Recent benthonic foraminifera from Brasil : morphology and ecology. Part II

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RECENT BENTHONIC FORAMINIFERA FROM BRASIL. MORPHOLOGY AND ECOLOGY PART II

BY

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3. CRIBROSTOMOIDES CUSHMAN AND HAPLOPHRAGMOIDES CUSHMAN FROM THE CAMPOS SHELF.

ABSTRACT

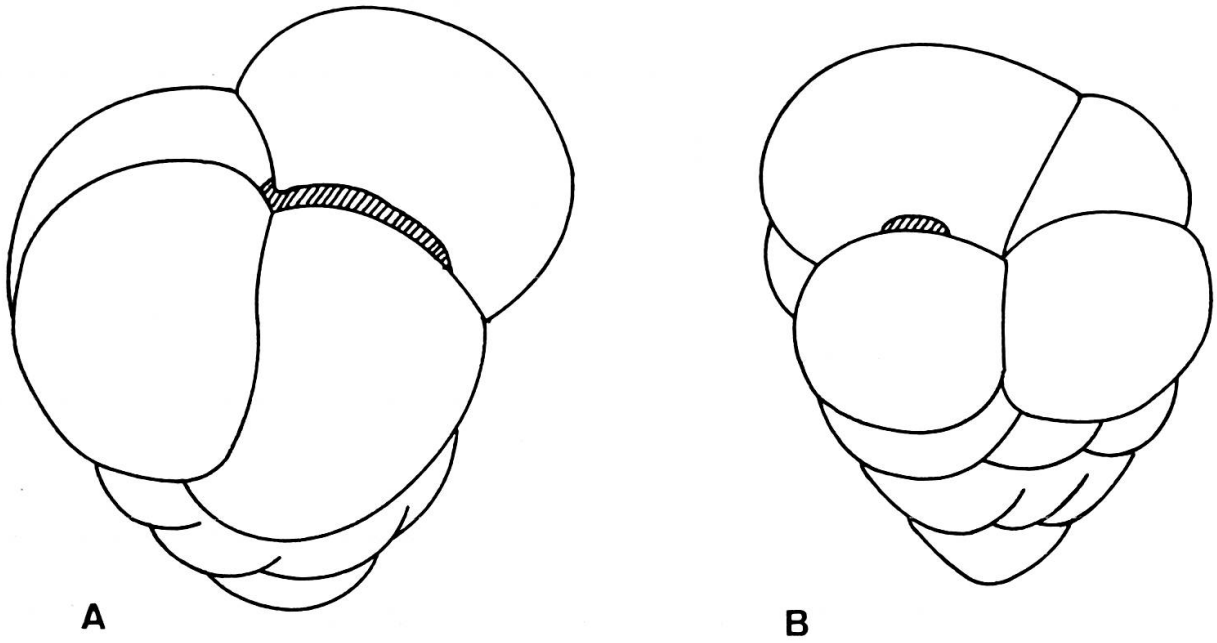
Cribrostomoides jeffreysi (WILLIAMSON) occurs abundantly in the shallow waters of the Campos shelf, Brasil, Lat. between S 21° 30′ and 22° 30′ and Long. between W 40° 30′ and 41° 30′. Associated are very rare *Cribrostomoides crassimargo* (NORMAN). Both are well known temperate to cold water species and their occurrence in the Campos area is due to the cold water influx of the southern Falkland (Malvin) current.

In addition to these species are also described as new *Cribrostomoides compactus*, n. sp., *Cribrostomoides siphonapertus*, n. sp., and a small representative of *Haplophragmoides?* CUSHMAN.

The gross morphology of all these lituolids is illustrated by scanning photographs. In some cases photographs are presented of specimens made transparent in immersion oil.

The benthonic foraminiferal assemblages of the Campos shelf, Brasil, Lat. S 21° 30′/22° 30′, Long. W 40° 30′/41° 30′ (location map text-fig. 1 in BRÖNNIMANN and BEURLEN, 1977) contain in the near-shore area to a depth of about 50 m 4 species of cribrostomoids represented by abundant and well preserved *Cribrostomoides jeffreysi* (WILLIAMSON), 1858, rare *Cribrostomoides crassimargo* (NORMAN), 1892, *Cribrostomoides compactus* BRÖNNIMANN and BEURLEN, n. sp., and *Cribrostomoides siphonapertus* BRÖNNIMANN and BEURLEN, n. sp.

