

20. DISTRIBUTION OF HOLOCENE BENTHIC FORAMINIFERS IN THE IZU-BONIN ARC¹

Kunio Kaiho² and Akira Nishimura³

ABSTRACT

The distribution of Holocene benthic foraminifer species in bottom sediments in the Izu-Bonin Arc region of the northwestern Pacific Ocean has been investigated on the basis of 23 samples recovered from depths between 1100 and 4100 m. The benthic foraminifer faunas identified can be grouped into four species assemblages corresponding to four bathymetric zones: the abyssal zone (below 3700 m water depth), lower bathyal zone (2600–3600 m), lower middle bathyal zone (1600–2300 m), and upper middle bathyal zone (above 1300 m). The dominance of such an agglutinated foraminifer as *Rhabdammina* sp. characterizes the abyssal zone, whereas assemblages devoid of calcareous foraminifers distinguish the zone deeper than the carbonate compensation depth (CCD). The occurrence of *Bulimina aculeata* d'Orbigny enables the recognition of the following three bathymetric zones: the lower bathyal zone characterized by such deep-sea species as *Oculosiphon* sp., *Saccorhiza ramosa* (Brady), *Alabamina* sp., and *Pullenia bulloides* (d'Orbigny); the lower middle bathyal zone defined by the occurrence of *B. aculeata*; and the upper middle bathyal zone characterized by the lack of *B. aculeata* as well as the dominance of such species as *Uvigerina proboscidea* Schwager and *Sphaeroidina bulloides* d'Orbigny.

To estimate Quaternary and Pliocene paleobathymetry in the Izu-Bonin region, three water-depth indexes will work well: 3700 m for the CCD, 2300 m for the deepest habitat of *B. aculeata*, and 1600 m for the shallowest habitat of *B. aculeata*.

INTRODUCTION

The first record of Holocene smaller benthic foraminifers from the Izu-Bonin region is contained in this report. The purpose of this study is to clarify the distribution of Holocene calcareous benthic foraminifers in the middle bathyal to abyssal depths. Kaiho used the results to estimate paleowater depths of this region in this volume (Kaiho, this volume).

Figure 1 and Table 1 show sampling localities and water depths. Table 2 presents the distribution of benthic foraminifers and their abundances as well as planktonic foraminifer abundance and preservation. Plates 1 through 5 cover most of the species found in the present study.

MATERIALS AND METHODS

We investigated the distribution of Holocene benthic foraminifer species in bottom sediments in the Izu-Bonin Arc region of the northwestern Pacific Ocean between latitudes of 27°30'N and 33°32'N on the basis of 23 samples recovered from depths between 1100 and 4100 m. Of these, 21 samples consist of mud recovered from a 4- to 5-cm depth below seafloor that were collected by a pilot corer of *Hakurei-maru* of Geological Survey of Japan and 2 samples are mud taken from 2- to 4-cm depths below seafloor during Ocean Drilling Program (ODP) Leg 126 drilling at Sites 790 and 792.

In the top 1 cm of samples from the same sites, agglutinated foraminifers are very abundant, but calcareous benthic foraminifers are rare. Because samples from a 4- to 5-cm depth below seafloor contain more calcareous benthic foraminifers, we used them to analyze the distribution of Holocene benthic foraminifer species. This selection of deeper level samples was made because calcareous foraminifers occupy most of the fossil assemblages occurring in bathyal depths of the Izu-Bonin region (Kaiho, this volume).

Samples were washed through a 250-mesh screen (63- μ m opening) and dried.

RESULTS

We differentiated four species assemblages: Assemblage A, B, C, and D. These assemblages correspond to the following four bathymetric zones (Fig. 2): the abyssal zone (>3700 m water depth), lower bathyal zone (2600–3600 m), lower middle bathyal zone (1600–2300 m), and upper middle bathyal zone (<1300 m).

Assemblage A

The two deepest samples (3765 and 4125 m water depths) contain such agglutinated foraminifer species as *Rhabdammina* sp., *Haplophragmoides* sp., and *Trochammina* sp. The absence of calcareous foraminifers (Table 2) marks the zone deeper than the carbonate compensation depth (CCD).

Assemblage B

Deep-sea agglutinated species such as *Oculosiphon* sp., *Saccorhiza ramosa* (Brady), and *Eggerella bradyi* Cushman and calcareous species such as *Pullenia bulloides* (d'Orbigny), *Alabamina* sp., *Astronion pusillum* Hornibrook, *Bolivina pusilla* Schwager, and *Cibicidoides wuellerstorfi* (Schwager) characterize five samples recovered from depths between 3567 and 2649 m in the lower bathyal zone. Among these species, *A. pusillum* occurs continuously and abundantly from the upper part of this zone to the lower middle bathyal zone. The lack of *Bulimina aculeata* d'Orbigny as well as the dominance of such primitive agglutinated species as *Oculosiphon* sp. and *S. ramosa* define the lower bathyal zone.

Assemblage C

The occurrence of *Bulimina aculeata* defines the lower middle bathyal zone. *Bulimina aculeata* is one of the most abundant species together with *A. pusillum* in this zone. Other dominant species are *Bolivina pusilla*, *Alabamina* sp., *Pullenia bulloides*, *Sphaeroidina bulloides* d'Orbigny, *Oculosiphon* sp., *Saccorhiza ramosa*, *Melonis barleeanus* (Williamson), *Pyrgo murrhina* Schwager, and *Eggerella bradyi*.

The occurrence of *Sigmoilopsis schlumbergeri* (Silvestri), *Uvigerina hispida*, and *Uvigerina hispidocostata* Cushman and Todd is

¹ Taylor, B., Fujioka, K., et al., 1992. *Proc. ODP, Sci. Results*, 126: College Station, TX (Ocean Drilling Program).

² Institute of Geology and Paleontology, Tohoku University, Sendai 980, Japan.

³ Geological Survey of Japan, 1-1-3 Higashi, Tsukuba 305, Japan.

