

22. MIDDLE CRETACEOUS PLANKTONIC FORAMINIFERS OF THE ANTARCTIC MARGIN: HOLE 693A, ODP LEG 113¹

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ABSTRACT

A planktonic foraminiferal fauna of probable late Aptian age is recorded in Cores 113-693A-47R and -48R, located on the Antarctic continental margin. Moderate to highly productive surface waters and upper bathyal paleodepths are inferred from benthic and planktonic foraminifers, and other biotic and mineral components in the >63 μm size fraction.

INTRODUCTION AND METHODS

ODP Site 693 lies on a mid-slope bench (2370 m) along the eastern continental margin of the Weddell Sea (70°49.9'S, 14°34.4'W) (Fig. 1). Five samples from Cores 113-693A-47R and -48R were examined. The samples span a 19 m interval within Unit VII (435.7–455.0 m sub-bottom). The sediments consist of organic-rich clayey mudstones and claystones.

Samples were boiled in a weak hydrogen peroxide-calgon solution and then washed over a 63 μm (230 mesh) sieve. The residues were split, where necessary, and at least 300 specimens of foraminifers were picked, identified, and counted. The residues were then examined for rare species and to determine the relative abundance of other biotic and mineral components (Fig. 2).

AGE OF FAUNA

The most likely age of the planktonic foraminiferal fauna recovered at ODP Site 693 is early late Aptian, although a latest Aptian-early Albian age cannot be ruled out entirely based on our limited knowledge of high latitude assemblages of middle Cretaceous age. The age assignment is based on the following evidence.

1. The absence of taxa with radially elongate chambers, such as *Leupoldina cabri* (Sigal), *Hedbergella roblesae* (Obragon), or *H. similis* Longoria, suggests an age younger than early Albian (e.g., Longoria, 1974; Sliter, 1989; Leckie, in press).

2. Possible precursors(?) of *Hedbergella trocoidea* (Gandolfi), here referred to as *H. aff. trocoidea*, support the interpretation of a "pre-*H. trocoidea*" age (i.e., an age no younger than late Aptian). However, Leckie (1984) recorded *H. aff. trocoidea* into the middle Albian of DSDP Site 545 in the eastern North Atlantic. Likewise, Gradstein (1978) recorded a form attributable to *H. aff. trocoidea* into the middle Albian of DSDP Site 390 in the western North Atlantic.

3. The presence of *Globigerinelloides aff. G. blowi* (Bolli) group suggests correlation with the *G. ferreolensis* or *G. algerianus* zones (Fig. 3). However, neither of the nominal taxa are present in the Site 693 material. In addition, Leckie (1984) recorded forms attributable to the *G. blowi* group into the Albian of DSDP Site 545.

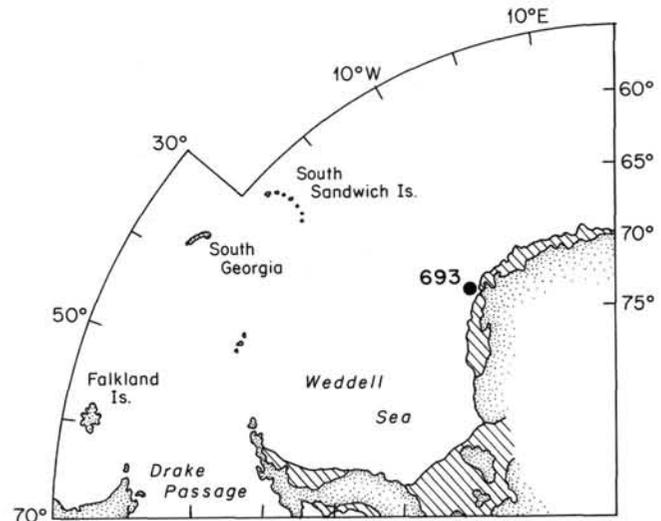


Figure 1. Map showing the location of ODP Site 693.

