47.2/10/5: 70–72 cm], pl. 77: figs. 2–5 [Zone P2, DSDP Hole 20C/6/4: 72–74 cm; Brazil Basin, South Atlantic Ocean], pl. 82: figs. 1–3 [Zone P2, recollection of *Globorotalia uncinata* type locality, Trinidad], pl. 84: fig. 2, pl. 85: fig. 9 [Zone P3, DSDP Hole 47.2/10/2: 80–82 cm; Shatsky Rise, northwestern Pacific Ocean]. [Not Morozova, 1961.]

Morozovella uncinata (Bolli).—Snyder and Waters, 1985:448, 449, pl. 10: figs. 1, 2 [*Globorotalia uncinata* Zone, DSDP Site 550/37/5: 59–61 cm; Porcupine Abyssal Plain, northeastern Atlantic Ocean].

ORIGINAL DESCRIPTION.—"Shape of test low trochospiral, spiral side almost flat or slightly convex, umbilical side distinctly convex; equatorial periphery distinctly lobate; axial periphery rounded to subangular. Wall calcareous, perforate, surface finely spinose. Chambers subangular, inflated, laterally compressed; 12–15, arranged in about 2$^1/_2$ whorls, the 5–6 chambers of last whorl increasing moderately in size. Sutures on spiral side strongly curved, depressed; on umbilical side radial, depressed. Umbilicus fairly narrow, deep, open. Aperture a low arch; interiomarginal, extraumbilical-umbilical. Coiling random. Largest diameter of holotype 0.35 mm." (Bolli, 1957a:74.)

DIAGNOSTIC CHARACTERS.—Nonspinose, weakly cancellate, elongate-oval, plano-convex to moderately high spired, moderately lobulate test with 5–8 chambers in last whorl; chambers occasionally so loosely coiled as to form secondary spiral apertures between them; sutures on umbilical side radial, depressed, on spiral side incised and strongly recurved yielding typically trapezoidal-shaped chambers; axial periphery subangular, noncarinate but with rugose muricae often situated along peripheral margin of early chambers of last whorl; umbilicus typically narrow, deep, bordered by weakly developed circumumbilical shoulder formed by raised periumbilical chamber extensions; aperture a narrow interiomarginal, umbilical-extraumbilical arch extending to peripheral margin.

DISCUSSION.—Blow (1979) argued the case for including *uncinata* Bolli, 1957a, as a junior synonym of *praecursoria* Morozova, 1957. Our examination of the holotypes of both of these forms leads us to reject this interpretation. Rather, we interpret *praecursoria* as an advanced, atypically large end-member of *inconstans* that is characterized by rounded chambers and an axial periphery, and we reserve for *uncinata* those forms exhibiting the typical anguloconical (but noncarinate) test with distinctly incised and recurved spiral intercameral sutures. *Acarinina indolensis* Morozova (1959) is a small form of *P. uncinata* with five chambers in the final whorl but, nevertheless, exhibits the characteristic morphology of this species.

STABLE ISOTOPES.—*Praemurica uncinata* has more positive $\delta^{13}C$ and more negative $\delta^{18}O$ than *Subbotina* and *Globanomalina* and has an isotopic signature similar to that of *Morozovella praeangulata* (Shackleton et al., 1985; Berggren and Norris, 1997). There is a pronounced increase in $\delta^{13}C$ with increased size in *P. uncinata* (Kelly et al., 1996; Norris, 1996).

STRATIGRAPHIC RANGE.—Zone P2 to lower Zone P3.

GLOBAL DISTRIBUTION.—This taxon has been widely reported in the literature from predominantly low latitude (sub)tropical localities. Shutskaya (1970a, 1970b) recorded it from several localities in the northern Caucasus. This species does not appear to occur in high southern latitudes (Stott and Kennett, 1990; Huber, 1991b), and we have not found it in our examination of material from the southern part of the Indian Ocean (Figure 30).

ORIGIN OF SPECIES.—This species evolved from *Praemurica inconstans* at the base of Zone P2 by extension of the umbilically conical chambers into most of the final whorl, and by the formation of blunt pustules around the umbilicus and on the initial chambers of the final whorl.

REPOSITORY.—Holotype (USNM P5048) deposited in the Cushman Collection, National Museum of Natural History. Examined by WAB and RDN.

Family GUEMBELITRIIDAE Montanaro Gallitelli, 1957

(by S. D'Hondt, C. Liu, and R.K. Olsson)

Guembelitriinae Montanaro Gallitelli, 1957:136 [subfamily].

Guembelitriidae El-Naggar, 1971:431 [nomen translatum ex subfamily].

ORIGINAL DESCRIPTION.—"Test triserial; chambers globular; aperture basal, arched, simple." (Montanaro Gallitelli, 1957:136.)

DIAGNOSTIC CHARACTERS.—Original description of foraminiferal tests assignable to subfamily Guembelitriinae does not apply to all members of family Guembelitriidae. Tests of guembelitriid foraminifera either triserial (*Guembelitria* spp.), trochospiral (*Parvularugoglobigerina* spp., *Globoconusa* spp.), or nearly triserial in initial whorl and approximately biserial in later whorls (*Woodringina* spp.). Chambers usually globular or subglobular, increasing gradually in size. Aperture usually a loop-shaped arch, often slightly infolded on one side, marked by a fine lip. Surface texture microperforate, smooth to pustulous; when present, pustules or small mounds generally perforated by one or more pores ("pore-mounds") (*Guembelitria, Parvularugoglobigerina, Woodringina*) or peripherally associated with pores (*Globoconusa*).

DISCUSSION.—Montanaro Gallitelli (1957) emended the family Heterohelicidae Cushman, 1927a, by creating the subfamily Guembelitriinae for the triserial genera *Guembelitria* Cushman, 1933, and *Guembelitriella* Tappan, 1940. Loeblich and Tappan (1957a) assigned *Woodringina* Loeblich and Tappan, 1957, to the Guembelitriinae, implicitly modifying the definition of the Guembelitriinae to include forms that are triserial in the first whorl and biserial in later whorls. El-Naggar (1971) raised the Guembelitriidae to family status, and Blow (1979) explicitly broadened its definition to include morphotypes with biserial and trochospiral stages.

The assignment of biserial *Woodringina* species to the Guembelitriidae rests on the hypothesis that *Woodringina* species were derived from *Guembelitria cretacea* Cushman, 1933. This phylogenetic hypothesis is a subset of the broader

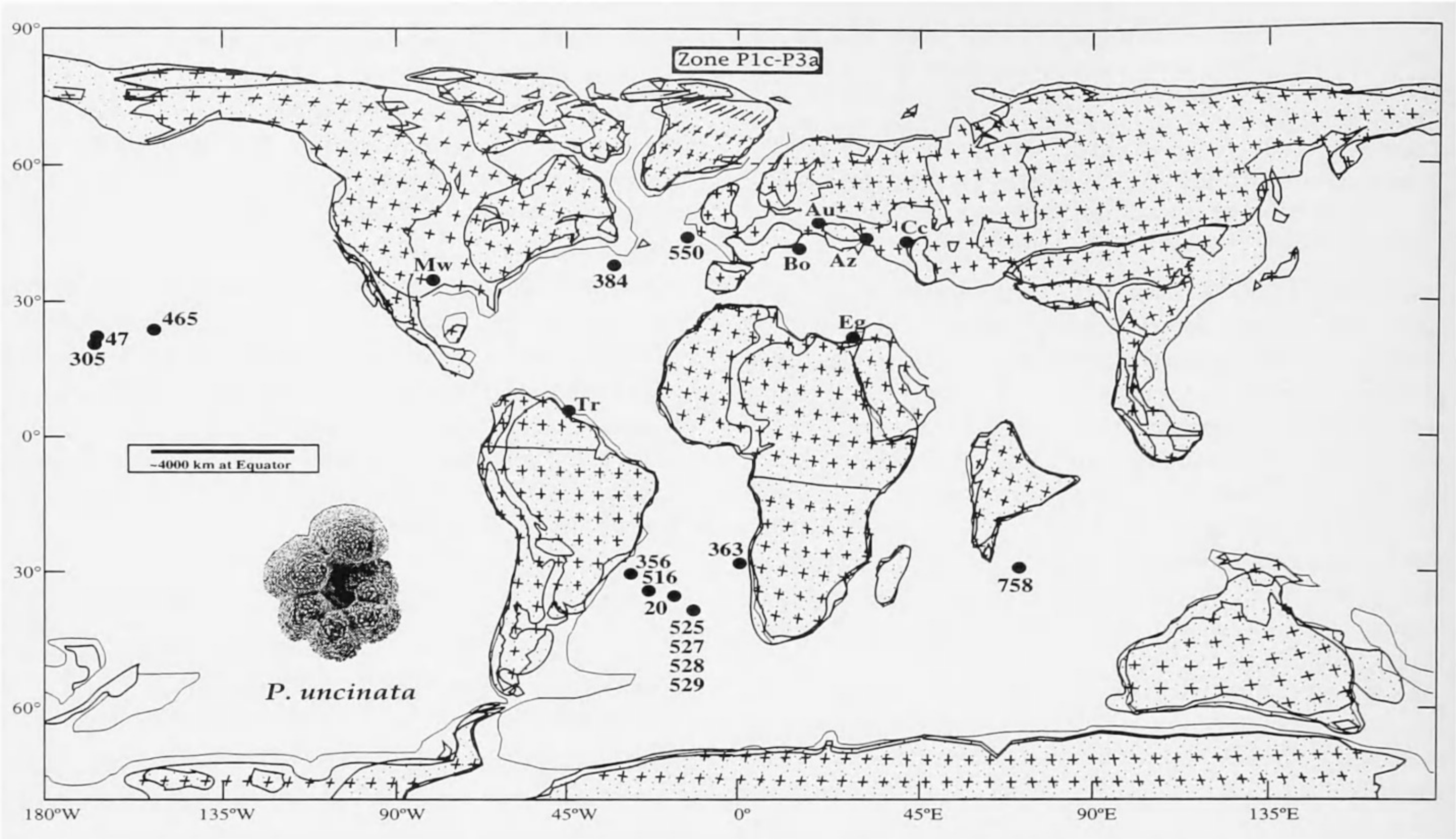

FIGURE 30.—Paleobiogeographic map showing distribution of *Praemurica uncinata* (Bolli) in Zone P2.

hypothesis that *Chiloguembelina midwayensis* (Cushman, 1940), is lineally derived from *Guembelitria cretacea* Cushman, 1933, via *Woodringina claytonensis* Loeblich and Tappan, 1957 (Olsson, 1970, 1982; Premoli Silva, 1977; Li and Radford, 1991; Olsson et al., 1992; Liu and Olsson, 1992). This broader hypothesis is supported by cladistic analysis, based on shared apertural, surface textural, and juvenile characters (D'Hondt, 1991). Given the apparent phylogenetic relationship of *Chiloguembelina midwayensis* to *Guembelitria cretacea,* the Guembelitriidae constitutes a paraphyletic family because it does not include descendent species assigned to the Chiloguembelinidae. The relationship of many post-Paleocene microperforate taxa (i.e., *Cassigerinella* Pokorńy, 1955, *Corrosina* Thalmann, 1956, and *Gallitellia* Loeblich and Tappan, 1986) to the Guembelitriidae remains largely unexplored.

Recent studies have documented morphologic intergradation and shared surface-textural and apertural characteristics between *Guembelitria cretacea* and members of the trochospiral genera *Parvularugoglobigerina* Hofker, 1978, and *Globoconusa* Khalilov, 1956 (D'Hondt and Keller, 1991; Liu and Olsson, 1992; Olsson et al., 1992) (Plates 63–68). These demonstrate the general validity of several recent phylogenetic hypotheses for the origin of the latter genera (Olsson, 1970, 1982; Premoli Silva, 1977; Smit, 1982; Olsson et al., 1992). On this basis, we assign both *Parvularugoglobigerina* and *Globoconusa* to the Guembelitriidae.

Among the primary morphologic characters that unite the Guembelitriidae is a close surface-textural association of pores and pustules (Liu and Olsson, 1992; Olsson et al., 1992) (Plates 63–68). Where the pores directly perforate the surface mounds (or pustules), these perforated mounds are commonly referred to as "pore-mounds." Interspecimen and intraspecimen variation in surface texture from smooth to pore-mound is exhibited by *Guembelitria cretacea, Woodringina claytonensis,* and *Parvularugoglobigerina* species (D'Hondt and Keller, 1991; Liu and Olsson, 1992; Olsson et al., 1992) (Plates 63–68). The degree of pore-mound expression within a specimen appears ontogenetically variable, with the ultimate chamber often exhibiting more weakly developed pore-mounds than immediately preceding chambers (Liu and Olsson, 1992) (Plates 63–68). Furthermore, the pustules (pore-mounds) are often asymmetrically perforate (Plate 63: Figure 6, Plate 65: Figure 6, Plate 67: Figure 14).

The phyletic relationship of *Parvularugoglobigerina, Globoconusa, Woodringina,* and *Chiloguembelina* to *Guembelitria cretacea* indicates that both trochospiral and biserial chamber arrangements divergently evolved within the planktonic foraminifera (Olsson, 1982; Smit, 1982; D'Hondt, 1991; Liu and Olsson, 1992). Such relationships have clearly not been accounted for by taxonomic schemes, which separate serial and trochospiral morphotypes at the superfamily level (i.e., Loeblich and Tappan, 1988).

Genus *Guembelitria* Cushman, 1933

Chiloguembelitria Hofker, 1978:60.

TYPE SPECIES.—*Guembelitria cretacea* Cushman, 1933.

ORIGINAL DESCRIPTION.—"Test similar to *Gümbelina*, but triserial; wall calcareous, finely perforate; aperture large, at the inner edge of the last-formed chamber." (Cushman, 1933:37.)

DIAGNOSTIC CHARACTERS.—Test small and triserial. Aperture bordered by a distinct lip and often slightly asymmetric. Wall structure microperforate; surface texture of well-preserved specimens characterized by presence of pore-mounds.

DISCUSSION.—Confusion remains over the taxonomic status of *Chiloguembelitria,* which Loeblich and Tappan (1988) retained as a valid genus and Kroon and Nederbragt (1990) suggested is a junior synonym of *Guembelitria.* This confusion is exacerbated by the absence of a designated holotype for *Chiloguembelitria* or its type species, *Chiloguembelitria danica* Hofker, 1978. Nonetheless, it appears that no morphological characters consistently distinguish *Chiloguembelitria* spp. from *Guembelitria* spp. The original description and illustration of *C. danica* Hofker, 1978, resembles *Guembelitria cretacea* Cushman, 1933, in its apertural characteristics and its consistent triseriality (Plate 63). The absence of distinct chiloguembelitriid characters indicates that, as suggested by Kroon and Nederbragt (1990), *Chiloguembelitria danica* Hofker, 1978, is a junior synonym of *Guembelitria cretacea* Cushman, 1933.

Guembelitria cretacea Cushman, 1933

FIGURE 31; PLATE 8: FIGURES 1–3; PLATE 13: FIGURE 3; PLATE 63: FIGURES 1–12

Guembelitria cretacea Cushman, 1933:37, pl. 4: fig. 12a,b [upper Maastrichtian, Navarro Fm., Texas].—Olsson, 1970:601, pl. 91: figs. 4, 5 [upper Maastrichtian, Redbank Fm., New Jersey].—Smith and Pessagno, 1973:15, pl. 1: figs. 1–8 [upper Maastrichtian, Corsicana Fm., Texas].—Keller, 1989:319, figs. 1-1, 1-2 [lower Danian, Brazos River, Texas].—D'Hondt, 1991:172, pl. 1: figs. 1, 3, 5, 6 [Zone Pα, DSDP Site 577/12/5: 94–96 cm; Shatsky Rise, northwestern Pacific Ocean], figs. 2, 4 [lower Danian, Brazos River, Texas], pl. 2: fig. 2 [Zone Pα, DSDP Site 577/12/5: 94–96 cm; Shatsky Rise, northwestern Pacific Ocean], fig. 3 [Zone Pα, DSDP Site 528/31/CC: 14–15 cm; Walvis Ridge, South Atlantic Ocean].—D'Hondt and Keller, 1991:93, pl. 3: fig. 1 [Zone Pα, DSDP Site 577/12/5: 115–117 cm; Shatsky Rise, northwestern Pacific Ocean].—Liu and Olsson, 1992:341, pl. 1: figs. 1, 2 [Zone Pα, Pine Barren Mbr., Clayton Fm., Millers Ferry, Alabama].