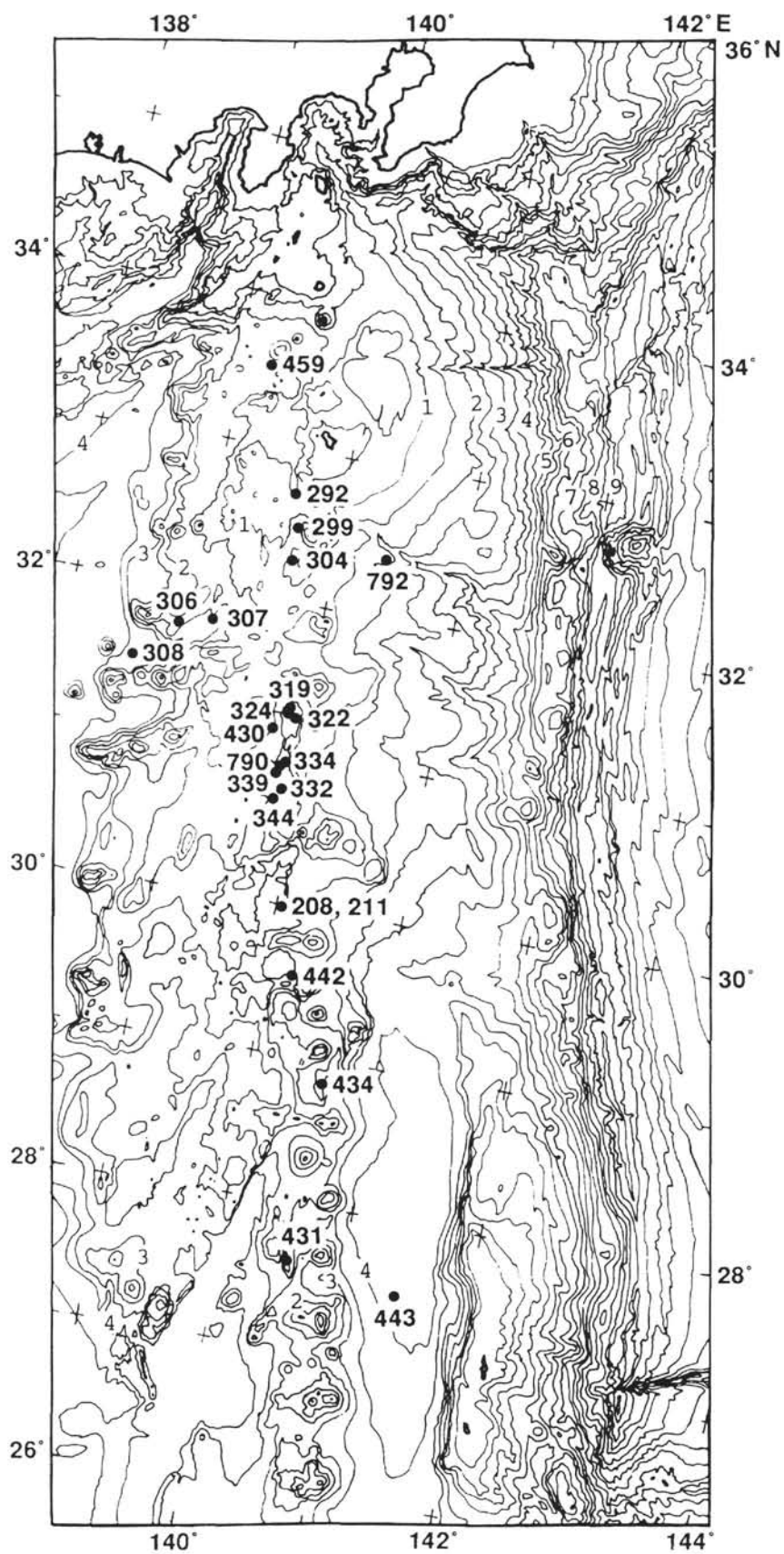


Figure 1. Bathymetric map (500-m contour interval) of the Izu-Bonin region (Taylor et al., this volume)

