UPPER MAESTRICHTIAN PLANKTONIC FORAMINIFERA FROM GALICIA BANK, WEST OF SPAIN

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ABSTRACT. An upper Maestrichtian assemblage of planktonic foraminifera is described from a sample of chalk dredged from Galicia Bank, a non-magnetic seamount off the west coast of Spain. The presence of post-Maestrichtian planktonic species in the sample is attributed to the burrowing of mud-feeding organisms. It is suggested that the very high percentage of planktonic individuals in the upper Maestrichtian limestone of Galicia Bank is a product of depth and proximity to an open oceanic environment during deposition.

This paper describes the members of an assemblage of planktonic foraminifera which were used to date a fragment of soft chalky limestone (Funnell 1964) dredged from the upper slopes of the Galicia Bank, a flat-topped non-magnetic seamount off the west coast of Spain. The sample D. 3804.1, which was dredged from a depth of 650–700 m. at 42° 36' N., 11° 35' W. (station D. 3804), is one of a series of samples obtained from the slopes of the seamount during the summer of 1958 (Black et al. 1964).

The assemblage contains species and subspecies diagnostic of the upper Maestrichtian, and equates with the Abathomphalus mayaroensis zone of Trinidad (Bolli 1957), the Globotruncanina contusa zone of Tunisia (Dalbiez 1955), the KF zone of Upper Austria (Wille-Janoschek 1966), and the Pseudotextularia elegans zone of southern Scandinavia (Berggren 1962), which are the highest Maestrichtian zones in their respective areas.

In a count of 507 specimens, 95% were planktonic (including 22% heterohelicids), 5% benthonic, and 0-2% post-Maestrichtian contaminants.

The contaminants, which include planktonic species of mid-Tertiary and upper Tertiary to Recent origin, were probably introduced into the samples via burrows or borings (Funnell 1964). Black (1964) attributed a mixed assemblage of Cretaceous and Tertiary coccoliths in the same sample to the burrowing of mud-feeding organisms.

Investigations of the ratio of planktonic to benthonic individuals in Recent sediments by Smith (1955), Grimsdale and Morkhoven (1955), and Hay (1960) suggest that, despite variations attributable to local conditions, a general relationship exists between increasing proportion of planktonic individuals, depth, and proximity to the open oceans. Grimsdale and Morkhoven considered sediments containing over 98% planktonic individuals as indicative of a depth of deposition of at least 700 m. Hay (1960) suggested that the upper Cretaceous Mendez and Paleocene Velasco formations of the Tampico embayment, whose faunas both contain 90%, or more planktonic species, were deposited 'in waters at least 250 and probably more than 500 m deep'.

The paucity of data concerning conditions in the Upper Cretaceous, and the debatable procedure of including the heterohelicids in planktonic counts, suggests that the planktonic/benthonic ratio provides at the most an approximation of the depth of deposition during this period (see Funnell 1967, pp. 339–40). Nevertheless the high ratio of planktonic species (95% including the heterohelicids; 73% excluding the heterohelicids) in

the upper Maestrichtian limestone of the Galicia Bank is most probably indicative of an open oceanic environment, and is not at variance with the depth of deposition from which the sample was dredged.

The line illustrations were prepared by Mrs. J. K. Friend (née Bean) in 1964; the electron micrographs were taken by the Cambridge Instrument Company Ltd. on a Steroscan II in 1967. In all cases except one the same specimen was used on both occasions. 'Hypotype' and illustrated specimens have been deposited in the Sedgwick Museum, Cambridge, together with complete synonymies and bibliography of the species described.

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SYSTEMATIC DESCRIPTIONS

Family HETEROHELICIDAE Cushman 1927
Subfamily HETEROHELICINAE Cushman 1927
Genus HETEROHelix Ehrenberg 1843

Heterohelix globulosa (Ehrenberg)

Plate 1, figs. 1, 2; text-fig. 1

1834 Textilaria globulosa Ehrenberg, p. 135, pl. 4, fig. 4 (fide Ellis and Messina 1940 et seq.).
1931 Guembelina globulosa (Ehrenberg); Visser, p. 254, pl. 8, fig. 8.
1960 Guembelina globulosa (Reuss); Hoffker, p. 224, fig. 18, pl. 225, fig. 39.
1961 Heterohelix globulosa (Ehrenberg); Sald and Kendany, p. 331, pl. 2, fig. 1.
1966 Heterohelix globulosa (Ehrenberg); Barr, p. 503, pl. 78, figs. 5, 6.
1966 Guembelina globulosa (Ehrenberg); Hoffker, p. 107, pl. 10, fig. 110.
1966 Guembelina cf. globulosa (Ehrenberg); Hoffker, p. 170, pl. 29, fig. 63.
1966 Heterohelix globulosa (Ehrenberg); Lehmann, p. 314, pl. 2, fig. 9.
1966 Heterohelix globulosa (Ehrenberg); Wille-Janosek, pp. 148, 149, 151, no fig.

TEXT-FIG. 1. Heterohelix globulosa (Ehrenberg),
(a) lateral view, (b) apertural view; No. 1165, × 100.

Description. In the specimens examined the test is composed of 15 chambers. The first 4 or 5 are small and coiled about the proloculus, later chambers are biserially arranged and increase in size and globosity, a development which is most apparent in the last 4 chambers. The chamber surfaces are ornamented with fine longitudinal costae; pores are confined to the intercostate surfaces. The aperture is simple, slit-like, interiormarginal.

Stratigraphical distribution. H. globulosa is recorded from the Santonian (Klüper 1956) to upper Maestrichtian.