Guembelitria irregularis Morozova, 1961:17, pl. 1: fig. 9 [Danian, Tarkhankut, Crimea].—D'Hondt, 1991:172, pl. 1: fig. 7 [Zone Pα, DSDP Site 577/12/5: 94-96 cm; Shatsky Rise, northwestern Pacific Ocean].

Chiloguembelitria danica Hofker, 1978:60, pl. 4: fig. 14 [holotype: Danian, DSDP Hole 47.2, sample depth unknown; Shatsky Rise, northwestern Pacific Ocean].—Loeblich and Tappan, 1988:452, pl. 484: figs. 3–6 [holotype], figs. 7, 8 [Danian, DSDP Hole 47.2, sample depth unknown; Shatsky Rise, northwestern Pacific Ocean].

Guembelitria (?) *trifolia* (Morozova).—Blow, 1979:1384, pl. 61: fig. 9 [Zone Pα, DSDP Hole 47.2/11/5: 148–150 cm; Shatsky Rise, northwestern Pacific Ocean]. [Not *Globigerina* (*Eoglobigerina*) *trifolia* Morozova, 1961.]

Guembelitria azzouzi Salaj, 1986:49, pl. 1: figs. 1–6, pl. 2: fig. 1 [base of Danian, El Haria, Tunisia].

Guembelitria besbesi Salaj, 1986:50, pl. 1: figs. 7–9 [base of Danian, El Haria, Tunisia].

Guembelitria trifolia (Morozova).—Keller, 1989:319, figs. 3-3, 3-4 [lower Danian, Brazos River, Texas].—D'Hondt and Keller, 1991:93, pl. 3: fig. 2 [Zone Pα, DSDP Site 577/12/5: 115–117 cm; Shatsky Rise, northwestern Pacific Ocean]. [Not *Globigerina (Eoglobigerina) trifolia* Morozova, 1961.]

ORIGINAL DESCRIPTION.—"Test small, triserial; chambers globular, nearly spherical; sutures much depressed; wall smooth, finely perforate; aperture large, semicircular or semi-elliptical at the inner margin of the last-formed chamber. Length of holotype 0.20 mm.; breadth 0.17 mm." (Cushman, 1933:37.)

DIAGNOSTIC CHARACTERS.—Test small, triserial, composed of globular chambers with strongly depressed sutures. Aperture bordered by distinct lip; aperture often slightly asymmetric due to infolding of lip along one side of aperture (as in *Woodringina* and *Chiloguembelina*). Wall structure microperforate; surface texture often characterized by blunt pore-mounds; i.e., mounds marked by one or more pores (Plate 63: Figure 6).

DISCUSSION.—As discussed previously, *Chiloguembelitria danica* Hofker, 1978, appears to be a high-spired form of *Guembelitria cretacea* Cushman, 1933. Similarly, the primary characters of *Guembelitria irregularis* Morozova, 1961 (Plate 8: Figures 1–3), and *Guembelitria azzouzi* Salaj, 1986, are indistinguishable from those of *Guembelitria cretacea.* In contrast, *Guembelitria dammula* Voloshina, 1961 (Plate 12: Figures 7–9), appears to differ from *Guembelitria cretacea* sensu stricto by its three-chamber series being aligned more strictly parallel to its axis of test coiling. Closer examination of the type population of *G. dammula* may be necessary to determine whether it should be reduced to a junior synonym of *G. cretacea* or retained as a separate taxon.

Salaj (1986) designated a short-spired earliest Paleocene form of *Guembelitria* as *G. besbesi.* Other authors have identified that short-spired form of *Guembelitria* as *Guembelitria* (?) *trifolia* (Morozova) or *Guembelitria trifolia* (Morozova) (Blow, 1979; Keller, 1989; D'Hondt, 1991). The latter designations are incompatible with our interpretation of *Globigerina* (*Eoglobigerina*) *trifolia* Morozova, 1961, as a variant of *Globoconusa daubjergensis* (Brönnimann, 1953) (Plate 8: Figures 4–6). In any case, the short-spired *Guembelitria* morphotype intergrades with *G. cretacea* sensu stricto (Plate 63). The former differs from the latter only in having a shorter spire. Along with *G. cretacea* sensu stricto, the short-spired morphotype is present in uppermost Maastrichtian near-shore sequences (D'Hondt, 1991) and is abundant in lowermost Paleocene planktonic foraminiferal assemblages (D'Hondt and Keller, 1991). The stratigraphic and biogeographic association of these intergrading morphotypes suggests that the short-spired form (= *Guembelitria besbesi* Salaj, 1986) is a morphologic variant of *G. cretacea.*

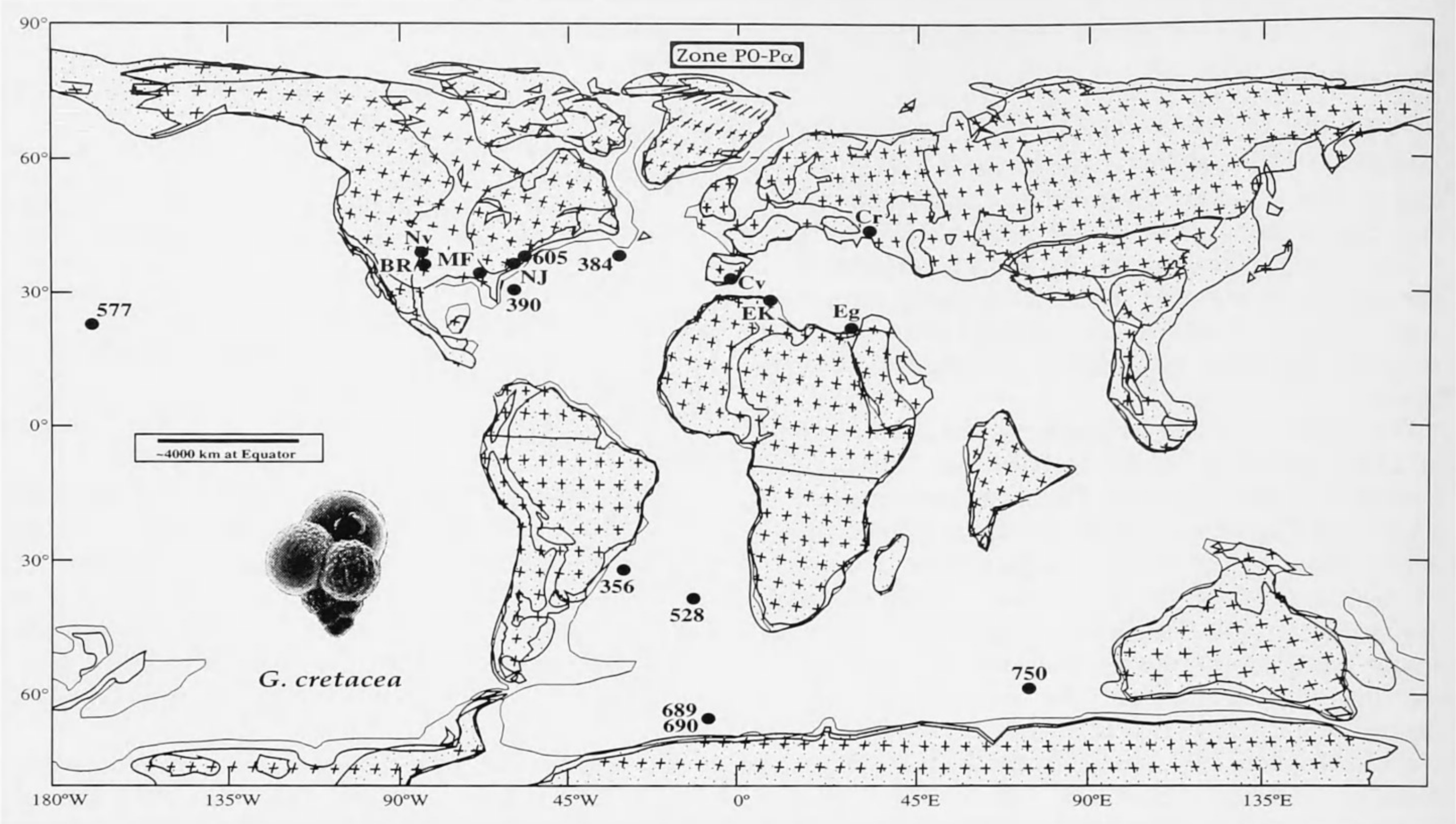

FIGURE 31.—Paleobiogeographic map showing distribution of *Guembelitria cretacea* Cushman in the Danian.

STABLE ISOTOPES.—Biogeographic and oxygen isotopic data suggest that *G. cretacea* inhabited a near-surface planktonic niche (Boersma et al., 1979; Boersma, 1984a; D'Hondt and Zachos, 1993).

STRATIGRAPHIC RANGE.—Maastrichtian to Zone P1b.

GLOBAL DISTRIBUTION.—During the Maastrichtian, *G. cretacea* was generally limited to near-shore environments and only rarely was present in the open ocean (Davids, 1966; Olsson, 1970; Smith and Pessagno, 1973). Immediately following the Cretaceous/Tertiary boundary event, *G. cretacea* radiated into the open ocean, where it was abundant at low and middle latitudes (Olsson, 1970; Smit and van Kempen, 1987; D'Hondt and Keller, 1991; Liu and Olsson, 1992). In Zone P0 and lower Zone Pα it was a cosmopolitan planktonic foraminiferal taxon. Biogeographic and oxygen isotopic data suggest that *G. cretacea* inhabited a near-surface planktonic niche (Boersma et al., 1979; Boersma, 1984a; D'Hondt and Zachos, 1993) (Figure 31).

ORIGIN OF SPECIES.—Unknown.

REPOSITORY.—Holotype (USNM CC19022) deposited in the Cushman Collection, National Museum of Natural History. Examined by SD, CL, and RKO.

Genus *Globoconusa* Khalilov, 1956

Globastica Blow, 1979:1231.

TYPE SPECIES.—*Globoconusa conusa* Khalilov, 1956 = *Globigerina daubjergensis* Brönnimann, 1953.

ORIGINAL DESCRIPTION.—"Test high conical, turret-like, tapering toward the initial end. Dorsal side strongly convex, with a conical spire, its apex at the initial chamber. The height of the cone exceeds the diameter of its base or is nearly equal to it. On the dorsal side all whorls are visible, in general represented by semispherical chambers; on ventral side subspherical chambers are observed only in the last whorl." (Khalilov, 1956:249; translated from Russian).

DIAGNOSTIC CHARACTERS.—Test tiny, low to high trochospire of 2–2$^{1}/_{2}$ whorls; each whorl comprised of 3–4 inflated, subglobular chambers. Wall calcareous, microperforate, with distinctly hispid surface; pustules often peripherally associated with a small pore (and vice-versa). Aperture a very small, low arch, with umbilical position. Test sometimes marked by one or more small supplementary apertures on spiral side.

DISCUSSION.—*Globoconusa conusa* Khalilov, 1956, is widely considered to be a junior synonym of *Globigerina daubjergensis* Brönnimann, 1953 (Loeblich and Tappan, 1964, 1988; Khalilov, 1967; Morozova et al., 1967, Olsson, 1970; Premoli Silva, 1977; Hofker, 1978; Smit, 1982; Toumarkine and Luterbacher, 1985; Brinkhuis and Zachariasse, 1988; Stott and Kennett, 1990; D'Hondt and Keller, 1991; Huber, 1991b; Li and Radford, 1991; Liu and Olsson, 1992; Olsson et al., 1992). A different opinion was held by Blow (1979), who noted that Khalilov's (1956:249) type description of *Globoconusa conusa* differs from the holotype of *G. daubjergensis* in some respects (i.e., the test of *G. conusa* was originally described as "strongly thickened" and "covered with small, dense pits"). On this basis, Blow (1979) created the generic designation *Globastica* for *Globigerina daubjergensis* and related forms.

Globoconusa daubjergensis (Brönnimann, 1953)

FIGURE 32; PLATE 8: FIGURES 4–6; PLATE 15: FIGURES 13, 14; PLATE 64: FIGURES 1–12

Globigerina daubjergensis Brönnimann, 1953:340, text-fig. 1 [Danian, Daubjerg Quarry, Denmark].

Globoconusa conusa Khalilov, 1956:249, pl. 5: fig. 2a–c [Danian, northeastern Azerbaidzhan].—Blow, 1979:1386, pl. 257: fig. 10 [Danian, DSDP Hole 20C/6/4: 72–74 cm; Brazil Basin, South Atlantic Ocean], fig. 11 [Thanet Sands, Reculver, Kent, England].

Globigerinoides daubjergensis (Brönnimann).—Loeblich and Tappan, 1957a:184, pl. 40: fig. 1a–c [upper Danian, Sweden], pl. 40: fig. 8a–c [Zone P1, Pine Barren Mbr., Clayton Fm., Alabama], pl. 41: fig. 9a–c [Zone P1c, McBryde Mbr., Clayton Fm., Alabama], pl. 42: figs. 6a–7c [Zone P1c, Brightseat Fm., Maryland], pl. 43: fig. 1a–c [Zone P1, Kincaid Fm., Texas], pl. 44: figs. 7, 8a–c [Zone P2, Wills Point Fm., Texas].—Olsson, 1960:43, pl. 8: figs. 4–6 [Zone P1, basal Hornerstown Fm., New Jersey].

Globigerina kozlowskii Brotzen and Pożaryska, 1961:162, pl. 1: figs. 1–14, pl. 2: figs. 1–17, pl. 3: figs. 1a–2c [Danian, Pamietowo, Poland].

Globigerina (Eoglobigerina) trifolia Morozova, 1961:12, pl. 1: fig. 1 [Danian, Tarkhankut, Crimea].

Globoconusa tripartita Morozova et al., 1967:193, pl. 5: figs. 4–6 [Danian, Kopet-Dagh, Crimea].

Globoconusa daubjergensis gigantea Bang, 1969:65, pl. 4: figs. 1–3b [type Danian, Denmark].

Globoconusa daubjergensis (Brönnimann).—Olsson, 1970:601, pl. 92: fig. 2a,b [lower Danian, Pine Barren Mbr., Clayton Fm., Millers Ferry, Alabama], figs. 5a–6b [Danian, basal Hornerstown Fm., New Jersey].—Keller, 1993:1, pl. 3: figs. 1–3 [Danian, ODP Hole 690C/15/1: 19–21 cm], pl. 4: figs. 11–13 [Danian, Hole 690C/15/1: 121–123 cm; Weddell Sea, Southern Ocean].

Globastica daubjergensis (Brönnimann).—Blow, 1979:1235, pl. 74: figs. 7–9 [Zone P1, DSDP Hole 47.2/11/2: 148–150 cm; Shatsky Rise, northwestern Pacific Ocean], pl. 256: figs. 1–9 [Zone D2, Danian, Karlstrup, Denmark], pl. 257: figs. 3, 4 [upper Danian, Ostratorp, Sweden].

