

**DIAGNOSTIC CHARACTERS.**—Test wall microperforate; aperture marked by a thin lip. Apertural position and height somewhat variable. Biserial portion of test distinctly twisted, although less so than *W. claytonensis*. *Woodringina hornerstownensis* distinguished from *W. claytonensis* by “the elongate tapering test and the almost straight sutures” (Olsson, 1960:29). *Woodringina hornerstownensis* often with six or more pairs of biserial chambers, whereas *W. claytonensis* usually limited to five or fewer.

**DISCUSSION.**—The holotype illustration and description of *Chiloguembelina taurica* Morozova, 1961, closely resembles *W. hornerstownensis* Olsson, 1960. *Chiloguembelina taurica* was originally described as being characterized by a “high narrow test, weakly compressed bilaterally, its height two to three times the width. Lateral outlines at first subtriangular, later almost parallel” (Morozova, 1961:18). The test of *C. taurica* is formed of 10–12 spheroidal chambers, and its intercameral sutures are almost straight. Although not visible in the holotype illustrations, the aperture of *C. taurica* was described as semicircular and basal (Morozova, 1961). Based on its type illustration and description, *Chiloguembelina taurica* Morozova, 1961, should be considered a possible junior synonym of *Woodringina hornerstownensis* Olsson, 1960. The holotype illustrations and descriptions of *Heterohelix gradata* Khalilov, 1967, and *Heterohelix gradata normalis* Khalilov, 1967, also closely resemble *Woodringina hornerstownensis* Olsson, 1961. *Heterohelix gradata normalis* was originally described as being characterized by an elongate “wedge-shaped [test], gradually broadening toward the obliquely trimmed-off apertural end ... chambers biserially arranged, in each offset row there are 6–8 spherical chambers. ... Aperture semilunate, much shifted from the median frontal position and shielded on one side by a moderately protruding lip” (Khalilov, 1967:173). From this description *H. gradata normalis* is indistinguishable from *W. hornerstownensis* in general test morphology. Furthermore, it appears to share the asymmetry of apertural shape and position that is diagnostic of *Woodringina* and related taxa. *Heterohelix gradata* sensu stricto was distinguished from *H. gradata normalis* by its last 4–10 chambers being much larger than the preceding chambers (Khalilov, 1967). It also appears to share the chamber shape, adult chamber arrangement, and apertural asymmetry of *W. hornerstownensis*. Given the general congruence of their original illustrations and descriptions with *W. hornerstownensis*, *Heterohelix gradata* Khalilov and *H. gradata normalis* Khalilov should be considered possible junior synonyms of *W. hornerstownensis* Olsson, 1960. The original descriptions of *H. gradata* and *H. gradata normalis* stated that the tests of these taxa are covered with large pores (Khalilov, 1967). If so, these taxa are distinguishable from *W. hornerstownensis* on the basis of wall structure. Close examination of wall structure and other relevant characters (i.e., the presence or absence of initial triseriality) in type populations of *H. gradata* and *H. gradata normalis* are necessary to conclusively define the taxonomic status of these taxa relative to *W. hornerstownensis*.

**STABLE ISOTOPES.**—Biogeographic and stable isotopic data suggest an open-ocean, warm shallow-water habitat for *W. hornerstownensis*, similar to that of *W. claytonensis* (D'Hondt and Keller, 1991; Liu and Olsson, 1992; D'Hondt and Zachos, 1993).

**STRATIGRAPHIC RANGE.**—Zone P $\alpha$  to Zone P3b.

**GLOBAL DISTRIBUTION.**—Widespread in high and low latitudes (Figure 34).

**ORIGIN OF SPECIES.**—This species is generally considered to have descended from *Guembelitra cretacea* via *W. claytonensis* (Olsson, 1970, 1982; Smit, 1977, 1982; D'Hondt, 1991; Li and Radford, 1991; Olsson et al., 1992; Liu and Olsson, 1992).

**REPOSITORY.**—Holotype (USNM 626457) deposited in the Cushman Collection, National Museum of Natural History. Unfigured paratypes deposited at Princeton University (No. 81038) and Rutgers University (No. 5026). All specimens examined by SD, CL, and RKO.

### Family CHILOGUEMBELINIDAE Reiss, 1963

(by S. D'Hondt and B.T. Huber)

**ORIGINAL DESCRIPTION.**—“Trochospirally coiled with two chambers per coil arranged around an elongated axis. Test usually twisted. Aperture single, an interiomarginal asymmetrical low to high arch, bordered by an asymmetrically situated flap which is often protruding and platelike, or terminal, situated on a short neck. No distinct toothplates. Ornamentation if present consisting of inflational papillae or short spines.” (Reuss, 1963:55.)

**DIAGNOSTIC CHARACTERS.**—Small test comprised of biserially arranged chambers, often with a slightly twisted coiling axis. Intercameral sutures distinct, depressed, and often somewhat oblique. Wall calcareous and microperforate with smooth to pustulous surface texture. Aperture arched, rimmed by narrow lip, and generally infolded on one side of ultimate chamber. Many *Chiloguembelina* species with well-developed flap or flange bordering aperture along infolded side.

**DISCUSSION.**—As noted in the discussion of the Guembelitriidae, the Chiloguembelinidae appears to be a monophyletic or paraphyletic family descended from *Guembelitra cretacea* via *Woodringina claytonensis* (Olsson, 1970, 1982; Premoli Silva, 1977; Smit, 1982; D'Hondt, 1991; Li and Radford, 1991; Liu and Olsson, 1992; Olsson et al., 1992). It is generally believed that this family was monophyletic throughout the Paleocene. Its post-Paleocene status is less clear, as the relationships of *Chiloguembelina* to such late Paleogene and Neogene taxa as *Streptochilus* Brönnimann and Resig, 1971, and *Cassigerinella* Pokorný, 1955, is presently uncertain.

Reiss (1963) originally assigned both *Chiloguembelina* and *Zeauvigerina* to the Chiloguembelinidae. Given the Late Cretaceous occurrence of *Zeauvigerina* (Huber and Boersma, 1994) and the earliest Paleocene derivation of *Chiloguembelina* from a guembelitriid ancestor, retention of this assignment