Geographical distribution. A widely distributed species ranging from approximately 55° N. (Vigso and Rødvig, Denmark; Hoffker 1960) to 25° S. (Carnarvon Basin, W. Australia; Belford 1960). Within these latitudes it is recorded from the Pacific Ocean (Hamilton 1953), California (Martin 1964), the U.S. Gulf Coast (Cushman 1946), Mexico (Ohvera 1959), Cuba (van Wessem 1943), northern Europe (Visser 1951), the circum-Mediterranean, and India (Nagappa 1959).
**Heterohelix striata** (Ehrenberg)

Plate 1, figs. 3, 4; text-fig. 2

- 1839 *Textularia striata* Ehrenberg, p. 135, pl. 4, figs. 1, 2, 3 (file Ellis and Messina 1940 et seq.).
- 1946 *Guembelina striata* (Ehrenberg); Cushman, p. 104, pl. 45, figs. 4, 5.
- 1953 *Pseudoguembelina striata* (Ehrenberg); Brönnimann and Brown, p. 154, fig. 6.
- 1959 *Heterohelix striata* (Ehrenberg); Olvera, pp. 71, 72, pl. 2, figs. 4, 8.
- 1964 *Heterohelix striata* (Ehrenberg); Martin, p. 85, pl. 11, fig. 1.
- 1964 *Pseudoguembelina striata* (Ehrenberg); Said and Sabry, p. 394, pl. 3, fig. 21.
- 1966 *Heterohelix striata* (Ehrenberg); Wille-Janoschek, pp. 148, 149, 151, no fig.
- 1966 *Guembelina striata* (Ehrenberg); Hofker, pp. 31, 64, 79, 150, 189, 318; pl. 3, fig. 68; pl. 10, fig. 109; pl. 14, figs. 80, 81; pl. 23, figs. 116, 117; pl. 33, fig. 76; pl. 34, fig. 105; pl. 73, fig. 166.
- 1966 *Heterohelix striata* (Ehrenberg); Lehmann, p. 315, pl. 2, fig. 8.

**Description.** In the specimens examined 10–12, more or less globular, biserially arranged chambers increase gradually in size, and are ornamented with fine longitudinal costae which do not extend across the sutures. The aperture is simple, lunate, interiomarginal; pores are confined to the intercostate surfaces.

**Stratigraphical distribution.** Common in the Maastrichtian but also occurs in the upper Campanian (Wille-Janoschek 1966).

**Geographical distribution.** *H. striata* is geographically widespread. It ranges from approximately 57° N. (Kjølby Gaard, Denmark; Berggren 1960) to 25° S. (Carmarvon Basin, West Australia; Belford 1960); between these latitudes it is recorded from the Pacific Ocean (Hamilton 1953), California (Martin 1964), the U.S. Gulf Coast (Cushman 1946), Mexico (Olvera 1959), Cuba (Brönnimann and Brown 1953), Puerto Rico (Pessagne 1960), northern Europe, the circum-Mediterranean, and Pakistan (Nagappa 1960).

**Heterohelix ultimatumula** (White)

Plate 1, figs. 5, 6; text-fig. 3

- 1929 *Guembelina ultimatumula* White, p. 39, pl. 4, fig. 13.
- 1959 *Heterohelix ultimatumula* (White); Olvera, pp. 72, 73, pl. 1, fig. 16.

**Description.** In the specimens examined 10–12, more or less globular, biserially arranged chambers increase gradually in size, and are ornamented with fine longitudinal costae which do not extend across the sutures. The aperture is simple, lunate, interiomarginal; pores are confined to the intercostate surfaces.

**Stratigraphical distribution.** Common in the Maastrichtian but also occurs in the upper Campanian (Wille-Janoschek 1966).

**Geographical distribution.** *H. ultimatumula* is geographically widespread. It ranges from approximately 57° N. (Kjølby Gaard, Denmark; Berggren 1960) to 25° S. (Carmarvon Basin, West Australia; Belford 1960); between these latitudes it is recorded from the Pacific Ocean (Hamilton 1953), California (Martin 1964), the U.S. Gulf Coast (Cushman 1946), Mexico (Olvera 1959), Cuba (Brönnimann and Brown 1953), Puerto Rico (Pessagne 1960), northern Europe, the circum-Mediterranean, and Pakistan (Nagappa 1960).
Description. The specimens examined consist of about 10 biseriately arranged chambers; the first 6 are radially costate and increase gradually in size and globosity, the last 4 chambers are large, globose, smooth or finely costate; the ultimate chamber is smaller than the penultimate. The aperture is large, simple, lunate, interiomarginal; pores are distributed between the costae.

Stratigraphical distribution. Campanian (Pessagno 1962) to upper Maastrichtian.

Geographical distribution. Records of this species are confined to the northern hemisphere between 50° N. (Glons, Belgium; Hoffer 1958) and 18° N. (Puerto Rico; Pessagno 1962). Within these latitudes it is reported from the Pacific Ocean (Hamilton 1953), the U.S. Gulf Coast (Pessagno 1962), Mexico (Olvera 1959), Cuba (Voorwijk 1937), Germany (Hoffer 1956), and Egypt (Said and Kenawy 1956).

Genus Planoglobulina Cushman 1927

Planoglobulina acervulinoide (Egger)

Plate 1, figs. 7, 8; text-fig. 4

1900 Guembelina acervulinoide (Egger), p. 36, pl. 14, figs. 20-22 (ideo Ellis and Mestina 1940 et seq.).

1926 Pseudotextularia acervulinoide (Egger); Cushman, p. 17, pl. 2, fig. 5.

1927a Planoglobulina acervulinoide (Egger); Cushman, p. 158, pl. 27, fig. 3.

1966 Pseudotextularia acervulinoide (Egger); Wille-Janschek, pp. 39, 151, taf. 9, taf. 8, fig. 8.

TEXT-FIG. 4. Planoglobulina acervulinoide (Egger), (a) lateral view, (b) apertural view; No. 1158, × 100.

EXPLANATION OF PLATE 1

Figs. 1-6. Heterohelix spp. 1, 2, H. globulosa (Ehrenberg), lateral and apertural views; No. 1165, × 150. 3, 4, H. striata (Ehrenberg), lateral and apertural views; No. 1164, × 270. 5, 6, H. ultima-tumida (White), lateral and apertural views; No. 1166, × 95.

Figs. 7-8. Planoglobulina acervulinoide (Egger), lateral and apertural views; No. 1158, × 76.