ORIGINAL DESCRIPTION.—"The specimens are very small for the genus [*Globigerina*]. The outline of the trochoid test is distinctly lobulate. The spiral side is pointed in the initial portion. The umbilicus is small and shallow. The final whorl, the dominant portion of the test, consists of 3 to 4 gradually in size increasing subglobular chambers. The sutures of the final whorl are strongly incised, those of the early test are not clearly visible. The extremely small, subcircular aperture opens into the shallow umbilical depression. The rough surface is covered by minute irregularly distributed spines. The thin walls are finely perforate. The direction of coiling is undetermined, 11 out of 19 specimens are coiling to the right hand side.

"The maximum diameter of the tests varies from 0.125 mm to 0.2 mm, average 0.15 mm. The height of the test is ± 0.12 mm and the aperture has a diameter of ± 0.02 mm. Common in sample 38." (Brönnimann, 1953:340.)

DIAGNOSTIC CHARACTERS.—Test characterized by microperforate wall structure, with outer surface covered by abundant small pustules. Wide variation in spire height; some specimens marked by relatively low trochospire, others display relatively high spire (similar to short-spired *Guembelitria cretacea*). Occasionally exhibits small secondary (intercameral) apertures; both primary and secondary apertures sometimes covered by bullae.

DISCUSSION.—The morphology of *G. daubjergensis* has been described in detail by several authors (Brönnimann, 1953; Loeblich and Tappan, 1957a; Troelsen, 1957; Blow, 1979). Troelsen (1957:120) recognized two forms as end-member morphologic variants of *Globigerina daubjergensis* Brönnimann, noting that the two variants "grade imperceptibly into each other." One of these contains four chambers in each whorl, whereas the other is a three-chambered form (*Eoglobigerina trifolia* Morozova, 1961, *Globigerina tripartita* Morozova et al., 1967, and *Globastica* sp. Type 1 of Blow, 1979). Blow (1979:1244) suggested that the three-chambered form "is one of three later differentiates from the basic *Globastica daubjergensis*-morphotype." Close examination of lowermost Paleocene sequences, however, suggests that the first appearance of the three-chambered morphotype preceded that of the four-chambered morphotype (D'Hondt and Keller, 1991).

Some specimens assigned to the three-chambered morphotype appear morphologically intermediate between *Guembelitria cretacea* and *Globoconusa daubjergensis* (Plate 63: Figures 7–9). The existence of such intermediate forms in lowermost Paleocene sediments has often been interpreted to demonstrate the evolution of *G. daubjergensis* from *G. cretacea* (Olsson, 1970, 1982; Premoli Silva, 1977; Smit, 1977, 1982; Li and Radford, 1991; Liu and Olsson, 1992).

Blow (1979:1235) suggested that *G. daubjergensis, G. daubjergensis gigantea,* and *G. kozlowskii* should probably be considered as only subspecifically related. Bang (1969) proposed the subspecies designation *Globoconusa daubjergensis gigantea* for morphotypes of *G. daubjergensis* that are marked by an umbilical bulla and secondary bullae in intercameral sutures. The holotype illustration of *Globigerina kozlowskii* Brotzen and Pożaryska (1961) has a higher initial spire and tighter coiling mode than the holotype of *G. daubjergensis.* Nonetheless, the former falls within the range of morphologic variability of the latter. Hence, *G. kozlowskii* is a junior synonym of *G. daubjergensis.*

Recrystallization renders the holotype of *Postrugoglobigerina praedaubjergensis* Salaj difficult to unambiguously identify (Salaj, 1986, pl. 3: fig. 7); however, Salaj (1986) considered *Postrugoglobigerina praedaubjergensis* immediately ancestral to *G. daubjergensis,* and the only other illustrated specimen assigned to *P. praedaubjergensis* is a *Globoconusa daubjergensis* specimen (Salaj, 1986, pl. 3: figs. 8, 9).

STABLE ISOTOPES.—Although its abundance in near-shore sequences indicates a near-surface planktic habitat (Troelsen,

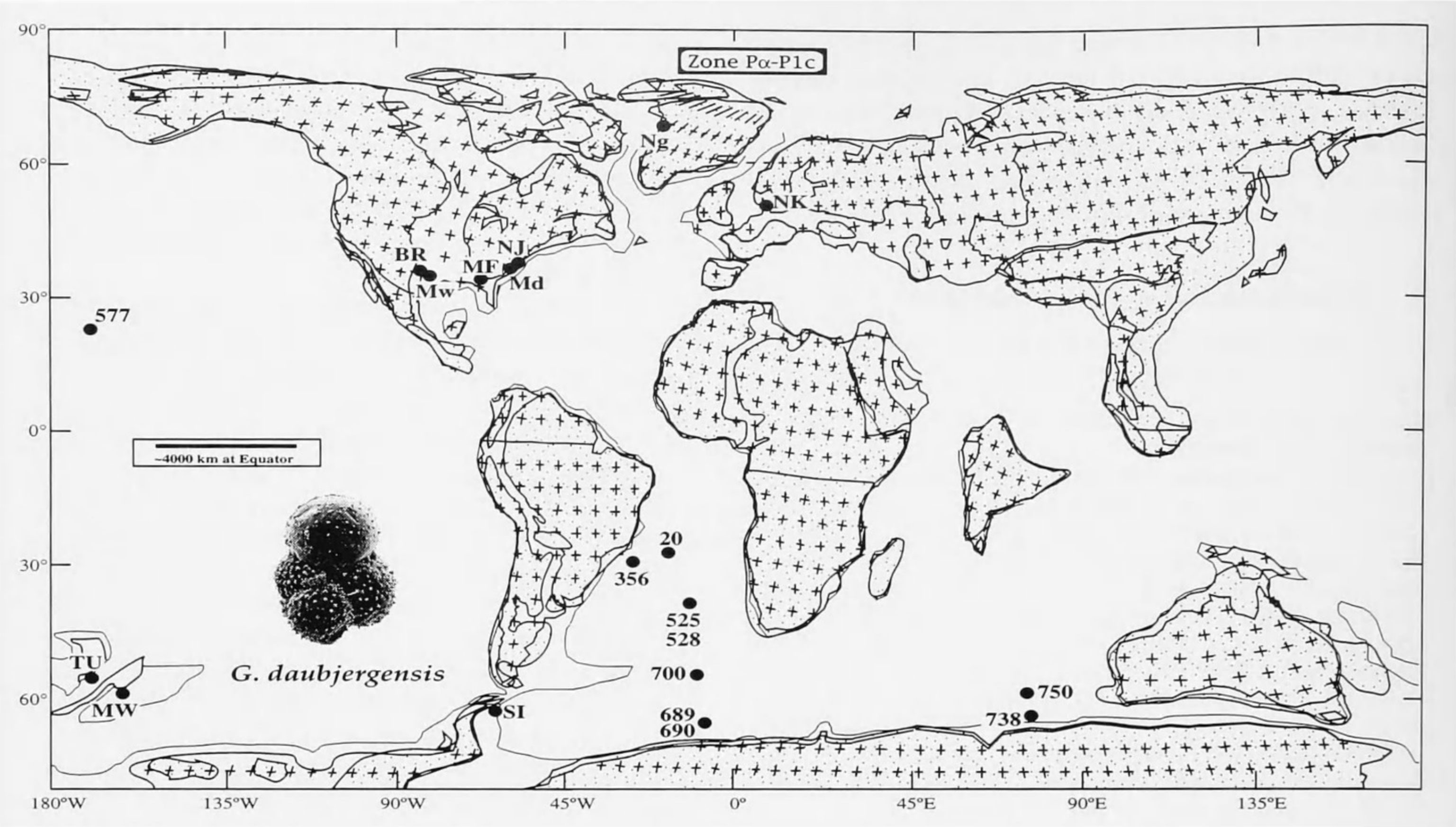

FIGURE 32.—Paleobiogeographic map showing distribution of *Globoconusa daubjergensis* (Brönnimann) in Zones Pα and P1.

1957; Keller, 1989; Liu and Olsson, 1992), its oxygen isotopic signature and open-marine abundance patterns suggest a preference for relatively cool water masses (Premoli Silva and Boersma, 1989; D'Hondt and Keller, 1991; Liu and Olsson, 1992; D'Hondt and Zachos, 1993).

STRATIGRAPHIC RANGE.—Basal Zone Pα to Zone P1c.

GLOBAL DISTRIBUTION.—*Globoconusa daubjergensis* was abundant in high-latitude and near-shore planktonic foraminiferal assemblages (Troelsen, 1957; Keller, 1989; Premoli Silva and Boersma, 1989; Liu and Olsson, 1992). It was rare in low-latitude open-marine environments (Premoli Silva and Boersma, 1989; D'Hondt and Keller, 1991; Liu and Olsson, 1992) (Figure 32).

ORIGIN OF SPECIES.—*Globoconusa daubjergensis* is considered to be a direct descendent of *Guembelitria cretacea* (Bang, 1969; Olsson, 1970, 1982; Premoli Silva, 1977; Smit, 1977, 1982; Li and Radford, 1991; Liu and Olsson, 1992).

REPOSITORY.—Holotype (USNM CC64879) deposited in the Cushman Collection, National Museum of Natural History. Examined by SD, CL, and RKO.

Genus *Parvularugoglobigerina* (Hofker, 1978), emended

Postrugoglobigerina Salaj, 1986:52.

TYPE SPECIES.—*Globigerina eugubina* Luterbacher and Premoli Silva, 1964.

ORIGINAL DESCRIPTION.—"Very small species with 3-6 chambers in the last-formed whorl; at the dorsal side all chambers visible; at the ventral side only those of the last-formed coil; chambers globular, with sutures depressed on both sides; umbilical cavity very small; walls thin, consisting of one lamella, with small pustules in between the pores; often the pustules are found in rows, as in *Rugoglobigerina*. Pores fine, pipelike, at the surface ending in a funnel, as in some species they end in pits of the wall. Aperture an umbilical-extraumbilical, crescent-like opening, with slightly thickened border, or a narrow poreless lip." (Hofker, 1978:60.)

DIAGNOSTIC CHARACTERS.—Original description inaccurate, especially with respect to surface texture. Test typically small, with moderate to flat trochospire consisting of 2½ whorls of globular or subglobular chambers. Chambers gradually increase in size; 3½–7 chambers in each whorl, separated by radial and depressed sutures on both spiral and umbilical sides. Umbilicus closed. Aperture umbilical to extraumbilical, ranging from comma-shaped arch to long narrow opening extending up apertural face in nearly equatorial position. Aperture bordered by a slight lip. Surface texture microperforate, pustulous or smooth; when pustulous, well-preserved parvularugoglobigerinids exhibit pore-mound surface texture characteristic of guembelitriid taxa. Pores do not end in pits; pustules not aligned.

DISCUSSION.—As noted by several previous authors, Hofker's (1978) description of *Parvularugoglobigerina eugubina* (Luterbacher and Premoli Silva) does not accurately describe *Globigerina eugubina* Luterbacher and Premoli Silva, 1964 (Bang, 1979; Brinkhuis and Zachariasse, 1988; Loeblich and Tappan, 1988; Liu and Olsson, 1992; Olsson et al., 1992). Nonetheless, the genus *Parvularugoglobigerina* was erected with *Globigerina eugubina* Luterbacher and Premoli Silva, 1964, as the type species, and it remains the generic label for that species and related forms (Hofker, 1978; Brinkhuis and Zachariasse, 1988; Loeblich and Tappan, 1988; Olsson et al., 1992).

The type species of *Postrugoglobigerina* is *Postrugoglobigerina hariana* Salaj, 1986. Because *Postrugoglobigerina hariana* Salaj, 1986, is a junior synonym of *Globigerina eugubina* Luterbacher and Premoli Silva, 1964, *Postrugoglobigerina* Salaj, 1986, is a junior synonym of *Parvularugoglobigerina* Hofker, 1978.

Parvularugoglobigerinids generally resemble woodringinids in their surface texture and apertural characteristics.

Parvularugoglobigerina alabamensis (Liu and Olsson, 1992)

PLATE 65: FIGURES 1–6

Guembelitria? *alabamensis* Liu and Olsson, 1992:341, pl. 2: figs. 1–7 [Zone P1a, Pine Barren Mbr., Clayton Fm., Millers Ferry, Alabama].

ORIGINAL DESCRIPTION.—"Test small, 110–160 μm in height and 90–135 μm in largest diameter, height-width ratio 1.0–1.2; 10–13 globular or spherical chambers arranged in a high trochospire, triserial in the early and trochospiral in the later ontogenetic stage, with 3 to 4, mostly 3$^{1}/_{2}$ to 4 chambers in the last formed whorls; sutures deeply incised; umbilicus open, narrow and shallow; aperture semicircular, high, with a distinct narrow but thick lip, umbilical, symmetrically situated at the base of the last formed chamber. Wall microperforate, early chambers have intensive small pore mounds, later chambers are covered with dense blunt pustules and less frequent pore-mounds." (Liu and Olsson, 1992:341.)

DIAGNOSTIC CHARACTERS.—Typically characterized by 2$^{1}/_{2}$ whorls, each composed of 3–4 inflated subglobular chambers, increasing slowly in size. Aperture low, centrally located, umbilical, marked by a distinct lip. Sometimes characterized by presence of pore-mounds (Plate 65: Figure 6).

DISCUSSION.—*Parvularugoglobigerina alabamensis* differs from *Guembelitria cretacea* by possessing 3$^{1}/_{2}$–4 (rather than 3) chambers in the outer whorl. It resembles *G. cretacea* in its apertural characteristics and presence of pore-mounds. *Parvularugoglobigerina alabamensis* sensu stricto differs from *Parvularugoglobigerina extensa* in having a less elongate aperture that does not extend extraumbilically.

STABLE ISOTOPES.—No data available.

STRATIGRAPHIC RANGE.—Zone Pα to Zone P3b.

GLOBAL DISTRIBUTION.—Similar to *Parvularugoglobigerina eugubina.*

ORIGIN OF SPECIES.—This species evolved from *Guembelitria cretacea. Parvularugoglobigerina alabamensis* appears as a morphologically intermediate form between *G. cretacea* and *Parvularugoglobigerina extensa* Blow. For example, the apertural characteristics of *P. alabamensis* more closely resemble those of *G. cretacea* than do those of typical *P. extensa* (compare Plates 63 and 65); however, the exact phylogenetic relationship of *Parvularugoglobigerina alabamensis* to *Parvularugoglobigerina extensa* is unclear, in part because the first known occurrence of *P. extensa* is stratigraphically lower than the first known occurrence of *P. alabamensis.* It appears likely that either *P. alabamensis* evolved from *G. cretacea* independently of *P. extensa* (Liu and Olsson, 1992) or *P. alabamensis* was ancestral to *P. extensa,* but the known stratigraphic record of *P. alabamensis* is incomplete. The first hypothesis is stratigraphically simpler, but evolutionarily more complex, than the second because the former necessarily entails iterative evolution of four-chambered parvularugoglobigerine morphotypes from *G. cretacea.*

TYPE LOCALITY.—Forty feet above the base of the Clayton Fm. at Millers Ferry, Alabama.

REPOSITORY.—Holotype (USNM 460338) and paratypes (USNM 460339–460342) deposited in the Cushman Collection, National Museum of Natural History. Examined by SD, CL, and RKO.

Parvularugoglobigerina eugubina (Luterbacher and Premoli Silva, 1964)

FIGURE 33; PLATE 66: FIGURES 1–12; PLATE 67: FIGURES 1–14

Globigerina anconitana Luterbacher and Premoli Silva, 1964:107, pl. 2: fig. 3a–c [*Globigerina eugubina* Zone, Gubbio, central Appenines, Italy].

