

BENTHONIC FORAMINIFERA FROM THE MAESTRICHTIAN CHALK OF GALICIA BANK, WEST OF SPAIN

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ABSTRACT. Benthonic foraminifera associated with a planktonic foraminiferal assemblage of Upper Maestrichtian age are described. The assemblages are from a chalk fragment dredged from a non-magnetic seamount, Galicia Bank, off the western coast of Spain. Three new species, *Anomalinooides hyphalus*, *Nuttallides galiciensis*, and *Nuttallinella lusitanica* are described, and one new name, *Neoeponides hillebrandti* for *Eponides whitei* Hillebrandt is proposed. The assemblage is compared with those previously described from the Tethyan realm.

FUNNELL (1964) and Funnell, Friend, and Ramsay (1969) have recorded an Upper Maestrichtian assemblage of planktonic foraminifera from a chalk fragment dredged from Galicia Bank, a non-magnetic seamount off the Spanish coast. This paper describes the associated benthonic foraminifera from the same sample, D. 3804.1., which was obtained from the top of the seamount, at a depth of between 650 and 700 m., and at 42° 36' N., 11° 35' W. (*vide* Black, Hill, Laughton, and Matthews 1964).

The 354 benthonic foraminifera obtained from this sample have been assigned to 52 species, which, with the exception of the three new species described, have all been previously recorded from Upper Cretaceous or Lower Tertiary horizons. The complete list is given in Table 1. Of the 39 species positively identified and previously recorded, 7 have not been recorded from horizons younger than the Maestrichtian, 24 have been recorded from both Maestrichtian and Palaeocene horizons, 7 have been recorded from the Palaeocene but not from the Maestrichtian, and one, *Buliminella grata* Parker and Bermudez has been recorded from the Eocene or Oligocene of California, Cuba, and Trinidad. Beckmann (1960), however, suggested that *B. grata* may be identical with *B. beaumonti* Cushman and Renz. If this is so, then the lower range of *B. grata* should be extended into the Lower Danian, where *B. beaumonti* was recorded by von Hillebrandt (1962) from the Reichenhall-Salzburg basin; this would be more in agreement with the ranges of the other non-Maestrichtian species.

Of the seven species restricted to Upper Cretaceous horizons, *Brizalina incrassata* (Reuss), *Pyramidina szajnochae* (Grzybowski), and *Pseudovigerina cristata* (Marsson) have been recorded from numerous localities, and can therefore be regarded as reliable stratigraphic indices. *Pseudovigerina rugosa* Brotzen and *Lenticulina pseudovortex* (Marie) are much more restricted geographically, and have been recorded from comparatively few localities; *Verneuilina convexa* Olszewski and *Heterostomella mexicana* Cushman have only been recorded from the *Belemnitella mucronata* zone of the Polish chalk, and from the Mendez Shale of Mexico respectively. These last four species are considered to be of rather doubtful stratigraphic value.

None of the seven Palaeocene species are accepted stratigraphic indices; only *Valvulabamina scrobiculata* (Schwager) and *Eponides lotus* (Schwager) are widely distributed geographically, and potentially useful in this context. *Neoeponides hillebrandti* nom. nov. and *Gaudryina limbata* Said and Kenawy have both been recorded from the