Although *C. jeffreysi* had been well described already by WILLIAMSON (1858, p. 34, pl. 3, fig. 72, 73) under the name of *Nonionina jeffreysii* (see remarks by HOEGLUND, 1947, p. 147, by MURRAY, 1971, pl. 4, p. 23, and by HAYNES, 1973, p. 30) a redescription of this common temperate to cold water lituolid accompanied by scanning photographs showing the morphological variability should enable other workers to recognize and distinguish *C. jeffreysi* from other species of *Cribrostomoides* and in particular from *Haplophragmoides canariensis* (d'ORBIGNY) with which



TEXT-FIGURE 1. — Diagrammatic illustration of the apertural features of *Trochammina brasiliensis* BRÖNNIMANN and BEURLEN (A), and of *Trochammina vesicularis* GOËS sensu EARLAND (B). Not to scale.

it had been often confounded (see list of synonyms in HAYNES, 1973, p. 29, and also HAYNES' remarks on *Haplophragmoides canariense* on p. 30; see also remarks by HOEGLUND (1947, p. 147) that BRADY (1884, p. 310) and others after him have erroneously placed WILLIAMSON'S *Nonionina jeffreysii* into synonymy with d'ORBIGNY'S *Nonionina canariensis*). LOEBLICH and TAPPAN (1964, p. C 225, fig. 135, 1*a*, 1*b*) have reillustrated *Haplophragmoides canariensis* (d'ORBIGNY) from the Recent of the Philippines. The figured specimen shows an interiomarginal not an areal aperture as do representatives of *Cribrostomoides* CUSHMAN, 1910 (type species *Lituola subglobosum* G.O. SARS, 1871).

It is, however, most improbable that LOEBLICH and TAPPAN'S specimen from the Philippines represents *Haplophragmoides canariensis* (d'ORBIGNY). Mrs. Y. LECALVEZ (1974) recently revised the originals of the foraminiferal species described by d'ORBIGNY (1839) from the Canary Islands. As far as *Nonionina canariensis* d'ORBIGNY is concerned, Mrs. LECALVEZ states (1974, p. 36) that the type specimen is lost and that the original material of d'ORBIGNY does not contain any individual referable to *Nonionina canariensis* hence one does not know exactly what *N. canariensis* looks like. This problem was discussed during a visit to Mrs. LECALVEZ' laboratory on 21 January 1977 and it was found that the gross morphological differences between d'ORBIGNY'S type specimen as illustrated by his pl. 3, fig. 12 (d'ORBIGNY, 1839) and that chosen by LOEBLICH and TAPPAN (1964, p. C 223, fig. 135, 1*a*, *b*) to represent *Haplophragmoides canariensis* suggest the presence of 2 different species of *Haplophragmoides* hence the specimen from the Philippines should not be placed into

Haplophragmoides canariensis. Further, *Nonionina canariensis* d'ORBIGNY, 1839, should be considered a nomen non conservandum sine tipo and no longer be used.

Cribrostomoides crassimargo (NORMAN), 1892, which was placed by BRADY (1884, pl. 35, fig. 4*a*, *b*) into *Haplophragmium canariense* d'ORBIGNY [= *Haplophragmoides canariensis* (d'ORBIGNY)] differs strongly from *C. jeffreysi*. It is also a temperate to cold water lituolid (the lectotype designated by LOEBLICH and TAPPAN, 1964, p. C 225. fig. 136, 3*a*, 3*b* is from the Bog Fjord, East Finmark, at a depth of 100-110 fathoms) and here illustrated by 2 scanning photographs showing the gross morphology of this species. *Cribrostomoides compactus*, n. sp., and *Cribrostomoides siphonapertus*, n. sp., are new species which differ from both *C. jeffreysi* and *C. crassimargo*. In addition to these cribrostomoids is illustrated a very small and rare *Haplophragmoides* sp.?

Lituolacea DE BLAINVILLE, 1825
Family Lituolidae DE BLAINVILLE, 1825
Genus *Cribrostomoides* CUSHMAN, 1910
Type-species *Lituola subglobosum* G. O. SARS, 1871