4. The absence of *Ticinella* and *Rotalipora* suggests a pre-latest Aptian age. *Ticinella bejaouaensis* Sigal probably evolved from *Hedbergella trocoidea* during the latest Aptian and is characterized by its tiny, poorly-developed secondary apertures. Neither of these robust taxa were observed in the Hole 693A material. The first well-developed ticinellids appear in the middle Albian (FAD of *T. primula* Luterbacher marks the base of the middle Albian). The rotaliporids first appeared during the early late Albian (Fig. 3). It could be argued that such negative evidence is a function of the relatively high paleolatitude of Site 693 during middle Cretaceous time. However, *Ticinella* has been recorded by Krasheninnikov and Basov (1983) from the Albian of the Falkland Plateau (South Atlantic) and *Rotalipora* has been recorded in Cenomanian sediments from the Falkland Plateau (Sliter, 1976) and the Naturaliste Plateau (southeastern Indian Ocean; Herb, 1974).

5. The hedbergellids of Site 693 have a very characteristic surface texture which has been observed on hedbergellids of late Aptian-early Albian age (see taxonomic discussion under *H. infractetacea* group).

6. The absence of *Heterohelix* (FAD during the late Albian becoming particularly persistent by latest Albian time) indicates an age older than late Albian. Significant in that Site 693 was a relatively shallow continental margin setting, an environment that

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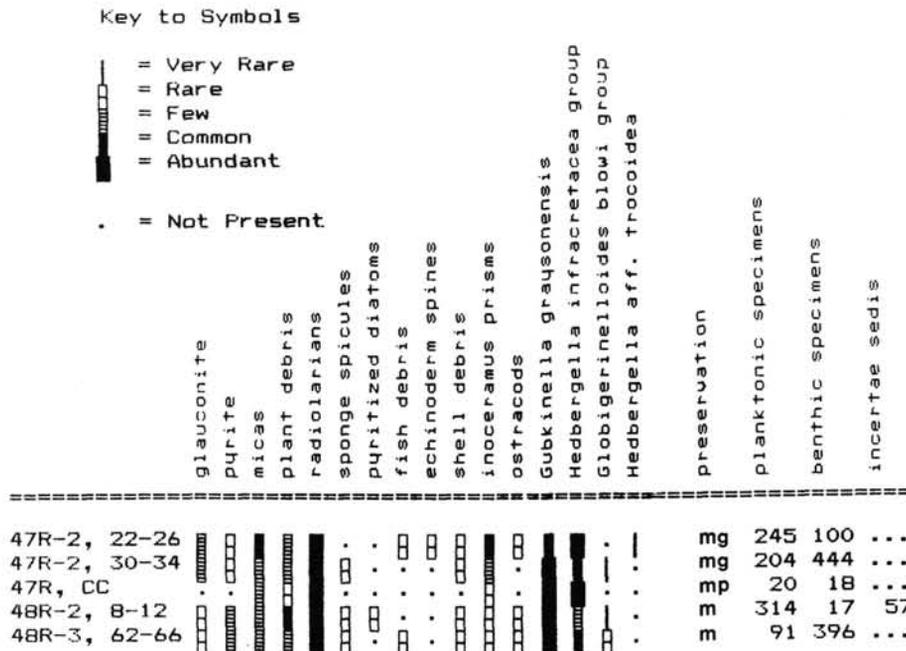


Figure 2. Distribution and relative abundance of planktonic foraminifers and other biotic and mineral components of the >63 μm fraction from Cores 113-693A-47R and -48R. For the planktonic foraminifers, relative abundances are as follows: Abundant = >25%; Common = 16%-25%; Few = 6%-15%; Rare = 3%-5%; and Very rare = <2%. Preservation: mg = moderately good; m = moderate; mp = moderately poor.