Figs. 9-10. Pseudotextularia elegans (Rzhák), lateral and apertural views; No. 1159, × 68.

Figs. 11-12. Pseudoguembelina costulata (Cushman), lateral and apertural views; No. 1163, × 165.
**GENUS PSEUDOTEXTULARIA** Rzehak 1891

**Pseudotextularia elegans** (Rzehak)

Plate 1, figs. 9, 10; text-fig. 5

- 1888 *Caenolina elegans* Rzehak, p. 191, no fig.
- 1929 *Guembelina elegans* (Rzehak); White, pp. 34, 35, pl. 4, fig. 8.
- 1946 *Guembelina plummerae* Loetterle; Cushman, p. 104, pl. 45, figs. 1–3.
- 1959 *Guembelina plummerae* Loetterle; Nagappa, p. 163, pl. 7, figs. 5–6.
- ? 1960 *Pseudotextularia elegans* (Rzehak); Berggren, pp. 183, 190, no fig.
- ? 1960 *Guembelina plummerae* Loetterle; Nagappa, p. 48, no fig.

**TEXT-FIG. 5.** Pseudotextularia elegans (Rzehak), (a) lateral view, (b) apertural view; No. 1159, × 100.

**Description.** The specimens examined have a more or less conical test, with biserially arranged, longitudinally costate chambers which increase gradually in size and globosity. The aperture is simple, lunate, intermediomarginal; pores are confined to the surfaces between the costae.

**Stratigraphical distribution.** Santonian (Wille-Janschek 1960) to upper Maastrichtian.

**Geographical distribution.** A widespread species ranging from approximately 57° N. (Kjølbye Gaard, Denmark; Berggren 1960) to 16° S. (Madagascar; Lys 1960). Between these latitudes it is recorded from the Pacific Ocean (Hamiton 1933), the U.S. Gulf Coast (Cushman 1940), Mexico (White 1929), Cuba (van Wessen 1943), Puerto Rico (Pessagno 1960), the north Atlantic (Saito *et al.* 1966), northern Europe, the circum-Mediterranean, Pakistan, and India (Nagappa 1959, 1960).
Genus **Pseudoguembelina** Brönimann and Brown 1953

**Pseudoguembelina costulata** (Cushman)

Plate 1, figs. 11, 12; text-fig. 6

1938 *Guembelina costulata* Cushman, p. 16, pl. 3, figs. 7-9.

1953 *Pseudoguembelina costulata* (Cushman); Brönimann and Brown, pp. 153, 154, fig. 5.

Description. In the specimens examined the test consists of 5–7 pairs of somewhat depressed, biseriially arranged chambers which increase in size and are ornamented with fairly fine longitudinal costae, some of which extend across the sutures. The primary aperture is narrow, simple, lunate; accessory apertures are developed at the chamber bases on the central suture line.

*Stratigraphical distribution.* Campanian (Pessagno 1960) to Maastrichtian.

*Geographical distribution.* Records of this species are confined to the northern hemisphere between 34° N. (Arkansas; Cushman 1949) and 18° 15' N. (Puerto Rico; Pessagno 1960). Within these latitudes it has been reported from the Pacific Ocean (Hamilton 1953), Texas (Montanaro Gallitelli 1957), the U.S. Gulf Coast, Cuba (van Wesem 1943), and Egypt (Ansary and Fakhri 1958).

**Pseudoguembelina excolata** (Cushman)

Plate 2, figs. 1, 2; text-fig. 7

1926 *Guembelina excolata* Cushman, p. 20, pl. 2, fig. 9.

1953 *Pseudoguembelina excolata* (Cushman); Brönimann and Brown, p. 153, figs. 1-4.

Description. In the specimens examined 4–7 pairs of chambers are arranged biserially; the initial 3 pairs increase gradually in size, later chambers increase rapidly in size and

**EXPLANATION OF PLATE 2**

Figs. 1–2. *Pseudoguembelina excolata* (Cushman), lateral and apertural views; No. 1161, ×114.

Figs. 3–4. *Racemoguembelina fructicosa* (Egger), lateral and apertural views; No. 1160, ×74.

Figs. 5–10. *Abathomphalus* spp. 5–7, *A. nuyuensis* (Bolli), ventral, edge, and dorsal views; No. 1177, ×70, 8–10, *A. intermedius* (Bolli), ventral, edge, and dorsal views; No. 1178, ×120.

Figs. 11–13. *Globotruncana arca* (Cushman), ventral, edge, and dorsal views; No. 1167, ×71.
degree of inflation. The chambers are coarsely costate, some costae extend across the sutures. The aperture is small, simple, lunate.

Stratigraphical distribution. Maestrichtian, but also occur in the upper Campanian (U. Taylor Formation, U.S. Gulf Coast; Cushman 1946).

Geographical distribution. A widespread species in the northern hemisphere where it ranges from approximately 47° N. (Salzburg and Graz, Austria; Küpper 1956, Wichert 1956) to 19° N. (Pacific Ocean; Hamilton 1953). Between these latitudes it is recorded from the Tampico embayment, Mexico (Olvera 1959), Cuba (Brönntmann and Brown 1953), U.S. Gulf Coast (Cushman 1946) and New Jersey (Olsson 1960), and the circum-Mediterranean as far east as the Sinai Peninsula (Said and Kenawy 1956).

