

## 36. "BOLBOFORMA": A MIOCENE ALGAE(?) OF POSSIBLE BIOSTRATIGRAPHIC AND PALEOCLIMATIC VALUE<sup>1</sup>

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### INTRODUCTION

Site 558 was drilled between Anomalies 13 and 15 (latitude 37°46.2'N; longitude 37°20.61'W) at a water depth of 3754 m, and Site 563 was drilled on Anomaly 13 (latitude 33°38.53N; longitude 43°46.04'W) at a water depth of 3786 m. At both sites lower Oligocene to Pleistocene sediments were recovered. In samples from Hole 558 (at approximately 205–214 m) and from Hole 563 (at approximately 195–205 m), the identified planktonic foraminifers indicate foraminiferal Zone N14 (middle Miocene). Within these intervals, tiny (65 to 180 μm) calcareous spheres, individuals of the fossil group called *Bolboforma*, are fairly common to abundant. *Bolboforma* was originally described by von Daniels and Spiegler (1974) as a genus of *incertae sedis* (possibly a Protozoa) from uppermost Oligocene and Miocene deposits of northwestern Germany. In 1976, these little organic bodies were first recorded and described from deep-sea sediments recovered on DSDP Leg 35 by Rögl and Hochuli (1976), who referred them to calcareous algae. Since then, they have been recorded from deep-sea sediments recovered on DSDP Leg 48 by Auffret and Pastouret (1979) and Murray (1979) and on DSDP Leg 80 by Müller et al. (in press). In all cases they seem to be confined to the Miocene in the deep-sea material and, when present, apparently occur in abundance.

It has been suggested (Rögl and Hochuli, 1976; Murray 1979) that this fossil group might be a worldwide biostratigraphic indicator in deep-sea sediments. It may also be of some value in climatic interpretations because intervals characterized by dissolution and probably associated with cooler waters are dominated numerically by *Bolboforma* (Müller et al., in press).

### LITHOLOGY AND FAUNAL ASSOCIATION

At both Sites 558 and 563, samples in which *Bolboforma* are found are white to off-white, nannofossil-foraminiferal chalky and marly oozes. Planktonic foraminifers are fairly common to abundant but show some fragmentation and/or dissolution and some crystalline overgrowth on the globorotalid forms. Benthic foraminifers, ostracodes, fish teeth, sponge spicules, and radiolarians are also present and range in abundance from few to fairly common. The faunal association of plank-

tonic foraminifers indicate that these samples belong in the *Globigerina nepenthes*-*Globorotalia siakensis* N14 Zone. This zone is recognized by the first occurrence of *Globigerina nepenthes* at the base and the last occurrence of *Globorotalia siakensis* at the upper boundary. The first appearance datum (FAD) of *Globigerina nepenthes* is recognized in Samples 558-6,CC and 563-5,CC. This gives us a numeric age of approximately 12 + Ma and places the samples near the boundary of planktonic foraminiferal Zone N13/N14 and nannofossil Zones CN7b/CN7a (upper NN9).

### SYSTEMATIC CONSIDERATIONS AND PREVIOUS OCCURRENCES

As noted earlier, *Bolboforma* was first described from upper Oligocene and Miocene sediments in northwestern Germany by von Daniels and Spiegler (1974), who thought that the forms belonged to a fossil group of test-forming protozoans. Although they also noted that in previously published accounts this form had been described as the foraminifer *Lagena*, they discuss in some detail the affinities of *Bolboforma* to the testacea, tinninna, and the calcareous algae. The eleven new species (*B. metzmacher*, *B. clodiusi*, *B. laevis*, *B. reticulata*, *B. aculeata*, *B. armata*, *B. intermedia*, *B. rotunda*, *B. spinosa*, *B. spiralis*, and *B. irregularis*) that they describe have distinct stratigraphic ranges and show definite changes in faunal assemblages and abundances in the lower Miocene Vierlande and Hemmoor stages of northwestern Germany.