TABLE I
Stratigraphical and Geographical Distribution of Recorded Species

	% of Population	Mexico	U.S. Gulf Coast	Trinidad	N.W. Europe	S.A.E. Central Europe	N. Alps	Egypt	N. Spain
<i>Haplaphragmoides</i> sp.	<1								
<i>Spiraplectammina dentata</i> (Alth)	<1		C ²	C ¹	C ⁷		P ⁵	P ⁸	C ⁴
<i>Spiraplectammina</i> cf. <i>S. spectabilis</i> (Grzybowski)	1								
<i>Trochammina</i> sp.	<1								
<i>Verneuilina convexa</i> Olszewski	<1				C				
<i>V. korreri</i> Said & Kenawy	<1							C - P ⁸	
<i>Gaudryina</i> cf. <i>G. laevigata</i> Franke	<1						P ⁵	P ⁸	
<i>G. limbata</i> Said & Kenawy	<1								
<i>Heterostomella mexicana</i> Cushman	8	C ²							
<i>Arenobulimina frankei</i> (Brotzen)	<1				C ⁷ P				
<i>Dorothia trochoides</i> (Marsson)	2	C - P ⁹			C	C. P	P ⁵		C ⁴
<i>Martinottiella alabamensis</i> (Cushman)	1		P ³						
<i>Nodosaria</i> cf. <i>N. velascoensis</i> Cushman	<1				C	C	C	C - P ⁸	
<i>Neoflabellina rugosa</i> (D'Orbigny)	1	C - P ⁹	C ² P ³		C	C		C - P ⁸	
<i>Lenticulina navicula</i> (D'Orbigny)	1	P ²		C ²	C ² C ² C ²			C - P ⁸	
<i>L. pseudovortex</i> (Marie)	<1								
<i>L. rotulata</i> (Lamarck)	2		C ²	C - P ¹	C ² C ² C ²			C - P ⁸	
<i>Lagena apiculata</i> (Reuss)	<1		C ²	C - P ¹	C ² C ² C ²		C. P ⁵ P ⁵		
<i>Guttulina communis</i> (D'Orbigny)	1-5	P ⁹	P ³		C ⁶ C ⁶ P			C ⁸	
<i>Bulimina</i> cf. <i>B. midwayensis</i> Cushman & Parker	<1								
<i>Præbulimina reussi</i> (Morrow)	<1	C ⁹	C ²	C ¹	C ⁶	C	? P ⁵	P ⁸	
<i>Pyramidina szajnochae</i> (Grzybowski)	<1	C ⁹			C ⁶	C			C ⁴
<i>Buliminella grata</i> Parker & Bermudez	1-5		T	T	C ⁷		? P ⁵		
<i>Pseudouvirgerina cristata</i> (Marsson)	<1		C ²	C ¹		C			
<i>P. rugosa</i> Brotzen	<1				C ⁷				
<i>Orthokarstenia</i> cf. <i>O. clarki</i> (Cushman & Campbell)	<1				C ⁶ P				
<i>Bolivina oedumi</i> Brotzen	<1				C ⁶ P		? P ⁵		
<i>Brizalina incrassata</i> (Reuss)	8	C ⁹	C ²	C ¹	C ⁶ P	C	C	C ⁸	C ⁴
<i>Aragonia manilifera</i> (Galloway & Morrey)	<1	P							
<i>A. ouezanensis</i> (Rey)	<1				C - P	C - P	P ⁵		C ⁴
<i>Quadriformina</i> cf. <i>Q. allomorphinoides</i> (Reuss)	<1								
<i>Globocassidulina</i> sp.	<1								
<i>Lamarckina rugulosa</i> Plummer	<1		P ³		T				
<i>Asterigerina</i> cf. <i>A. crassaformis</i> Cushman & Siegfus	<1								
<i>Nuttallides galiciensis</i> sp. nov.	4-5								
<i>Nuttallinella lusitanica</i> sp. nov.	6								
<i>Valvulabamina aegyptiaca</i> (Le Roy)	1							P	
<i>V. lenticula</i> (Reuss)	3-5	C	C ²	C - P ¹	C ⁶	C		P ⁸	
<i>V. scrobiculata</i> (Schwager)	4	P	? P			P		P	
<i>Nonionella robusta</i> Plummer	<1		C ²				P ⁵	C	
<i>Pullenia jarvisi</i> Cushman	<1	P ²		C - P ¹	C		P ⁵		
<i>Neoeponides hillebrandti</i> nom. nov.	<1	? P					P ⁵		
<i>Eponides lotus</i> (Schwager)	<1	C - P ⁹	P			P	P ⁵	P	
<i>Gavelinella vombensis</i> (Brotzen)	3				C		P ⁵		C ⁴
<i>Gyroidinoides girardanus</i> (Reuss)	<1		C ²	T ¹			P ⁵	C ⁸	
<i>G. globosus</i> (Hagenow)	2-5	P ⁹		C - P ¹	C ⁷	C	P ⁵	P ⁸	
<i>Goctocameratus</i> (Cushman & Hanna)	3			T ¹	C ⁷ P	P			
<i>Stensioina esnehensis</i> Nakkady	4-5				C			C - P	C ⁴
<i>Anomalinoidea hyphalus</i> sp. nov.	21-5								
<i>A. velascoensis</i> (Cushman)	7	P ⁹			C - P		C. P ⁵		
<i>Osangularia velascoensis</i> (Cushman)	<1	P ⁹		P ¹	C		P ⁵		
<i>Rotalia hermi</i> Hillebrandt	1								C ⁴

Key

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|-----------------------------|--------------------------|
| C = Cretaceous | 4 Herm, 1965 |
| P = Paleocene | 5 Hillebrandt, 1962 |
| T = Tertiary younger than P | 6 Hofker, 1957 |
| ? = doubtful identification | 7 Hofker, 1966 |
| 1 fide Beckmann, 1960 | 8 Said & Kenawy, 1956 |
| 2 Cushman, 1946 | 9 White, 1928-9 |
| 3 Cushman, 1951 | |