Genus Racemiguembelina Montanaro Gallitelli 1957

Racemiguembelina fructicosa (Egger)

Plate 2, figs. 3, 4; text-fig. 8

1895 Pseudotextularia varians Rzhak, pp. 217, 218, pl. 7, figs. 2, 3 (fide Ellis and Messina 1940 et seq.)

1900 Guembelina fructicosa Egger, p. 35, pl. 14, figs. 8, 19 (? 24, 25, 26) (fide Ellis and Messina 1940 et seq.).

1929 Pseudotextularia varians var. mendezensis White, p. 41, pl. 4, fig. 16.

1929 Pseudotextularia varians var. textulariformis White, p. 41, pl. 4, fig. 17.

1946 Pseudotextularia varians Rzhak; Cushman, p. 110, pl. 47, figs. 4-9.

1955 Pseudotextularia varians Rzhak; Wichert, p. 104, no fig.

1957 Pseudotextularia varians Rzhak; Hofker, pp. 422, 424, text-fig. 478a-b.

1957 Racemiguembelina fructicosa (Egger); Montanaro Gallitelli, pp. 142, 143, pl. 32, figs. 14, 15.

1958 Pseudotextularia elegans (Rzhak); Witwicka, p. 195, pl. 8, figs. 6, 7.

1959 Pseudotextularia elegans (Rzhak); Nagappa, p. 197, pl. 7, figs. 7, 8.


1960 Pseudotextularia varians Rzhak; Vinogradov, pl. 6, figs. 34, 35, tabs. 1, 2.

Text-fig. 8. Racemiguembelina fructicosa (Egger). (a) lateral view, (b) apertural view; No. 1160, ×100.
Description. In the specimens examined the test is conical. Its chambers, which initially are biseriately arranged, later proliferate, increase in size, and become more globular. The chambers are ornamented with coarse longitudinal costae. The aperture is multiple; apertures open into the lumen of the cone through a bridge of shell material which joins opposing chambers.

Stratigraphical distribution. Common in the Maestrichtian, but is also recorded from the upper Campanian (Kikoine 1948).

Geographical distribution. This species is widely distributed in the northern hemisphere. It ranges from approximately 57° N. (Vigsø, Denmark; Hofker 1960) to 19° 34' N., 171° 54' W. (Pacific Ocean; Hamilton 1953); within these latitudes it is recorded from the Tampico embayment, Mexico (White 1929), the U.S. Gulf Coast (Cushman 1946), Cuba (Voorwijk 1937), the north Atlantic (Saito et al. 1966), English Channel (Curry 1962), Germany (Hofker 1957), Austria (Wicher 1956), Poland (Witwicka 1958), Roumania (Vinogradov 1960), Egypt (Said and Kerdany 1961), and India (Nagappa 1959).

Family GLOBOTRUNCANIIDAE Broten 1942

Genus ABATHOMPHALUS Bolli, Loeblich, and Tappan 1957

Abathomphalus mayaroensis (Bolli)

Plate 2, figs. 5-7: text-fig. 9

1951 G. mayaroensis Bolli, p. 198, pl. 35, figs. 10-12.
1953 G. mayaroensis Bolli; Subbotina, p. 181, pl. 8, figs. 2a-c.
1955 G. mayaroensis (Bolli); Brönnimann and Brown, pp. 553-4, pl. 22, figs. 10-12.
1957 A. mayaroensis (Bolli); Bolli, Loeblich, and Tappan, p. 43, pl. 11, figs. 1a-c.
1957 A. mayaroensis (Bolli); Bolli, p. 54, text-fig. 10.
1957 G. (G. planata) Edgell, p. 115, pl. 4, figs. 7-9.

TEXT-FIG. 9. Abathomphalus mayaroensis (Bolli), (a) dorsal, (b) edge, and (c) ventral views; No. 1177, ×100.

Description. In the specimens examined the test is trochospiral, concavo-convex, with two widely separated keels and a tegillum covering the umbilicus. In spiral view the periphery is lobed. About 12–14 chambers are arranged in 3 whorls with 4–5 chambers in the last whorl. The spiral and radial sutures are arcuate, thick, raised, and beaded. The surface of the chambers is generally smooth and finely perforate. In umbilical view the
radial sutures are straight and unthickened. The chambers are slightly inflated and slope rather steeply towards the narrow umbilicus; their surfaces have a granular and finely porous appearance. The primary aperture is extra-umbilical. A delicate tegillum extends across the umbilicus from the margin of the last chamber, and is provided with accessory intralaminal apertures. In peripheral view the two strongly beaded keels are separated by a wide band of granular appearance.

*Stratigraphical distribution.* Generally regarded as characteristic of, and confined to, the uppermost Maestrichtian.

*Geographical distribution.* Ranges from approximately 57° N. (Kjölsby Gaard, Denmark; Berggren 1960) to 22° S. (NW. Australia; Edgell 1957). It has also been recorded from the western side of the Gulf of Mexico (Hay 1969, Trinidad; Bolli 1951), the Pyrenees (Marguin 1960), and the circum-Mediterranean area generally as far as the eastern side of the Black Sea (Subbotina 1953) and Madagascar (Lys 1960). Though regarded by Olsson (1964) as a Tethyan form (it does not occur in New Jersey, U.S.A.) it was clearly wide-ranging at least as occasional examples.

*Abathomphalus intermedius* (Bolli)

Plate 2, figs. 8-10; text-fig. 10

1951 *Globotruncanites intermedius* Bolli, p. 197, pl. 35, figs. 7-9.
1955 *Rugotruncanites intermedius* (Bolli); Brönnimann and Brown, p. 533, pl. 22, figs. 13-15.
1956b *Marginotruncanites intermedius* (Bolli); Hofker, p. 75, pl. 10, figs. 74a-e.
1957 *Abathomphalus intermedius* (Bolli); Bolli, p. 54, no fig.
1960 *Abathomphalus intermedius* (Bolli); Bolli and Cita, pp. 153, 154, no fig.
1962 *Pragueglobotruncanites* (Pragueglobotruncanites) *intermedius* (Bolli); Berggren, p. 31, pl. 7, figs. 2n-e.

TEXT-FIG. 10. *Abathomphalus intermedius* (Bolli), (a) dorsal, (b) edge, and (c) ventral views; No. 1178, × 100.

*Description.* In the specimens examined the test is trochosiral concavo-convex with two delicate keels separated by a granular area. In dorsal view the periphery is lobed. Approximately 8–9 chambers are arranged in 3 whorls with 3–4 chambers in the last whorl. The spiral and radial sutures are arcuate, thickened but not raised. The chamber surfaces are smooth and finely perforate. On the ventral surface the chambers are weakly inflated, the radial sutures are thickened and slightly depressed. The primary aperture is extra-umbilical; a delicate tegillum which extends across the umbilicus from the margin of the last chamber is provided with at least 3 intralaminal apertures.