Globigerina eugubina Luterbacher and Premoli Silva, 1964:105, pl. 2: fig. 8a–c [*Globigerina eugubina* Zone, Gubbio, central Appenines, Italy].—Premoli Silva and Bolli, 1973:526, pl. 7: figs. 2–5 [*Globigerina eugubina* Zone: figs. 2–4, DSDP Site 152/10/1: 127–130 cm; fig. 5, DSDP Site 152/10/CC; Nicaragua Rise, Caribbean Sea].—Smit, 1982:339, pl. 1: figs. 1–20, pl. 2: figs. 1–8 [Zone Pα, Gredero, southeastern Spain].—Keller, 1988:257, pl. 3: figs. 8–10 [Zone Pα, El Kef, Tunisia]; 1989:321, pl. 6: figs. 3, 6 [Zone Pα, Brazos River, Texas].

Globigerina sabina Luterbacher and Premoli Silva, 1964:108, pl. 2: fig. 6a–c [*Globigerina eugubina* Zone, Gubbio, central Appenines, Italy].

Globigerina umbrica Luterbacher and Premoli Silva, 1964:106, pl. 2: fig. 2a–c [*Globigerina eugubina* Zone, Gubbio, central Appenines, Italy].

Globorotalia (*Turborotalia*) cf. *hemisphaerica* (Morozova).—Blow, 1979:1077, pl. 64: fig. 8 [Zone Pα, DSDP Hole 47.2/11/3: 148–150 cm; Shatsky Rise, northwestern Pacific Ocean].

Globorotalia (*Turborotalia*) *longiapertura* Blow, 1979:1085, pl. 56: figs. 3, 4 [Zone Pα, DSDP Hole 47.2/11/6: 148–150 cm], pl. 58: figs. 3–5 [Zone Pα, DSDP Hole 47.2/11/5: 148–150 cm], pl. 63: figs. 1–9 [Zone Pα, DSDP Hole 47.2/11/4: 148–150 cm], pl. 68: fig. 3 [Zone Pα, DSDP Hole 47.2/11/3: 148–150 cm], pl. 72: fig. 1 [given as Zone P1, DSDP Hole 47.2/11/1: 148–150 cm; Shatsky Rise, northwestern Pacific Ocean].

Globorotalia (*Turborotalia*)? cf. *pentagona* (Morozova).—Blow, 1979:1088, pl. 64: fig. 1 [Zone Pα, DSDP Hole 47.2/11/4: 148–150 cm; Shatsky Rise, northwestern Pacific Ocean].

Globorotalia (*Turborotalia*) cf. *tetragona* (Morozova).—Blow, 1979:1113, pl. 64: fig. 7 [Zone Pα, DSDP Hole 47.2/11/3: 148–150 cm; Shatsky Rise, northwestern Pacific Ocean] [in part, not pl. 67: fig. 5].

Postrugoglobigerina hariana Salaj, 1986:53, pl. 3: figs. 1–3, 5 [base of Danian, El Haria, Tunisia].

Globigerina cf. *edita* (Subbotina).—Keller, 1988:257, pl. 3: fig. 18 [Zone Pα, El Kef, Tunisia].

Globigerina (*Eoglobigerina*) *hemisphaerica* Morozova.—Keller, 1988:257, pl. 3: figs. 6, 7, 11 [Zone Pα, El Kef, Tunisia]. [Not *Globigerina* (*Eoglobigerina*) *hemisphaerica* Morozova, 1961.]

Globigerina (*Eoglobigerina*) *taurica* Morozova.—Keller, 1988:257, pl. 3: figs. 4, 5 [Zone Pα, El Kef, Tunisia]. [Not *Globigerina* (*Eoglobigerina*) *taurica* Morozova, 1957.]

Parvularugoglobigerina eugubina (Luterbacher and Premoli Silva).—D'Hondt and Keller, 1991:96, pl. 4: figs. 4–6 [Zone Pα, DSDP Site 577/12/5: 115–117 cm; Shatsky Rise, northwestern Pacific Ocean].—Liu and Olsson, 1992:345, pl. 3: figs. 1–11 [Zone Pα, Pine Barren Mbr., Clayton Fm., Millers Ferry, Alabama]. [Not Hofker, 1978:60, pl. 2: figs. 6–10, pl. 3: figs. 1, 2.]

Parvularugoglobigerina longiapertura (Blow).—D'Hondt and Keller, 1991:96, pl. 4: figs. 7, 8 [Zone Pα, DSDP Site 577/12/5: 115–117 cm; Shatsky Rise, northwestern Pacific Ocean].

Parvularugoglobigerina morphotype 3, D'Hondt and Keller, 1991:93, pl. 3: figs. 10, 11 [Zone Pα, DSDP Site 577/12/5: 115–117 cm; Shatsky Rise, northwestern Pacific Ocean].

Parvularugoglobigerina cf. *eugubina* (Luterbacher and Premoli Silva).—Liu and Olsson, 1992:345, pl. 3: fig. 12 [Zone Pα, Pine Barren Mbr., Clayton Fm., Millers Ferry, Alabama].

ORIGINAL DESCRIPTION.—"Test very small, trochospiral; umbilical side flat, spiral side almost flat; the initial part of the spire is slightly raised relative to the final whorl. Composed of 12 to 14 globular chambers, disposed in 2½ whorls; the final whorl contains 6 chambers that increase gradually in size. The final chamber occupies about ¼ to ⅕ of the test's surface. The periphery is lobate. Sutures depressed and radial on the umbilical side, depressed and slightly arcuate on the spiral side. Umbilicus quite large. Aperture at the base of the final chamber in an umbilical position. Surface slightly rugose.
Dimensions:

holotype	length	0.13 mm	
	width	0.095 mm	
	depth	0.06 mm.	
paratypes		A	B
	length	0.11 mm	0.13 mm
	width	0.105 mm	0.11 mm
	depth	0.045 mm	0.055 mm."

(Luterbacher and Premoli Silva, 1964:105; translated from Italian.)

DIAGNOSTIC CHARACTERS.—Test a small trochospire with 2½ whorls, each whorl with 4½–8 inflated subglobular chambers; chambers increasing slowly in size; first and last whorls usually with same number of chambers. Spire height low to moderate. Test wall microperforate, well-preserved specimens sometimes exhibit surficial pore-mounds (Plate 67: Figure 14). Aperture elongate, marked by thickened rim; apertural position ranges from umbilical to nearly peripheral (Plates 66, 67). Individual specimens sometimes exhibit dorsal aperture (Plate 66: Figure 6) or both dorsal and umbilical apertures on final chamber (Plate 66: Figure 9); some showing more than one dorsal aperture.

DISCUSSION.—Premoli Silva and Bolli (1973) declared *Globigerina umbrica* Luterbacher and Premoli Silva, 1964, and *Globigerina sabina* Luterbacher and Premoli Silva, 1964, to be junior synonyms of *Globigerina eugubina* Luterbacher and Premoli Silva, 1964. This broadened the concept of *eugubina* to include moderately spired forms with 4½ chambers in the final whorl (*Globigerina sabina*) and forms with 7 chambers in the final whorl (*Globigerina umbrica*). We also include in this broadened concept *Globigerina anconitana* Luterbacher and Premoli Silva (1964), a species that was described from the same assemblage as these species. Smit (1982) first noted that *Globorotalia longiapertura* Blow, 1979, is a junior synonym of *Globigerina eugubina* Luterbacher and Premoli Silva.

Following Premoli Silva and Bolli (1973) and Smit (1982), we treat several intergrading morphotypes as variants of *P. eugubina* (Plates 66, 67). These include a moderately spired form with 4½–5 chambers (Plate 66: Figures 1, 2, Plate 67: Figures 13, 14) in each whorl (= *Globigerina sabina* Luterbacher and Premoli Silva, 1964; *Globorotalia* (*Turborotalia*) *longiapertura* paratypes of Blow, 1979, Plate 63: Figures 1–3; *Parvularugoglobigerina* morphotype 3 of D'Hondt and Keller, 1991; *Parvularugoglobigerina* cf. *eugubina* of Liu and Olsson, 1992) and a relatively low-spired form characterized by 5–8 chambers per whorl (Plate 66: Figures 7, 8, 10–12, Plate 67: Figures 1, 3, 10, 12) that has an apertural extension from the umbilicus to a near peripheral location and slightly more embracing chambers with less deeply incised sutures (the *longiapertura* morphotype of Blow, 1979).

Globigerina minutula Luterbacher and Premoli Silva, 1964, was described along with *Globigerina eugubina* from the Gubbio section. The holotype drawing of *G. minutula* illustrates a very low trochospiral, 3-chambered form, which closely resembles Plate 65: Figure 13 that was selected from the type level. The specimen is completely recrystallized so that it is uncertain whether it is a microperforate or normal perforate taxon. Consequently, given its generalized morphology, we cannot accurately identify this taxon.

Although badly preserved, the type specimen of *Postrugoglobigerina hariana* Salaj, 1986, is indistinguishable from *Parvularugoglobigerina eugubina*. The holotype of *P. hariana* is a low trochospiral form with a pore-mound surface texture, five globular chambers in each of two whorls, a low rate of chamber expansion, and a "narrow slot-like interiomarginal umbilical aperture at the base of the last chamber" (Salaj, 1986:53). Consequently, *Postrugoglobigerina hariana* Salaj, 1986, is regarded as a junior synonym of *Parvularugoglobigerina eugubina* (Luterbacher and Premoli Silva, 1964). In addition, we include in *P. eugubina* a number of forms identified by Blow (1979) and Keller (1988) to various species of cancellate Danian species (see synonomy). The illustrations of Blow and Keller clearly show a microperforate wall structure; therefore, these identifications are incorrect. The general morphology of their illustrated forms falls within the broadened concept of *P. eugubina*.

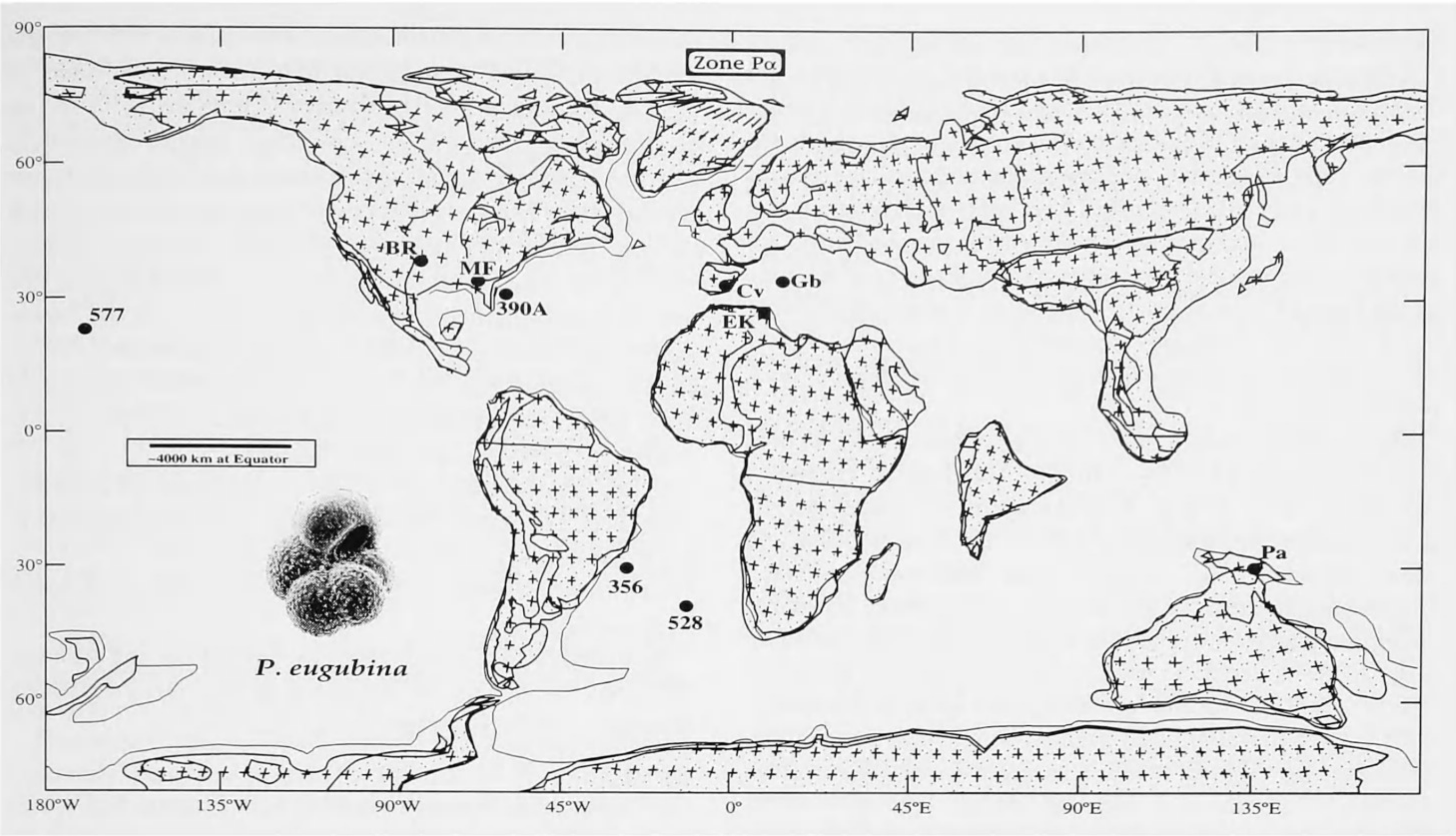

FIGURE 33.—Paleobiogeographic map showing distribution of *Parvularugoglobigerina eugubina* (Luterbacher and Premoli Silva) in Zone Pα.

STABLE ISOTOPES.—Oxygen isotopic data suggest that *P. eugubina* occupied a slightly deeper or cooler-season planktic niche than co-occurring *G. cretacea* and *Woodringina* spp. (Boersma et al., 1979; Boersma, 1984a; D'Hondt and Zachos, 1993).

STRATIGRAPHIC RANGE.—Zone Pα.

GLOBAL DISTRIBUTION.—Biogeographic data indicate that *P. eugubina* was a low to middle latitude taxon with an open-ocean affinity (Premoli Silva and Bolli, 1973; Premoli Silva and Boersma, 1989; D'Hondt, 1991; D'Hondt and Keller, 1991; Liu and Olsson, 1992) (Figure 33).

ORIGIN OF SPECIES.—This species evolved from *Guembelitria cretacea* via *Parvularugoglobigerina extensa* at the base of Zone Pα.

REPOSITORY.—Holotype (No. C20532) and paratype (Nos. C20554, C20555) are deposited in the Basel Museum of Natural History, Switzerland.

Parvularugoglobigerina extensa (Blow, 1979)

PLATE 65: FIGURES 7–13

Woodringina hornerstownensis group, Premoli Silva and Bolli, 1973:538, 540, pl. 6: fig. 10, pl. 7: fig. 1 [*Globigerina eugubina* Zone, DSDP Site 150/10/2: 78–50 cm; Caribbean Sea]. [Not Olsson, 1960.]

Eoglobigerina? *extensa* Blow, 1979:1220, pl. 69: fig. 7 [Zone P1, DSDP Hole 47.2/11/3: 0–5 cm], pl. 74: figs. 1, 2 [Zone P1, DSDP Hole 47.2/11/3: 148–150 cm; Shatsky Rise, northwestern Pacific Ocean].

Eoglobigerina? *fodina* Blow, 1979:1221, pl. 57: figs. 5, 6 [Zone Pα, DSDP Hole 47.2/11/5: 148–150 cm; Shatsky Rise, northwestern Pacific Ocean].