Reichenhall-Salzburg Basin, and from the Tampico embayment, Mexico, and Sinai respectively. Nakkady (1959, p. 457) suggested that *G. limbata* is conspecific with *G. pyramidata* Cushman, which has been recorded from Upper Cretaceous and Palaeocene localities in Mexico, North America, Egypt, North-west and Central Europe, etc. *G. limbata* can therefore be only tentatively regarded as a typical Palaeocene species. The records of the remaining three species, *Martinottiella alabamensis* (Cushman), *Aragonia monilifera* (Galloway and Morrey), and *Valvalabamina aegyptiaca* (LeRoy) restrict their occurrences to the Clayton Formation of the U.S. Gulf States, the 'Upper Cretaceous' (= *Globorotalia pseudobulloides* (Plummer) sub-zone) of Tabasco, Mexico, and the Esna Shale of Egypt respectively. *Lamarckina rugulosa* Plummer, which, on the evidence of Table 1 might appear to be restricted to the Palaeocene, has been recorded from the Maestrichtian (Redbank Formation) of New Jersey by Olsson (1960).

The benthonic assemblage has therefore a rather indeterminate Maestrichtian-Palaeocene aspect, for which at least two possible interpretations may be suggested.

Beckmann (1960) indicated that in Trinidad the benthonic fauna, unlike the associated planktonic fauna, continues across the Cretaceous-Tertiary boundary with comparatively few modifications. Thus it is possible that the ranges of the nominally Palaeocene species should be extended to include the uppermost Maestrichtian.

An alternative explanation is that the Palaeocene species are contaminants in a Maestrichtian assemblage. Referring to the planktonic forms, Funnell (1964, p. 422) stated that 'The post-Maastrichtian (probable Mid-Tertiary, and Upper Tertiary to Recent) contaminants were probably introduced into the chalk via very narrow burrows or borings'. Black (1964) also suggested that the burrowing of mud-feeding organisms was more likely to have accounted for the thorough mixing of Upper Cretaceous and Middle Eocene coccoliths in this sample, than redeposition of eroded Cretaceous forms. He regarded this last process as improbable in such an exposed position as the shallower parts of the seamount. It would also appear an unlikely explanation for the composition of the benthonic assemblage when the ratio of exclusively Palaeocene to potentially older individuals (i.e. 1:9) is considered.

The apparent absence of Palaeocene planktonic foraminifera from the sediment might be thought to favour the totally Maestrichtian assemblage interpretation, but this effect might also be produced by the rarity of lowest Tertiary planktonic foraminifera in the vicinity, leaving only Palaeocene benthonics to contaminate the previously deposited Maestrichtian. Neither of the two interpretations suggested is entirely satisfactory and clearly this question cannot be resolved on the evidence at present available.

Although the assemblage is perhaps numerically insignificant, its geographically isolated position encourages any attempt at palaeoecological or palaeogeographical correlation. Comparatively little information is available on these aspects of micro-palaeontology, but in common with other faunal groups the areal distribution of certain foraminiferal assemblages in the Upper Cretaceous has been interpreted in terms of Boreal and Tethyan faunal realms. Wicher (1953; 1956) and Bettenstaedt and Wicher (1955) indicated that the northern limits of the warm water *Globotruncana* populations exhibit a southward trend throughout the Upper Cretaceous, interrupted only by sporadic incursions into the higher latitudes of the Boreal realm. This southward migration was apparently reversed in the Upper Maestrichtian (*casimirovensis* zone), when nominally Tethyan forms established themselves in the Boreal realm. Bettenstaedt and Wicher

do not make it entirely clear whether the indigenous Boreal species were displaced further northward or whether there was an intermixing of faunas across the Boreal-Tethyal boundaries; nor do they indicate what palaeoclimatic significance their terms 'Boreal' or 'Tethyal' have in the Upper Maestrichtian, although Wicher (1953) had proposed that the northward migration of *Pseudotextularia elegans* (Rzehak) in the *casimirovensis* zone could have been related to the introduction of a contemporary warm-water mass. Bettenstaedt and Wicher (p. 497) made one further interesting point: 'When considering the whole fauna the difference of facies between Tethys and Boreal is in most cases of greater importance than the distance of localities.' This had already been stressed by Wicher (1949) when he attempted to correlate the Upper Cretaceous succession of the Tampico Embayment with that of Eurasia, and by Keller (1939).