*Stratigraphical distribution.* Middle to upper Maestrichtian (El-Naggar 1966).

*Geographical distribution.* The species ranges from approximately 57° N. (Kjölsby Gaard, Denmark; Berggren 1965) to 10° N. (Trinidad; Bolli 1951). It has also been recorded from Mexico, Colombia (Gandolfi 1955), Cuba (Brönnimann and Brown 1955), NW. Germany and Holland (Hofker 1956b), and from the Nile Valley (El-Naggar 1966).
Genus *Globotruncana* Cushman 1927

*Globotruncana arca* (Cushman)

Plate 2, figs. 11–13; Plate 3, figs. 1–3; text-fig. 11

1926 *Pulvinula arca* Cushman, p. 23, pl. 3, fig. 1.
1927b *Globotruncana arca* (Cushman); Cushman, p. 91, pl. 19, figs. 11a–c.
1960 *Globotruncana lepoldi* Bolli; Olson, p. 50, pl. 11, figs. 1–3.

TEXT-FIG. 11. *Globotruncana arca* (Cushman), (a) dorsal, (b) edge, and (c) ventral views; No. 1167, ×100.

*Descriptions.* In the specimens examined the test is trochospiral, biconvex, with the strongest convexity on the spiral surface. On the spiral surface 14–19 chambers are arranged in 3–4 whorls, with 5–7 chambers in the final whorl. Both spiral and radial sutures are arcuate, thickened, raised, and beaded; on some specimens granules developed on the apex of the spire obscure the early chambers. The chamber surfaces are planar, sometimes concave, generally smooth and finely porous. The radial sutures of the umbilical surface are thickened and beaded; the thickening extends around the umbilical edge of each chamber. Chamber surfaces are smooth, sometimes granular, finely porous. The wide umbilicus is sometimes covered by a non-porous plate; the primary aperture is intra-umbilical; both it and relict apertures of preceding chambers open into the umbilicus. Apertures associated with the umbilical plate are both infra- and intralaminal. The lobed peripheral margin is bordered by two keels which are separated by a wide granular area.

*Stratigraphical distribution.* Mainly Maastrichtian, but has also been recorded from the upper Campanian (Kisakiewicz 1956).

*Geographical distribution.* *G. arca* is apparently cosmopolitan; it ranges from approximately 57° N. (Kjølby Gaard, Denmark; Berggren 1960) to 22° S. (NW. Australia; Edgell 1957). Within these latitudes it is recorded from the Pacific (Hamilton 1953), Vancouver (McCullough 1964), on the west coast (Douglas and Siler 1966), Gulf (Cushman 1946), and east coast (Olson 1960) of North America, Mexico (Hay 1960), Cuba, Trinidad (Bolli 1951), northern Europe, the circum-Mediterranean area, the Caucasus (Subbotina 1953), and West Pakistan (Nagappa 1960).
**Globostracana conica** White

Plate 3, fig. 4-6; text-fig. 12

- 1928 *Globostracana conica* White, p. 285, pl. 38, fig. 7.
- 1955 *Globostracana stuarti conica* (White); Gandolfi, p. 65, pl. 5, fig. 8.
- 1956 *Globostracana cf. conica* White; Ksiazkiewicz, p. 283, fig. 61.

TEXT-FIG. 12. *Globostracana conica* White, (a) dorsal, (b) edge, and (c) ventral views; No. 1170, ×100.

**Description.** In the specimens examined the test is spheroidal; its umbilical side is obtusely conical and truncated. On the spiral surface 27 chambers are arranged in 4 whorls with 8 chambers in the last. The chambers increase rapidly in size in the first 2 whorls, less so in the third, and are approximately equal in the fourth; they are triangular in the early whorls, quadrangular in the last. Both spiral and radial sutures are thickened, raised, and beaded; beading is pronounced on the last whorl. On the umbilical surface the radial sutures are thickened, weakly beaded, and extend on to the umbilical edges of the chambers. The primary and relict apertures of preceding chambers open into the umbilicus. The circular periphery is characterized by a single prominent keel with traces of a second.

**Stratigraphical distribution.** Santonian to upper Maastrichtian (Cita 1948, Douglas and Sliyer 1966).

**Geographical distribution.** *G. conica* is widely distributed in the northern hemisphere where it ranges from approximately 50° N. (Bachowice, Poland; Ksiazkiewicz 1956) to 11° N. (NE. Colombia; Gandolfi 1955). Between these latitudes it is recorded from the west coast of N. America (Douglas and Sliyer 1966), Tampico, Mexico (Hay 1900), Trinidad (Bollin 1931), Puerto Rico (Passagino 1960), Tunisia (Dalbiez 1955), and the circum-Mediterranean area as far as the Sinai Peninsula (Said and Kenawy 1956).

**Globostracana contusa** (Cushman)

Plate 3, figs. 7-9; text-fig. 13

- ?1926 *Pulviniflora arca var. contusa* Cushman, p. 23, no fig.
- 1966 *Globostracana formicola* Plummer; Douglas and Sliyer, pp. 110–11, pl. 2, figs. 2, 4 (non figs. 1, 3).
1966 *Globostrumana contusa* patelliformis Gandolfi; El-Naggar, pl. 8, figs. 1a–c.

1966 *Marginostrumana contusa* (Cushman); Hofker, p. 95, pl. 17, fig. 78.

**Text-Fig. 13.** *Globostrumana contusa* (Cushman), (a) dorsal, (b) edge, and (c) ventral views; No. 1169, ×100.

**Description.** In the specimens examined the test is trochospiral, slightly lobed, strongly spiroconvex with a deep umbilicus. Its spiral surface contains 13–19 chambers arranged in three whorls with 4–7 in the last. The chambers, which are initially circular and inflated, become triangular and flat and finally crescentic with undulating surfaces. The sutures are thick and beaded, the chamber surfaces finely porous. On the umbilical side the chamber surfaces are coarsely papillate and porous, and the thickened, beaded radial sutures extend around the umbilical edges of the chamber. The primary and relict apertures open into the umbilicus; associated apertural portici are present on some specimens. Two closely spaced carinae are developed on the umbilical side of the peripheral surface.

