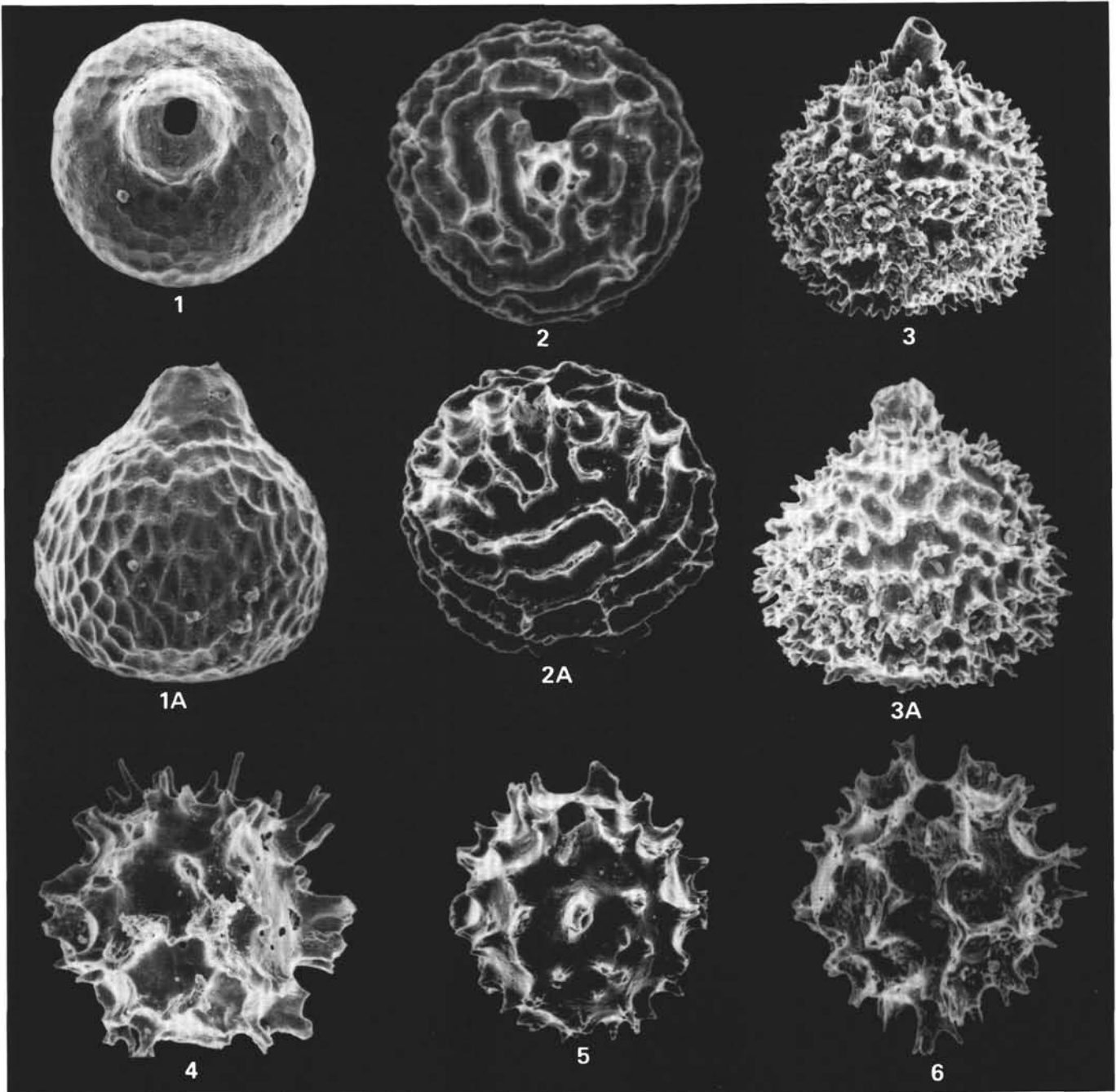


Plate 1. Species of *Bolboforma*. 1, 1a. *Bolboforma metzmacheri* (Clodius)  $\times 600$ , Sample 105-646-74X-4, 10-12 cm. 2, 2a. *Bolboforma* sp. A,  $\times 600$ , monocamerate, flattened, bladed ridges; Sample 105-646-74X-4, 10-12 cm. 3, 3a. *Bolboforma* sp. B,  $\times 600$ , monocamerate, spinose, irregular ridges; Sample 105-646-71X-2, 60-62 cm. 4 and 5. *Bolboforma irregularis* Daniels and Spiegler,  $\times 600$ , Sample 105-647-28R-4, 91-98 cm. 6. *Bolboforma irregularis* Daniels and Spiegler,  $\times 600$ ; Sample 105-647-30R-3, 110-112 cm.