Globigerina minutula Luterbacher and Premoli Silva.—Smit, 1982:338, pl. 3: figs. 3–6 [Zone Pα, Gredero, southeastern Spain]. [Not Luterbacher and Premoli Silva, 1964.]

Globoconusa conusa (Khalilov).—Keller, 1988:257, pl. 3: figs. 12–14 [Zone P0b, El Kef, Tunisia]; 1989:319: figs. 3, 9–11 [Zone Pα, Brazos River, Texas]. [Not Khalilov, 1956.]

Parvularugoglobigerina morphotype 1, D'Hondt and Keller, 1991:93, pl. 3: figs. 3–5, 7–10 [figs. 3, 4, 7–10, Zone Pα, DSDP Site 577/12/5: 115–117 cm; Shatsky Rise, northwestern Pacific Ocean; fig. 5, lower Danian, Brazos River, Texas].

Parvularugoglobigerina morphotype 2, D'Hondt and Keller, 1991:96, pl. 41: figs. 1, 2 [Zone Pα, DSDP Site 577/12/5: 115–117 cm; Shatsky Rise, northwetern Pacific Ocean].

Parvularugoglobigerina aff. *eugubina* (Luterbacher and Premoli Silva).—Liu and Olsson, 1992:345, pl. 2: figs. 8–11 [Zone Pα, Pine Barren Mbr., Clayton Fm., Millers Ferry, Alabama].

ORIGINAL DESCRIPTION.—"The small test is coiled in a distinct, tightly expressed, trochospire with 9–10 chambers comprising the spire and four chambers in the last whorl. In dorsal aspect, the chambers are inflated, closely appressed, closely-set and quite strongly embracing and the dorsal intercameral sutures are subradially to sinuously disposed. The dorsal and ventral intercameral sutures are depressed to moderately incised. In ventral aspect, the chambers are inflated, subglobular, but embracing. The umbilicus is closed and the aperture extends from the umbilicus extensively towards the anterior side of the last chamber and is a widely open, almost rectangular, opening bordered by a weakly developed but thickened porticus. The equatorial profile is strongly lobulate but almost circular in outline whilst the axial profile shows the distinct early trochospire and subglobular nature of the later chambers. The wall is very finely perforate and the mural-pits are very widely and sparsely developed; the mural pores do not open into pore pits but the wall bears fine pustules which may be the bases of normal spines. Maximum diameter of holotype 0.198 mm. as measured electronically. The name *extensa* derives adjectively from the extensive nature of the aperture." (Blow, 1979:1220.)

DIAGNOSTIC CHARACTERS.—Characterized by 2$^{1}/_{2}$ whorls, each composed of 3$^{1}/_{2}$–4 inflated subglobular chambers, increasing slowly in size. Aperture centrally located, umbilical–extraumbilical, marked by distinct lip, often elongate, and often asymmetrically oriented. Test wall microperforate. Despite original description, pustules are not bases of normal spines but guembelitriid pustules typically either perforated by pores (pore-mounds) or peripherally associated with pores.

DISCUSSION.—*Parvularugoglobigerina extensa* is a moderately high-spired form and is morphologically intermediate between *Guembelitria cretacea* and *Parvularugoglobigerina eugubina*. *Parvularugoglobigerina extensa* primarily differs from *G. cretacea* sensu stricto by possessing 3$^{1}/_{2}$–4 (rather than 3) chambers in the outer whorl and by typically having an elongate aperture that extends extraumbilically.

Eoglobigerina? *fodina* Blow, 1979, was originally described as characterized by a small but open umbilicus and a circular aperture "extending from the opening in a slightly oblique manner, into the terminal face of the last chamber" (Blow, 1979:1221). The name *fodina* was derived from the Latin word for pit or tunnel and applied to the apertural shape, which was described as looking like the entrance to a London Underground Railway tunnel (Blow, 1979:1221). The slight differences between the holotypes of *extensa* and *fodina* result from elongation of the former's aperture toward the umbilicus. Given the extreme plasticity of apertural morphology and location in related taxa (i.e., *Parvularugoglobigerina eugubina* and *Woodringina* species), such minor differences appear insufficient to maintain *extensa* and *fodina* as separate taxa. Consequently, we have reduced *Eoglobigerina*? *fodina* Blow, 1979, to a junior synonym of *Parvularugoglobigerina extensa* (Blow, 1979). In addition, the 3$^{1}/_{2}$–4 chambered inflated subglobular, microperforate forms described by Premoli Silva and Bolli (1973), Smit (1982), Keller (1988), D'Hondt and Keller (1991), and Liu and Olsson (1992) under various names (see synonomy) are placed in *P. extensa*.

Although Blow (1979:1220) provisionally placed *extensa* and *fodina* in the genus *Eoglobigerina*, he recognized their microperforate structure as quite "distinct from the normal perforate, cancellate or reticulate, wall of the *eobulloides-trivialis-edita* group." On that basis, he expressed doubt that assignment of those forms to *Eoglobigerina* would be maintained in future studies. On the basis of wall structure and texture, Blow (1979) suggested that *extensa* and *fodina* (= *extensa*) were more closely related to *Globastica* (= *Globoconusa*) *daubjergensis* than to any other species assigned to *Eoglobigerina*. He further hypothesized that "either *fodina* or *extensa* might be ancestral to *daubjergensis* or, alternatively the various forms only share a common ancestor" (Blow, 1979:1221). The latter interpretation is consistent with the present hypothesis that *Globoconusa daubjergensis* and *Parvularugoglobigerina extensa* both evolved directly from *Guembelitria cretacea* (Olsson, 1970, 1982; Premoli Silva, 1977; Smit, 1982; Liu and Olsson, 1992; Olsson et al., 1992).

STABLE ISOTOPES.—No data available.

STRATIGRAPHIC RANGE.—Upper Zone P0 through Zone Pα.

GLOBAL DISTRIBUTION.—Similar to *Parvularugoglobigerina eugubina*.

ORIGIN OF SPECIES.—This species evolved from *Guembelitria cretacea*.

REPOSITORY.—Holotype (BP Cat. No. 39/60) and paratype (BP Cat. No. 40/24) are deposited at The Natural History Museum, London. Examined by GJ.

Genus *Woodringina* Loeblich and Tappan, 1957

TYPE SPECIES.—*Woodringina claytonensis* Loeblich and Tappan, 1957b.

ORIGINAL DESCRIPTION.—"Test free, early stage with a single whorl of three chambers, followed by a biserial stage; chambers inflated; wall calcareous, radial in structure, finely perforate; aperture a low arched slit, bordered above by a slight lip. Family Heterohelicidae. Paleocene. Monotypic." (Loeblich and Tappan, 1957b:39.)

DIAGNOSTIC CHARACTERS.—Tests contain an initial whorl of 3 chambers, later whorls of 2 chambers each. Test wall microperforate, marked by a guembelitriid surface texture (smooth walled or bearing perforate pustules). Aperture usually asymmetrically positioned and thin apertural lip infolded on one side.

DISCUSSION.—Although *Woodringina* remains limited to the Paleocene, it is no longer monotypic. It was assigned to the subfamily Guembelitriinae by Loeblich and Tappan (1957b). Elevation of the subfamily Guembelitriinae to the family Guembelitriidae (El-Naggar, 1971; Blow, 1979; Loeblich and Tappan, 1988) removed it from the family Heterohelicidae.

Woodringina claytonensis Loeblich and Tappan, 1957

PLATE 13: FIGURES 6–8; PLATE 68: FIGURES 1–6

Woodringina claytonensis Loeblich and Tappan, 1957b:39: fig. 1a–d [lower Danian, Pine Barren Mbr., Clayton Fm., Alabama]; 1957a:178, pl. 40: fig. 6 [holotype reillustrated].—D'Hondt, 1991:172, pl. 1: figs. 8, 11, 12 [figs. 8, 12, DSDP Site 577/12/5: 94–96 cm; fig. 11, lower Danian, Brazos River, Texas], pl. 2: figs. 4, 12 [DSDP Site 577/12/5: 94–96 cm; Shatsky Rise, northwestern Pacific Ocean].—Liu and Olsson, 1992:341, pl. 1: figs. 4–6

[Zone Pα, Pine Barren Mbr., Clayton Fm., Millers Ferry, Alabama].—MacLeod, 1993:61, pl. 3: figs. 8–14 [ODP Hole 690C/15X/2: 28–30 cm; Maud Rise, Southern Ocean].

Woodringina hornerstownensis Olsson.—Keller, 1988:257, pl. 3: fig. 15 [Zone Pα, El Kef, Tunisia]; 1989:319: figs. 3–6 [lower Danian, Brazos River, Texas]. [Not *Woodringina hornerstownensis* Olsson, 1960.]

Woodringina kelleri MacLeod, 1993:63, pl. 4: figs. 1–3 [Danian, DSDP Site 577A/12/2: 44–46 cm; Shatsky Rise, northwestern Pacific Ocean].

Woodringina cf. *kelleri* MacLeod, 1993:63, pl. 3: figs. 4, 5, 12 [Zone Pα, El Kef, Tunisia].

ORIGINAL DESCRIPTION.—"Test free, tiny, flaring rapidly; early stage with a single whorl of three chambers (reduced 'triserial'), commonly followed by three or more, rarely up to five, pairs of biserial chambers, the plane of biseriality slightly twisted in development; chambers few in number, subglobular, increasing rapidly in size; sutures distinct, constricted; wall calcareous, finely perforate and very finely hispid; aperture a low arched slit bordered above by a slight lip, somewhat asymmetrical in position.

"Length of holotype 0.15 mm.; greatest breadth 0.12 mm. Other specimens range from 0.12 to 0.22 mm. in length." (Loeblich and Tappan, 1957b:39.)

DIAGNOSTIC CHARACTERS.—In general, original description accurately describes diagnostic features of *W. claytonensis,* except for description of microperforate wall as hispid. Some specimens smooth-walled (Loeblich and Tappan, 1988), others characterized by presence of scattered pore-mounds (Plate 68: Figure 6). In other respects, species highly variable morphologically, with apertural height varing from high to low. Twisted plane of biseriality, apertural asymmetry, and triseriality of the first whorl more strongly pronounced in some specimens than in others within same assemblages.

DISCUSSION.—MacLeod (1993:92) described *Woodringina kelleri* as distinguished from *Woodringina claytonensis* by the former's "laterally compressed adult chambers, and ... its large elongate aperture that is surrounded by a well-developed discontinuous apertural rim;" however, the final chambers of both holotypes are similarly subglobular in edge and plan view (compare MacLeod, 1993, pl. IV: figs. 1–3 to Loeblich and Tappan, 1957b, pl. 39: fig. 1; see also Plate 13: Figures 6, 7). The only other figured specimen identified by MacLeod (1993) as *W. kelleri* also lacks laterally compressed chambers and closely resembles the *W. claytonensis* holotype in the shape of its final chambers (compare D'Hondt, 1991, pl. 2: fig. 4 to Loeblich and Tappan, 1957b, pl. 39: fig. 1). Comparison of the respective apertural characteristics of *W. claytonensis* and *W. kelleri* is complicated by the absence of *W. claytonensis* paratype specimens and the physical obstruction of the *W. claytonensis* holotype aperture. Nonetheless, the *W. claytonensis* holotype also appears to have a large elongate aperture surrounded by a well-developed, discontinuous apertural rim (Plate 13: Figure 7). The aperture of the *W. kelleri* holotype (Plate 13: Figure 8) does appear to be more centrally located than that of the *W. claytonensis* holotype. This difference appears insufficient to warrant maintenance of *W. kelleri* as a separate taxon, given the pronounced variability in position, height, and number of apertures exhibited by otherwise similar specimens in populations of *Woodringina* and other guembelitriid genera (i.e., *Guembelitria* and *Parvularugoglobigerina*). Hence, we consider *Woodringina kelleri* MacLeod, 1993, a junior synonym of *Woodringina claytonensis* Loeblich and Tappan, 1957.

STABLE ISOTOPES.—The stable isotopic signature of this species suggests an affinity for relatively warm near-surface water masses (D'Hondt and Zachos, 1993).

STRATIGRAPHIC RANGE.—Basal Zone Pα to Zone P1b.

GLOBAL DISTRIBUTION.—*Woodringina claytonensis* was most abundant in low-latitude open-ocean assemblages (D'Hondt and Keller, 1991; Liu and Olsson, 1992). It was rare in high-latitude open-marine environments (Liu and Olsson, 1992).

ORIGIN OF SPECIES.—This species is considered to have descended from *Guembelitria cretacea* (Olsson, 1970, 1982; Smit, 1977, 1982; D'Hondt, 1991; Li and Radford, 1991; Olsson et al., 1992; Liu and Olsson, 1992). D'Hondt (1991) and Liu and Olsson (1992) illustrated forms that are morphologically intermediate between *Guembelitria cretacea* Cushman, 1933, and *Woodringina claytonensis* Loeblich and Tappan, 1957. Such morphotypes are triserial in early whorls and biserial in later whorls (*Guembelitria irregularis* Morozova, 1961, of D'Hondt, 1991) (Plate 63: Figure 12; Plate 68: Figure 5).

REPOSITORY.—Holotype (USNM P5685) deposited in the Cushman Collection, National Museum of Natural History. Examined by SD, CL, and RKO.

Woodringina hornerstownensis Olsson, 1960

FIGURE 34; PLATE 13: FIGURES 4, 5; PLATE 68: FIGURES 7–14

Woodringina hornerstownensis Olsson, 1960:29, pl. 4: figs. 18, 19 [Zone P3b, Hornerstown Fm., New Jersey].—D'Hondt, 1991:172, pl. 2: figs. 5–8 [figs. 5, 8, Zone P1a, DSDP Site 577/12/4: 34–36 cm; Shatsky Rise, northwestern Pacific Ocean; figs. 6, 7, Zone P3b, Hornerstown Fm., New Jersey].—Liu and Olsson, 1992:341, pl. 1: fig. 8 [Midway Group, Plummer Stop 14, Kaufman Co., Texas].—MacLeod, 1993:63, pl. 4: figs. 6, 7, 11, 13 [lower Danian, El Kef, Tunisia].

Chiloguembelitria taurica Morozova.—Keller, 1988:257, pl. 3: fig. 3 [Zone Pα, El Kef, Tunisia]. [Not *Chiloguembelitria taurica* Morozova, 1961.]

ORIGINAL DESCRIPTION.—"Test small, elongate, slightly twisted, rather rapidly tapering, about twice as long as broad. Initial end consists of whorl of three chambers, rest of test consists of biserial arrangement of chambers. Wall smooth, surface of last two chambers may be finely spinose, especially near the aperture. Chambers numerous, somewhat inflated, wider than high, increasing more rapidly in width than height as added. Sutures distinctly depressed, nearly at right angles to axis of test. Aperture a low arch at one side of final chamber, directed inward, with a small lateral flange along the periphery. Length 0.15 mm. Width 0.10 to 0.15 mm." (Olsson, 1960:29.)

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. hornerstownsis* 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 Pα 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 *Guembelitria 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." (Ruess, 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 *Guembelitria 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. It's 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* Pokorńy, 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

PLATE 8

Russian Primary Type Specimens

(bars = 100 μm)

FIGURES 1–3.—*Guembelitria irregularis* Morozova, 1961:17, pl. 1: fig. 9, holotype no. 3510/13a, Moscow GAN; Danian, Tarkhankut, Crimea. See "Discussion" for *Guembelitria cretacea.*

FIGURES 4–6.—*Globigerina* (*Eoglobigerina*) *trifolia* Morozova, 1961:12, pl. 1: fig. 1, holotype no. 3510/4, Moscow GAN; Danian, Tarkhankut, Crimea. See "Discussion" for *Globoconusa daubjergensis.*

FIGURES 7–9.—*Acarinina multiloculata* Morozova, 1961:15, pl. 2: fig. 5, holotype no. 3510/10, Moscow GAN; Montian, Balka Nasypkoiskaya, Crimea. Probably a reworked specimen of *Hedbergella planispira* (Tappan, 1940).