**Stratigraphical distribution.** Probably exclusively Maastrichtian, though the species has been recorded in the upper Campanian of Poland (Bieda 1958).

**Geographical distribution.** The species is widely distributed. It ranges from approximately 57° N. (Kjölby Gaard, Denmark; Hofker 1960) to 22° S. (NW. Australia; Edgell 1957). It is also recorded from the west coast of North America (Douglas and Sliter 1966), and New Jersey (Olsson 1960), Tampico embayment, Mexico (Hay 1960), Trinidad (Bolli 1951), northern Europe, the circum-Mediterranean area, and West Pakistan (Nagappa 1960).

*Globostrumana falsostuarti* Sigal

Plate 3, figs. 10–12; text-fig. 14

1951 *Globostrumana conica* White; Bolli, p. 196, pl. 34, figs. 13–15.

1952 *Globostrumana falsostuarti* Sigal, p. 43, fig. 46.

**Explanation of Plate 3**

Description. In the specimens examined the test is trochospiral, circular, weakly lobed, and biconvex. Its spiral surface contains 25 chambers arranged in 3½ whorls with 7–8 approximately equal chambers in the last. Sutures are thick, raised, and beaded. The chamber surfaces are smooth and finely porous on both sides of the test; on the umbilical side the thickened radial sutures extend around the umbilical edge of the chambers. Both primary and relict apertures open into the wide umbilicus; their associated portici extend obliquely into the umbilicus. Traces of a tegillum are preserved on some specimens. A single prominent keel and weak traces of a closely separated second keel on the final chambers, are present on the peripheral surface.

Stratigraphical range. Campanian to upper Maestrichtian (Bolli 1951).

Geographical distribution. Records of this species are confined to the northern hemisphere. It has been reported from Trinidad (Bolli 1951), Southern Limburg (Hofker 1966), Upper Bavaria (Knipscheer 1956), Morocco (Lehmann 1966), Algeria (Sigal 1952), and Tunisia (Dubiez 1955).

Globotruncana gansseri Bolli

Plate 4, figs. 1–3; text-fig. 15

1950 **Globotruncana gansseri** Bolli, p. 87, no fig.
1951 **Globotruncana gansseri** Bolli; Bolli, p. 196, pl. 35, figs. 1–3.
1957 **Globotruncana (Globotruncana) luderi** Tille; Edgell, p. 113, pl. 2, figs. 7–9.
1960 **Globotruncana monmouthensis** Olsson, p. 50, pl. 10, figs. 22–24.

Description. In the specimens examined the test is trochospiral, umbilical-convex, with a lobed periphery. On its spiral surface 15 chambers are contained in 2½ whorls with 5–6 chambers in the last. Initially inflated, they are followed by chambers whose surfaces slopes towards the spiral apex. The sutures are curved, raised, and beaded, the chamber surfaces smooth and finely porous, weakly papillose on the final whorl. Ventrally the chambers are coarsely papillose, the papillae becoming scattered on the last chamber; the sutures are radial and depressed. Both the primary and relict apertures open into
the umbilicus; the primary has a delicate porticus. A single heavily beaded keel is developed on the peripheral surface.

![Diagram](Image)

**Text-fig. 15. Globotruncana gansseri** Bolli, (a) dorsal, (b) edge, and (c) ventral views; No. 1175, ×100.

**Stratigraphical distribution.** Lower to upper Maestrichtian (Wille-Janoschk 1966).

**Geographical distribution.** A widely distributed species which ranges from approximately 57° N. (Kjøby Gaard, Denmark; Berggren 1962) to 22° S. (NW. Australia, Edgell 1957). Between these latitudes it is reported from the Pacific (Hamilton 1953), the West Coast and New Jersey (North America; Douglas and Sitter 1966, Olsson 1960), Mexico (Olvera 1959), the Caribbean area, the North Atlantic (Saito et al. 1966), Northern Europe, the circum-Mediterranean area, and Madagascar (Lys 1960).

**Globotruncana havanensis** Voorwijk

**Plate 4, figs. 4–6; test-fig. 16**

1937 *Globotruncana havanensis* Voorwijk, pp. 195, 197, pl. 1, figs. 25, 26, 29.
1951 *Globotruncana citae* Bolli, p. 197, pl. 35, figs. 4–6.
1955 *Rugotruncana havanensis* (Voorwijk); Brönnimann and Brown, p. 552, pl. 22, figs. 4–6; pl. 24, figs. 5, 10.
1955 *Globotruncana citae* Bolli; Gandolfi, p. 51, pl. 3, fig. 11.
1956 *Marginotruncana citae* (Bolli); Hofker, pp. 76, 79, fig. 72.
1957 *Globotruncana (Globotruncana) citae* Bolli; Edgell, p. 111, pl. 1, figs. 13–15.
1959 *Globotruncana citae* Voorwijk; Olvera, pp. 94–96, pl. 4, figs. 12, 13, 14.
1960 *Praeglobotruncana havanensis* (Voorwijk); Berggren, pp. 183, 190, no fig.
1960 *Rugoglomigerina havanensis* Olsson, p. 49, pl. 10, figs. 19–21.

![Diagram](Image)

**Text-fig. 16. Globotruncana havanensis** Voorwijk, (a) dorsal, (b) edge, and (c) ventral views; No. 1176, ×100.

**Description.** In the specimens examined the test is trochospiral, spiroconvex, ventrally flat or weakly concave. On the spiral surface 9 weakly inflated chambers are arranged
in approximately 2 whorls with 4 chambers in the last. The sutures are arcuate depressed, on the ventral surface radial depressed; the chamber surfaces are smooth and porous. The aperture is intra-umbilical, bordered by a porticus which extends towards the umbilicus. A single weakly developed keel is present on the peripheral surface.

Stratigraphical distribution. Recorded mainly from the Maestrichtian though it is also reported from the Campanian of Trinidad (Bolli 1957).