From his detailed study of the Upper Cretaceous of Russia and Europe, Keller concluded that there were two major micro-faunas corresponding to two climatic zones. The first of these, the northern zone, is typified by the sediments of the Russian platform; the second, the southern zone, by the calc-marl and flysch facies of the Crimean-Caucasian geosynclinal region. The foraminifera of the northern and southern zones are essentially dissimilar, and within the southern zone those of the calc-marl facies can be readily distinguished from those of the flysch facies, by the greater proportion of planktonic foraminifera in the latter. Keller's northern zone may be equated with the Boreal of Bettenstaedt and Wicher, and his southern zone with their Tethyal.

Geographically the benthonic foraminifera from Galicia Bank have affinities with those previously described from the Mexican Gulf coasts, from North-west and Central Europe, and from Egypt. Of the eighteen previously described species, which individually comprise 1% or more, and collectively 55.5% of the benthonic population (see Table 1), fifteen have been recorded from the Americas and fifteen from Europe and Egypt: three are apparently restricted to the New World, and three to the Old World. These geographically restricted species are generally those that have been recorded from one or two localities, and are therefore also stratigraphically restricted. Thus *Heterostomella mexicana* Cushman and *Martinottiella alabamensis* (Cushman) are restricted to the Americas, and *Valvalabamina aegyptiaca* (LeRoy) to Egypt. *Rotalia hermi* Hillebrandt, recorded from the Reichenhall-Salzburg Basin (von Hillebrandt 1962) and North-west Spain (Herm 1965) and *Stensioina esnehensis* Nakkady, originally described from the Egyptian Esna shales (Nakkady 1950) and subsequently recorded from the Upper Maestrichtian of Germany, Denmark and Belgium (Hofker 1956, 1960, 1962, 1966) and of North-west Spain (Herm 1965) are more widespread, although restricted to the Old World. Trümper (1968) suggested that *S. esnehensis* may be synonymous with *S. pommerana* Brotzen, which is very widely distributed in Eurasia, but which has not been found in America. The possible conspecificity of *Buliminella grata* Parker and Bermudez and *B. beaumonti* Cushman and Renz, and the consequent extension of the geographical range of *B. grata* has already been mentioned (p. 189).

The majority of the benthonic species occur in assemblages from areas formerly occupied by Tethys *sensu* Bettenstaedt and Wicher (1955), corresponding with Keller's (1939) southern zone, and two, *Pyramidina szajnochae* (Grzybowski) and *Aragonia ouezzanensis* (Rey) were considered by Bettenstaedt and Wicher to be restricted to the Tethyan zone. The planktonic/benthonic ratio of the Galicia Bank assemblage is 19:1, which compares closely with the ratios from flysch sediments (e.g. the Tampico

embayment; the Reichenhall-Salzburg Basin). There is, however, no evidence of association with a local flysch facies; the nearest flysch of comparable age outcropping on the north coast of Spain in Guipuzcoa Province, nearly 800 km. to the east. Nevertheless the Upper Maestrichtian microfauna of these flysch deposits is very similar to that of Galicia Bank, not only in terms of planktonic/benthonic ratios, but also in terms of the number of species in common.

It would appear that the similarities between the Galicia Bank and 'flysch' assemblages are not the result of similar sedimentological histories, although some of the factors that determined the components of flysch microfaunas may also have been operative in the area of Galicia Bank during the deposition of the Maestrichtian chalk. One plausible palaeoecological interpretation of this assemblage is that it is representative of an essentially Tethyan calc-marl facies, but under the influence of an open ocean environment, resulting in the high proportion of planktonic individuals.

Any attempt to interpret this assemblage definitively either palaeoecologically or stratigraphically is restricted by the limited amount of material available. Subsequent oceanographic investigations may therefore resolve some of the problems which have been outlined.

SYSTEMATIC DESCRIPTIONS

Only new species and those with new specific, or combinations of, names are considered; the other species are well documented elsewhere (see, for example, the references cited in the key to Table 1.

Genus MARTINOTTIELLA Cushman 1933

Martinottiella alabamensis (Cushman) 1940

- 1940 *Listerella laevis* Cushman, p. 54, pl. 9, fig. 8. [non] *Listerella laevis* Finlay 1939, p. 97, pl. 14, fig. 79.
1947 *Schenckia alabamensis* Cushman, p. 51, pl. 8, fig. 10.

Remarks. The genus *Schenckia* Thalmann 1942 has been suppressed as a junior synonym of *Martinottiella* (*vide* Loeblich and Tappan 1964): *S. alabamensis* Cushman is therefore included in the genus *Martinottiella*.