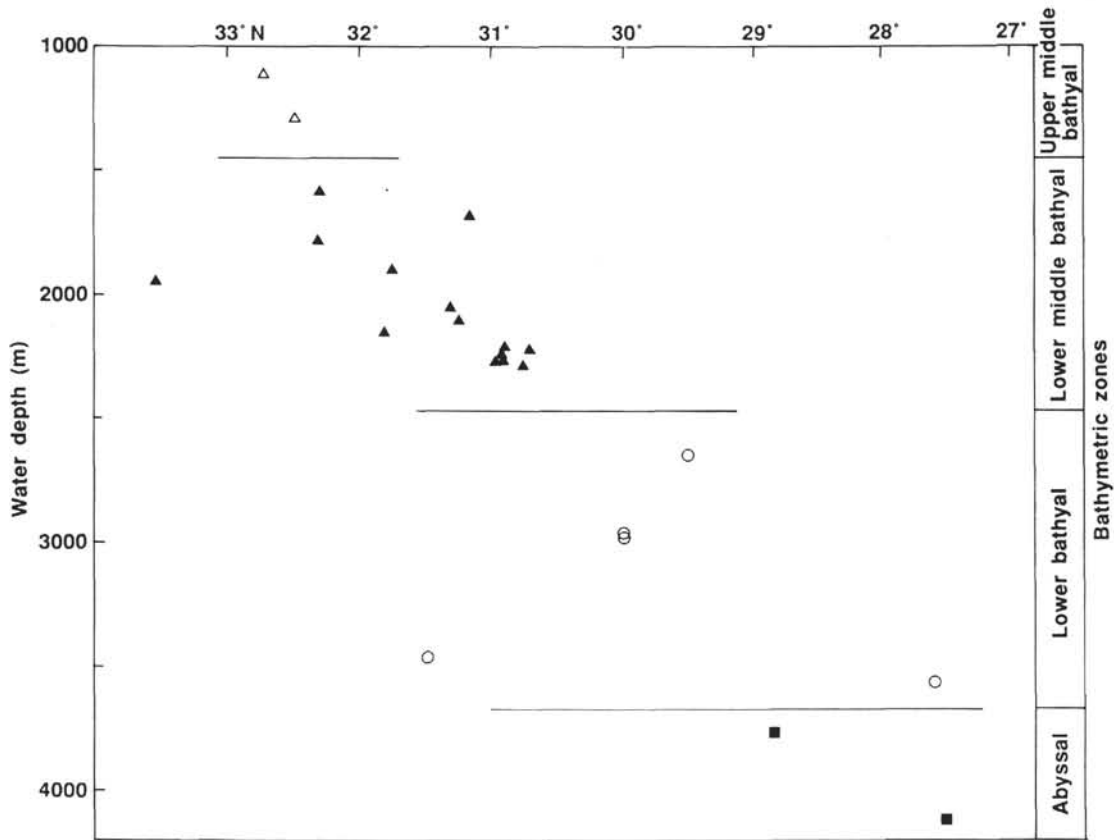


Figure 2. Distribution of Holocene benthic foraminifer assemblages and bathymetric zones in the Izu-Bonin region. Solid squares = Assemblage A, open circles = Assemblage B, solid triangles = Assemblage C, and open triangles = Assemblage D.

Table 1. List of samples used for foraminifer analysis in the Izu-Bonin region.

Sample no. for Table 2	Sample no. or core, section, interval (cm)	Latitude (N)	Longitude (E)	Depth (mbst)
1	RC292, 4-5	32°43.78'	139°35.64'	1109
2	RC299, 4-5	32°30.13'	139°35.64'	1290
3	RC304, 4-5	32°16.08'	139°39.55'	1590
4	RC430, 4-5	31°25.62'	139°44.98'	1680
5	126-792B-IH-1, 2-4	32°23.96'	140°22.81'	1782
6	RC306, 4-5	31°45.06'	138°50.89'	1900
7	RC459, 4-5	33°31.47'	139°14.46'	1945
8	RC319, 4-5	31°19.08'	139°50.18'	2052
9	RC324, 4-5	31°17.03'	139°50.23'	2075
10	RC322, 4-5	31°14.97'	139°53.36'	2105
11	RC307, 4-5	31°48.06'	139°07.18'	2154
12	RC339, 4-5	30°52.33'	139°48.20'	2212
13	RC344, 4-5	30°42.27'	139°49.96'	2220
14	126-790A-IH-1, 2-4	30°54.95'	139°50.66'	2222
15	RC334, 4-5	30°57.94'	139°53.13'	2279
16	RC332, 4-5	30°49.89'	139°53.14'	2286
17	RC442, 4-5	29°32.96'	139°12.29'	2649
18	RC211, 4-5	29°59.88'	140°02.66'	2960
19	H208, 4-5	29°59.97'	140°01.56'	2980
20	RC308, 4-5	31°30.04'	138°32.02'	3464
21	RC431, 4-5	27°35.80'	140°32.92'	3567
22	RC434, 4-5	28°50.96'	140°35.15'	3765
23	RC443, 4-5	27°30.10'	141°23.86'	4125

restricted to this zone, *Sphaeroidina bulloides* to the middle bathyal zone, and *Karrerulina apicularis* (Cushman) to the lower part of the lower middle bathyal and the lower bathyal zones. *Oculosiphon* sp. is abundant in the lower part of the lower middle and lower bathyal zones. The species composition in the lower part of this zone slightly differs from that in the upper part because of the presence of *Karrerulina apicularis* (Cushman), abundant *Oculosiphon* sp., and rare *Chilostomella oolina* Schwager, and the lack of *Neovigerina ampullacea* (Brady). The

boundary water depth of the lower and upper parts lies between 2154 and 1945 m. Three samples between 2105 and 2052 m depths have intermediate characteristics between the lower and upper parts.

Assemblage D

Both the lack of *Bulimina aculeata* and the dominance of such species as *Neovigerina ampullacea* (Brady), *Sphaeroidina bulloides*, *Cibicides wuellerstorfi*, *Chilostomella oolina*, *Paracassidulina sagamiensis* (Asano and Nakamura), and *Pyrgo murrhina* characterize the upper middle bathyal zone. These species are most dominant in this zone except for *P. murrhina*, which is also common in the lower part. This fauna suggests the least oxygenated bottom-water condition among the faunas studied.

DISCUSSION

Most of the Holocene species encountered in this study, including *Bulimina aculeata*, first appeared in the Pliocene to Oligocene (van Morkhoven, 1986). Thus, the results of this study worked well in estimations of Quaternary and Pliocene paleobathymetry in the Izu-Bonin region (Kaiho, this volume).

In view of the results of this study, three water depths are important for paleobathymetric interpretation: namely, the CCD and the deepest and shallowest depths of occurrence of *B. aculeata*. We can estimate these three depths as 3700 m for the CCD, 2300 m for the deepest occurrence of *B. aculeata*, and 1600 m for the shallowest occurrence of *B. aculeata*.

In other areas on the Pacific side of Japan, the shallowest occurrence of *B. aculeata* is about 1000 m or shallower, but the deepest occurrence appears to be stable around 2300 m (Inoue, 1989; Akimoto, 1989; Yasuda, 1989). The CCD in the Shikoku Basin is deeper than 4000 m (Akimoto, 1989). Of the three depths that are useful for

ACKNOWLEDGMENTS

We would like to thank the co-chief scientists, B. Taylor and K. Fujioka, for their encouragement during the course of the present study. We are very grateful to T. Saito and Y. Takayanagi for reviewing the manuscript.