Geographical distribution. G. havanensis ranges from approximately 57° N. (Kjöby Gaard, Denmark; Høkner 1960) to 22° S. (NW. Australia; Edgill 1957). Within these latitudes it is recorded from the West Coast of North America (Douglas and Sliter 1966), Tampico embayment, Mexico (Obera 1959), NE. Colombia (Gandolfi 1955), Cuba (Brönnimann and Brown 1955), Trinidad (Bolli 1951), northern Europe, and the circum-Mediterranean region as far east as Scutari on the north-east shores of the Black Sea (Subbotina 1953).

*Globotruncana stuartii* (de Lapparent)

Plate 4, figs. 7-9; text-fig. 17

TEXT-FIG. 17. *Globotruncana stuartii* (de Lapparent), (a) dorsal, (b) edge, and (c) ventral views; No. 1171, ×100.
1918 Rosalina stuarti de Lapparent, pp. 11, 12, pl. 12, fig. 4, pl. 13, fig. 5a-c.
1936 Globotruncanella stuarti (de Lapparent); Renz, pp. 19, 20, pl. 6, figs. 35-41; pl. 8, fig. 6.
1962 Globotruncanella (Globotruncanella) stuarti stuarti Pessagno, chart 2, pl. 2, figs. 1-3.

Description. In the specimens examined the test is trochospiral, almost biconvex; its periphery is circular and entire. On the spiral surface 12–26 chambers are contained in 2½–3½ whorls, with 4–7 in the last; the initially circular chambers are followed by triangular and finally quadrangular chambers. The sutures are thickened, raised, beaded; ventrally the radial sutures extend on to the umbilical edge of each chamber. Chamber surfaces are smooth and finely porous. Both primary and secondary apertures open into the umbilicus; delicate asymmetrical triangular portioi extend obliquely into the umbilicus from each chamber. A single prominent keel is developed on the peripheral surface.

Stratigraphical distribution. Upper Campanian to upper Maastrichtian (Bolli 1951).

Geographical distribution. A widely distributed species, ranging from approximately 57°N. (Kjölby Gaard, Denmark; Berggren 1962) to 16°S. (Madagascar; Lys 1960). It is also recorded from Trinidad (Bolli 1951), Puerto Rico (Pessagno 1962), W. Nigeria (Reymont 1960), northern Europe, the circum-Mediterranean region, and Pakistan (Nagappa 1959).

Globotruncanella stuarti stuartiformis Dalbiez

Plate 4, figs. 10-12; text-fig. 18

1951 Globotruncanella stuarti de Lapparent; Tilev, pp. 34-41, pl. 1, figs. 1, 4 (non 3); text-figs. 7, 8 (non 9).
1955 Globotruncanella (Globotruncanella) elevata stuartiformis Dalbiez, p. 109, text-fig. 10.
1961 Globotruncanella elevata stuartiformis Dalbiez; Scheinbrenova, p. 70, pl. 15, fig. 1.
1962 Globotruncanella (Globotruncanella) stuarti stuartiformis Dalbiez; Pessagno, p. 362, pl. 2, figs. 4-6.
1966 Globotruncanella elevata stuartiformis Dalbiez; Wille-Janoschek, pp. 103-5, 147, 148, 149, 150, pl. 7, figs. 6-8; taf. 9.

Description. In the specimens examined the test is trochospiral, biconvex, with a weakly lobed periphery. On its spiral surface 19–22 chambers are arranged in 3–3½ whorls with 5–6 in the last; chambers are triangular but the final 2 or 3 are quadrangular. Both spiral and radial sutures are raised, thick, and beaded; ventrally the thickened radial sutures extend around the umbilical edges of the chambers. The chamber surfaces are smooth and finely porous. Both the primary and relief apertures open into the umbilicus; delicate portioi which extend obliquely into the umbilicus are sometimes preserved. The peripheral surface is uncinarinate.


Geographical distribution. G. stuarti stuartiformis is so far unrecorded from the southern hemisphere; it ranges from approximately 49°N. (W. Carpathians; Scheinbrenova 1961) to 18°N. (Puerto Rico; 18°S.).

EXPLANATION OF PLATE 4

Figs. 1–12. Globotruncanella spp. 1–3, G. guasseri Bolli, ventral, edge, and dorsal views; No. 1175, × 85, 4–6, G. haemenesis Voorwijk, ventral, edge, and dorsal views; No. 1176, × 170, 7–9, G. stuarti (de Lapparent), ventral, edge, and dorsal views; No. 1171, × 59, 10–12, G. stuarti stuartiformis Dalbiez, ventral, edge, and dorsal views; No. 1172, × 59.
Pessagno 1962). Between these latitudes it has been recorded from the Pacific Ocean (Hamilton 1953), the west coast of North America (Douglas and Sliter 1966), New Jersey (Olsson 1964), the north Atlantic (Saito et al. 1966), northern Europe, and the circum-Mediterranean area as far as SE. Turkey (Tilev 1951).

**Text-fig. 18.** *Globotruncana sullii stuartiformis* Dalbier, (a) dorsal, (b) edge, and (c) ventral views; No. 1172, ×100.

*Globotruncana* cf. *aspera* Hofker

Plate 5, figs. 1-3; text-fig. 19

1956c *Globotruncana* aspera Hofker, p. 327, figs. 14, 15.
1966 *Globotruncana* aspera Hofker, p. 30, pl. 3, fig. 66.

**Text-fig. 19.** *Globotruncana* cf. *aspera* Hofker, (a) dorsal, (b) edge, and (c) ventral views; No. 1174, ×100.
Description. In the specimens examined the test is umbilico-convex, with a lobed periphery and flat or apically concave spiral surface. In spiral view 13–16 chambers are arranged in approximately 2½ whorls with 5 or 6 in the last. Sutures are accurate, thick, and beaded; ventrally they are radial depressed. The chamber surfaces are rough, finely porous dorsally, rugose ventrally. The primary aperture is intra-umbilical; a tegillum extends across the umbilicus and is provided with at least 3 intralaminal apertures. Two widely separated keels are developed on the peripheral surface.