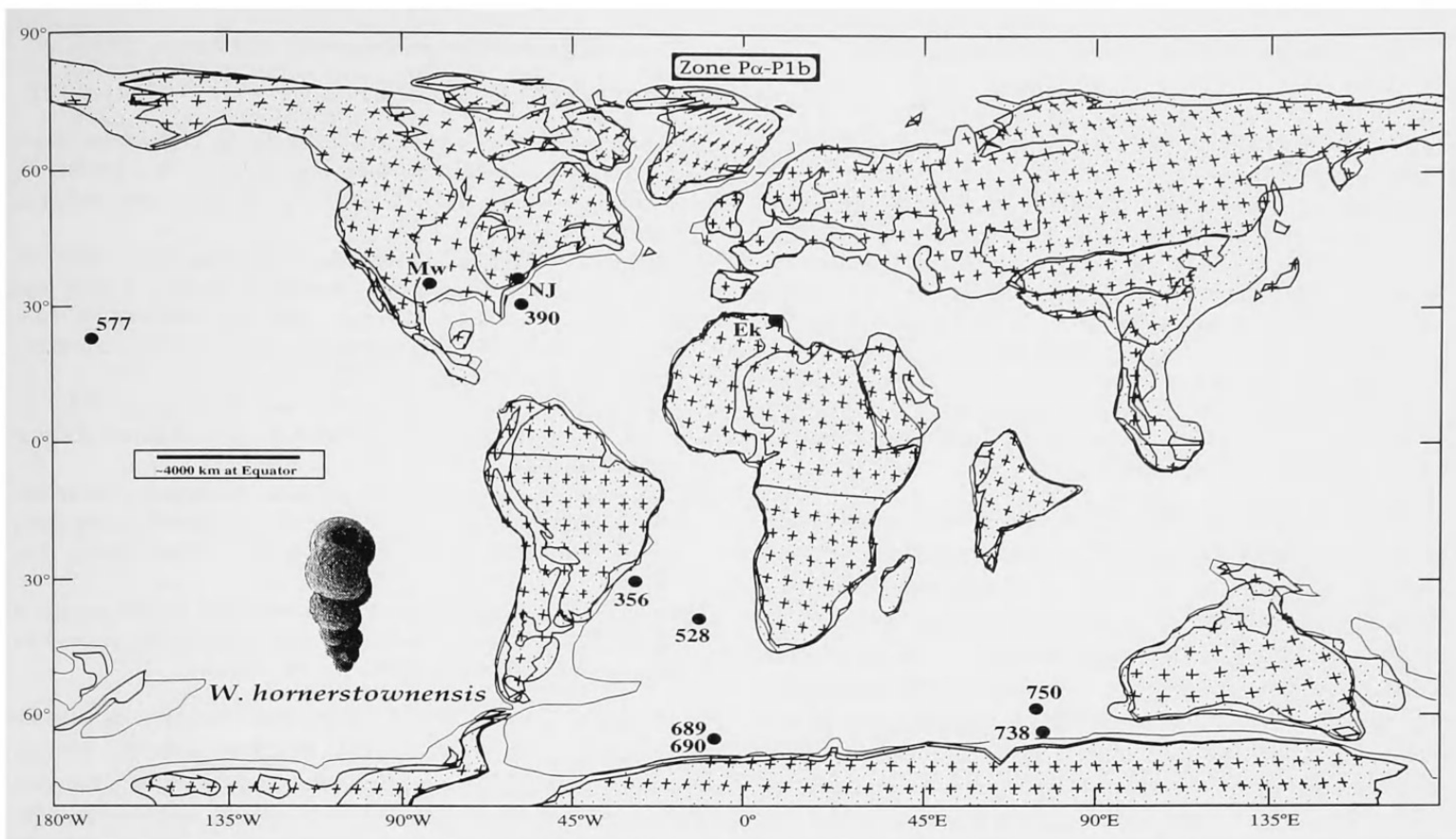


FIGURE 34.—Paleobiogeographic map showing distribution of *Woodringina hornerstownensis* Olsson in Zones P1 to P3.

would render the Chiloguembelinidae a polyphyletic group. On these grounds, *Zeauvigerina* should no longer be assigned to the Chiloguembelinidae.

### Genus *Chiloguembelina* Loeblich and Tappan, 1956

TYPE SPECIES.—*Chiloguembelina midwayensis* (Cushman, 1940).

ORIGINAL DESCRIPTION.—“Test free, flaring; inflated chambers biserially arranged, with a tendency to become somewhat twisted; sutures distinct, depressed; wall calcareous, finely perforate, radial in structure, surface smooth to hispid; aperture a broad low arch bordered with a pronounced neck-like extension of the chamber; commonly this forms a more strongly developed flap at one side, so that the aperture appears to be directed toward one of the flat sides of the test.” (Loeblich and Tappan, 1956:340.)

DIAGNOSTIC CHARACTERS.—The original description is diagnostic of many *Chiloguembelina* species (i.e., *Chiloguembelina midwayensis* (Cushman, 1940), *C. crinita* (Glaessner, 1937b), and *C. morsei* (Kline, 1943)). The diagnostic characters of *Chiloguembelina* species include the microperforate surface texture, slight twisting of the coiling axis, and infolding of the apertural lip on one side. The apertural flap noted by Loeblich and Tappan (1956) and Reiss (1963) characterizes *C.*

*midwayensis* and closely related taxa (*C. morsei* and *C. crinita*). This flap is located on the apertural side that is not infolded and results from extension of the apertural lip (and its trailing chamber wall) over the preceding chamber. The apertural infolding and opposing flap render the chiloguembelinid aperture distinctly asymmetric with respect to the plane of biserial symmetry. This apertural asymmetry and twisting of the coiling axis are much reduced in the late Paleocene taxa *Chiloguembelina trinitatensis* (Cushman and Renz, 1942) and *Chiloguembelina wilcoxensis* (Cushman and Ponton, 1932). Apertural asymmetry is variably expressed in *C. wilcoxensis*; although apertural asymmetry occurs in early ontogeny, the apertures of terminal chambers appear to be symmetric in some *C. wilcoxensis* specimens and asymmetric in others (Plate 70: Figures 11, 12, 16, 17).

DISCUSSION.—The microperforate surface texture, apertural asymmetry, and twisted coiling axis are the primary features that unite *Chiloguembelina* species with woodringinids and other Paleocene descendants of *Guembelitra cretacea*. The biserial first whorl of *Chiloguembelina* species distinguishes them from *Woodringina* species.

Beckmann (1957) proposed that *Gümbelina trinitatensis* Cushman and Renz and *Gümbelina wilcoxensis* Cushman and Ponton descended from *Chiloguembelina crinita* (Glaessner). On this basis, Beckmann (1957) assigned *trinitatensis* and *wilcoxensis* to the genus *Chiloguembelina*.



*Chiloguembelina crinita* (Glaessner, 1937)

PLATE 69: FIGURES 1–8

*Gümbelina crinita* Glaessner, 1937b:383, pl. 4: fig. 34a,b [Paleocene, beds from Gorjatschij Kljutsch].

*Chiloguembelina crinita* (Glaessner).—Beckmann, 1957:89, text-figs. 14 (1–4), pl. 21: fig. 4a,b [*Globorotalia pseudomenardii* and *Globorotalia velascoensis* Zones (Zones P4 and P5), lower Lizard Springs Fm., Trinidad].—Loeblich and Tappan, 1957a:178, pl. 49: fig. 1 [upper Paleocene, Hornerstown Fm., New Jersey], pl. 51: figs. 1a–3 [Vincentown Fm., New Jersey], pl. 56: fig. 1a,b [Aquia Fm., Maryland], pl. 60: fig. 6 [Nanafalia Fm., Alabama], pl. 62: fig. 1 [Velasco Fm., Mexico].—MacLeod, 1993:66, pl. 6: figs. 1, 2, 5, 6 [lower Zone P6, ODP Hole 738C/10R/4: 34–36 cm; Kerguelen Plateau, southern Indian Ocean]. [Not Huber, 1991b:448, pl. 6: figs. 2, 3; 1991c:461, pl. 2: figs. 3, 4.]