REFERENCES

- Akimoto, K., 1989. Recent foraminifera from Enshunada. In Takayanagi, Y., and Ishizaki, K. (Eds.), *Collected Papers on Foraminifera from the Japanese Islands*: Sendai (Toko Press), 93–104. (In Japanese)
- Inoue, Y., 1989. Northwest Pacific foraminifera as paleoenvironmental indicators. *Sci. Rept. Inst. Geosci., Univ. Tsukuba, Sec. B*, 10:57–162.

- van Morkhoven, F.P.C.M., Berggren, W. A., Edwards, A. S., et al., 1986. Cenozoic cosmopolitan deep-water benthic foraminifera. *Bull. Cent. Rech. Explor.-Prod. Elf-Aquitaine*, Mem. 11.
- Yasuda, H., 1989. Benthic foraminifera and sedimentary facies of the lower slope basin off Shikoku, Japan. In Takayanagi, Y., and Ishizaki, K. (Eds.), *Collected Papers on Foraminifera from the Japanese Islands*: Sendai (Toko Press), 83–92. (In Japanese)

Date of initial receipt: 31 October 1990

Date of acceptance: 18 March 1991

Ms 126B-138

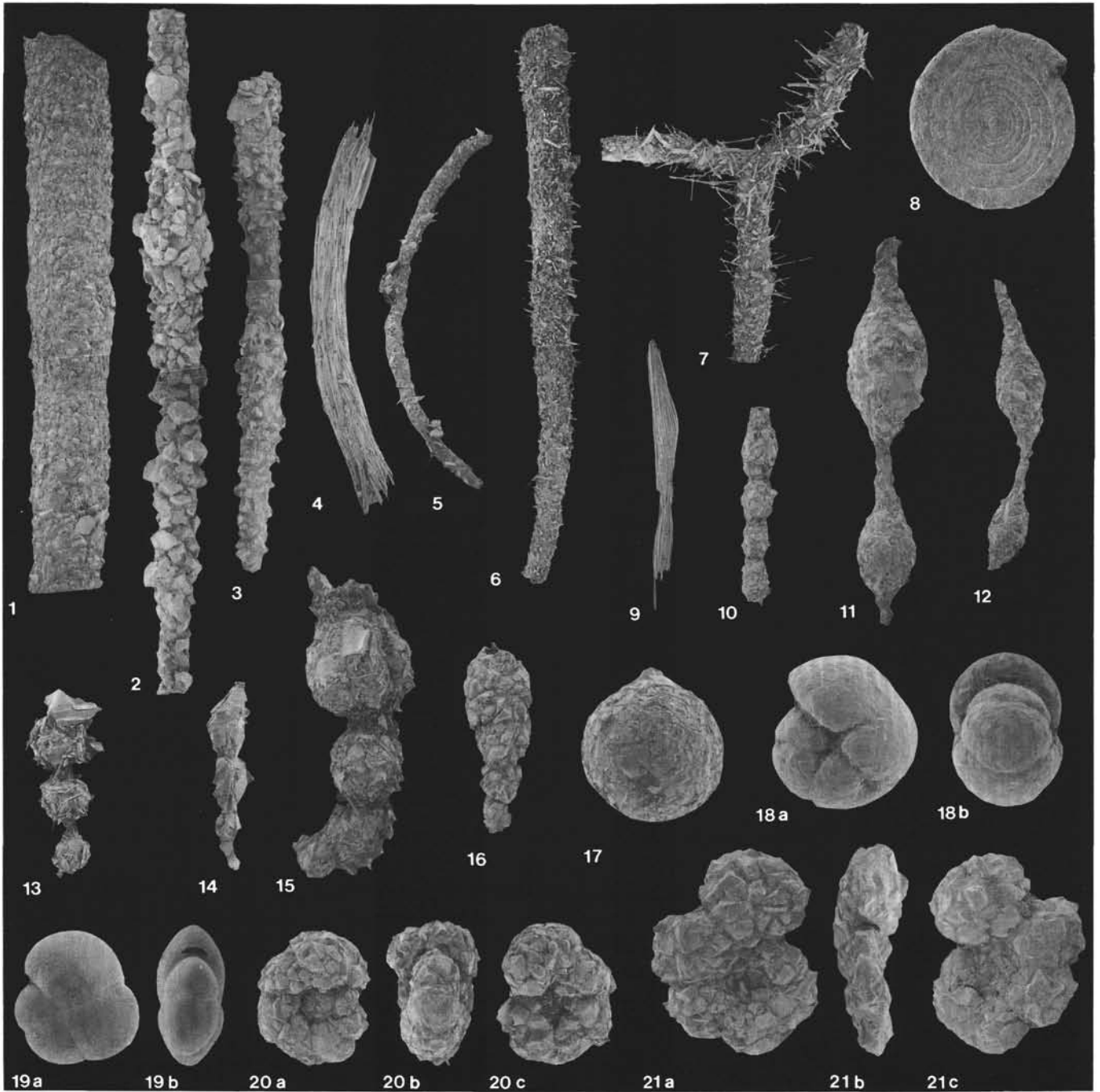


Plate 1. 1. *Rhabdammina?* sp., Sample RC307, 4–5 cm (21×). 2, 3. *Oculosiphon* sp.; (2) Sample RC431, 4–5 cm (21×); (3) Sample RC307, 4–5 cm (21×). 4. *Rabdamminella* sp., Sample 126-792B-1H-1, 2–4 cm (21×). 5. *Rhizammina* sp., Sample RC299, 4–5 cm (21×). 6, 7. *Saccorhiza ramosa* (Brady); (6) Sample RC319, 4–5 cm (21×); (7) Sample 126-792B-1H-1, 2–4 cm (21×). 8. *Ammodiscus* sp., Sample RC332, 4–5 cm (33×). 9. *Reophax spiculifer* Brady, Sample 126-792B-1H-1, 2–4 cm (21×). 10. *Nodulina* sp., Sample RC308, 4–5 cm (21×). 11, 12. *Hormosinella distans* (Brady), Sample 126-790A-1H-1, 2–4 cm (21×). 13. *Reophax guttifer* Brady, Sample RC322, 4–5 cm (47×). 14, 15. *Reophax scorpiurus* Montfort; (14) Sample RC332, 4–5 cm (21×); (15) Sample RC307, 4–5 cm (21×). 16. *Reophax dentaliniformis* Brady, Sample RC319, 4–5 cm (21×). 17. *Saccamina sphaerica* M. Sars, Sample RC324, 4–5 cm (33×). 18. *Cribrostomoides* sp. A, Sample RC306, 4–5 cm (33×). 19. *Cribrostomoides* sp. B, Sample 126-790A-1H-1, 2–4 cm (47×). 20. *Haplophargmoides* sp. A, Sample RC431, 4–5 cm (21×). 21. *Discamina* sp., Sample RC304, 4–5 cm (21×).