FIGURES 10–12.—*Globigerina* (*Eoglobigerina*) *eobulloides* Morozova, 1959:1115, text-fig. 1a–c, holotype no. 3508/1, Moscow GAN; Danian, Tarkhankut, Crimea. See *Eoglobigerina eobulloides.*

FIGURES 13–15.—*Globigerina* (*Eoglobigerina*) *hemisphaerica* Morozova, 1961:11, pl. 1: fig. 4, holotype no. 3510/3, Moscow GAN; Danian, Tarkhankut, Crimea. See "Discussion" for *Eoglobigerina edita.*

FIGURES 16–18.—*Globigerina* (*Eoglobigerina*) *theodosica* Morozova, 1961:11, pl. 1: fig. 6, holotype no. 3510/2, Moscow GAN; Danian, Tarkhankut, Crimea. See "Discussion" for *Eoglobigerina edita.*

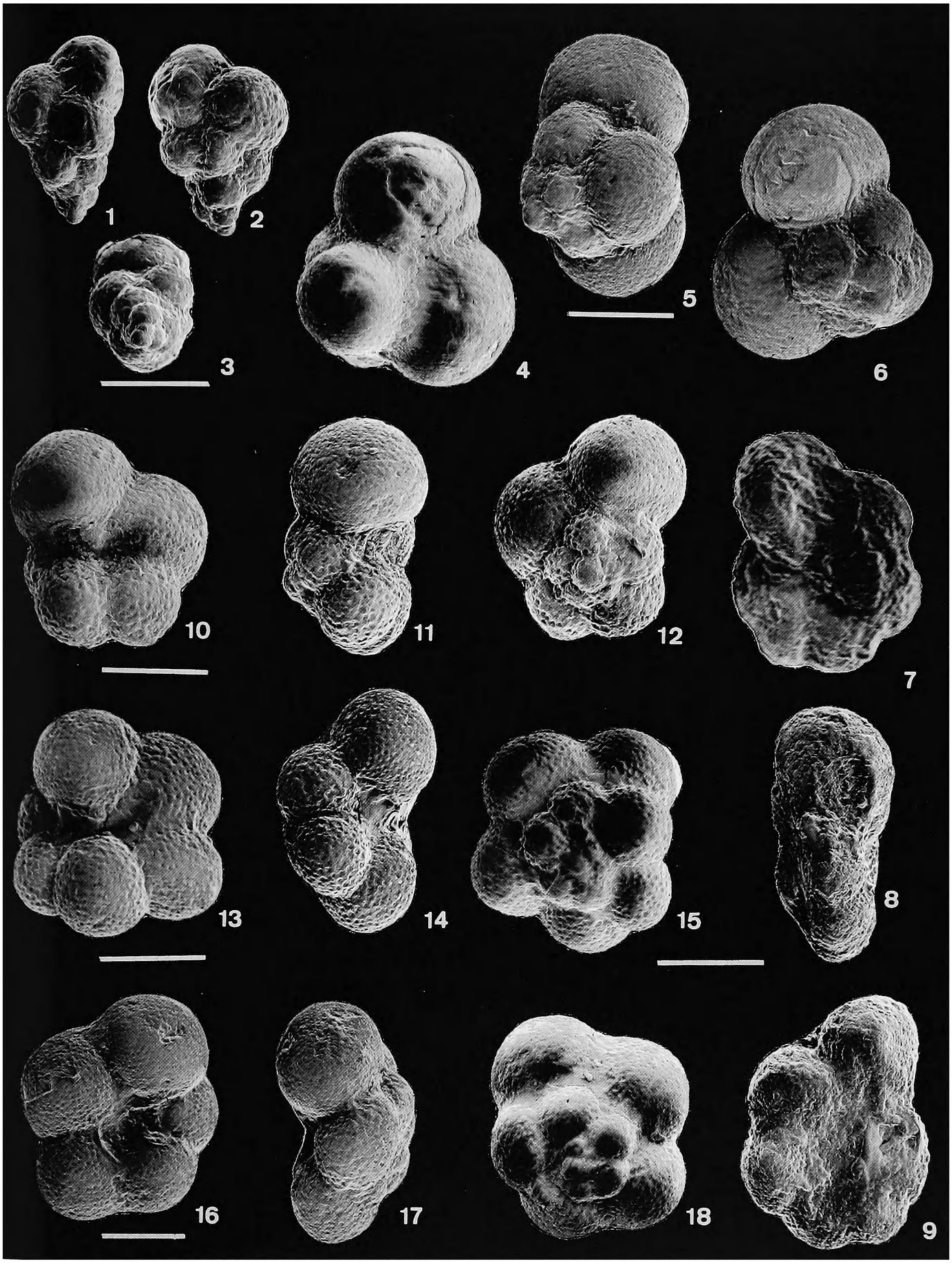
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PLATE 12

Russian Primary Type Specimens

(bars = 100 μm)

FIGURES 1–3.—*Acarinina acarinata* Subbotina, 1953:229, pl. 22: fig. 5, paratype no. 4129, St. Petersburg VNIGRI (378/160); zone of compressed globorotaliids, Paleocene–lower Eocene, Series F1, Khieu River, Caucasus. See "Discussion" for *Acarinina nitida.*

FIGURES 4–6.—*Acarinina intermedia* Subbotina, 1953:227, pl. 20: fig. 15, holotype no. 4095, St. Petersburg VNIGRI (378/124); zone of compressed globorotaliids, Paleocene?, Goryache Klynch horizon, Kuban River, Caucasus. See "Discussion" for *Acarinina nitida.*

FIGURES 7–9.—*Guembelitria dammula* Voloshina, 1961, hypotype; Paleocene, P0, Bjala (K/T section no. 2b, 1–2 cm above boundary), Bulgaria. See "Discussion" for *Guembelitria cretacea.*

FIGURES 10–12.—*Globanomalina imitata* (Subbotina, 1953), hypotype; Paleocene, P1b/c, Bjala (K/T section no. 2b, sample Sum 24/12), Bulgaria. See *Globanomalina imitata.*

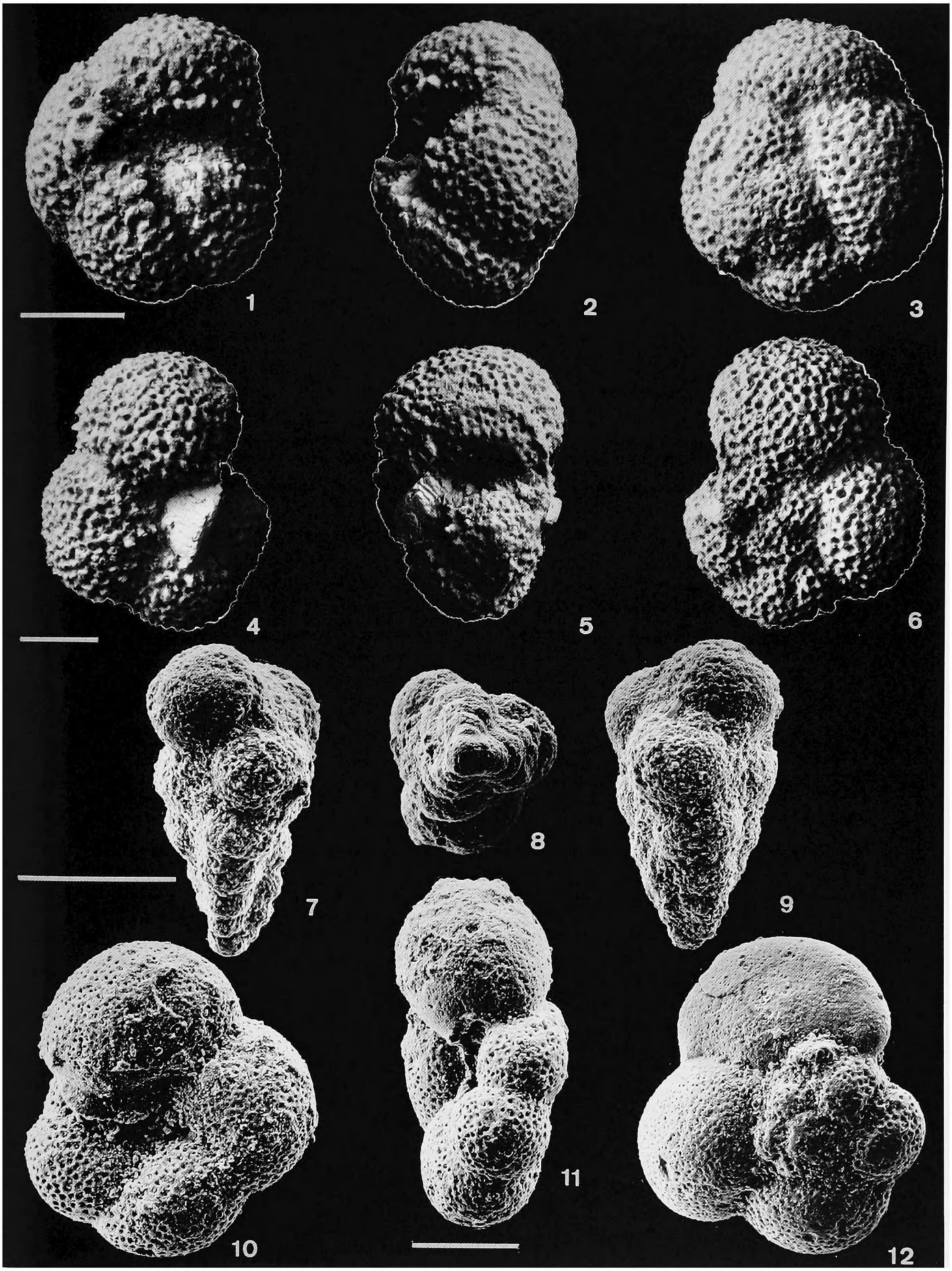
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PLATE 13

USNM Primary Type Specimens

(bars = 50 μm)

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, Hornerstown 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 Pα, 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 trinitatensis* 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.

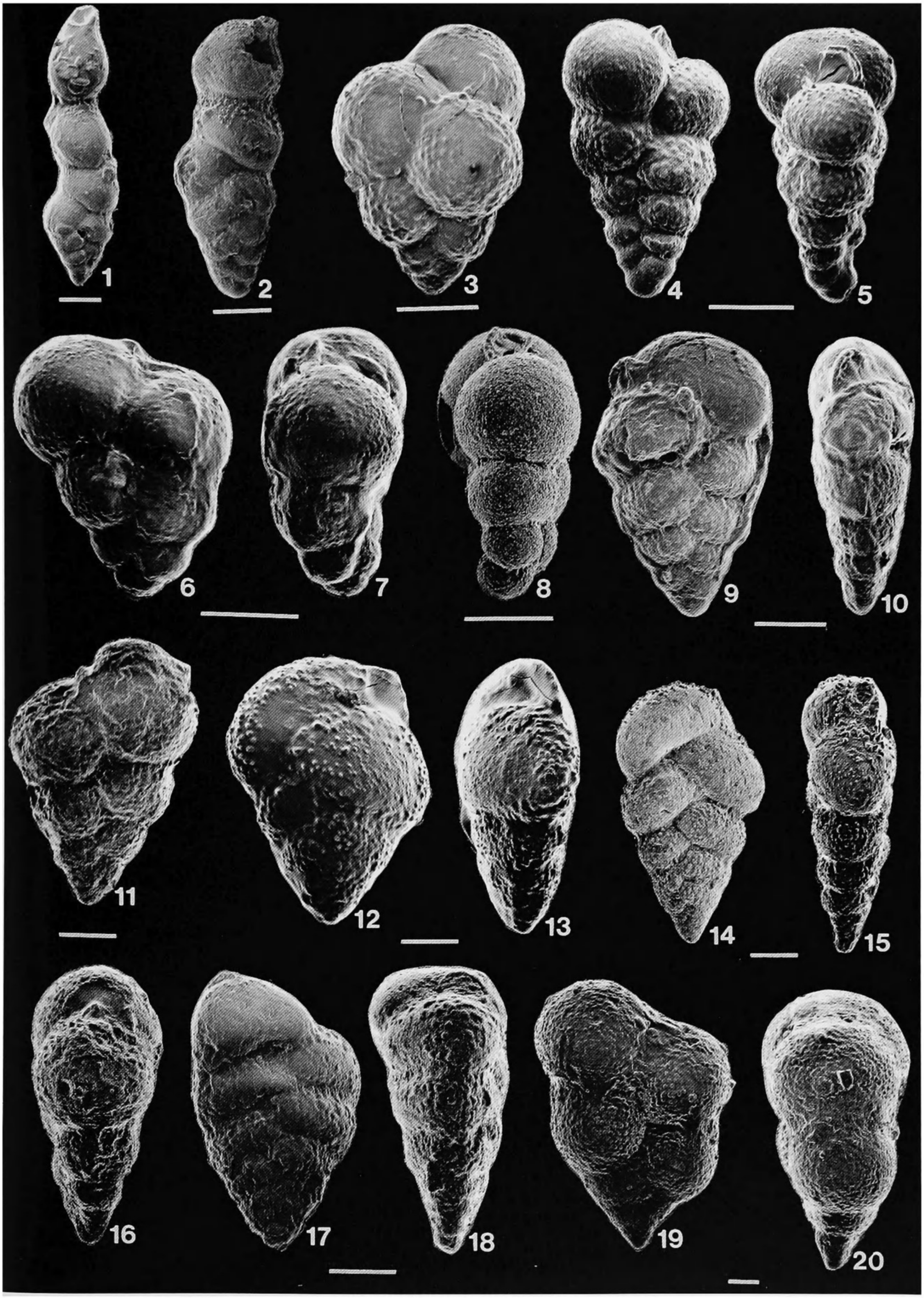
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PLATE 15

USNM Primary Type Specimens

(bars = 50 μm)

FIGURES 1–3.—*Globorotalia strabocella* Loeblich and Tappan, 1957, holotype, USNM P5879; Nanafalia Fm., Alabama.

FIGURES 4, 7, 8.—*Globigerina soldadoensis* Brönnimann, 1952, holotype, USNM 370085; Lizard Springs Fm., Trinidad; type locality of *Globorotalia velascoensis* Zone of Bolli, 1957a = Zone P5.

FIGURES 5, 6.—*Globigerina aquiensis* Loeblich and Tappan, holotype, USNM P5839; Aquia Fm., Aquia Creek, Virginia.

FIGURES 9, 10.—*Globigerina chascanona* Loeblich and Tappan, 1957 (= *Acarinina subsphaerica* (Subbotina)), holotype, USNM P5842; Zone P4, uppermost Hornerstown Fm., New Jersey.

FIGURES 11, 12, 15.—*Globorotalia crassata* (Cushman) var. *aequa* Cushman and Renz, 1942, holotype, USNM CC38210; near base of *Globorotalia subbotinae* Zone, Soldado Fm., Trinidad.

FIGURES 13, 14.—*Globigerina daubjergensis* Brönnimann, 1953, holotype, USNM CC64879; Danian, Daubjerg Quarry, Denmark.