HOEGLUND proposed in 1947 the lituolid genus *Labrospira* for planispiral, agglutinated foraminifera with a simple interior, a simple wall and an oblong transversely placed areal (interio-areal in HOEGLUND's terminology) aperture. HOEGLUND based *Labrospira* on *Haplophragmium crassimargo* NORMAN, 1892, as type-species. The lectotype of *Haplophragmium* [= *Cribrostomoides*] *crassimargo* was designated by LOEBLICH and TAPPAN in 1964 (p. C 225, fig. 136, 3*a*, 3*b*). However, *H. crassimargo* shows the same generic features as *Lituola subglobosum* G.O. SARS, 1871 (= *Cribrostomoides bradyi* CUSHMAN, 1910) the type-species of *Cribrostomoides*. Hence *Labrospira* HOEGLUND, 1947, is a junior synonym of *Cribrostomoides* CUSHMAN, 1910. HOFKER (1976), p. 54, 55, fig. 38), in a recent paper on Caribbean foraminifera, reported *C. bradyi* from a depth of 800 m W of Frederiksted, St. Croix. Thin sections of his specimens showed the early chambers to be streptospirally arranged. In this they differ according to HOFKER from *Lituola subglobosum* (= *C. bradyi*) as described by HOEGLUND from the Skagerak (1947, p. 144, 145, pl. 11, fig. 2, text-fig. 126). HOEGLUND did not find an early irregular enrollment but he described the adult test as "planispiral or nearly so" and his illustration pl. 11, fig. 2 shows a slight terminal asymmetry. Haplophragmoidinines which have the streptospiral enrollment and an areal aperture are placed in *Recurvoides* EARLAND, 1934 (type species *R. contortus* EARLAND). According to HOFKER (1976, p. 55) it is not clear whether *C. bradyi* should be placed into *Recurvoides* and he considered the possibility that the genera with areal slit-like apertures (and planispiral or streptospiral enrollment) may belong together. This would mean that in particular *Recurvoides* EARLAND, 1934, would

fall into synonymy with *Cribrostomoides* CUSHMAN, 1910. In order to arrive at a conclusion in this matter, the taxonomic significance of the type of enrollment in this group of Recent foraminifera will have to be studied in detail. It may be that this feature is, as in the case of the Involutinidae BÜTSCHLI, 1880 (ZANINETTI, 1976), a criterium valid on the species level only.

Cribrostomoides jeffreysi (WILLIAMSON), 1858
Pl. 1, fig. 1-5, 7-10, 12, 13; Pl. 2, fig. 1-6

Dr. J. R. HAYNES, Department of Geology, Aberystwyth, Wales, most kindly checked some specimens from our Brasilian material and found them to be identical with those described by him from the Cardigan Bay (HAYNES, 1973, p. 29-31, pl. 2, fig. 5, 6; pl. 8, fig. 9; pl. 29, fig. 10, text-fig. 5, Nos. 8-10) (Letter of 24 May, 1976),

Synonymy :

1858. *Nonionina jeffreysii* WILLIAMSON, p. 34, pl. 3, fig. 72, 73.

1876. *Nonionina jeffreysii* WILLIAMSON. TERQUEM, p. 71, fig. 22. (1875-1880).

1878. *Haplophragmium jeffreysii* (WILLIAMSON). BERTHELIN, p. 24, N°. 20 (fide Haynes, 1973, p. 29).

1884. *Haplophragmium canariense* BRADY, partim, p. 310, pl. 35, fig. 1-3, 5 not 4 (not d'ORBIGNY).

1920. *Haplophragmoides canariense* CUSHMAN, p. 38, pl. 8, fig. 1.

?1925. *Haplophragmoides columbiense* CUSHMAN, n. sp., p. 39, pl. 6, fig. 2.

1931. *Haplophragmoides canariensis* (d'ORBIGNY). WIESNER, p. 95, pl. 11, fig. 135.

1938. *Haplophragmoides canariensis* (d'ORBIGNY). RHUMBLER, p. 178, fig. 16, 17.

1938. *Haplophragmoides canariensis* (d'ORBIGNY). BARTENSTEIN and BRAND, p. 391, fig. 9.

?1939. *Haplophragmoides columbiense* CUSHMAN. CUSHMAN and MCCULLOCH, p. 72, pl. 5, fig. 8-10.

?1939. *Haplophragmoides columbiense* CUSHMAN var. *evolutum* CUSHMAN and MCCULLOCH, n. var., p. 73, pl. 5, fig. 11, 12; pl. 6, fig. 1, 2.

?1939. *Haplophragmoides hancocki* CUSHMAN and MCCULLOCH, n. sp., p. 79, 80, pl. 6, fig. 5, 6.

?1944. *Haplophragmoides columbiensis* CUSHMAN, p. 11, pl. 2, fig. 1.

?1947. *Haplophragmoides columbiense* CUSHMAN. CUSHMAN and TODD, p. 4, pl. 1, fig. 6.