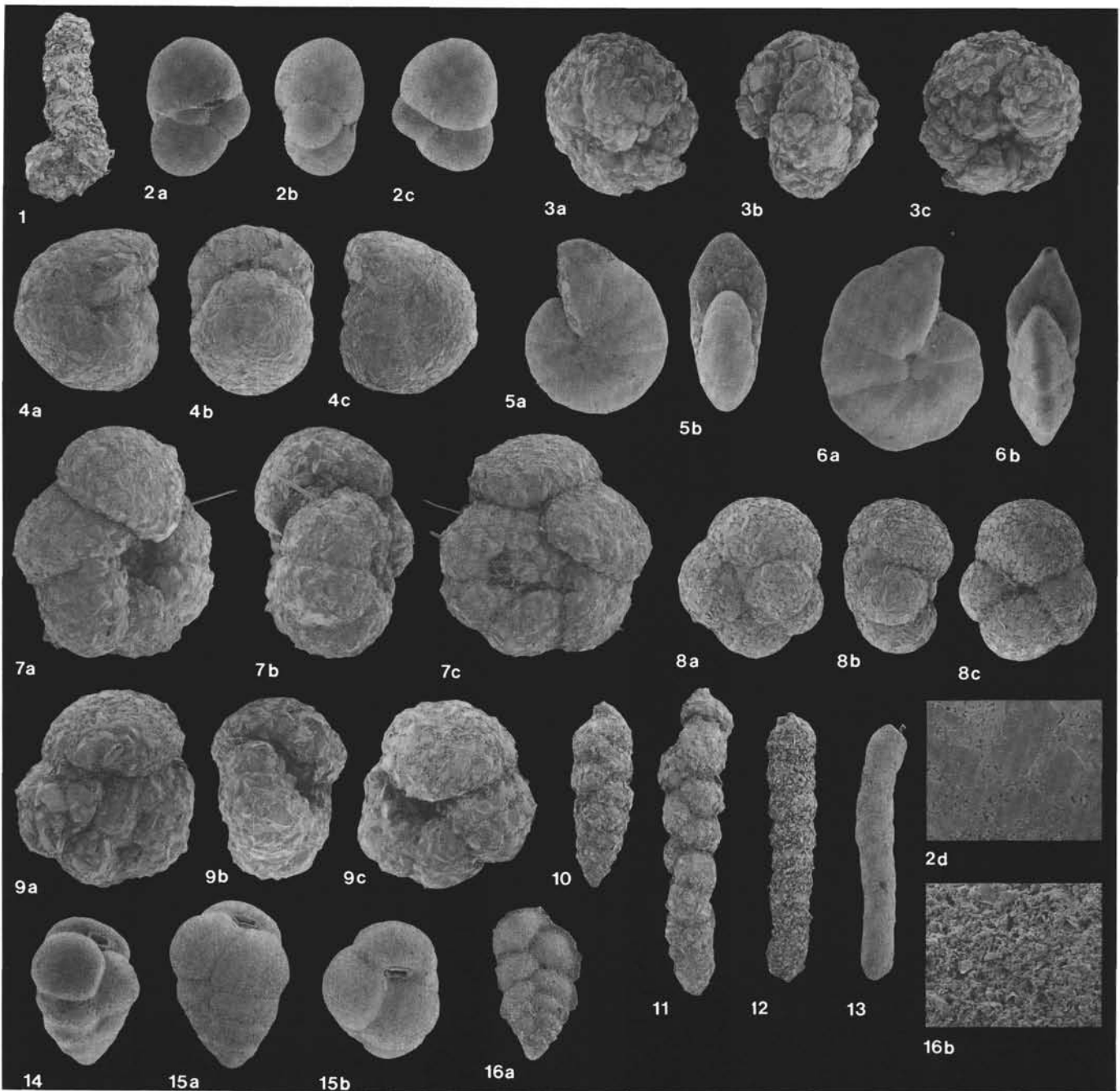


Plate 2. 1. *Ammobaculites* sp., Sample RC322, 4–5 cm (21×). 2. *Cystammina pauciloculata* (Brady), Sample RC344, 4–5 cm (2a–c, 46×; 2d, 698×). 3. *Thalmanammina* sp. A, Sample RC431, 4–5 cm (21×). 4. *Recurvoides* sp., Sample RC308, 4–5 cm (33×). 5. *Cyclammina cancellata* Brady, Sample RC334, 4–5 cm (21×). 6. *Cyclammina* cf. *trullissata* (Brady), Sample RC319, 4–5 cm (33×). 7, 9. *Trochammina* sp. A, Sample RC319, 4–5 cm (7, 21×; 9, 33×). 8. *Trochammina* sp. B, Sample RC319, 4–5 cm (33×). 10, 11. *Karrerulina apicularis* (Cushman); (10) Sample RC308, 4–5 cm (37×); (11) Sample RC319, 4–5 cm (33×). 12. *Martinotiella hosoyaensis* Asano, Sample RC306, 4–5 cm (21×). 13. *Martinotiella communis* (d'Orbigny), Sample RC299, 4–5 cm (21×). 14, 15. *Eggerella bradyi* Cushman; (14) Sample RC442, 4–5 cm (33×); (15) Sample RC319, 4–5 cm (33×). 16. *Textularia* sp., Sample RC292, 4–5 cm (16a, 21×; 16b, 698×).