In 1976, Rögl and Hochuli found these calcareous bodies in lower Miocene sediments drilled in the Antarctic during Leg 35 at Site 325 on the continental rise of the Bellingshausen Sea (65°02.79'S; 73°40.40'W). Based on the accompanying foraminiferal fauna, they assigned the sediments to Zones N6/N7, (lower Miocene to upper Burdigalian). Rögl and Hochuli, after a comparative study of the test and wall structure of *Bolboforma* with various encysting stages of protozoans and algae, concluded that the most advisable classification would be in an "hitherto unknown" group of the planktonic algae Chrysomondales to which the Coccolithineae also belong. At Site 325 they recorded four of the species described by von Daniels and Spiegler (*B. clodiusi*, *B. spinosa*, *B. laevis*, and *B. cf. rotunda*) and one *B. sp.*, possibly abnormal, form (Rögl and Hochuli, 1976, Plates 1 and 2). They conclude that this fauna from the lower Miocene of the Antarctic area is stratigraphically transitional in composition of species and variety of forms to the material described by von Daniels and Spiegler from northwestern Germany.

<sup>1</sup> Bougault, H., Cande, S. C., et al., *Init. Repts. DSDP*, 82: Washington (U.S. Govt. Printing Office).

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In 1979, on DSDP Leg 48, Murray recognized six species, *B. aculeata*, *B. clodiusi*, *B. intermedia*, *B. laevis*, *B. metzmacheri*, and *B. spiralis* from Sites 403, 404, and 406, drilled on the margin of Rockall Plateau. He noted that the occurrence of the genus at these sites is mainly in Zone N17, possibly ranging from N16–N18. On the same leg, at Site 400 (Hole 400A) Auffret and Pastouret (1979) also noted the occurrence of abundant algae cysts (Rögl and Hochuli, 1976) in Cores 400A-20–400A-36, which are assigned to the middle and upper Miocene. They also noted high dissolution rates in their samples within this interval.

On Leg 80 at Site 550 (48°30.91'N; 13° 26.37'W), Müller et al. (in press) found *Bolboforma* (but did not speciate the genus) in cores of middle and late Miocene age, Zone N16. He called them reproductive bodies (?) of an unknown algae and noted that they differed from calcispheres in shape and possession of spines.

#### **BOLBOFORMA FROM LEG 82 AND CORRELATION WITH OTHER AREAS**

The most recent discovery of *Bolboforma* is recorded here from middle Miocene sediments recovered on DSDP Leg 82, North Atlantic. *Bolboforma* is present at Site 558 in Samples 558-5,CC; 558-6-1, 61–64 cm; 558-6-2, 61–64 cm; 558-6-3, 61–64; 558-6-5, 61–64 cm; 558-6-6, 61–64 cm; and at Site 563 in Samples 563-5-2, 62–64 cm; 563-5-3, 62–64 cm; 563-5-4, 62–64 cm; 563-5-6, 62–64 cm; and 563-5-7, 19–21 cm in sediments assigned to the lower part of planktonic foraminiferal Zone N14. Four species (*B. clodiusi*, *B. spinosa*, *B. rotunda*, and *B. spiralis*) have been identified, and these are fairly common to abundant in the investigated samples.

At Site 558, Samples 558-5,CC, the common form is somewhat flattened and ornamented with spiral ridges in a petal-like arrangement. There are no prominent spines. A rounded aperture at the end of a projecting neck is obvious (Plate 1, Figs. 1, 2). This species is referred to *B. spiralis* and was originally recorded by von Daniels and Spiegler (1974) from the upper Oligocene-lower Miocene of northwestern Germany. This form was also observed in samples from the Palmer Ridge by L. Molinsky (personal communication to Rögl and Hochuli, 1976) and in samples from DSDP sites from the North Atlantic and the Bay of Biscay (Leg 12) (Molinsky, unpublished data, see Rögl and Hochuli, 1976).