Stratigraphical distribution. Hitherto G. aspersa has not been recorded from rocks younger than lower Upper Cenomanian.

Geographical distribution. Previous reports of this species are restricted to NW Germany and Holland (Hofker, 1956c; 1966).

Genus RUGOGLOBIGERINA Brönnimann 1952

Rugoglobigerina pustulata Brönnimann

Plate 5, figs. 4–6; text-fig. 20

1952 Rugoglobigerina reicheli pustulata Brönnimann, p. 20, pl. 2, figs. 7–9, text-figs. 6a–m, 7a–d.
1952 Rugoglobigerina reicheli hexacamerata Brönnimann, p. 23, pl. 2, figs. 10–12; text-figs. 8a–n.
1955 Rugoglobigerina hexacamerata hexacamerata Brönnimann; Gandolfi, p. 33, pl. 1, figs. 12e–c.
1956a Globigerina rugosa Plummer; Hofker, p. 53, text-fig. 1.
1960 Rugoglobigerina reicheli pustulata Brönnimann; Otsson, p. 50, pl. 10, figs. 13–15.
1962 Rugoglobigerina pustulata Brönnimann; Berggren, pl. 13, figs. 1a–c, text-fig. 10 (6–12).
1966 Rugoglobigerina pustulata Brönnimann; El-Naggar, p. 148, no fig.

TEXT-FIG. 20. Rugoglobigerina pustulata Brönnimann, (a) dorsal, (b) edge, and (c) ventral views; No. 1181, × 100.

Description. In the specimens examined the test is low trochospiral tending towards planispiral, biconvex with a markedly lobed periphery. On the spiral surface 12–16 chambers are contained in 2–3 whorls with 5–6 in the last. The sutures are depressed, the chamber surfaces granulate with or without costellae on the adult chambers. Both
primary and relict apertures open into the umbilicus. An umbilical tegillum with associated infralaminar and possibly intralaminar apertures is preserved on some specimens.

*Stratigraphical distribution.* *R. pastulata* has been recorded only from Maestrichtian sediments.

*Geographical distribution.* Geographically widespread in the northern hemisphere. It ranges from approximately 57° N. (Kjølbye Gaard, Denmark; Berggren 1962) to 10° N. (Trinidad; Brönnimann 1952). It is also recorded from New Jersey (U.S.A.; Olsson 1960), NE. Colombia (Gandolfi 1955), the Netherlands (Hofker 1956a), and the Nile Valley (El-Naggar 1966).

*Rugoglobigerina rotundata* Brönnimann 1952

Plate 5, figs. 7–9; text-fig. 21

1952 *Rugoglobigerina rugosa rotundata* Brönnimann, pp. 34–6, pl. 4, figs. 7–9; text-figs. 15, 16.

1955 *Globotruncana* (Rugoglobigerina) rotundata rotundata (Brönnimann); Gandolfi, p. 70, pl. 7, fig. 2.

1957 *Rugoglobigerina rugosa* (Plummer); Edgell, pp. 115, 118, pl. 4, figs. 10–12.

1962 *Rugoglobigerina rugosa rotundata* Brönnimann; Herm, pp. 61–2, pl. 3, fig. 4.

1966 *Rugoglobigerina rotundata* Brönnimann; Douglas and Sliter, p. 116, pl. 1, figs. 5, 6.

TEXT-FIG. 21. *Rugoglobigerina rotundata* Brönnimann. (a) dorsal, (b) edge, and (c) ventral views; No. 1179, × 100.

*Description.* In the specimens examined the test is trochospiral umbilico-convex with a lobed periphery. On the spiral surface the chambers are contained in 2 whorls with 5 chambers in the last. The sutures are radial depressed; the chamber surfaces are granulate; the adult chambers granulate, radially costellate. The primary aperture has a triangular porticus and is intra-umbilical.

*Stratigraphical distribution.* Campanian to Maestrichtian (Douglas and Sliter 1966).

*Geographical distribution.* The species is geographically widespread, ranging from approximately 57° N. (Kjølbye Gaard, Denmark; Berggren 1962) to 20° S. (NW. Australia; Edgell 1957). It is also recorded from the west coast of America (Douglas and Sliter 1966), NE. Colombia (Gandolfi 1955), Trinidad (Brönnimann 1952), Austria (Herm 1962), and the Nile Valley (El-Naggar 1966).

*Rugoglobigerina scotti* (Brönnimann)

Plate 5, figs. 10–12; text-fig. 22

1952 *Trinitiella scotti* Brönnimann, p. 57, pl. 4, figs. 4–6; text-fig. 30.

1957 *Rugoglobigerina scotti* (Brönnimann); Bolli, Loeblisch, and Tappan, pp. 43, 44, pl. 11, figs. 3, 4.
TEXT-FIG. 22. *Rugoglobigerina scotti* (Brönnimann), (a) dorsal, (b) edge, and (c) ventral views; No. 1180, ×100.

**Description.** In the specimens examined the test is trochosiral, umbilico-convex with a flattened spiral surface and lobed periphery. On the dorsal surface approximately 13 chambers are arranged in 2½ whorls with 5 chambers in the last. The sutures are arcuate dorsally, radial and depressed ventrally. The chamber surfaces are smooth or weakly granular dorsally, granulate ventrally, with costellae developed on the adult chambers on both surfaces. The primary aperture is umbilical; a tegulum with associated accessory infralaminal apertures covers the umbilicus. A single thickened beaded keel is developed on the peripheral surface.

**Stratigraphical distribution.** *R. scotti* has been recorded from the middle to upper Maastrichtian (El-Naggar 1966).

**Geographical distribution.** So far only recorded in the northern hemisphere. The species ranges from approximately 47° N. (Salzburg, Austria; Herm 1962) to 10° N. (Trinidad; Brönnimann 1953). Between these latitudes it has been recorded from Puerto Rico (Pessagno 1960), New Jersey (U.S.A.; Olsson 1964), Switzerland (Cormin-bœuf 1961), and the Nile Valley (El-Naggar 1966).

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