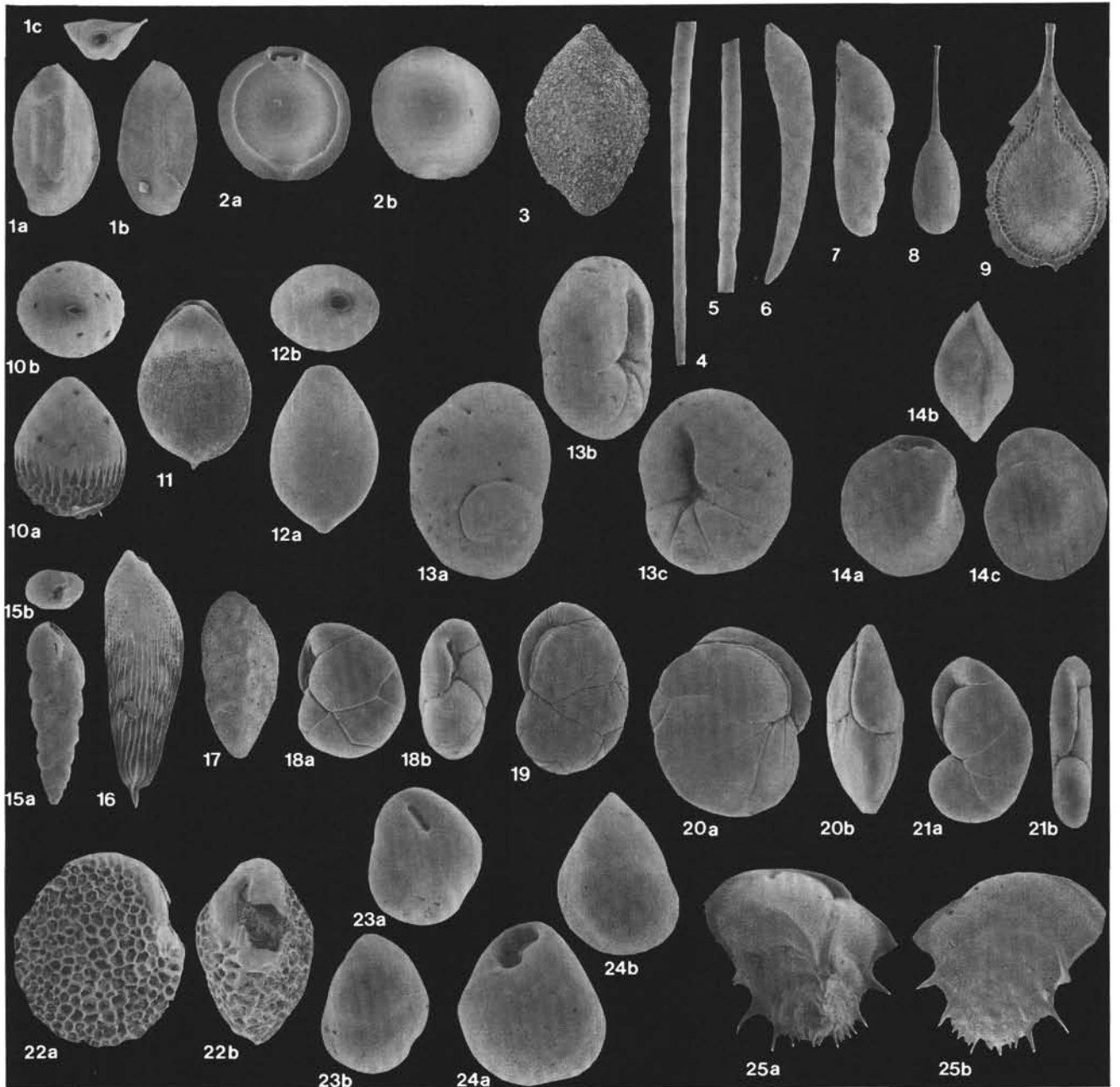


Plate 3. 1. *Quinqueloculina lamarckiana* d'Orbigny, Sample RC442, 4–5 cm (33×). 2. *Pyrgo murrhina* (Schwager), Sample RC459, 4–5 cm (21×). 3. *Sigmilopsis schlumbergeri* (Silvestri), Sample RC332, 4–5 cm (33×). 4, 5. *Bathysiphon filiformis* M. Sars; (4) Sample RC430, 4–5 cm (21×); (5) Sample RC431, 4–5 cm (21×). 6. *Dentalina communis* d'Orbigny, Sample 126-790A-1H-1, 2–4 cm (21×). 7. *Marginulina* sp., Sample RC292, 4–5 cm (21×). 8. *Lagena laevis* (Montagu), Sample RC442, 4–5 cm (48×). 9. *Fissurina formosa* (Schwager), Sample RC304, 4–5 cm (48×). 10. *Fissurina* sp. A, Sample RC442, 4–5 cm (33×). 11. *Parafissurina* sp., Sample RC442, 4–5 cm (48×). 12. *Fissurina* sp. B, Sample 126-790A-1H-1, 2–4 cm (72×). 13. *Ceratobulimina pacifica* Cushman and Harris, Sample RC319, 4–5 cm (33×). 14. *Hoeglundina elegans* (d'Orbigny), Sample RC459, 4–5 cm (48×). 15. *Bolivina pacifica* Cushman and McCulloch, Sample RC292, 4–5 cm (21×). 16. *Bolivina pusilla* Schwager, Sample 126-792B-1H-1, 2–4 cm (72×). 17. *Bolivina robusta* Brady, Sample RC299, 4–5 cm (48×). 18. *Globocassidulina depressa* (Asano and Nakamura), Sample RC299, 4–5 cm (72×). 19. *Paracassidulina nipponensis* (Eade), Sample RC299, 4–5 cm (72×). 20. *Paracassidulina sagamiensis* (Asano and Nakamura), Sample RC299, 4–5 cm (72×). 21. *Paracassidulina oshimai* (Aoki), Sample RC292, 4–5 cm (72×). 22. *Favocassidulina fавus* (Brady), Sample RC442, 4–5 cm (33×). 23. *Globocassidulina subglobosa* Brady, Sample RC431, 4–5 cm (21×). 24. *Globocassidulina moluccensis* (Germeraad), Sample 126-792B-1H-1, 2–4 cm (72×). 25. *Ehrenbergina pacifica* Cushman, Sample RC299, 4–5 cm (72×).