ORIGINAL DESCRIPTION.—“Test small, built up with about 10–15 spherical or oval-shaped, distinct, separated chambers. The spire of the initial chambers in existing specimens is not distinctly recognizable. The ratio of chamber width to the length varies strongly. The largest diameter of the last chamber is offset from the biserial plane. Consequently, the last chamber diagonally overlies the previous one, the median suture on both sides are not opposite each other and the test appears thereby somewhat distorted. The aperture opens not in the usual case towards the edge of the test, but in a direction which lies between the edge and the side of the test. In extreme cases, it is directed even along the suture of the last chamber in side view. The aperture is moderate in width, but high, half rounded and enclosed along the margin. The test surface in many specimens is covered by fine granulations, but in spite of their minuteness especially on the periphery, [there are] distinctly visible sharp tiny protuberances.

“Measurements.—length 0.17–0.22 mm.; width 0.10–0.15 mm.; thickness 0.05–0.1 mm.” (Glaessner, 1937b:383; translated from German.)

DIAGNOSTIC CHARACTERS.—Test biserial throughout, exhibiting characteristic chiloguembelinid apertural asymmetry; aperture marked by narrow lip, infolded on one side, and expanded into distinct apertural flange on opposite side. As noted by Beckmann (1957) and Loeblich and Tappan (1957a), later chambers subglobular. Sutures distinct and depressed. Test microperforate and last chambers finely hispid.

DISCUSSION.—The later chambers of *Chiloguembelina crinita* specimens are much higher and more inflated than those of *C. midwayensis* and *C. morsei*. These differences are readily observable, as late-stage chambers of *C. crinita* appear subglobular in edge and plan views.

STABLE ISOTOPES.—No data available.

STRATIGRAPHIC RANGE.—Lower Zone P4 to lower Zone P6.

GLOBAL DISTRIBUTION.—Cosmopolitan.

ORIGIN OF SPECIES.—*Chiloguembelina crinita* is believed to have evolved from *C. midwayensis* (Beckmann, 1957).

REPOSITORY.—Holotype deposited in the Collections of the Institute for Fuel-Research of the Academy of the Sciences of Russia (Paleontology Division), Moscow.

*Chiloguembelina midwayensis* (Cushman, 1940)

FIGURE 35; PLATE 13: FIGURES 9, 10, 12, 13; PLATE 69: FIGURES 16–22

*Gümbelina midwayensis* Cushman, 1940:65, pl. 11: fig. 15 [Paleocene, Sumter Co., Alabama].—Cushman and Todd, 1946:58, pl. 10: fig. 15 [Paleocene, Arkansas].—Cushman, 1951:37, pl. 11: figs. 7, 8 [Paleocene, Alabama, Arkansas, and Texas].

*Chiloguembelina midwayensis* (Cushman).—Loeblich and Tappan, 1957a:179, pl. 41: fig. 3 [Danian, Clayton Fm., Alabama], pl. 43: fig. 7a,b [Wills Point Fm., Texas], pl. 45: fig. 9a,b [Porters Creek Clay, Alabama].—D'Hondt, 1991:173, pl. 2: fig. 13 [Zone P4, DSDP Site 528/31/CC: 14–15 cm; Walvis Ridge, South Atlantic Ocean], fig. 14 [Zone P4, DSDP Site 577/12/5: 34–36 cm; Shatsky Rise, northwestern Pacific Ocean]. [Not Olsson, 1970:601, pl. 91: fig. 8.—MacLeod, 1993:66, pl. 6: figs. 3, 4, 7–10.—Huber and Boersma, 1994:282, pl. 3: fig. 3a–d.]

*Chiloguembelina midwayensis midwayensis* (Cushman).—Beckmann, 1957:90, text-fig. 14 (24–27), pl. 21: fig. 1a,b [*Globorotalia trinidadensis* through *Globorotalia velascoensis* Zones, lower Lizard Springs Fm., Trinidad].

*Chiloguembelina midwayensis strombiformis* Beckmann, 1957:90, text-fig. 14 (28–31), pl. 21: fig. 6a–c [*Globorotalia pseudomenardii* and *Globorotalia velascoensis* Zones, lower Lizard Springs Fm., Trinidad].

ORIGINAL DESCRIPTION.—“Test small, compressed, usually twice as long as broad, rapidly tapering, with the greatest breadth formed by the last pair of chambers, periphery rounded throughout, lobulate; chambers with breadth and height about equal, slightly overlapping, inflated, increasing rapidly in height as added; sutures distinct, depressed, very slightly curved, wall finely spinose; aperture high, arched, with distinct lateral flanges [sic]. Length 0.18–0.22 mm.; breadth 0.10–0.12 mm.; thickness 0.05 mm.” (Cushman, 1940:65.)

DIAGNOSTIC CHARACTERS.—Test small, compressed in thickness (depth), and rapidly tapering. Early chambers subspherical, successive chambers increase more rapidly in breadth than in height. Late-stage chambers cross the coiling axis and overlap immediately preceding chamber. In holotype, overlap so pronounced that maximum breadth of final chamber nearly equal to maximum breadth of test (Plate 13: Figures 9, 10). Holotype's surface covered with numerous small pustules; however, last two chambers contain few pustules. Contrary to the original description, aperture of each chamber with only one distinct lateral flange (the chiloguembelinid “flap” of Loeblich and Tappan, 1956) (Plate 69: Figures 16–22).

DISCUSSION.—*Chiloguembelina midwayensis strombiformis* Beckman, 1957, was erected as a Paleocene subspecies of *Chiloguembelina midwayensis* (Cushman, 1940). The chambers of the *C. midwayensis strombiformis* holotype (Plate 13: Figures 12, 13) expand much more rapidly in depth (thickness) than do those of *C. midwayensis* sensu stricto; in late-stage chambers of *C. midwayensis* sensu stricto, chamber breadth consistently exceeds chamber depth.

STABLE ISOTOPES.—The stable isotopic signature of *C. midwayensis* suggests that this species inhabited a deeper-water or cooler-season habitat than most co-occurring taxa (Boersma and Premoli Silva, 1983; D'Hondt and Zachos, 1993).