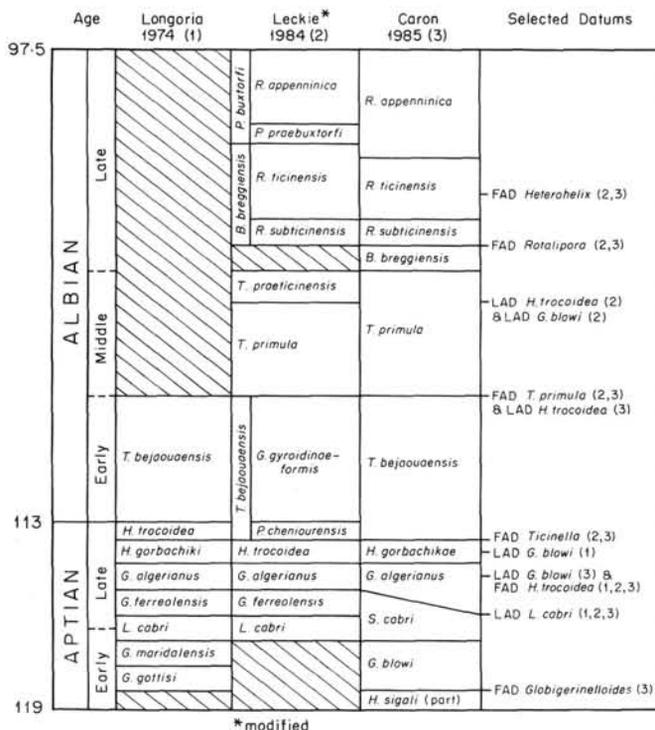


Figure 3. Comparison of Aptian-Albian zonal schemes for the low to mid-latitudes with the first (FAD) and last appearance datums (LAD) of selected taxa discussed in text. Ages of stage boundaries from Kent and Gradstein (1985).

probably would have been favorable for *Heterohelix* (Leckie, 1987).

Additional work is necessary to more accurately constrain the stratigraphic ranges of Aptian-Albian planktonic foraminifers, particularly high latitude taxa. As discussed below in the taxonomic notes, the specimens of *Globigerinelloides* aff. *blowi* group from Site 693 differ from typical Aptian representatives of *G. blowi* s.s. Are the differences attributable to the high paleolatitude of Site 693? Are the Site 693 specimens descendants of *G. blowi* s.s. or are they ecophenotypes? If *G. blowi* s.l. or related forms prove to range into the Albian, and if specimens of *Hedbergella infracretacea* from Site 693 are referable to *H. rischi* Moullade, then an early Albian age would be indicated for Cores 113-693A-47R and -48R. However, the occurrence of *G. blowi*-like forms in the absence of *H. trocoidea* s.s. and taxa with radially elongate chambers provide the best age constraints for this material.

PALEOENVIRONMENT

Paleoenvironmental information is drawn from both the assemblages of foraminifers and other sand-size components of the sediment assemblage (Fig. 4). Benthic foraminifers indicate an upper bathyal (200-500 m) paleodepth based on a paleobathymetric model of Sliter and Baker (1972) and Sliter (1985). The following evidence is used: (1) dominance of *Praebulimina* in most samples; (2) relatively low abundance of nodosariids, miliolids, and agglutinated taxa; (3) abundance of *Gyroidinoides*; and (4) co-occurrence of *Gavelinella*, *Osangularia*, *Coryphostoma*, and *Hoeglundina*. In addition, the relatively low proportion of planktonics relative to benthics and the variability in that ratio suggest an outer neritic to upper bathyal paleodepth for Cores 113-693A-47R and -48R (e.g., Phleger and Parker, 1951; Leckie, 1987). The abundance of detrital micas and plant debris likewise suggest proximity to a land mass.

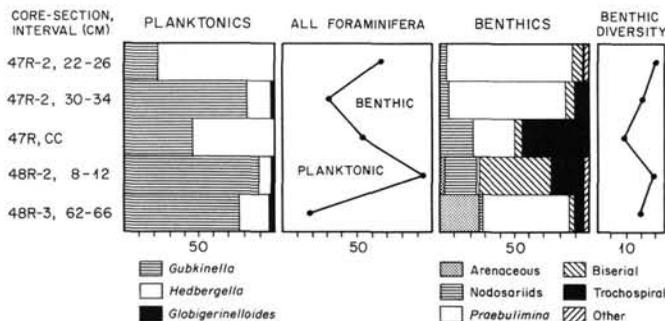


Figure 4. Trends in planktonic and benthic foraminifers through Cores 113-693A-47R and -48R. Proportions of benthics based on counts presented in Figure 2 with the exception of Sample 113-693A-48R-2, 8-12 cm, which was repicked to yield 182 specimens.

Components of the planktonic assemblages also provide information about surface water fertility. The variable abundance of *Gubkinella* (epicontinental sea fauna) relative to *Hedbergella* and *Globigerinelloides* (open marine shallow water fauna) suggests a relatively shallow continental margin and/or high fertility surface waters based on the paleoecologic model of Leckie (1987). The dominance of radiolarians in the $> 63 \mu\text{m}$ fraction supports the interpretation of high productivity, while the composition of the benthic foraminiferal assemblages supports a continental margin setting. An additional piece of evidence supporting the interpretation of high productivity is the elevated benthic to planktonic foraminiferal ratio (e.g., Leckie, 1987; Berger and Diester-Haass, 1988), although the conspicuous paucity of other benthic organisms (ostracods, sponge spicules, echinoderms) is also noted.