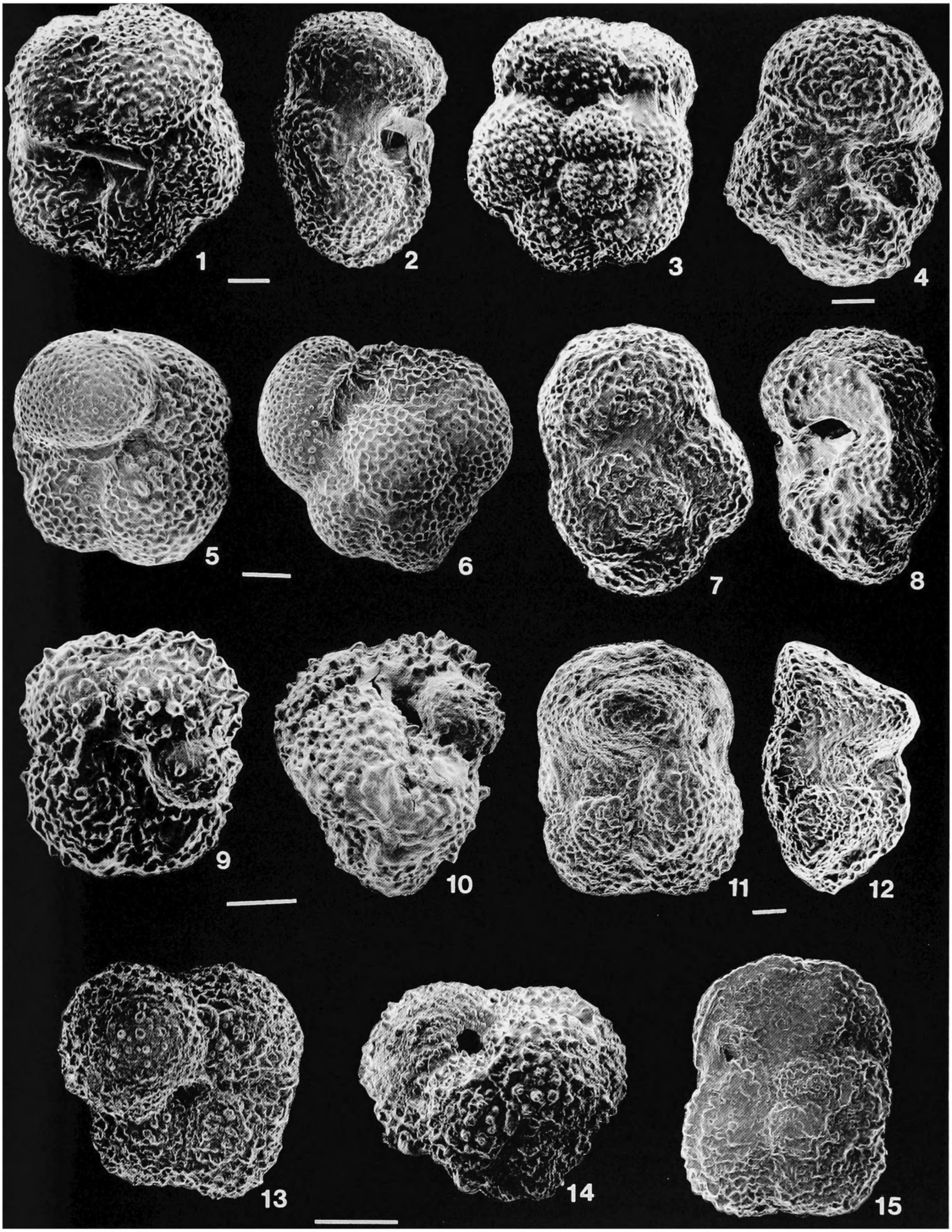
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PLATE 63

Guembelitria cretacea Cushman, 1933

(Figures 1–5, 7–12: bars = 50 μm; Figure 6: bar = 10 μm)

FIGURES 1–4.—Upper Maastrichtian, Redbank Fm., New Jersey.

FIGURES 5, 6, 10–12.—Zone Pα, Millers Ferry, Alabama, core 226, sample 18; Figure 6, view of wall of Figure 5 showing typical pore mounds of this species; Figure 12, specimen showing transitional morphology to *Woodringina*.

FIGURE 7.—Zone Pα, DSDP Hole 390A/11/5: 135–136 cm; Blake-Bahama Basin, North Atlantic Ocean.

FIGURES 8, 9.—Zone Pα, DSDP Site 577/12/5: 115–117 cm; Shatsky Rise, northwestern Pacific Ocean.

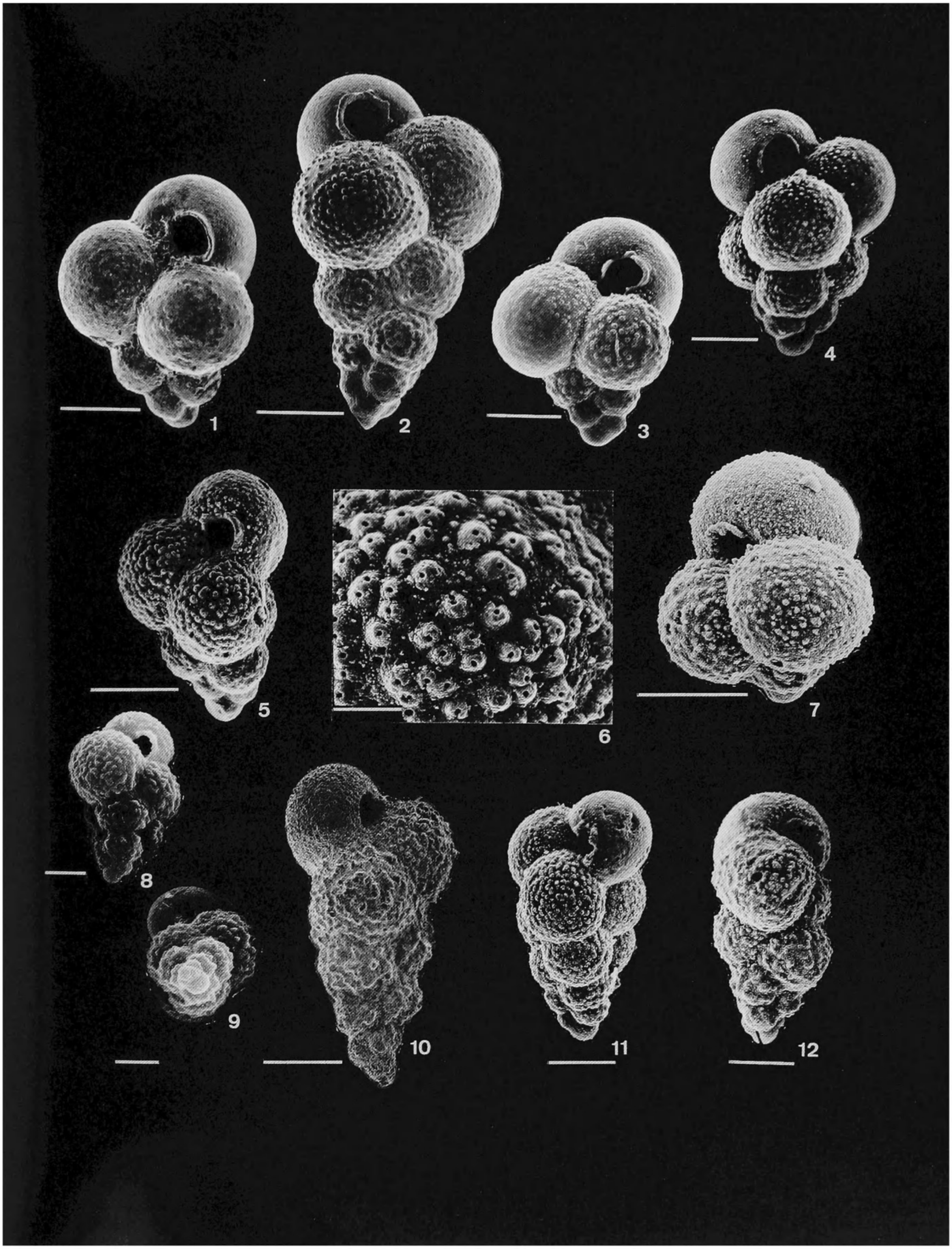
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PLATE 64

Globoconusa daubjergensis (Brönnimann, 1953)

(Figures 1–7, 10–12: bars = 50 μm; Figures 8, 9: bars = 10 μm)

FIGURES 1–3, 5, 6, 8, 9.—Zone P1c, Brightseat Fm., Maryland; Figure 8 (view of ultimate chamber of Figure 6) and Figure 9 (view of ultimate chamber of Figure 5) showing microperforate wall texture and poreless sharp pustules.

FIGURE 4.—Zone P0, Brazos River, Texas.

FIGURE 7.—Zone Pα, Millers Ferry, Alabama, core 225, sample 256.

FIGURES 10–12.—Zone P1c, Midway Fm., Texas, Plummer station 14.

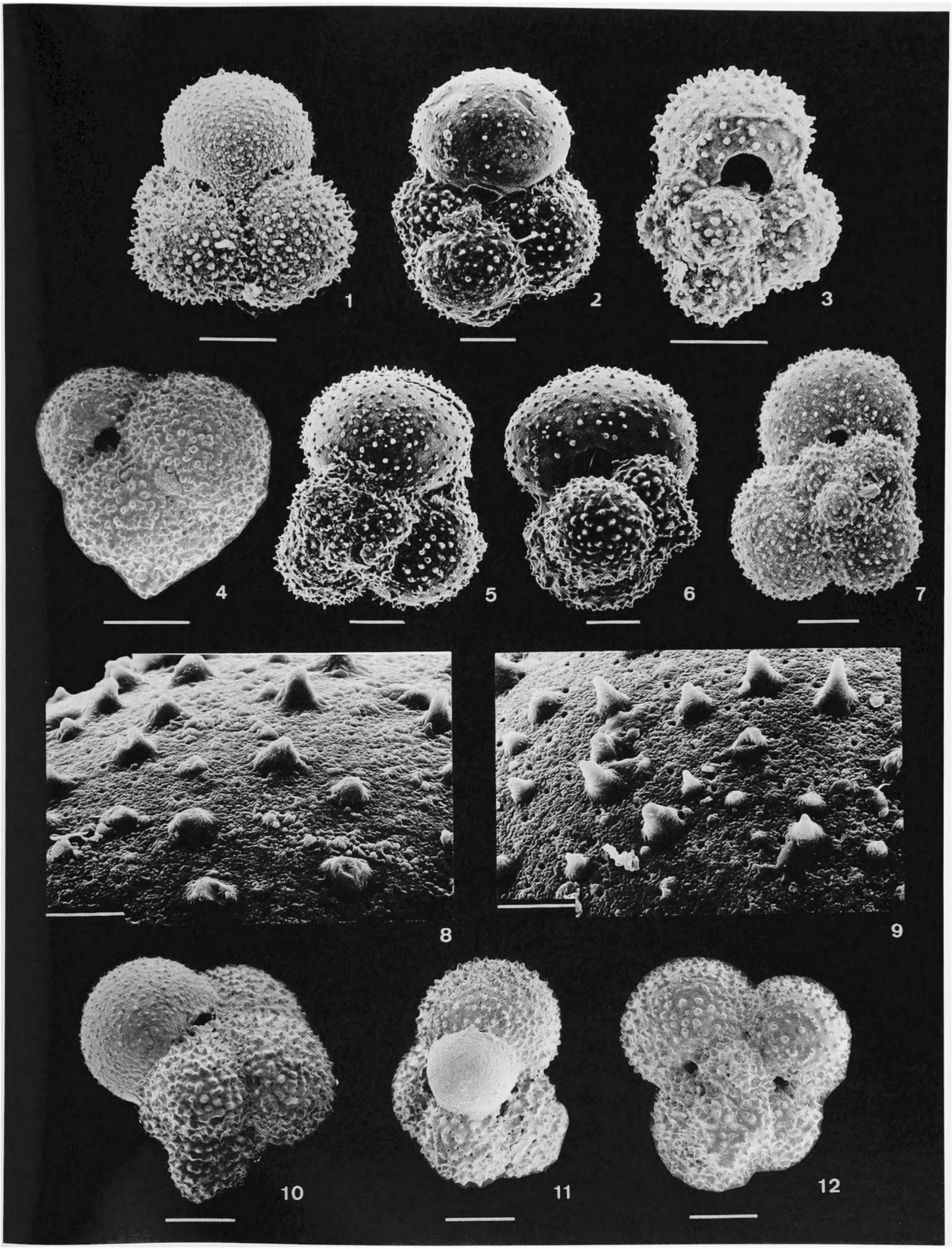
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PLATE 65

Parvularugoglobigerina alabamensis (Liu and Olsson, 1992)

(Figures 1–5: bars = 50 μm; Figure 6: bar = 10 μm)

FIGURE 1.—Zone P1a , Millers Ferry, Alabama, core 225, sample 265.

FIGURES 2, 3.—Zone P1a, Millers Ferry, Alabama, core 225, sample 266.

FIGURE 4.—Zone P1a, Millers Ferry, Alabama, core 226, sample 20.

FIGURES 5, 6.—Zone P1a, Millers Ferry, Alabama; Figure 5, holotype, sample 40 feet above Prairie Bluff Chalk; Figure 6, view of wall of 3rd chamber of holotype showing microperforate pore mound texture.

Parvularugoglobigerina extensa (Blow, 1979)

(bars = 50 μm)

FIGURES 7, 9–12.—Zone Pα, DSDP Site 577/12/5: 94–96 cm; Shatsky Rise, northwestern Pacific Ocean.

FIGURE 8.—Zone Pα, El Kef, Tunisia.

FIGURE 13.—Zone Pα, type level of *P. eugubina,* Gubbio section, central Appennines, Italy.

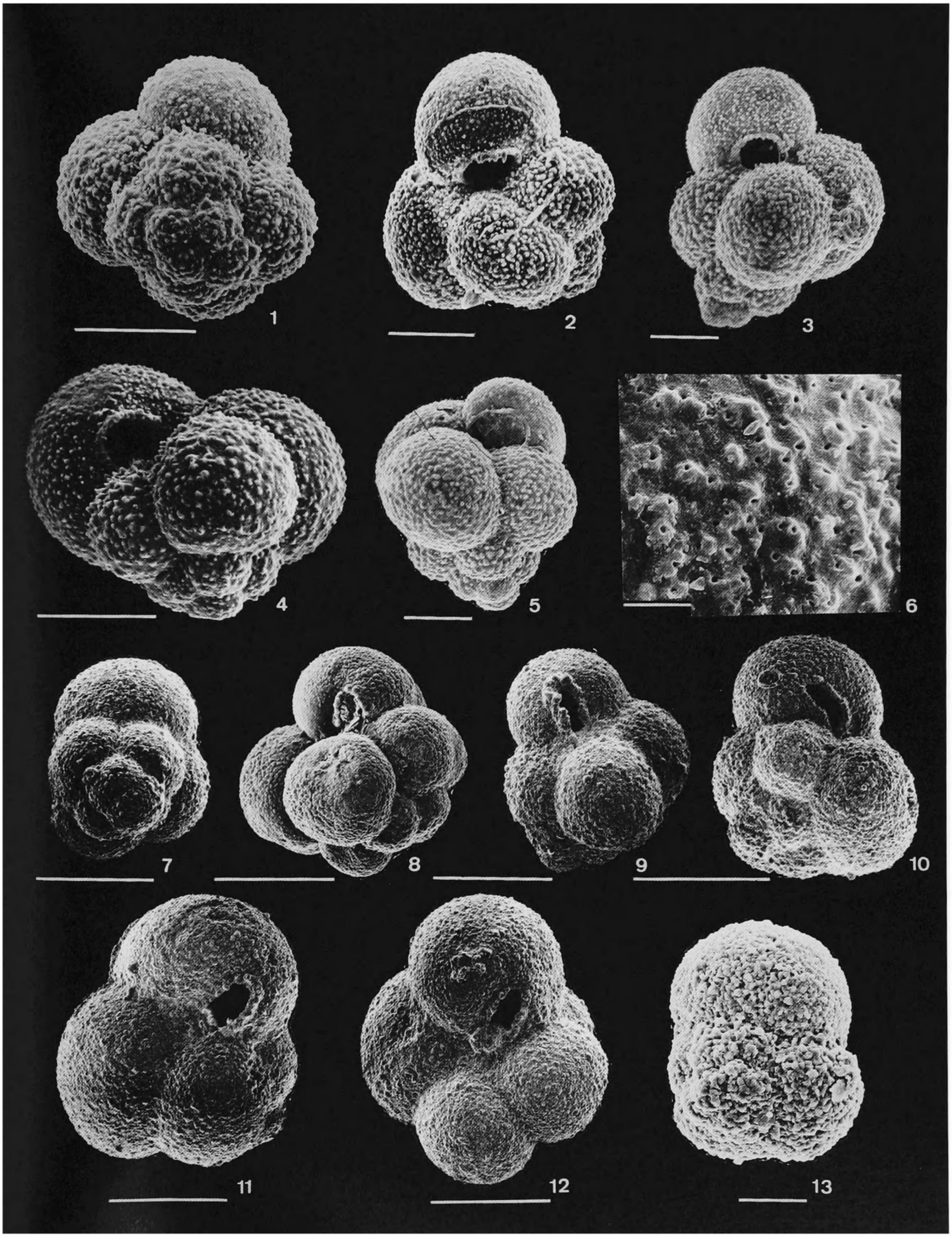
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PLATE 66

Parvularugoglobigerina eugubina (Luterbacher and Premoli Silva, 1964)

(Figures 1–4, 6–12: bars = 50 μm; Figure 5: bar = 10 μm)

FIGURES 1–5.—Zone Pα, Millers Ferry, Alabama, core 225, sample 328; Figure 5, view of wall of 2nd chamber of Figure 2 showing microperforate wall texture with a few incipient pore mounds.