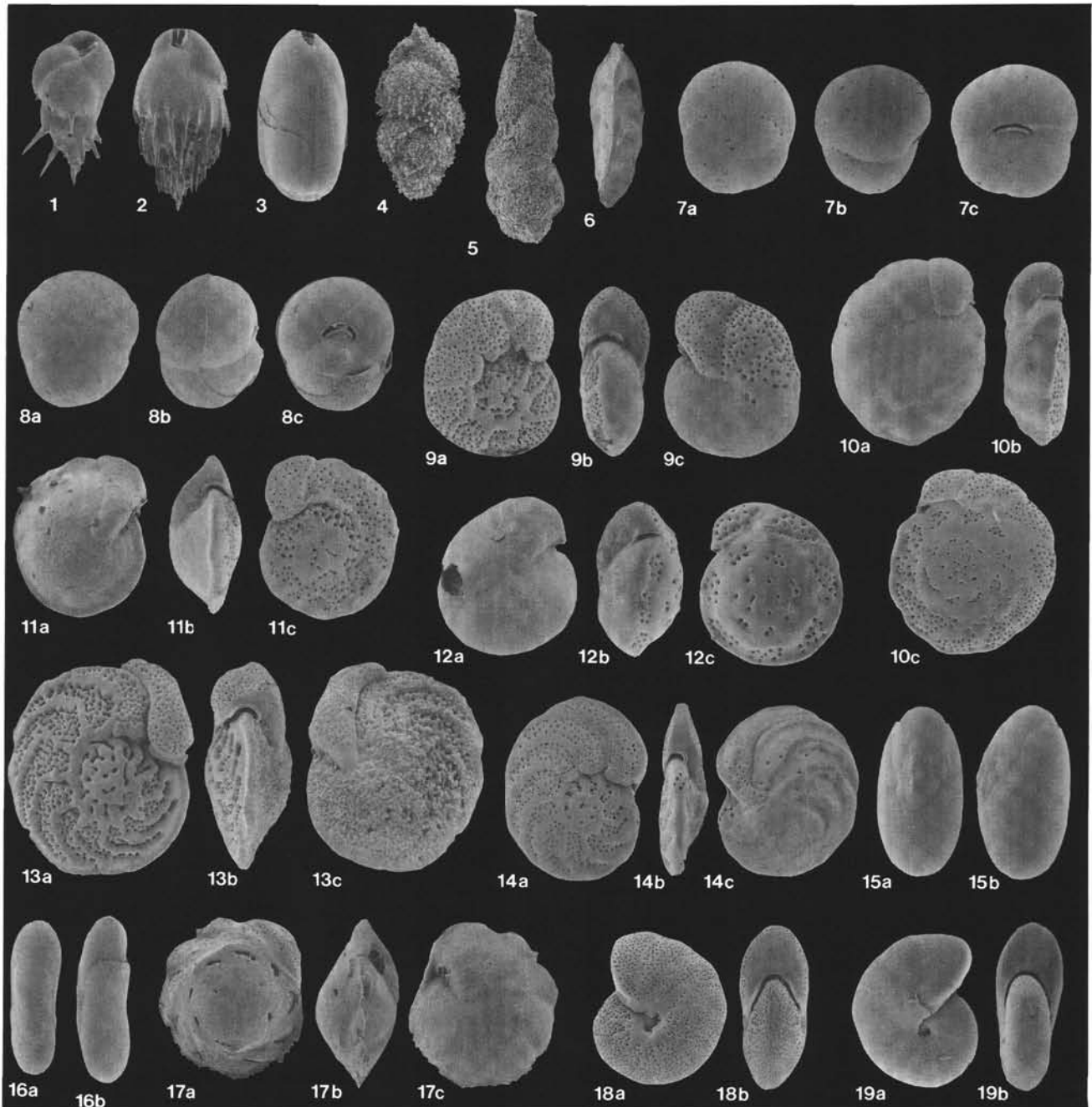


Plate 4. 1. *Bulimina aculeata* d'Orbigny, Sample RC459, 4-5 cm (33 \times). 2. *Bulimina striata* d'Orbigny, Sample RC292, 4-5 cm (48 \times). 3. *Globobulimina pacifica* Cushman, Sample RC459, 4-5 cm (33 \times). 4. *Uvigerina hispilocostata* Cushman and Todd, Sample RC319, 4-5 cm (33 \times). 5. *Uvigerina proboscidea* Schwager, Sample RC292, 4-5 cm (72 \times). 6. *Trifarina bradyi* Cushman, Sample RC299, 4-5 cm (48 \times). 7. *Sphaeroidina bulloides* d'Orbigny, Sample 126-792B-1H-1, 2-4 cm (33 \times). 8. *Sphaeroidina* sp. A, Sample RC459, 4-5 cm (33 \times). 9. *Cibicidoides* sp. A, Sample RC332, 4-5 cm (33 \times). 10. *Cibicidoides robertsonianus* (Brady), Sample RC306, 4-5 cm (33 \times). 11. *Cibicidoides mundulus* (Brady, Parker, and Jones), Sample RC430, 4-5 cm (33 \times). 12. *Cibicidoides havanensis* (Cushman and Bermudez), Sample RC344, 4-5 cm (48 \times). 13. *Cibicidoides* sp. B, Sample RC299, 4-5 cm (33 \times). 14. *Cibicidoides wuellerstorfi* (Schwager), Sample RC459, 4-5 cm (33 \times). 15. *Chilostomella oolina* Schwager, Sample RC459, 4-5 cm (33 \times). 16. *Chilostomella ovoidea* Reuss, Sample RC319, 4-5 cm (33 \times). 17. *Osangularia bengalensis* (Schwager), Sample 126-790A-1H-1, 2-4 cm (72 \times). 18. *Melonis barleeanus* (Williamson), Sample RC459, 4-5 cm (48 \times). 19. *Melonis* sp., Sample RC431, 4-5 cm (48 \times).