TAXONOMIC NOTES

Globigerinelloides aff. *G. blowi* group (Bolli) (Pl. 1, Figs. 8-13)

Planomalina blowi Bolli, 1959, p. 260, pl. 20, figs. 2, 3.

Globigerinelloides blowi (Bolli). Longoria, 1974, p. 82-83, pl. 4, figs. 4, 7, 11-13.

Globigerinelloides blowi s.l. (Bolli). Leckie, 1984, p. 593, pl. 1, figs. 4-8.

Description. Test small (0.10-0.15 mm), evolute. Five to six smooth, inflated, subspherical to ovoid chambers in the final whorl. Chambers increase gradually in size as added. Umbilicus wide. Aperture a low arch with thin lip; relict apertures not discernible.

Discussion. Typical specimens of *Globigerinelloides blowi* s.l. have four to five chambers in the final whorl (Masters, 1977; Leckie, 1984), although Longoria (1974, pl. 4, fig. 7) illustrates a specimen with as many as seven. Specimens from Hole 693A have five to six chambers in the final whorl.

Six-chambered forms bear a strong resemblance to *G. aptiense* Longoria (see illustrations by Longoria, 1974, and Leckie, 1984). *G. blowi* s.l. is characterized by its distinctive small size, smooth surface, and inflated chambers. *G. aptiense* tends to be larger, up to 0.40 mm according to Longoria (1974). In addition, the overall chamber shape and arrangement differ from *G. blowi* s.l., and *G. aptiense* lacks the smooth surface of *G. blowi* s.l. Therefore, despite having as many as six chambers in the final whorl, the specimens from Hole 693A are assigned to the *G. blowi* group.

Leckie (1984) noted that *G. blowi* s.l. is particularly common through the upper Aptian of DSDP Site 545 (eastern North Atlantic), and then becomes rare in lower and middle Albian strata.

Gubkinella graysonensis (Tappan) (Pl. 1, Figs. 1-7)

Globigerina graysonensis Tappan, 1940, p. 122, pl. 19, figs. 15-17.

Gubkinella graysonensis (Tappan). Longoria, 1974, p. 50, pl. 1, figs. 1-12; Leckie, 1984, p. 593, pl. 1, figs. 2-3.

Discussion. Distinctive compact, quadrilobate test. In adults, the aperture is a low arch with a thin lip and is umbilical in position. In ju-

veniles, the aperture can be more umbilical-extraumbilical in position (Pl. 1, Fig. 2). Both moderate spired (Pl. 1, Fig. 6) and high spired (Pl. 1, Fig. 7) forms are observed in the material from ODP Site 693.

This long-ranging taxon is especially characteristic of neritic environments (continental margins, epicontinental seas; e.g., Tappan, 1940; Longoria, 1974) as well as areas of upwelling (e.g., Leckie, 1987). Longoria (1974) reports a lower Aptian (*Leupoldina cabri* Zone) first occurrence for *G. graysonensis*.

Hedbergella infracretacea group (Glaessner) (Pl. 2, Figs. 1-18)

Globigerina infracretacea Glaessner, 1937, p. 28, text-fig. 1.

Hedbergella infracretacea (Glaessner). Glaessner, 1966, p. 181-185, pl. 1, figs. 1a-3c.

Hedbergella delrioensis (Carsey), early form. Leckie, 1984, p. 598, pl. 1, fig. 12, non: pl. 9, figs. 1-4, 8.

Description. Test small, maximum diameter to 0.31 mm. Five to six subspherical to ovoid chambers in the final whorl, increasing gradually in size as added. The dorsal side varies from a low trochospire to flat; low trochospire tends to be more prevalent in juveniles and five-chambered adults, although the populations display a continuous range of variation. Test surface perforate and slightly pustulose. Pores occur at the apices of the pustules. Pustules on earlier chambers of final whorl occur in aggregates yielding subtle patterns suggestive of rugae. Aperture extraumbilical-umbilical; developed as a moderate arch with a thin imperforate rim.