FIGURES 6, 8, 9, 12.—Zone Pα, DSDP Site 577/12/5: 115–117 cm.

FIGURES 7, 10.—Zone Pα, El Kef, Tunisia.

FIGURE 11.—Zone Pα, DSDP Site 577/12/5: 134–136 cm; Shatsky Rise, northwestern Pacific Ocean.

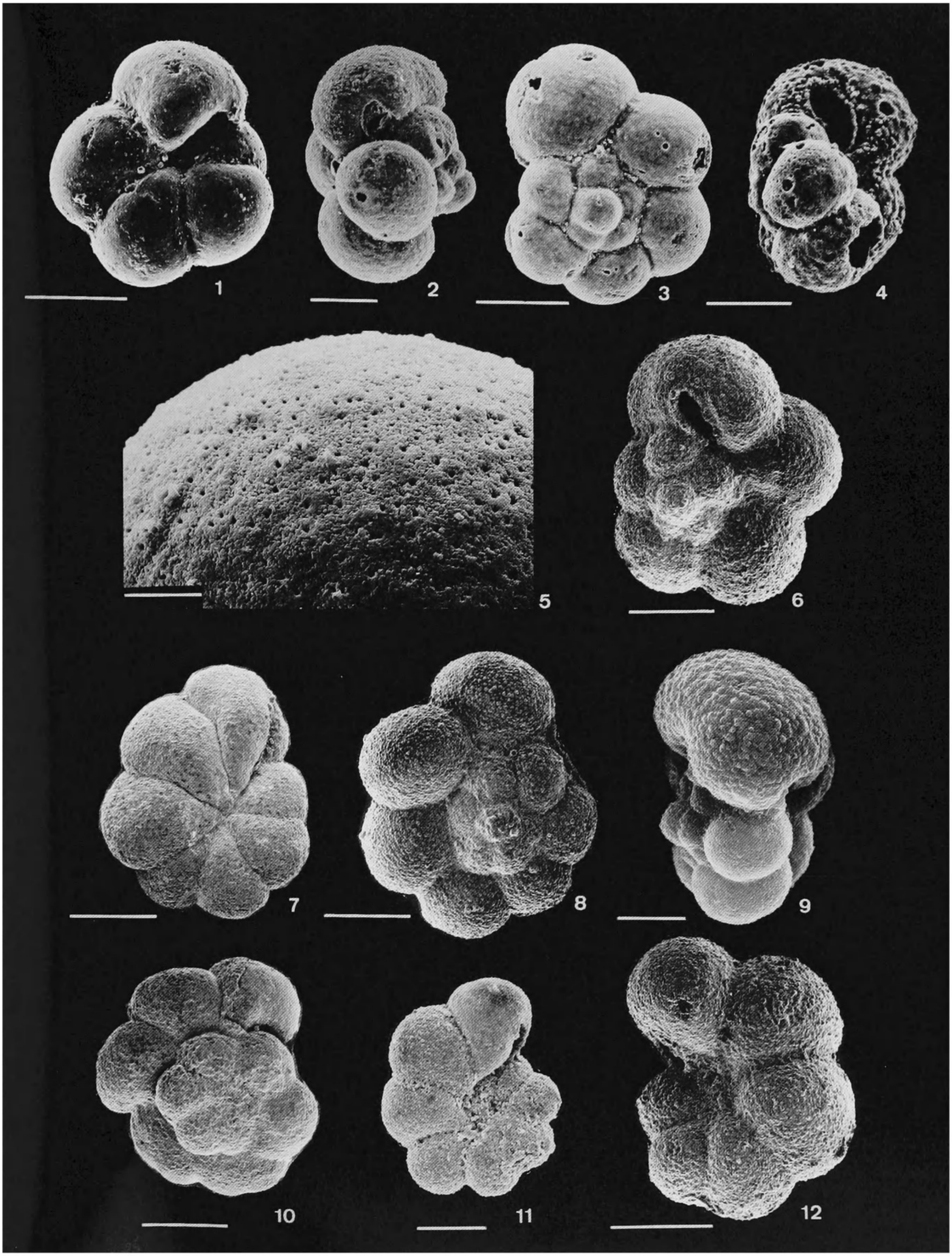
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PLATE 67

Parvularugoglobigerina eugubina (Luterbacher and Premoli Silva, 1964)

(Figures 1–10, 12, 13: bars = 50 μm; Figures 11, 14: bars = 10 μm)

FIGURES 1–9.—Zone Pα, type level of *P. eugubina,* Gubbio section, central Appennines, Italy.

FIGURES 10–12.—Zone Pα, DSDP Site 577/12/5: 125–126 cm; Shatsky Rise, northwestern Pacific Ocean; Figure 11, view of Figure 10 showing recrystallized wall that obscures microperforate wall texture.

FIGURES 13, 14.—Zone Pα, Millers Ferry, Alabama, core 226, sample 20; Figure 14, view of wall of 4th chamber of Figure 13 showing microperforate wall texture and scattered pore mounds.

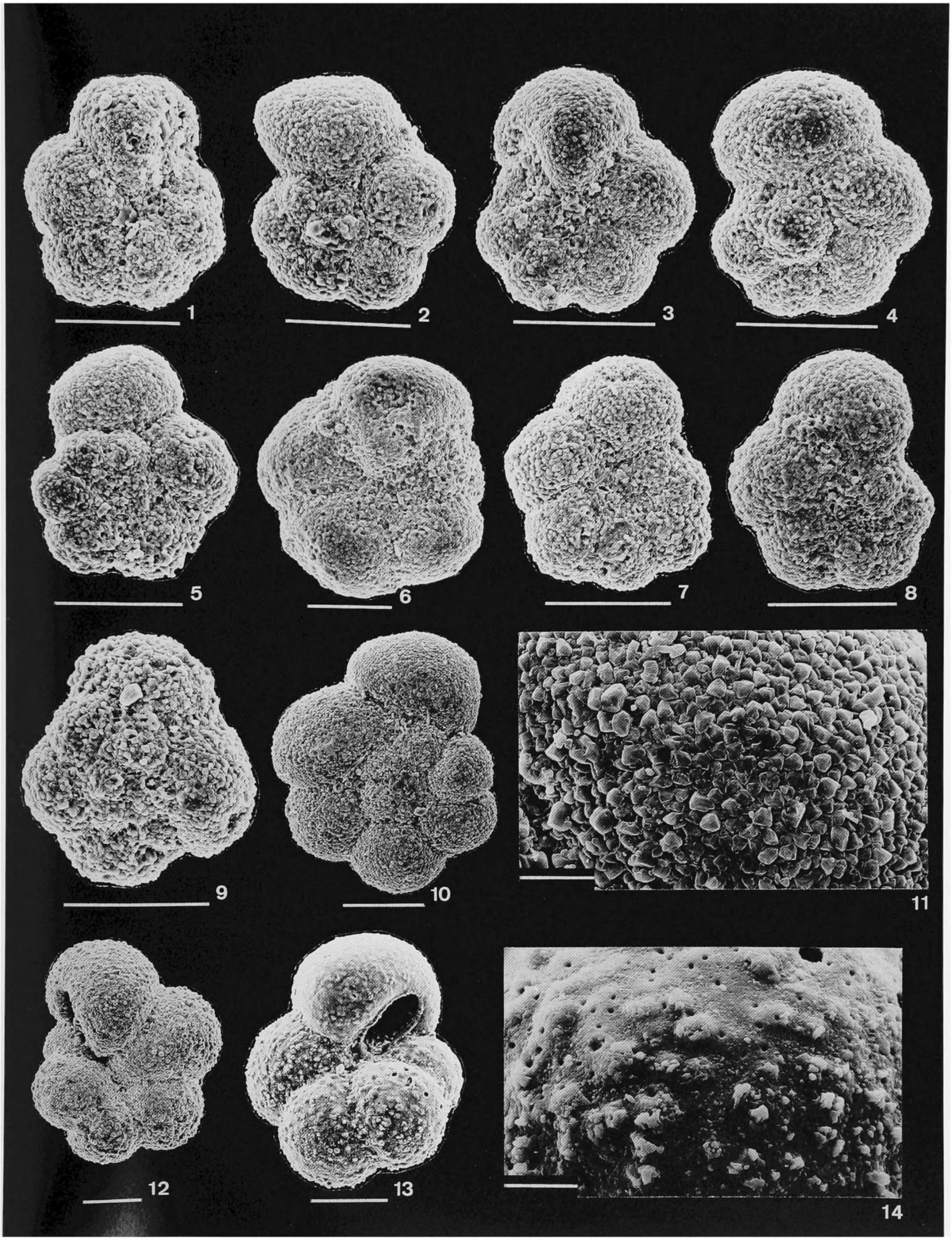
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PLATE 68

Woodringina claytonensis Loeblich and Tappan, 1957

(Figures 1-5: bars = 50 μm; Figure 6: bar = 10 μm)

FIGURE 1.—Zone P0, Brazos River, Texas.

FIGURES 2, 6.—Zone P1a, DSDP Hole 390A/11/5: 135–136 cm; Blake-Bahama Basin, North Atlantic Ocean; Figure 6, view of 2nd chamber of Figure 2 showing microperforate wall texture and blunt pustules.

FIGURE 3.—Zone Pα, Millers Ferry, Alabama, core 226, sample 18.

FIGURE 4.—Zone P1a, Midway Group, Texas, Plummer station 4.

FIGURE 5.—Zone Pα, DSDP Site 577/12/5: 115–117 cm; Shatsky Rise, northwestern Pacific Ocean, specimen showing intermediate morphology with *Guembelitria cretacea*.

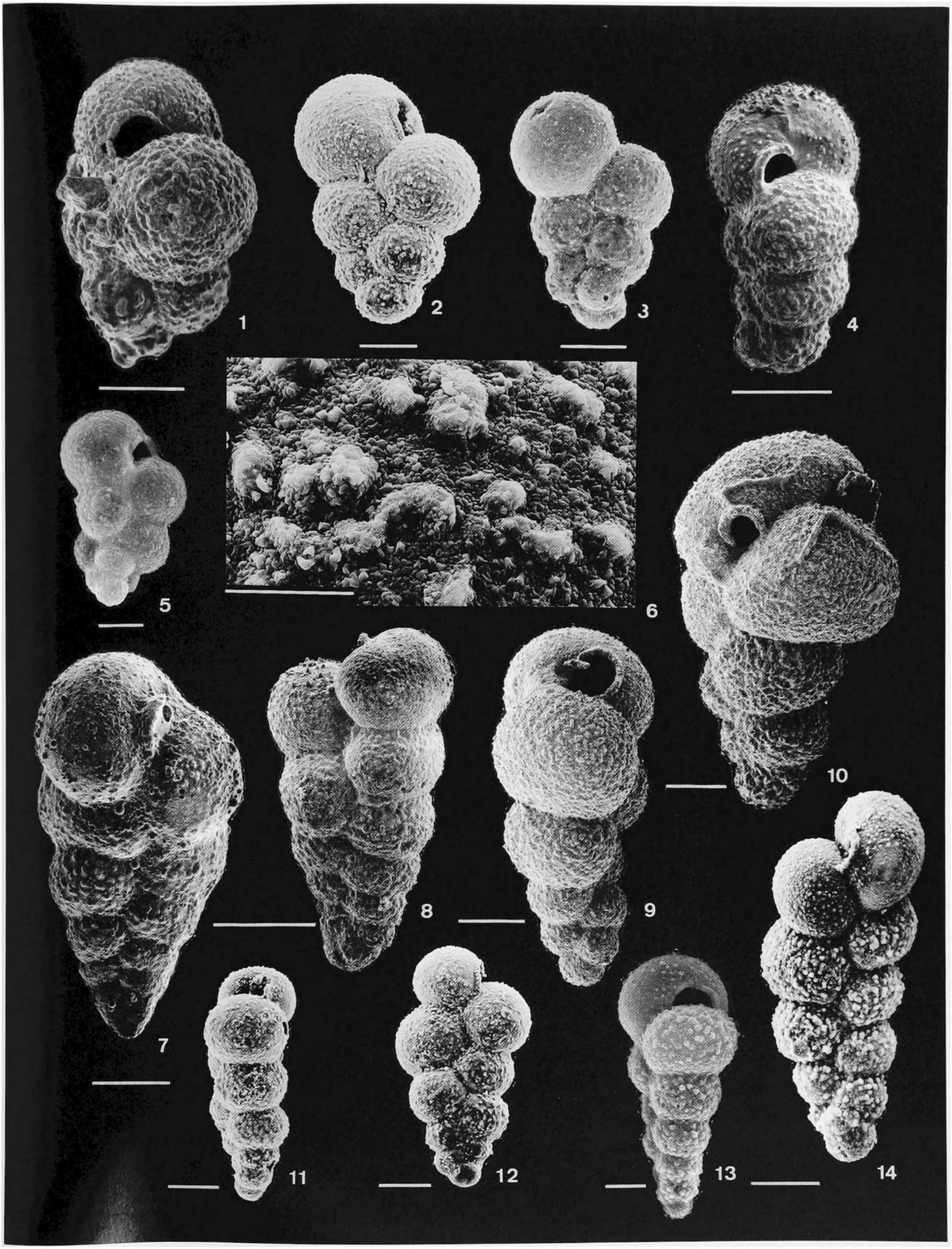
Woodringina hornerstownensis Olsson, 1960

(bars = 50 μm)

FIGURES 7, 8.—Topotypes, Zone P3, Hornerstown Fm., New Jersey.

FIGURES 9, 10, 13, 14.—Zone Pα, DSDP Site 577/12/5: 113–114 cm; Shatsky Rise, northwestern Pacific Ocean.

FIGURES 11, 12.—Zone P1c, Midway Fm., Texas, Plummer station 14.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D’Hondt, Steven, Liu, Chengjie, and Olsson, Richard K. 1999. "Family Guembelitriidae Montanaro Gallitelli, 1957." *Atlas of Paleocene planktonic foraminifera* 85, 77–88.

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