Murray (1979, p. 420) also recognized *B. spiralis* in upper Miocene (planktonic foraminiferal Zone N17) sediments recovered from Hole 406 (DSDP Leg 48) located in the southern margin of the Rockall Plateau (Murray, 1979).

In samples from Core 558-6, two species occur. *B. spinosa*, which has a well-rounded test and is covered with either short sharp or blunted rounded spines (Plate 1, Figs. 3, 4; Plate 2, Fig. 1), and *B. rotunda*, which is a globular intermediate form in which spines are either worn away or not developed. (Plate 2, Fig. 2). Both *B. spinosa* and *B. rotunda*, originally described from the upper Oligocene and lower Miocene of northwestern Germany, are also described by Rögl and Hochuli (1976)

from the lower Miocene of the Antarctic, DSDP Site 325.

At Site 563 in Core 563-5, the flattened onion-shaped form *B. clodiusi* is present. The surface of this species is ornamented with ridges from which rounded to angular, short, stout spines project (Plate 2, Figs. 2, 4) and a short neck of variable shape bordered by an apertural lip is conspicuous. *B. clodiusi*, originally described by von Daniels and Spiegler (1974) from middle to upper Miocene, has also been described by Rögl and Hochuli (1976) from the Antarctic lower Miocene (N6–N7 zones) and by Murray (1979) from upper Miocene (N16–N18) sediments from the Rockall Plateau.

#### **SUMMARY AND CONCLUSION**

Eight of the species originally described by von Daniels and Spiegler (1974) from northwestern Germany have been identified by later authors in deep sea sediments. Of the four species identified in the present report from the North Atlantic (*B. clodiusi*, *B. rotunda*, *B. spinosa*, and *B. spiralis*), two (*B. rotunda* and *B. spinosa*) have also been recorded from the Antarctic, one *B. spiralis* is also recorded from other parts of the North Atlantic (Rockall Plateau) and the Bay of Biscay, and one *B. clodiusi* has been described from the Rockall Plateau and the Antarctic.

Figure 1 shows the stratigraphic position of the reported occurrences of the genus *Bolboforma*. The presence of *Bolboforma* on Leg 12 1972, personal communication to Rögl and Hochuli (1976) by L. Molinsky, is not documented in Volume 12 of the *Initial Reports of the Deep Sea Drilling Project* and the stratigraphic range of the genus in those samples is not given, therefore this report cannot be referenced in Figure 1.

In the present study the genus has only been found in the middle Miocene, but it is possible that more complete sample coverage will extend this range. The species recognized are distinctive and with the aid of the scanning electron microscope, fairly easily identified, so it seems likely that *Bolboforma* will be a useful guide to the Miocene and that its species may eventually be zoned.

Figure 2 shows the geographic locations from which the genus is reported and illustrates its wide distribution. During the time *Bolboforma* flourished, reported occurrences indicate the environment of deposition was deep, moderate to lower, bathyal waters. The intervals are also characterized by varying degrees of dissolution and contain faunas generally associated with cooler waters.

*Bolboforma* was probably a planktonic algae that may have bloomed and prevailed during incursions of colder waters.