Discussion. The subtle "rugosity" developed in this taxon differs distinctly from the pattern in *Hedbergella libyca* or species of *Rugoglobigerina*; the rugae of these latter taxa are non-perforate, the pores occur between rugae rather than being developed upon the ornament. This particular surface texture has been observed on several hedbergellids of late Aptian to early Albian age (e.g., *H. trocoidea* and *H. delrioensis* of Krashennikov and Basov, 1983; *H. delrioensis* of Longoria, 1974; *Hedbergella* sp. 1, *H. aff. trocoidea*, *H. gorbachikae* and *H. cf. rischi* of Leckie, 1984; *Blefuscuiana cf. aptica* of Banner and Desai, 1988). It is possible that the "rugosity" is a preservational artifact of hedbergellids of this age, although Leckie (in press) has argued against widespread poor preservation as the principal cause for the marked decline in planktonic foraminiferal diversity during latest Aptian-early Albian time. Another possibility is that it represents primary ultrastructure and therefore is of phylogenetic significance.

Hedbergella infracretacea (Glaessner) has been a problematic taxon, especially with regard to its relationship with *H. delrioensis* (Carsey) (see discussions by Hermes, 1969; Longoria, 1974; Masters, 1977; Price, 1977). Glaessner (1966) attempted to clarify the species concept of *H. infracretacea* by illustrating three topotypes, all of which clearly show the absence of an apertural lip. This observation is ultimately what led the present author to assign the Hole 693A specimens to the *H. infracretacea* group. Glaessner (1937) also notes that this taxon has five to six chambers in its final whorl. Other diagnostic characteristics emphasized by other authors include the small size of *H. infracretacea* and its variable dorsal convexity. *H. delrioensis* s.s. is characterized by having four and one-half to five and one-half chambers in its final whorl, a flat dorsal side, a hispid test, and in possessing a spatulate lip. The populations from Hole 693A show a continuous range of variability in terms of size (up to 0.31 mm), dorsal convexity (moderately elevated to depressed early coil), and number of chambers in the final whorl (5-6). However, no specimens were observed with a "hispid" test or with an apertural lip, and therefore classification within *H. delrioensis* was rejected. *H. infracretacea* and *H. delrioensis* probably co-occur in some sediments of late Aptian to middle Albian age, but *H. delrioensis* s.s. is best developed in late Albian and Cenomanian assemblages (e.g., Price, 1977; Leckie, 1984).

Hedbergella infracretacea differs from *H. planispira* (Tappan) in lacking a well developed apertural lip and in lacking the characteristic circular outline of that taxon. In addition, *H. planispira* has up to eight chambers in the final whorl. Specimens of *H. infracretacea* from Hole 693A may include forms referable to *H. rischi* Moullade (*H. aff. infracretacea* of Moullade, 1966).

Hedbergella aff. *H. trocoidea* (Gandolfi) (Pl. 1, Figs. 14-17)

Anomalina lorneiana (d'Orbigny) var. *trocoidea* Gandolfi, 1942, p. 99, pl. 2, figs. 1a-c; pl. 4, figs. 2-3; pl. 13, figs. 2a-b, 5a-b.

Hedbergella aff. *trocoidea* (Gandolfi). Leckie, 1984, p. 599, pl. 3, figs. 5–10.

Discussion. This form differs from *Hedbergella trocoidea* in being smaller, having fewer chambers (six rather than seven to eight), and having less-embracing chambers. Differs from *Hedbergella infracretacea* group primarily by its slightly smaller size and its overall circular outline due to chambers which increase more slowly in size as added. *H. aff. trocoidea* differs from *H. planispira* (Tappan) in its absence of an apertural lip and its compact test with moderately elevated trochospire. It is similar to *H. excelsa* Longoria but differs in its absence of an apertural lip and its less elevated trochospire. *H. aff. trocoidea* differs from *H. occulta* Longoria in its absence of "deeply incised" sutures on the umbilical side. This taxon is similar to *H. hispaniae* Longoria but differs in that its last chamber does not "protrude" toward the umbilicus.