Genus PYRAMIDINA Brotzen 1948

Pyramidina szajnochae (Grzybowski) 1896

- 1896 *Verneuilina szajnochae* Grzybowski, p. 287, pl. 9, fig. 19. [*vide* de Klasz and Knipscheer 1954, q.v.].
1929 *Bulimina limbata* White, p. 48, pl. 5, fig. 9.
1944 *Reussella californica* Cushman and Goudkoff, p. 59, pl. 10, figs. 3-5.
1946 *Bulimina limbata* White; Cushman, p. 124, pl. 52, fig. 5.
1946 *Reussella limbata* (White); Keller, p. 93, pl. 1, fig. 11.
1951 *Reussella szajnochae* (Grzybowski); Noth, p. 65, pl. 7, fig. 7.
1954 *Reussella szajnochae szajnochae* (Grzybowski); de Klasz and Knipscheer, p. 605, pl. 45, figs. 1-13; tab. p. 605.
1955 *Reussella szajnochae* (Grzybowski); Bettenstaedt and Wicher, p. 502, figs. 11-18.
1957 *Reussella szajnochae* (Grzybowski); Hofker, p. 214, fig. 262.
1959 *Reussella szajnochae* (Grzybowski); Liszkowa, p. 69, pl. 3, figs. 3-5; pl. 9, fig. 2.
1959 *Reussella szajnochae californica* Cushman and Goudkoff; Olvera, p. 83, pl. 2, figs. 1, 2.
1961 *Reussella szajnochae* (Grzybowski); Scheibnerova, p. 41, pl. 3, fig. 1.
1964 *Reussella szajnochae* (Grzybowski); Martin, p. 91, pl. 12, fig. 4.
1965 *Reussella szajnochae szajnochae* (Grzybowski); Herm, p. 323.

Remarks. Loeblich and Tappan (1964) suggested that the genus *Pyramidina* should include those Upper Cretaceous species formerly referred to *Reussella* Galloway 1933 that have finely perforate walls and simple tooth-plates. *Verneuilina szajnochae* Grzybowski is here included in the genus *Pyramidina*.

Bettenstaedt and Wicher (1955) considered *P. szajnochae* to be restricted to 'Tethys'. Hofker (1957) and Liszkowa (1959) subsequently recorded the species from Northern Germany and Poland respectively; both these areas are within the Boreal zone as defined by Bettenstaedt and Wicher. *P. szajnochae* appears to be a useful index species in the Upper Cretaceous.

Genus BRIZALINA Costa 1856

Brizalina incrassata (Reuss) 1851

- 1851 *Bolivina incrassata* Reuss, p. 45, pl. 5, fig. 13.
 1929 *Bolivina incrassata* Reuss; White, p. 43, pl. 4, fig. 19.
 1946 *Bolivina incrassata* Reuss; Cushman, p. 127, pl. 53, figs. 8-11.
 1951 *Bolivina incrassata* Reuss; Noth, p. 64, pl. 9, fig. 8.
 1953 *Bolivina incrassata* Reuss; Le Roy, p. 20, pl. 10, figs. 4, 5.
 1955 *Bolivina incrassata* Reuss *gigantea* (Wicher 1949); Bettenstaedt and Wicher, p. 502, fig. 11-19.
 1956 *Bolivina incrassata* Reuss; Said and Kenawy, p. 144, pl. 4, fig. 19.
 1957 *Bolivina incrassata* Reuss; Hofker, p. 228, figs. 282-286, 288, 291, 292.
 1958 *Bolivina incrassata* Reuss; Bieda, p. 45, fig. 15.
 1961 *Bolivina incrassata* Reuss; Scheibnerova, p. 42, pl. 3, fig. 3.
 1963 *Bolivina incrassata* Reuss; Kaptarenko-Cernousova *et al.*, p. 111, pl. 27, fig. 7.
 1964 *Bolivina incrassata* Reuss; Martin, p. 90, pl. 11, fig. 14.
 1965 *Bolivina incrassata incrassata* Reuss; Herm, p. 333, text-figs. 12, 13.
 1966 *Bolivina incrassata* Reuss; Hofker, p. 39, pl. 5, fig. 42; p. 59, pl. 10, figs. 90, 91.

Remarks. *Brizalina* as emended by Loeblich and Tappan (1964) includes those species formerly placed in *Bolivina* d'Orbigny 1839 that lack retral chamber processes or crenulations. *B. incrassata*, lacking both retral processes and crenulations, is here referred to the genus *Brizalina*.