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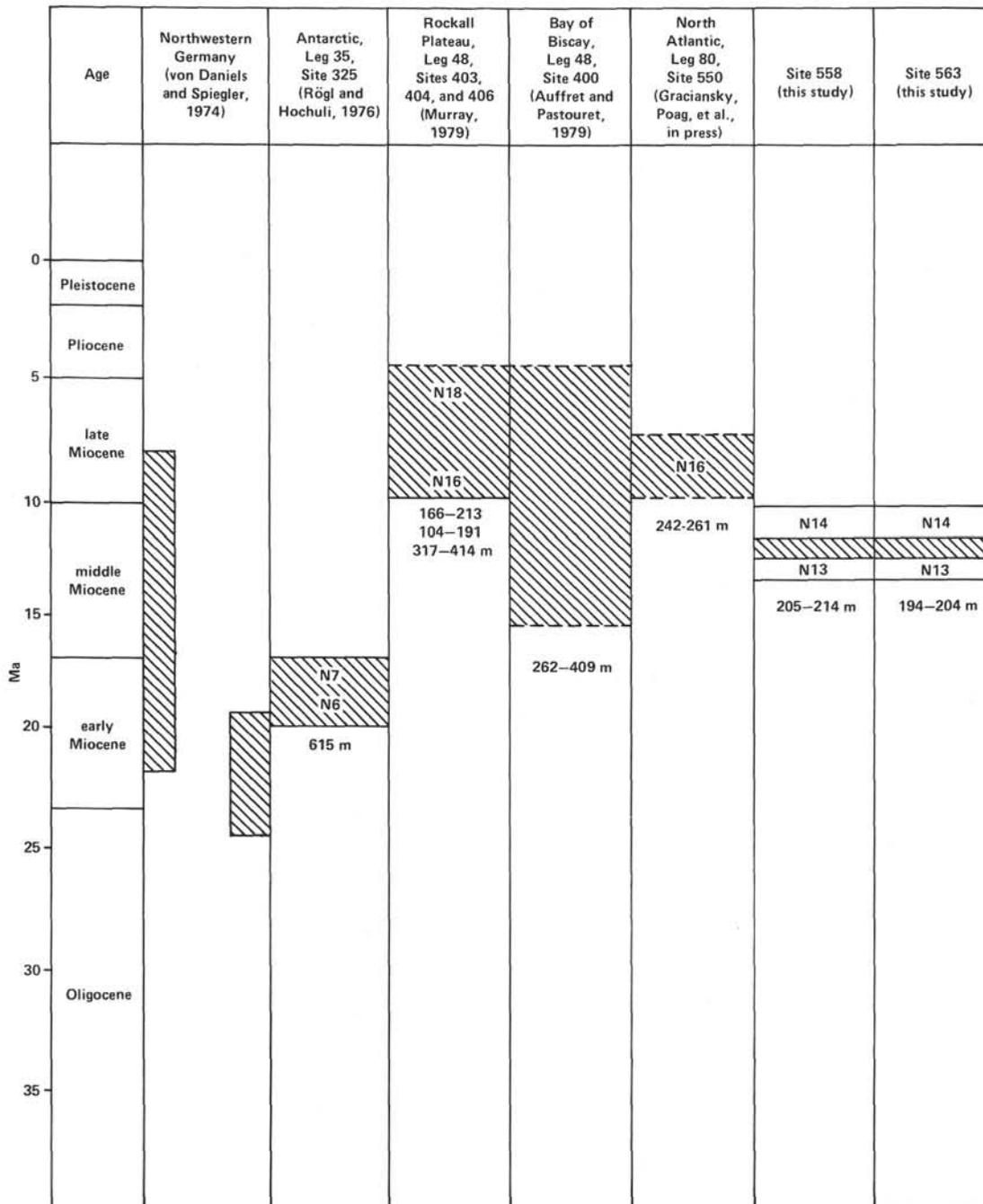


Figure 1. Stratigraphic distribution of *Bolboforma* recorded in the literature. Sub-bottom depths or depth intervals of *Bolboforma* occurrences are given in meters.