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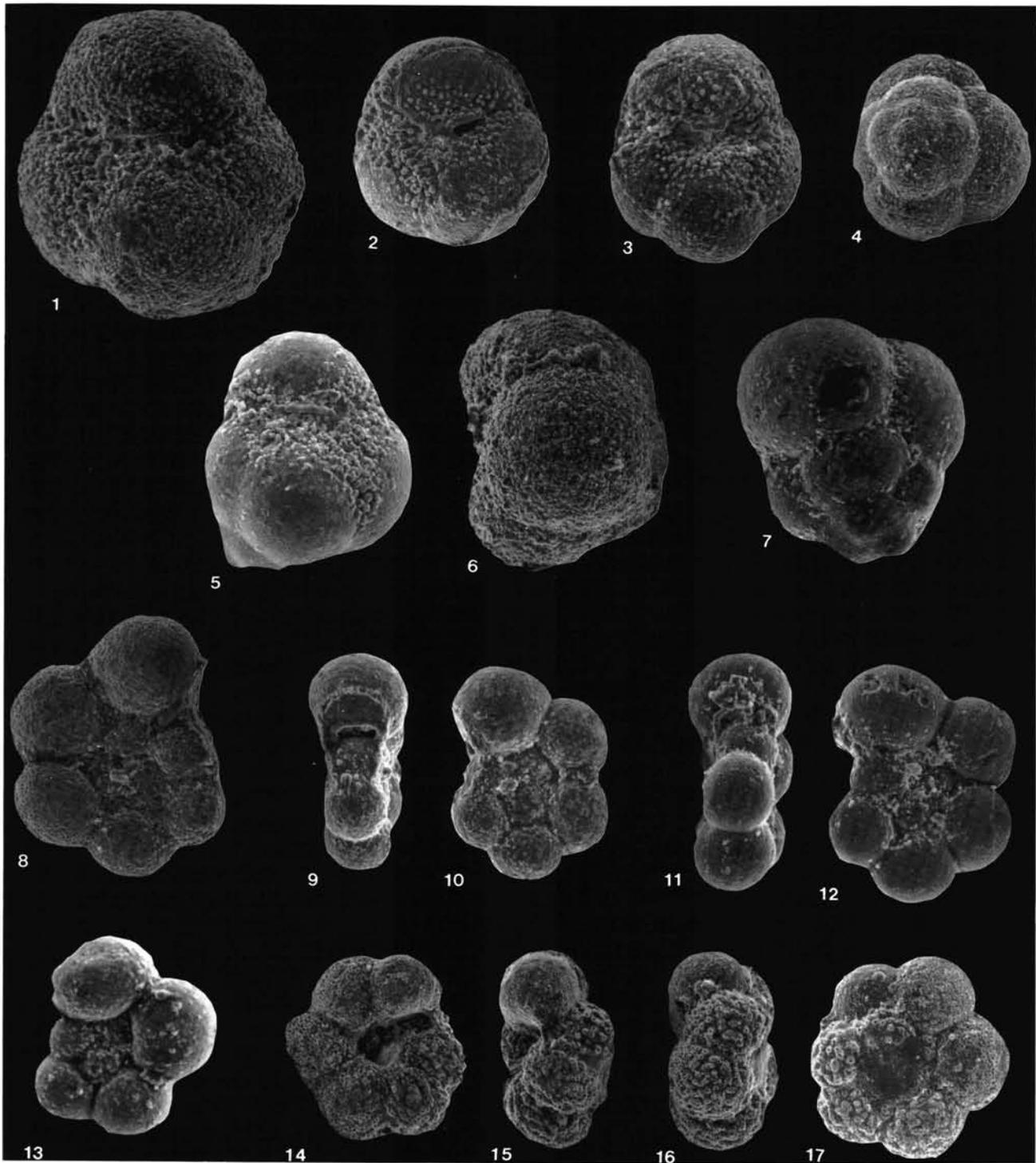


Plate 1. Figures 1-13, $\times 300$; Figures 14-17, $\times 200$. 1-7. *Gubkinella graysonensis* (3-4) Sample 113-693A-47R-2, 22-26 cm, (2) Sample 113-693A-47R-2, 30-34 cm, (1, 6) Sample 113-693A-48R-2, 8-12 cm, (5, 7) Sample 113-693A-48R-3, 62-66 cm. 8-13. *Globigerinelloides* aff. *G. blowi* group, Sample 113-693A-48R-2, 8-12 cm. 14-17. *Hedbergella* aff. *H. trocoidea*, Sample 113-693A-47R-2, 22-26 cm.