1947. *Labrospira jeffreysi* (WILLIAMSON). HOEGLUND, p. 146, 147, pl. 11, fig. 3; text-fig. 128 and 129 on p. 139.

1947. *Labrospira kosterensis* HOEGLUND, p. 147-149, pl. 11, fig. 4; text-fig. 130, 131.

1948. *Haplophragmoides canariense* (d'ORBIGNY). CUSHMAN, p. 26, pl. 2, fig. 15.

1948. *Haplophragmoides columbiensis* CUSHMAN. PARKER, pl. 4, fig. 17.

1952. *Labrospira jeffreysii* (WILLIAMSON). PARKER, p. 401, pl. 2, fig. 15, 17, 18, 19, 20.

1953. *Alveolophragmium jeffreysi* (WILLIAMSON). LOEBLICH and TAPPAN, p. 31, pl. 3, fig. 4-7.

1954. *Alveolophragmium* sp. PARKER, p. 488, pl. 1, fig. 22.

1957. *Labrospira jeffreysii* (WILLIAMSON). BOLTOVSKOY, p. 18, pl. 1, fig. 1-6.

1960. *Alveolophragmium advena* CUSHMAN. UCHIO, p. 52, pl. 1, fig. 20 ?, 21 ?, 22.

1961. *Cribrostomoides jeffreysii* (WILLIAMSON). BOLTOVSKOY, p. 266, pl. 2, fig. 15, 16 not 17.

1965. *Cribrostomoides jeffreysi* (WILLIAMSON). LUTZE, p. 89, pl. 15, fig. 10-13.

1967. *Cribrostomoides jeffreysii* (WILLIAMSON). TODD and LOW, p. A 5, pl. 1, fig. 21.

1967. *Haplophragmoides canariense* (d'ORBIGNY). HEDLEY, HURDLE and BURDETT, p. 18, text-fig. 7, pl. 5, fig. 4*a, b*.

1971. *Cribrostomoides jeffreysii* (WILLIAMSON). MURRAY, p. 23, pl. 4, fig. 1-5.

1973. *Haplophragmoides canariensis* (d'ORBIGNY). VOORTHUYSEN, p. 50, pl. 6, fig. 14*a-c*.

1973. *Cribrostomoides jeffreysii* (WILLIAMSON). MURRAY, pl. 9, fig. 5.

1973. *Cribrostomoides jeffreysii* (WILLIAMSON). HAYNES, p. 29, 30, pl. 2, fig. 5, 6; pl. 8, fig. 9; pl. 29, fig. 10; text-fig. 5, Nos. 8, 9, 10.

1974. *Cribrostomoides jeffreysi* (WILLIAMSON). LUTZE, p. 6, pl. 2, fig. 25, 26.

Morphological description

The small and free test, somewhat higher than wide in side view, is planispirally coiled, axially much compressed, and biumbilicate. The periphery is rounded in oral, lobate in lateral view. The enrollment is normally semievolute and may become almost evolute so that the penultimate and earlier whorls are at least partially visible in the umbilical depressions. Completely involute specimens have not been seen. The planispire is made up of 2 to 3 whorls with a total of 12 to 17 chambers, including the proloculus. The final whorl consists of 7 to 8 chambers which increase first gradually then rapidly as added. The last 2 chambers make up almost half the test. This is a distinct feature of *C. jeffreysi*. In lateral view, the chambers are triangular, of almost equal width and height, and with only little overlap on preceding ones. The well defined radial and spiral sutures are depressed. The radial sutures are either straight or very slightly curved. The maximum diameters of the Campos specimens

range from about 100 to slightly over 500 μ. The average maximum diameter ranges from 200 to 300 μ.

The oblong areal aperture crosses the septal face close to its base. It is never cribrate (HOFKER, 1976, p. 54, 55, fig. 38). A very thin protruding lip surrounds the aperture in its entirety. WILLIAMSON (1858) called it a "siphuncle". In larger specimens the lower apertural lip may almost touch the final whorl so that only very careful observation will show that the aperture is areal and not interiomarginal. We agree with HAYNES (1973, p. 30) that this "tendency of the aperture to be tucked under the overhanging apertural face becomes more marked with growth and is reflected in the curves of the septal sutures". Most of the specimens illustrated on pl. 1 exhibit this characteristic "tucking under" of the aperture.

The extremely delicate and simple imperforate walls are from 2 to 3 μ thick and agglutinated. The surface is an irregular mosaic of minute quartz flakes (pl. 2, fig. 5, 6).