This is a common and widespread species recorded from numerous Upper Cretaceous localities, and regarded as a useful index microfossil. Wicher (1949) stated that the larger form of this species, 'var. *gigantea*', which includes the Galicia Bank specimens, is restricted to the Maestrichtian.

Genus NUTTALLIDES Finlay 1939

Nuttallides galiciensis sp. nov.

Text-fig. 1a-c

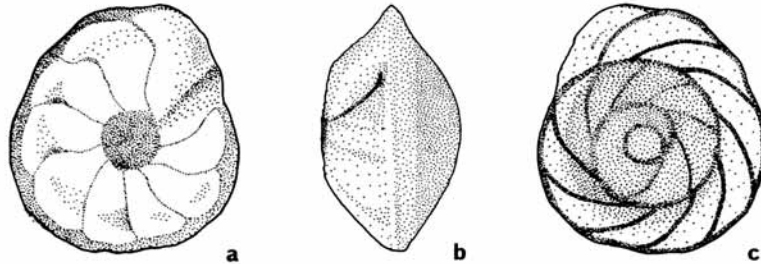
Holotype. Slide 1208a.

Material. 16 specimens. *Dimensions* of figured specimen and average dimensions (in brackets): max. diameter 0.275 (0.275) mm.; min. diameter 0.25 (0.25) mm.; thickness 0.15 (0.125) mm.

Diagnosis. An unequally biconvex species with flattened umbilical boss, and trochospiral coiling. Septal walls mono-lamellar; well-developed tooth-plate.

Description. Test trochoid, lenticular in section, unequally biconvex, with distinctly flattened umbilical boss. Periphery acute or sub-acute, with narrow poreless keel, crenulate. Umbilical side involute, inflated; umbilicus closed by translucent plug.

Spiral side a low cone, showing up to three previous whorls, though earlier whorls often indistinct. 8–11 chambers in final whorl; sutures curved, sigmoid, flush or slightly depressed between later chambers on umbilical side; straight, flush, and oblique on spiral side. Aperture rather variable although with distinct lip, extending along base of apertural face from umbilical boss to an indentation parallel to plane of coiling in apertural face near periphery. Wall radial, perforate; septal walls mono-lamellar. Tooth-plate structure well developed, extending as high ridge from behind indentation in apertural face to face of penultimate chamber, where it is attached to area formerly occupied by apertural lip.



TEXT-FIG. 1. *Nuttallides galiciensis* sp. nov. a, umbilical side; b, edge view; c, spiral side. $\times 150$.

Remarks. This species is very similar in many respects to *N. trumpyi* (Nuttall) but differs in its smaller size, more numerous chambers, and smaller umbilical plug.

Genus NUTTALLINELLA Belford 1959

Nuttallinella lusitanica sp. nov.

Text-fig. 2a–c

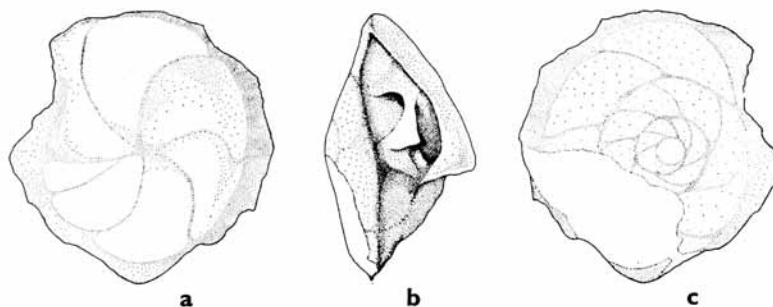
Holotype. Slide 1209.

Material. 20 specimens. *Dimensions* of figured specimen and average dimensions (in brackets): max. diameter 0.4 (0.3) mm.; min. diameter 0.375 (0.275) mm.; thickness 0.225 (0.2) mm.

Diagnosis. Unequally biconvex, trochospiral species with mono-lamellar septal walls, and well-developed tooth-plate with folded upper margin.

Description: Test trochospiral, unequally biconvex, lenticular in section. Periphery acutule with a rarely preserved poreless keel. Umbilical side involute, convex, with 7–9 chambers in final whorl, and very narrow umbilicus, usually partially closed by chambers of final whorl; spiral side flattened or slightly convex, showing up to 3 whorls. Sutures fairly distinct, curved, slightly sigmoid on umbilical side, usually slightly depressed near periphery, sometimes thickened near umbilicus; on spiral side straight, oblique, and flush. Wall smooth, finely perforate; septal walls mono-lamellar. Aperture slit-like, at base of apertural face, and extending from near periphery to umbilicus. A well-developed, ridge-like tooth-plate with folded upper margin extends diagonally across floor of chamber from near peripheral edge of apertural face to near the umbilicus on penultimate apertural face.