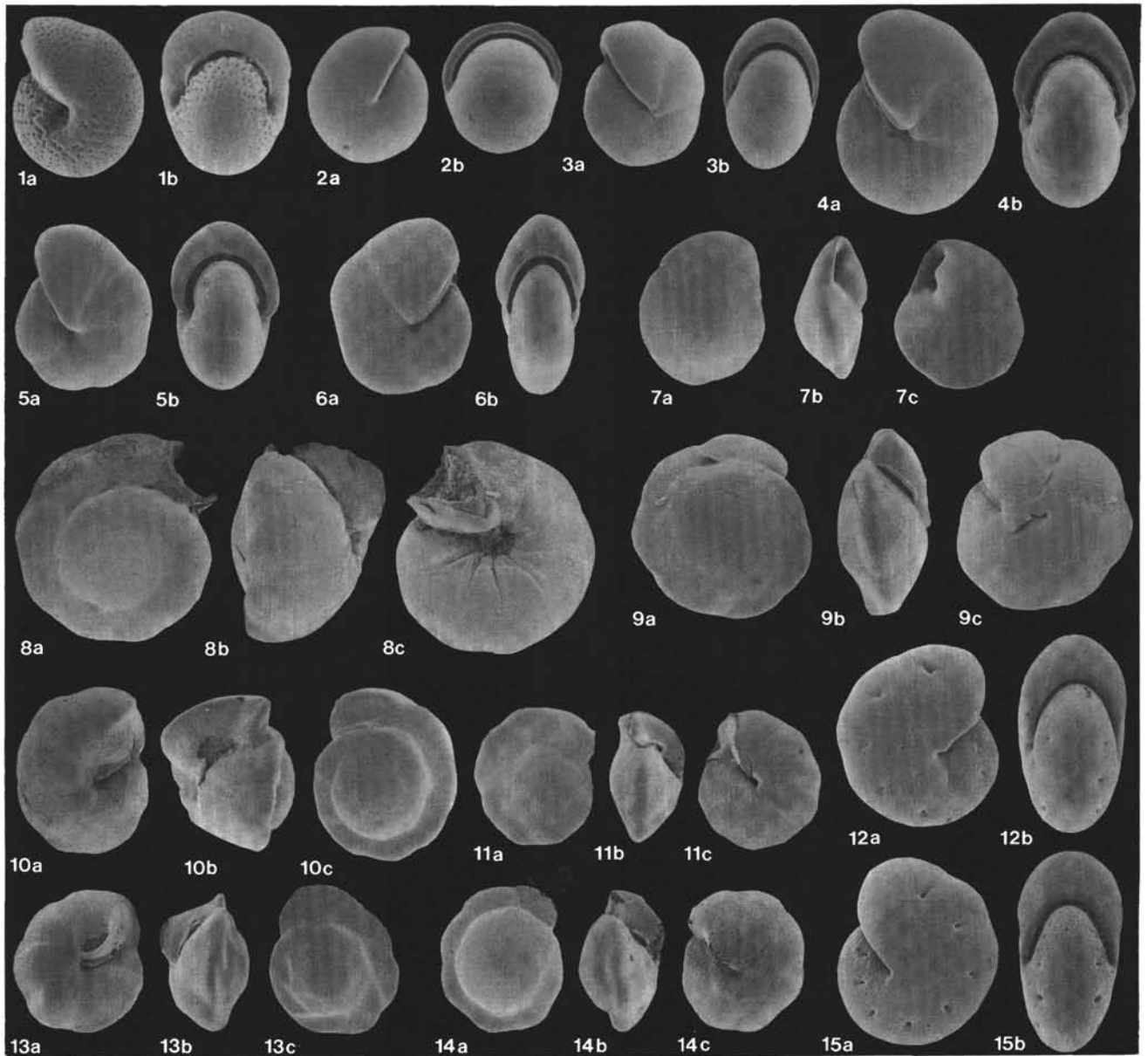


Plate 5. 1. *Melonis pompilioides* (Fichtel and Moll), Sample RC308, 4–5 cm (48×). 2. *Pullenia bulloides* (d’Orbigny), Sample 126-792B-1H-1, 2–4 cm (48×). 3, 4. *Pullenia* sp. A; (3) Sample RC431, 4–5 cm (48×); (4) Sample RC322, 4–5 cm (48×). 5, 6. *Pullenia quinqueloba* (Reuss); (5) Sample RC324, 4–5 cm (72×); (6) Sample RC324, 4–5 cm (72×). 7. *Alabama* sp., Sample RC306, 4–5 cm (72×). 8. *Gyroidinoides neosoldanii* (Brotzen), Sample RC304, 4–5 cm (21×). 9. *Oridorsalis umbonatus* (Reuss), Sample RC334, 4–5 cm (33×). 10. *Gyroidinoides* sp. A, Sample RC306, 4–5 cm (48×). 11. *Gyroidina* sp. A, Sample RC299, 4–5 cm (48×). 12, 15. *Astronion pusillum* Hornibrook, Sample 126-792B-1H-1, 2–4 cm (72×). 13. *Gyroidinoides* sp. B, Sample RC431, 4–5 cm (48×). 14. *Gyroidina* sp. B, Sample RC299, 4–5 cm (48×).