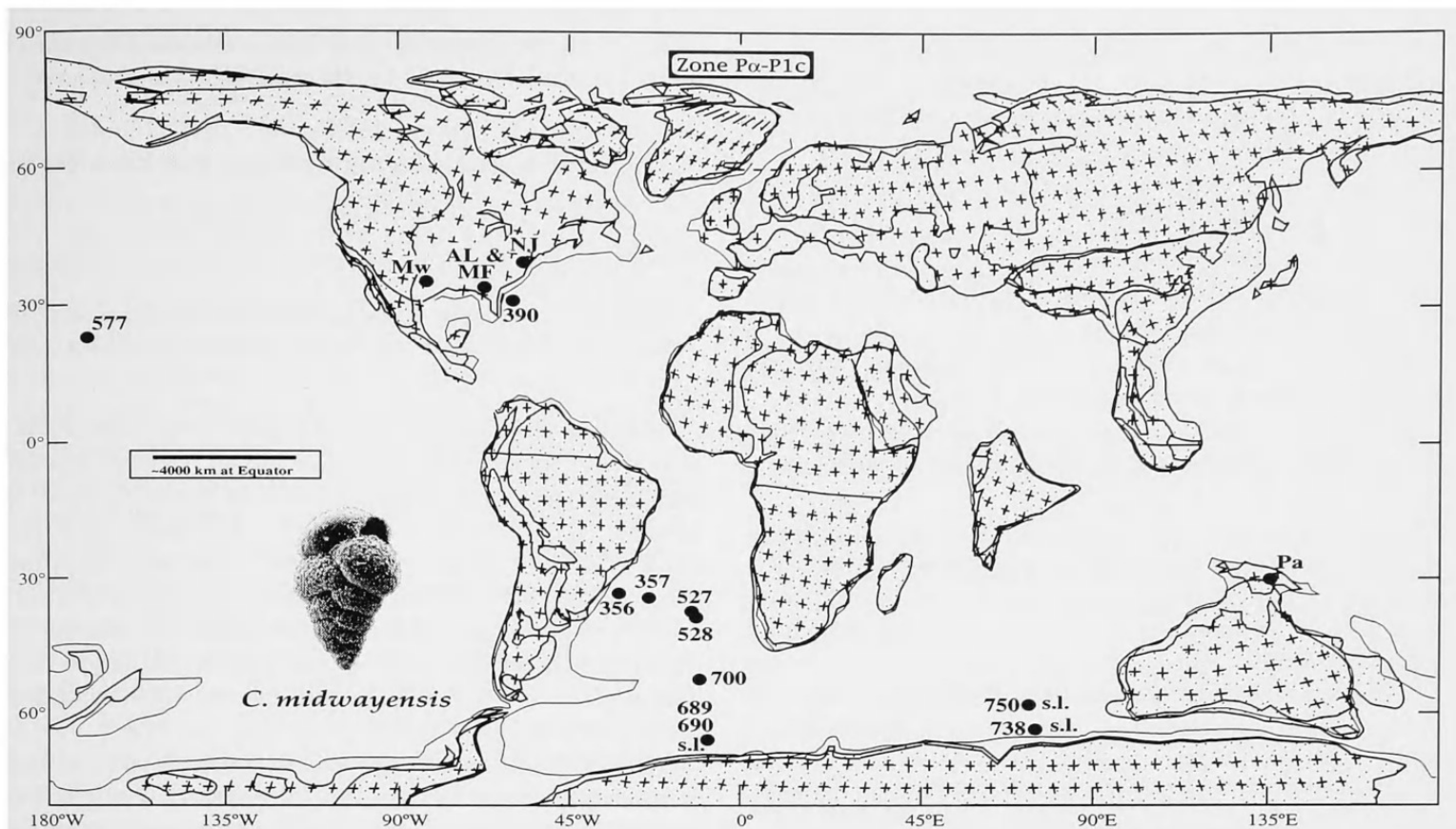


FIGURE 35.—Paleobiogeographic map showing distribution of *Chiloguembelina midwayensis* (Cushman) in the Danian. “s.l.” refers to sensu lato forms found at high latitude sites.

**STRATIGRAPHIC RANGE.**—Zone P $\alpha$  (D’Hondt, 1991) to Zone P5 (Beckman, 1957; Boersma, 1984b).

**GLOBAL DISTRIBUTION.**—*Chiloguembelina midwayensis* occurred at low and middle latitudes (Beckmann, 1957; Boersma, 1984b; D’Hondt and Keller, 1991; Liu and Olsson, 1992) (Figure 35).

**ORIGIN OF SPECIES.**—*Chiloguembelina midwayensis* evolved from *C. morsei* (Kline) (D’Hondt, 1991).

**REPOSITORY.**—Holotype (USNM CC35715) deposited in the Cushman Collection, National Museum of Natural History. Examined by SD, BTH, CL, and RKO.

### *Chiloguembelina morsei* (Kline, 1943)

PLATE 13: FIGURES 14, 15; PLATE 69: FIGURES 9–15

*Gümbelina morsei* Kline, 1943:44, pl. 7: fig. 12 [Danian, Porters Creek Clay, Clay Co., Mississippi].

*Chiloguembelina morsei* (Kline).—Loeblich and Tappan, 1957a:179, pl. 40: fig. 2a,b [Danian, Erslev, Mors, Denmark], pl. 41: fig. 4 [Clayton Fm., Alabama], pl. 42: fig. 1a,b [Brightseat Fm., Maryland], pl. 43: fig. 2 [Kincaid Fm., Texas], pl. 43: fig. 6a,b [Wills Point Fm., Texas]. [Not Huber, 1991a:448, pl. 6: figs. 6, 7.]

*Chiloguembelina midwayensis* (Cushman).—MacLeod, 1993:66, pl. 6: figs. 3, 4 [Danian, DSDP Hole 577A/12/2: 44–46 cm; Shatsky Rise, northwestern Pacific Ocean].

**ORIGINAL DESCRIPTION.**—“Test small, about twice as long

as broad, regularly tapering, with greatest breadth at apertural end, periphery rounded and lobulate; chambers with breadth greater than height, inflated, increasing rapidly in size, especially in breadth; sutures distinct, depressed; wall finely but distinctly spinose; aperture high, arched, with distinct lateral flanges [sic].” (Kline, 1943:44.)

**DIAGNOSTIC CHARACTERS.**—Test biserial throughout. Sutures distinct and depressed; basal sutures separating earliest chambers subhorizontal, those separating later chambers oblique. Successive chambers overlap, particularly in late ontogeny. Initial chambers subspherical. Chamber breadth increases more rapidly than chamber depth, with successive chambers exhibiting a greater breadth to depth ratio than predecessor, consequently, maximum breadth of each late-stage chamber greater than its maximum depth. Surface of holotype test marked by numerous small pustules; pustules less abundant on final chambers. Aperture of each chamber exhibiting only one distinct lateral flange.

**DISCUSSION.**—The gross morphology of *Chiloguembelina morsei* is very similar to that of *Chiloguembelina midwayensis*. Loeblich and Tappan (1957a) suggested that *C. morsei* can be distinguished from *C. midwayensis* sensu stricto by the former’s narrower test, more globular chambers, and more deeply constricted sutures. The two taxa are most readily distinguished by the narrowness of their tests; the chambers of



*C. morsei* expand less rapidly in breadth than those of *C. midwayensis*. Consequently, the periphery of the former defines a more acute angle ( $\sim 50^\circ$ ) than that of the latter ( $\sim 60^\circ$ ). Forms intermediate between *C. morsei* and *C. midwayensis* have been illustrated as *C. midwayensis* by D'Hondt (1991:173, pl. 2: figs. 13, 15).

STABLE ISOTOPES.—No data available.

STRATIGRAPHIC RANGE.—Zone P $\alpha$  (D'Hondt, 1991) to Subzone P1c (Boersma, 1984b).

GLOBAL DISTRIBUTION.—Low and middle latitudes (Boersma, 1984b; D'Hondt and Keller, 1991).

ORIGIN OF SPECIES.—*Chiloguembelina morsei* evolved from a *Woodringina* species in Zone P $\alpha$  (D'Hondt, 1991; Liu and Olsson, 1992).