Remarks. This species has the well-developed folded tooth-plate that Belford (1958) considered diagnostic of the genus *Nuttallina* Belford 1958 (*non* Dall 1871) = *Nuttallinella* Belford 1959. It is similar to *N. coronula* Belford, but differs in its generally unequally biconvex test, larger number of chambers in the final whorl, and less well-developed umbilicus.



TEXT-FIG. 2. *Nuttallinella lusitanica* sp. nov. a, umbilical side; b, edge view; c, spiral side $\times 100$.

Genus VALVALABAMINA Reiss 1963

Valvalabamina aegyptiaca (Le Roy) 1953

1953 *Valvulineria aegyptiaca* Le Roy, p. 53, pl. 9, figs. 21–23.

1956 *Valvulineria aegyptiaca* Le Roy; Said and Kenawy, p. 147, pl. 4, fig. 45.

Remarks. See *V. scrobiculata* (Schwager).

Valvalabamina scrobiculata (Schwager) 1883

1883 *Anomalina scrobiculata* Schwager, p. 129, pl. 29, fig. 18.

1931 *Planulina scrobiculata* (Schwager); Galloway and Morrey, p. 346, pl. 39, fig. 8.

1932 [?] *Valvulineria scrobiculata* (Schwager); Cushman and Ponton, p. 70, pl. 9, fig. 5.

1953 *Valvulineria scrobiculata* (Schwager); Le Roy, p. 53, pl. 9, figs. 18–29.

1954 *Anomalina* (*Anomalina*?) *scrobiculata* Schwager; Vassilenko, p. 61, pl. 3, fig. 5.

1956 [*non*] *Valvulineria scrobiculata* (Schwager); Said and Kenawy, p. 147, pl. 4, fig. 42.

1959 *Valvulineria scrobiculata* (Schwager); Nakkady, p. 460, pl. 2, fig. 5.

Remarks. Reiss (1963) selected *Rotalina lenticula* Reuss as the type species for the genus *Valvalabamina*. Basically *Valvalabamina* differs from *Valvulineria* Cushman 1926 in having a calcitic, granular wall structure, and an umbilical plate-like extension of the apertural lip which is almost completely fused with the chambers of the last whorl. *V. aegyptiaca* and *V. scrobiculata* both have granular, mono-lamellar walls and fused umbilical 'plates'; they are consequently referred to the genus *Valvalabamina*.

Genus NEOEPONIDES Reiss 1960

Neoeponides hillebrandti nom. nov.

1928 *Rotalia* cf. *partschiana* (D'Orbigny); White, p. 288, pl. 38, fig. 10.

1936 [*non*] *Eponides whitei* Brotzen, p. 167, pl. 12, figs. 5–8.

1962 *Eponides whitei* von Hillebrandt, p. 106, pl. 8, fig. 11.

Material. 1 specimen well preserved. *Dimensions.* Diameter 0.25 mm.; thickness 0.15 mm.

Diagnosis (from von Hillebrandt 1962, p. 106). 'Eine neue Art der Gattung *Eponides* mit folgenden Besonderheiten: Umbilikalseite nahezu plan, Spiralseite stark gewölbt, Nabelpfropf gekörnelt, Mündung extraumbilikal—interiomarginal in einer Bucht liegend. (Holotypus: Slg. München Prot. 1341).'

Description. Text trochoid, planoconvex. Umbilical side almost flat, involute; spiral side cone-shaped, evolute, showing 4 previous whorls; periphery acute with small keel. Chambers distinct, 10 in the final whorl. Sutures limbate, straight, almost radial on umbilical side; almost straight, sharply oblique on spiral side. On umbilical side sutures thicken towards umbilicus, and merge into large granular umbilical boss. Wall granular in appearance, perforate. Aperture simple; low arch beneath depression in apertural face, extending into area of umbilicus.

Remarks. *E. whitei* Hillebrandt 1962 is pre-occupied by *E. whitei* Brotzen 1936 and a new name, *Neoeponides hillebrandti* nom. nov., is proposed for von Hillebrandt's species. The morphological characters of this species are consistent with those described for the genus *Neoeponides* Reiss, and although no sections are available, this species is here assigned to that genus.

Genus ANOMALINOIDES Brotzen 1942

Anomalinoides hyphalus sp. nov.