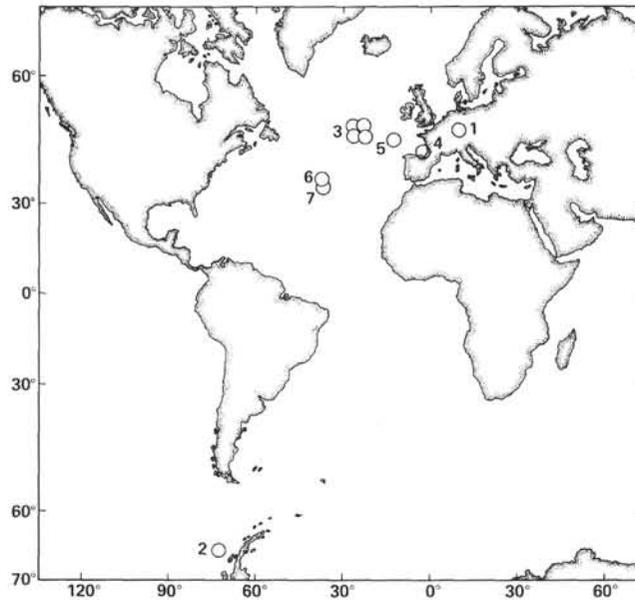


Figure 2. Known occurrences of *Bolboforma*. Numbers indicate the source of data, as follows: (1) Northwestern Germany (von Daniels and Spiegler, 1974); (2) Antarctic (Rögl and Hochuli, 1976); (3) Rockall Plateau (Murray, 1979); (4) Bay of Biscay (Auffret and Pastouret); (5) North Atlantic (Graciansky and Poag, in press); and (6) Site 558 and (7) Site 563 (this study).



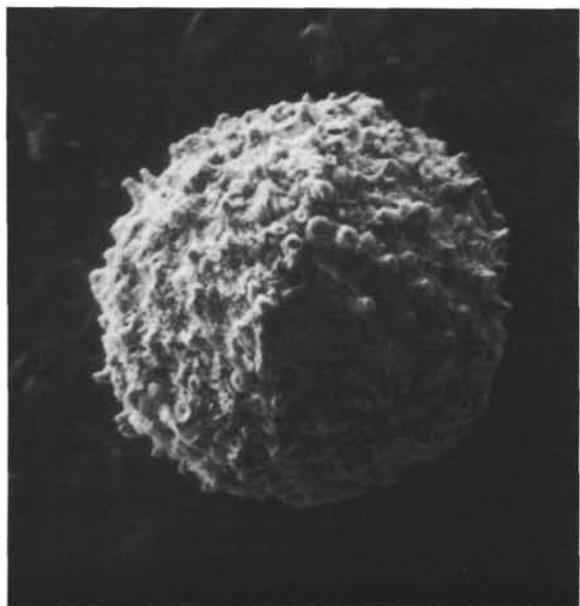
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100  $\mu$ m



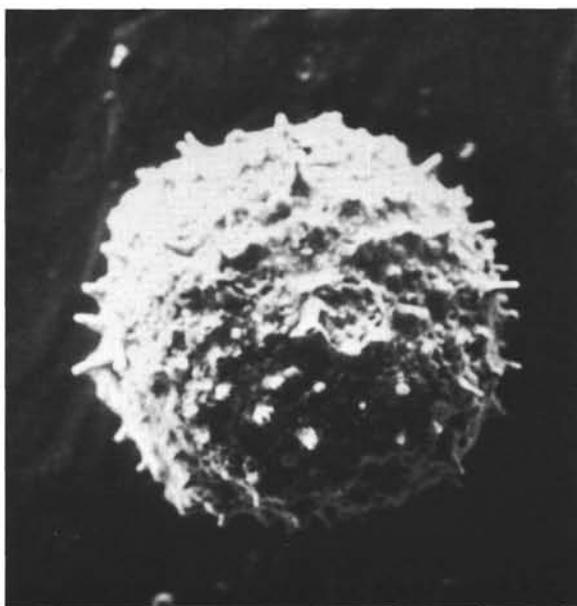
2

100  $\mu$ m



3

100  $\mu$ m



4

100  $\mu$ m

Plate 1. 1, 2. *Bolboforma spiralis*  $\times 400$ ; Section 558-6-6. 3, 4. *B. spinosa*  $\times 400$ ; Sample 558-5, CC.