REPOSITORY.—Holotype (USNM 487301) deposited in the Cushman Collection, National Museum of Natural History. Examined by SD, BTH, and RKO.

### *Chiloguembelina subtriangularis* Beckmann, 1957

PLATE 13: FIGURES 17, 18; PLATE 70: FIGURES 1–7

*Chiloguembelina subtriangularis* Beckmann, 1957:91, text-fig. 15 (39–42), pl. 21: fig. 5a,b [Paleocene, *Globorotalia pusilla pusilla* Zone, lower Lizard Springs Fm., Trinidad].—Said and Kerdany, 1961:331, pl. 2: fig. 6 [Paleocene, lower part of Esna Shale, Farafra Oasis, Egypt].

ORIGINAL DESCRIPTION.—“Test small, subtriangular, pointed at the base, compressed, with a subangular periphery. Chambers biserial, very slightly inflated. Sutures nearly horizontal, slightly depressed, at least in the later stages. Wall smooth. Aperture commonly slightly eccentric, semicircular to subquadrangular, may have a slight collar.” (Beckmann, 1957:91.)

DIAGNOSTIC CHARACTERS.—Test small, biserial with a subangular periphery, subtriangular in side view. Chambers increasing nearly twice as rapidly in breadth than in height, slightly inflated, successive chambers slightly overlapping previous chambers, sutures somewhat depressed and nearly straight, forming a low angle with the growth axis. Aperture a low, asymmetrically positioned, interiomarginal arch surrounded by a lip that narrows toward center of chamber. Length 140–220  $\mu\text{m}$ .

DISCUSSION.—This species is easily distinguished from other chiloguembelinids by its subtriangular test with a subangular periphery.

STABLE ISOTOPES.—No data available.

STRATIGRAPHIC RANGE.—Zone P1c to Zone P3.

GLOBAL DISTRIBUTION.—Reported from the low to middle latitudes worldwide.

ORIGIN OF SPECIES.—Beckmann (1957) suggested that *C. subtriangularis* descended from *C. midwayensis* during the Paleocene.

REPOSITORY.—Holotype (USNM P5783), figured paratypes (USNM P5784A–D), and unfigured paratypes (USNM P5785)

deposited in the Cushman Collection, National Museum of Natural History. Examined by SD and BTH.

### *Chiloguembelina trinitatensis* (Cushman and Renz, 1942)

PLATE 13: FIGURES 11, 16; PLATE 70: FIGURES 8–10, 14

*Gümbelina trinitatensis* Cushman and Renz, 1942:8, pl. 2: fig. 8 [Paleocene, Soldado Fm., Trinidad].

*Chiloguembelina trinitatensis* (Cushman and Renz).—Beckmann, 1957:91, text-fig. 15 (43–45), pl. 21: fig. 7a,b [*Globorotalia velascoensis* Zone, Lizard Springs Fm., Trinidad].

ORIGINAL DESCRIPTION.—“Test slightly longer than broad, moderately compressed, rapidly tapering, greatest breadth formed by the last-formed pair of chambers, periphery rounded, lobulate; chambers with breadth and height about equal, the last-formed pair in the adult usually much larger than the remainder of the test; sutures distinct, depressed, straight, nearly at right angles to the elongate axis; wall smooth or slightly hispid, aperture high, arched. Length of holotype 0.27 mm; breadth 0.20 mm; thickness 0.15 mm.” (Cushman and Renz, 1942:8.)

DIAGNOSTIC CHARACTERS.—Distinguished by biserial test with chambers increasing uniformly in breadth and height, and symmetrically centered, low-arched aperture surrounded by narrow, equidimensional lip.

DISCUSSION.—The holotype of this species differs from *C. crinita* by having an aperture that is symmetrically positioned on the chamber face, and it differs from *C. wilcoxensis* by its smaller size and slower, more continuous chamber-size increase. The holotype has been extensively recrystallized so the primary wall texture is difficult to discern.

STABLE ISOTOPES.—No data available.

STRATIGRAPHIC RANGE.—Zone P5 to lower Zone P6a. In Trinidad, Beckman (1957) recorded *C. trinitatensis* only in the *Morozovella velascoensis* Zone (= Zone P5), but observations by BTH suggest it ranges from Zone P5 to Zone P6a at DSDP Site 152.

GLOBAL DISTRIBUTION.—Reported primarily from low-latitude, near-shore marine sections.

ORIGIN OF SPECIES.—Beckmann (1957) suggested that *C. trinitatensis* descended from *C. crinita* during the Paleocene, but see discussion under *C. wilcoxensis*.

REPOSITORY.—Holotype (USNM CC38198) deposited in the Cushman Collection, National Museum of Natural History. Examined by BTH.

### *Chiloguembelina wilcoxensis* (Cushman and Ponton, 1932)

PLATE 13: FIGURES 19, 20; PLATE 70: FIGURES 11–13, 15–18

*Gümbelina wilcoxensis* Cushman and Ponton, 1932:66, pl. 8: figs. 16, 17 [lower Eocene, Wilcox Fm., Ozark, Alabama].

*Chiloguembelina wilcoxensis* (Cushman and Ponton).—Beckmann, 1957:92, text-fig. 15 (49–58), pl. 21: figs. 10, 12, 13 [upper Paleocene to lower Eocene, Lizard Springs Fm., Trinidad].—Huber, 1991b:440, pl. 6: figs. 4, 5

[Zone AP6a, early Eocene, ODP Hole 738C/8R: 264.35 mbsf, Kerguelen Plateau, southern Indian Ocean].

**ORIGINAL DESCRIPTION.**—"Test biserial, periphery broadly rounded; chambers distinct, much inflated, increasing very rapidly in the adult so that the last four chambers make up a very considerable amount of the entire test; sutures distinct, depressed; wall distinctly papillate throughout; aperture a low opening at the base of the last-formed chamber in the median line. Length 0.45 mm; breadth 0.35 mm; thickness 0.25 mm." (Cushman and Ponton, 1932:66.)

**DIAGNOSTIC CHARACTERS.**—Distinguished by large test size, broadly rounded periphery, rapid chamber-size increase in initial portion of test, and symmetrically centered, low-arched to semicircular aperture surrounded by an equidimensional lip.

**DISCUSSION.**—The final chamber in adult *Chiloguembelina wilcoxensis* may be normalform to strongly kummerform. The aperture on the final chamber may be a symmetrical low to moderately high semicircular arch, centered on the chamber face, and bordered by an equidimensional lip (Plate 70: Figures 11, 12), or they may be slightly asymmetrical, off-centered on the final chamber face, and bordered by an inequidimensional lip that is slightly infolded on one side (Plate 70: Figure 16).

The symmetrical shape and positioning of the aperture and equidimensional bordering lip on adult specimens of *C. wilcoxensis* are reminiscent of the Cretaceous Heterohelidae. Dissection of adult tests with symmetrical apertures in the center of the final chamber, however, reveal that the apertures on pre-adult chambers are asymmetrical in position and shape and the bordering lip is infolded on one side (Plate 70: Figure 12). Apertural asymmetry in early ontogeny is taken to represent a primitive feature shared with the *chiloguembelinid* stock, whereas apertural symmetry in adult specimens is considered a derived character that first appeared in *C. trinitatis*. *Chiloguembelina wilcoxensis* differs from this species by its larger, less tapering test.