Text-fig. 3a-c

1928 [?] *Planulina dayi* var.; White, p. 302, pl. 41, figs. 4, 5.

Holotype. Slide 1210.

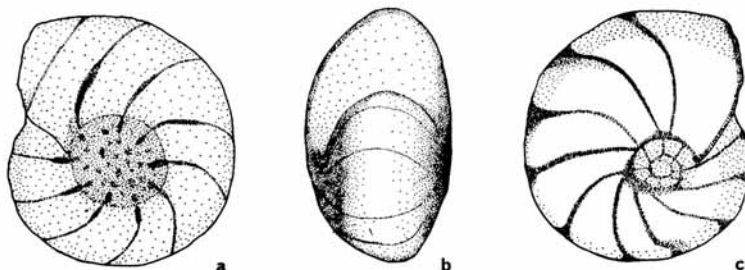
Material. 76 specimens. *Dimensions* of figured specimen and average dimensions (in brackets): max. diameter 0.4 (0.275) mm.; min. diameter 0.325 (0.225) mm.; thickness 0.225 (0.2) mm.

Diagnosis. Planoconvex-biconvex species with reversed trochospiral coiling. Umbilical area modified by flap-like extensions of chambers of last whorl; septal walls bilamellar.

Description. Test reversed trochospiral, involute, unequally biconvex-planoconvex; periphery subacute to rounded. Chambers distinct, up to 12 in final whorl. Spiral side convex, smooth, non-punctate, with transparent umbo through which previous whorls may be seen. Umbilical side flat or slightly convex, almost completely involute, deep umbilicus obscured by triangular flap-like extensions of later chambers, and by a sometimes imperfectly developed umbilical plug. Sutures curved, transparent, limbate, flush on spiral side; curved, limbate, raised, especially near centre of umbilical side. Umbilical side coarsely but sparsely punctate, especially in depressed areas between sutures. Aperture a low arch at base of apertural face, and extending between chambers where sutures have been excavated. Septal walls bilamellar.

Remarks. This species is very similar to *A. velascoensis* (Cushman) but differs primarily in lacking the distinct depressions between the sutures on the umbilical side. Similarities are also apparent between this species and *Gavelinella vombensis* (Brotzen). However the latter is always trochospiral, and there are no intermediate forms between the reversed trochospiral forms described here and the forms described as *G. vombensis*.

The variants of *Planulina dayi* White described by White (1928, p. 302, pl. 41, figs. 4, 5) appear to be similar to these forms, especially in the modification of the sutures on the umbilical side.



TEXT-FIG. 3. *Anomalinoides hyphalus* sp. nov. a, umbilical side; b, edge view; c, spiral side $\times 100$.

Anomalinoides velascoensis (Cushman) 1925

- 1925 *Anomalina velascoensis* Cushman, p. 21, pl. 3, fig. 3.
 1928 *Planulina velascoensis* (Cushman); White, p. 303, pl. 41, fig. 7.
 1946 *Anomalina velascoensis* Cushman; Cushman, p. 156, fig. 7.
 1951 [?] *Planulina velascoensis* (Cushman); Noth, p. 80, pl. 7, fig. 14.
 1959 [?] *Anomalina velascoensis* Cushman; Morgiel, p. 138, pl. 14, fig. 11.
 1961 [?] *Planulina velascoensis* Cushman; Scheibnerova, p. 52, pl. 11, fig. 4.
 1962 *Gavelinella velascoensis* (Cushman); von Hillebrandt, p. 102, pl. 8, figs. 3, 4.

Remarks. Cushman (1925, 1946) assigned this species to the genus *Anomalina* d'Orbigny 1826, but was at the time unaware of the internal arrangement of the chambers. Cushman's 'spiral thickening' on the 'dorsal side' is in fact an umbilical plug on the ventrum. This species has a convex spiral side, and a concave or flattened umbilical side, the early whorls on the spiral side being obscured by the partially involute later whorls, and by secondary implantation of calcite on the umbo. The chamber arrangement is reversed trochoid, and the aperture umbilical-extra-umbilical. These characters serve to distinguish the species of *Anomalinoides* from those of *Gavelinella* Brotzen 1942 and *Planulina* d'Orbigny 1826.

Acknowledgements. The author would like to thank Mrs. J. K. Friend, Dr. J. Hofker and Dr. Z. Reiss for their advice during the preparation of this work, and Dr. B. W. Funnell for critically reading the manuscript. The project was financed by an N.E.R.C. research grant.

Holotypes, figured specimens and hypotypes have been deposited in the Sedgwick Museum, Cambridge.

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Typescript received from author 20 August 1968