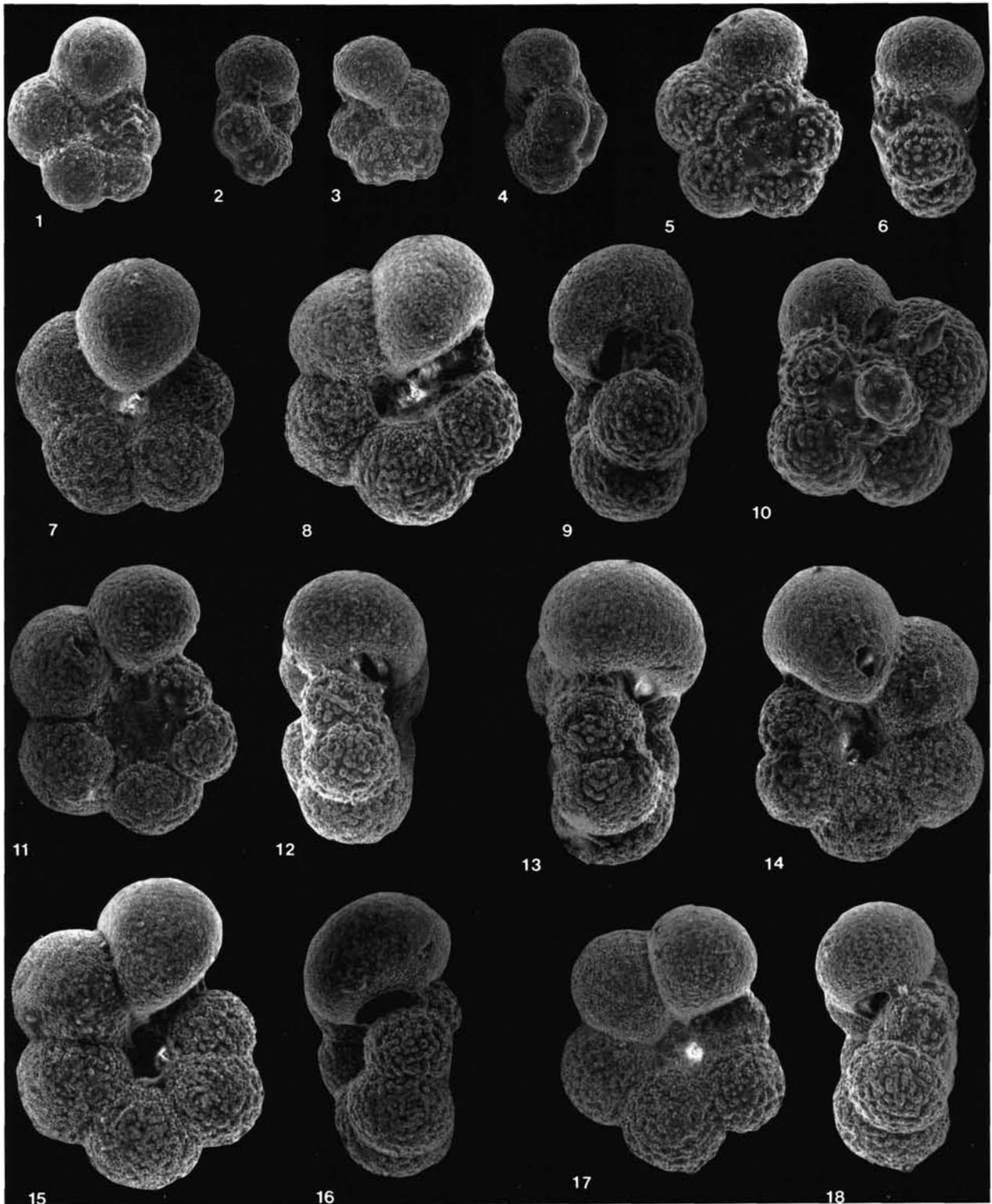


Plate 2. All figures $\times 200$. 1-18. *Hedbergella* aff. *H. infracretacea* group. (7-9, 11-18) Sample 113-693A-47R-2, 22-26 cm, (10) Sample 113-693A-47R-2, 30-34 cm, (1-6) Sample 113-693A-48R-2, 8-12 cm.