**STABLE ISOTOPES.**—No data available.

**STRATIGRAPHIC RANGE.**—Zone P4 to Zone P6a. The FAD of *C. wilcoxensis* is not well-constrained in published deep-sea records because many authors have not differentiated the *chiloguembelinid* species. In Trinidad, Beckmann (1957) recorded the FAD of *C. wilcoxensis* in the *Globorotalia pseudomenardii* Zone (= Zone P4), with an uncertain occurrence within the lower part of this zone, and the LAD at the top of the *Globorotalia velascoensis* Zone (= Zone P5). Observations by BTH of high-latitude samples from ODP Sites 698, 700, and 738 indicate that the FAD of this species is in the middle of Zone AP4 (~Zone P4) and its LAD in Zone AP6a (~Zone P6a).

**GLOBAL DISTRIBUTION.**—Reported from low to high latitudes worldwide.

**ORIGIN OF SPECIES.**—Although Beckmann (1957) suggested that *C. wilcoxensis* descended from *C. crinita* during the late Paleocene, it is more likely that *C. wilcoxensis* was derived

from *C. trinitatis* during the late Paleocene because *C. wilcoxensis* and *C. trinitatis* are more similar morphologically, and the study of Caribbean DSDP Site 152 indicates that the first occurrence of *C. trinitatis* is older than that of *C. wilcoxensis* (B. Huber, pers. observ., 1995). Both species have a similar pustulose wall texture suggesting that they are phylogenetically related (Plate 70, compare Figures 14 and 18).

**REPOSITORY.**—Holotype (USNM 16218) deposited in the Cushman Collection, National Museum of Natural History. Examined by BTH.

## Family HETEROHELICIDAE Cushman, 1927

(by B.T. Huber)

**ORIGINAL DESCRIPTION.**—"Test in the more primitive forms planospiral in the young, later becoming biserial, in the more specialized genera the spiral stage and even the biserial stage may be wanting and the relationships shown by other characters; wall calcareous, perforate, ornamentation in higher genera bilaterally symmetrical; aperture when simple, usually large for the size of the test, without teeth, in some forms with apertural neck and phialine lip." (Cushman, 1927:59.)

**DIAGNOSTIC CHARACTERS.**—Test with biserial arrangement of alternating chambers, final arrangement either multiple or uniserial; chambers, globular to ovoid in shape; wall smooth or striated with fine to coarse parallel ridges; aperture, a low, symmetrical arch, usually at base of ultimate chamber, may be terminal, may have accessory sutural apertures.

**DISCUSSION.**—Only simple, biserial forms survived into the Cenozoic. The latter portion of the test often becomes uniserial.

## Genus *Rectoguembelina* Cushman, 1932

**TYPE SPECIES.**—*Rectoguembelina cretacea* Cushman, 1932.

**ORIGINAL DESCRIPTION.**—"Test with the early chambers arranged in a biserial manner similar to *Guembelina*, later chambers uniserial and rounded in transverse section; chambers all inflated, distinct; sutures distinct, depressed; wall calcareous, thin, very finely perforate; aperture in the early stages similar to *Guembelina* in the adult terminal, rounded, with a distinct neck." (Cushman, 1932:6.)

**DIAGNOSTIC CHARACTERS.**—Transition from biserial to uniserial portion of test very abrupt, occurring after first four or more pairs of biserial chambers, without an intervening interval of gradually increasing chamber overlap. Apertures on biserial portion interiomarginal with a small, narrow arch; apertures on uniserial chambers terminal, circular, and aligned in rectilinear fashion, without lip or toothplate. Wall calcareous, microperforate; surface smooth to finely pustulose.

**DISCUSSION.**—Glaessner (1936) and Montanaro Gallitelli (1957) considered *Rectoguembelina* to be a junior synonym of *Tubitextularia* Sulc (type species = *Pseudotextularia bohémica* Sulc, 1929), whereas Loeblich and Tappan (1964, 1988)



## PLATE 13

### USNM Primary Type Specimens

(bars = 50  $\mu$ m)

FIGURE 1.—*Rectogümbelina cretacea* Cushman, 1932, holotype, USNM CC16308; upper Maastrichtian, Arkadelphia Clay, Hope, Arkansas.

FIGURE 2.—*Tubitextularia laevigata* Loeblich and Tappan, 1957 (= *Rectoguembelina cretacea* Cushman), holotype, USNM P5820; lower Paleocene, McBryde Limestone Mbr., Clayton Fm., Wilcox Co., Alabama.

FIGURE 3.—*Guembelitria cretacea* Cushman, 1933, holotype, USNM CC19022; upper Maastrichtian, Navarro Fm., Texas.

FIGURES 4, 5.—*Woodringina hornerstownensis* Olsson, 1960, holotype, USNM 626457; Zone P3b, Homerstown Fm., New Jersey.

FIGURES 6, 7.—*Woodringina claytonensis* Loeblich and Tappan, 1957, holotype, USNM P5685; lower Danian, Pine Barren Mbr., Clayton Fm., Alabama.

FIGURE 8.—*Woodringina kelleri* MacLeod, 1993 (= *Woodringina claytonensis* Loeblich and Tappan); Zone P $\alpha$ , DSDP Site 577A/12/2: 44–46 cm; Shatsky Rise, northwestern Pacific Ocean.

FIGURES 9, 10.—*Gümbelina midwayensis* Cushman, 1940, holotype, USNM CC35715; basal Midway Fm., Sumter Co., Alabama.