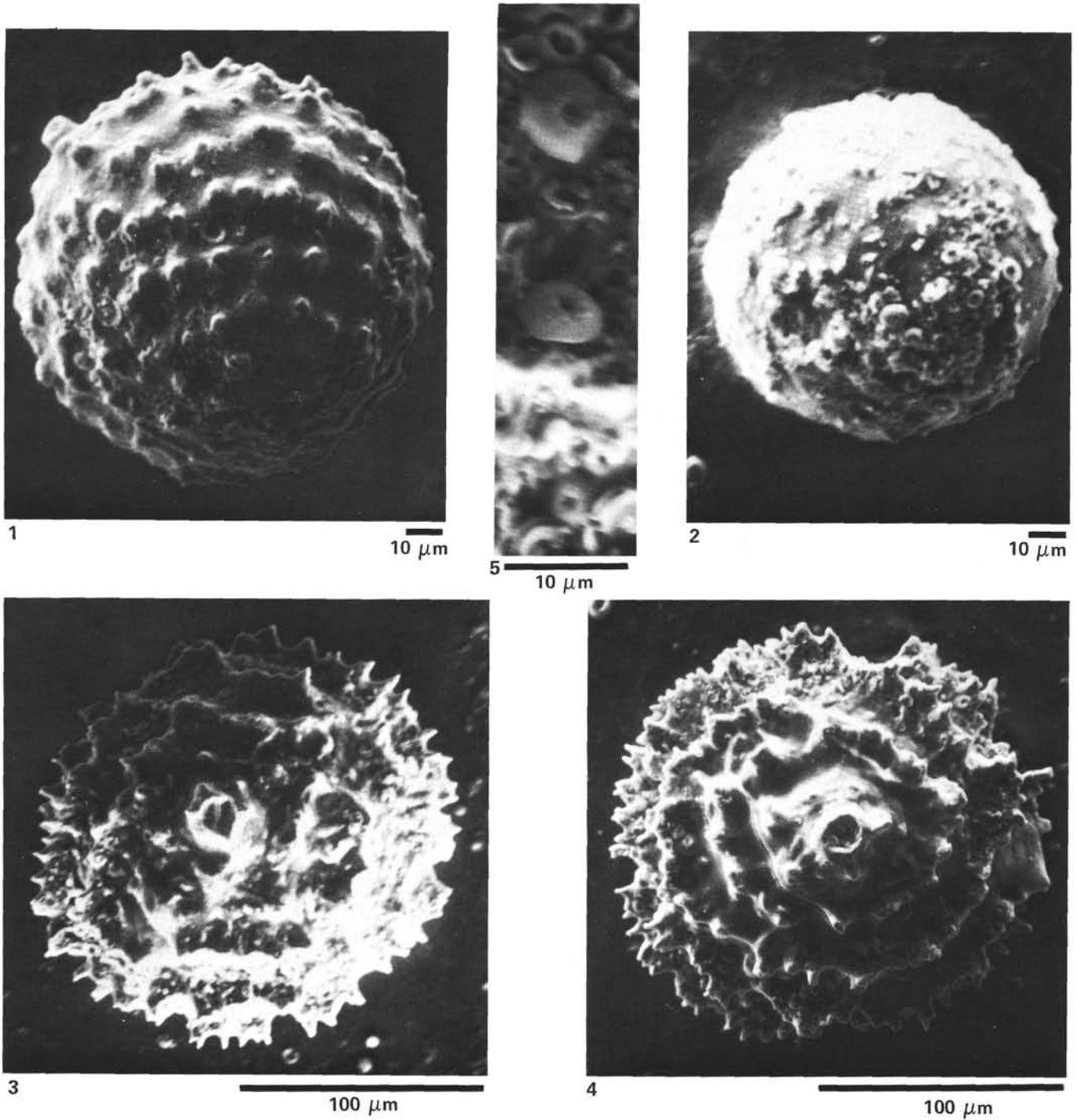


Plate 2. Section 558-6-6 (unless indicated otherwise). 1. *Bolboforma spinosa*  $\times 600$ . 2. *B. rotunda*  $\times 600$ ; Section 563-5-6. 3, 4. *B. clodiusi*  $\times 400$ . 5. Coccolith slurry  $\times 2000$ .