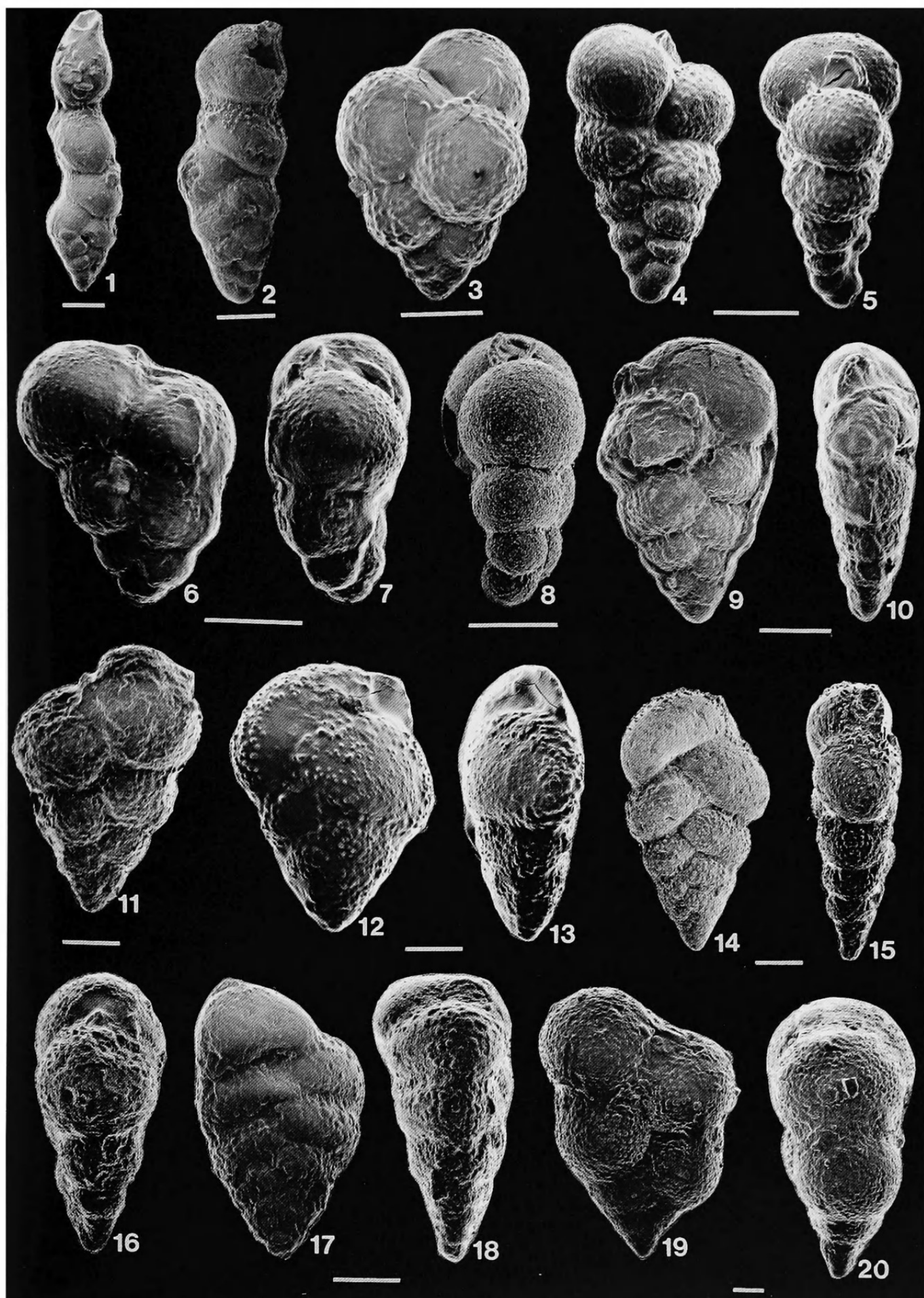
FIGURES 11, 16.—*Gümbelina trinitatis* Cushman and Renz, 1942, holotype, USNM CC38198; Paleocene, Soldado Fm., Trinidad.

FIGURES 12, 13.—*Chiloguembelina midwayensis strombiformis* Beckmann, 1957 (= *Chiloguembelina midwayensis* (Cushman)), holotype, USNM P5771; *Globorotalia pseudomenardii* Zone, Lizard Springs Fm., Trinidad.

FIGURES 14, 15.—*Gümbelina morsei* Kline, 1943, holotype, USNM 487301; Danian, Porters Creek Clay, Clay Co., Mississippi.

FIGURES 17, 18.—*Chiloguembelina subtriangularis* Beckmann, 1957, holotype, USNM P5783; *Globorotalia pusilla pusilla* Zone, lower Lizard Springs Fm., Trinidad.

FIGURES 19, 20.—*Gümbelina wilcoxensis* Cushman and Ponton, 1932, holotype, USNM 16218; Wilcox Fm., Ozark, Alabama.





**PLATE 69***Chiloguembelina crinita* (Glaessner, 1937)(Figures 1–7: bars = 50  $\mu$ m; Figure 8: bar = 10  $\mu$ m)

FIGURES 1–8.—Zone P4, Glendola Well, New Jersey, sample 230–232 feet; Figure 8, view of 2nd chamber of Figure 3 showing pustulose wall texture.

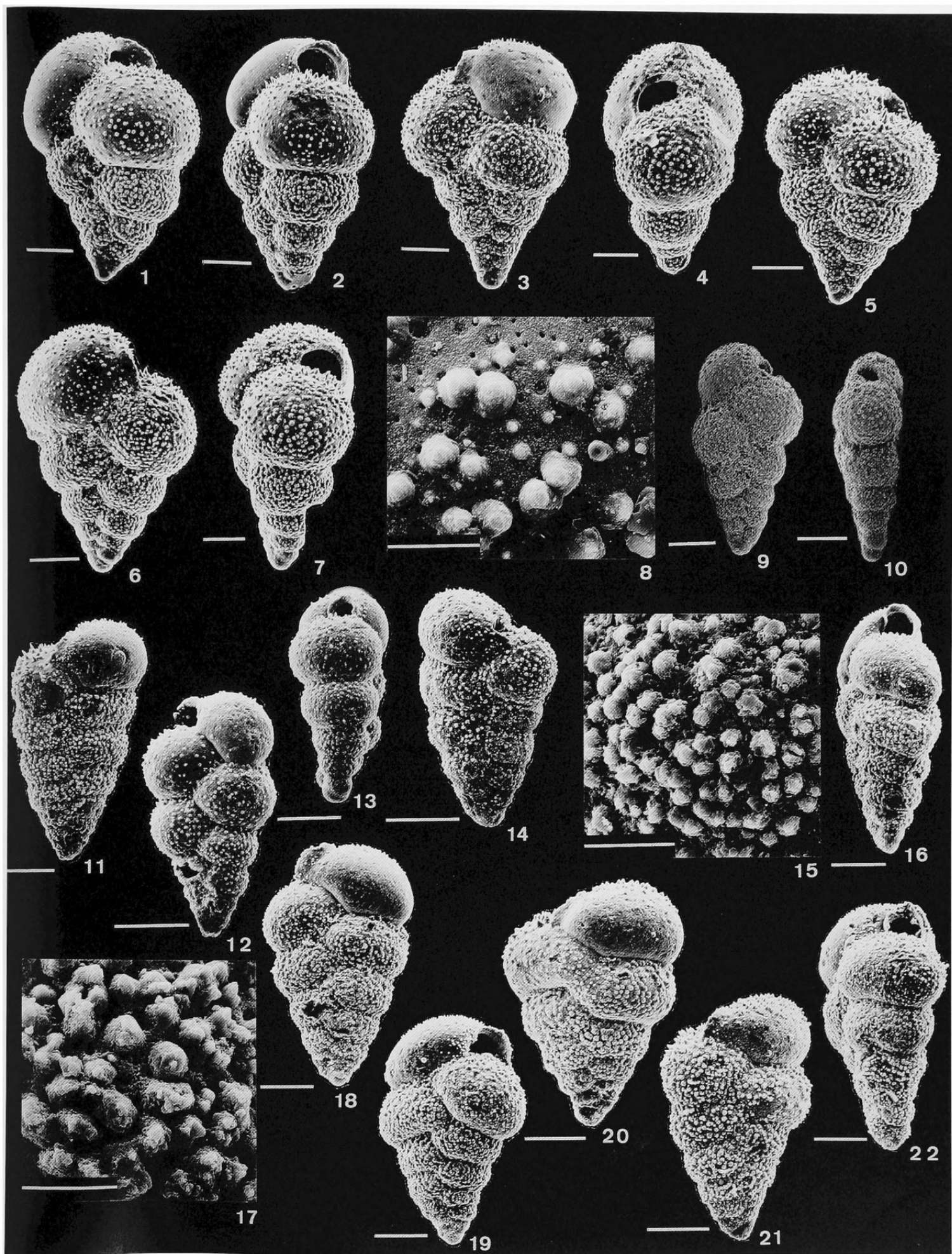
*Chiloguembelina morsei* (Kline, 1943)(Figures 9–14: bars = 50  $\mu$ m; Figure 15: bar = 10  $\mu$ m)

FIGURES 9, 10.—Danian, ODP Hole 690C/14R/1: 76–80 cm; Maud Rise, Southern Ocean.

FIGURES 11–15.—Zone P2, DSDP Site 356/25/5: 148–150 cm; São Paulo Plateau, South Atlantic Ocean; Figure 15, view of 3rd chamber of specimen showing pustulose wall texture.

*Chiloguembelina midwayensis* (Cushman, 1940)(Figures 16, 18–22: bars = 50  $\mu$ m; Figure 17: bar = 10  $\mu$ m)

FIGURES 16–22.—Zone P2, DSDP Site 356/25/5: 148–150 cm; São Paulo Plateau, South Atlantic Ocean; Figure 17, view of 3rd chamber of Figure 18 showing pustulose wall texture.





**PLATE 70***Chiloguembelina subtriangularis* Beckmann, 1957(Figures 1–3, 5–7: bars = 50  $\mu$ m; Figure 4: bar = 10  $\mu$ m)

FIGURES 1–7.—Zone P2, DSDP Site 356/25/5: 148–150 cm; São Paulo Plateau, South Atlantic Ocean; Figure 4, view of 2nd chamber of Figure 7 showing pustulose wall texture.

*Chiloguembelina trinitatis* (Cushman and Renz, 1942)(Figures 8–10: bars = 5  $\mu$ m; Figure 14: bar = 20  $\mu$ m)

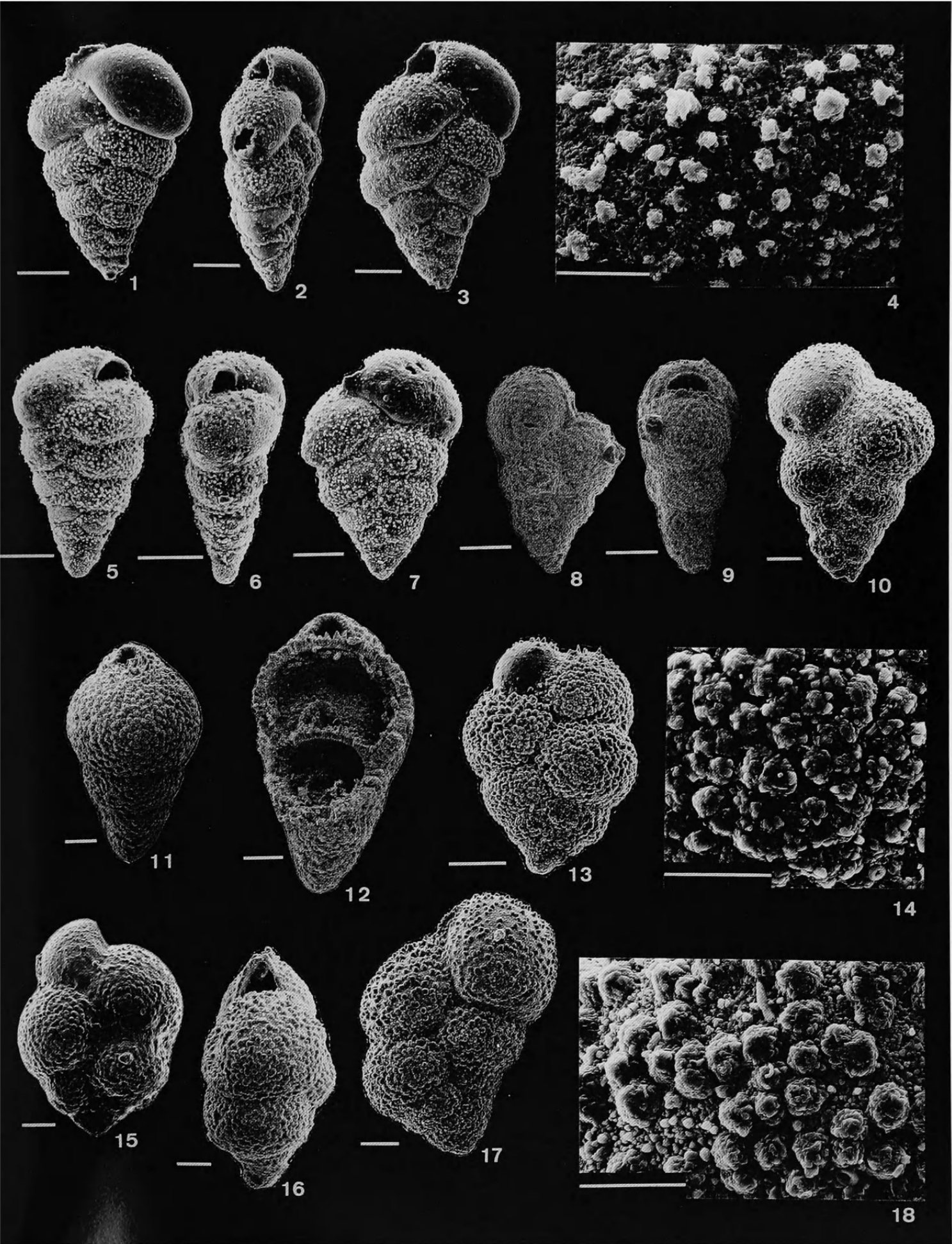
FIGURES 8, 9.—Zone P5, DSDP Site 152/4/3: 20–24 cm.

FIGURES 10, 14.—Zone P5, DSDP Site 152/4/2: 16–18 cm; Caribbean Sea; Figure 14, view of 3rd chamber of Figure 10 showing pustulose wall texture.

*Chiloguembelina wilcoxensis* (Cushman and Ponton, 1932)(Figures 11–13, 15–17: bars = 50  $\mu$ m; Figure 18: bar = 20  $\mu$ m)

FIGURES 11–13, 16–18.—Upper Paleocene, ODP Hole 690B/16X/5: 76–80 cm; Maud Rise, Southern Ocean; Figure 12, dissection of Figure 11 showing the asymmetrical position of apertures in earlier formed chambers; Figure 18, view of 2nd chamber of Figure 17 showing pustulose wall texture.

FIGURE 15.—Hypotype, specimen illustrated in Beckmann, 1957, pl. 21: fig. 13; lower Eocene, type *Globorotalia rex* Zone, Lizard Springs Fm., Trinidad.







D'Hondt, Steven and Huber, Brian T. 1999. "Family Chiloguembelinidae Reiss, 1963." *Atlas of Paleocene planktonic foraminifera* 85, 88–93.

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