Occasionally there are also some elongate elements such as diatoms and sponge spicules incorporated between the quartz flakes. In diluted HCl the wall does not disintegrate. However it turns completely colorless suggesting that the color is chemically bound to some calcareous component. In transparent preparations in immersion oil the interstices between the agglutinated elements show a granular substance as illustrated by pl. 2, fig. 6. The specimen on pl. 1, fig. 9 has been photographed in immersion oil and under crossed nicols. It very nicely shows the flat quartz flakes in the thin walls. The color of the walls is light brown to brown, in some cases also red-brown, in particular in the early portion of the test. This brownish color changes normally in the course of the last volution to very light brown, occasionally to almost colorless in the final chambers.

The plane of enrollment is ontogenetically quite variable (pl. 1, fig. 2), and the final chamber(s) may tend to arrange themselves uniserially. The specimens in which the ultimate chamber lifts itself up and does not touch any more the final whorl are quite common. An extreme specimen in which the aperture of the penultimate chamber becomes almost terminal and produces a final uniserial chamber with a truely terminal aperture is illustrated on pl. 1, fig. 7. A quite similar "monstrous specimen" was illustrated by BRADY (1884, pl. 35, fig. 5). LOEBLICH and TAPPAN (1953, p. 31, 32) mentioned in their Arctic specimens of *C. jeffreysi* an "occasional somewhat trochoid" enrollment. A detailed examination of the Campos material and of the illustrations found in the literature however do not show any trochoid enrollment. On the other hand, the positions of the chambers may somewhat vacillate in respect to the plane of enrollment so that, as mentioned above, some sort of irregular appearance of the final whorl may develop. The observation by LOEBLICH and TAPPAN (1953, p. 32) that "earlier whorls may be visible in the umbilical region on one side" may be due to such an irregular arrangement of the individual chambers of the final whorl but not to a trochospiral arrangement. We also have examined a

large number of specimens under immersion oil and never encountered a trochospiral enrollment be it ever so weak.

In order to study the early enrollment and the ontogenetic changes of the aperture a number of specimens were placed in immersion oil which made them almost transparent and permitted examination under the optical microscope (pl. 1, fig. 13).

Three of the transparent specimens show the following dimensions in microns:

Maximum height	*Maximum width*
340	250
450	340
510	410

The total number of chambers, including the proloculus, ranges in these specimens from 13 to 17. HOEGLUND (1947) counted in his Skagerak material from 13 to 16 chambers, and in the largest specimens up to 20 chambers. In this respect, the Campos specimens correspond therefore well with the specimens described by HOEGLUND. The specimens illustrated by BOLTOVSKOY (1957, p. 18, pl. 1, fig. 1-6) from the mouth of the Rio de la Plata, Argentina, differ from ours by the less distinct and throughout straight radial sutures and the larger agglutinated elements but otherwise they are identical with the Campos material. The Rio de la Plata specimens have maximum diameters from 150 to 600 μ.

The initial chamber of all of the specimens examined in immersion oil is a subglobular to irregularly ovoid body with an inner diameter of 25 to 30 μ. We did not find any prolcculi with a diameter from 8 to 11 μ referred by HOEGLUND (1947, p. 147) to the microspheric generation and it appears that only megalospheric individuals occur in the Campos material. The septal face of the proloculus is somewhat flattened as shown by the specimen pl. 1, fig. 13 and the areal prolocular aperture does not seem to possess the lips shown by all the later apertures.

Remarks on occurrence and ecology of Cribrostomoides jeffreysi on the eastern South American shelf.

On the Campos shelf we have encountered *C. jeffreysi* in most samples below the 20 m depth line to a depth of about 50 m. Its occurrence on the Campos shelf outside the 50 m depth line is unknown.

BOLTOVSKOY (1957) recorded *C. jeffreysi* from numerous stations outside the mouth of the Rio de la Plata. In some of the stations at the limit of the fluvio-marine and marine area (BOLTOVSKOY and LENA, 1974, map 1) where it occurs rarely to frequently, such as in stations 2180 and 2181, the surface salinity is distinctly subnormal. The bottom salinity is unknown but most probably that of the open ocean. No temperature measurements are given by BOLTOVSKOY in his 1957 paper but he

suggests that the temperature may be influenced either by the warm northern subtropical Brasil current or by the cold southern subantarctic Malvin (Falkland) current. In their later paper BOLTOVSKOY and LENA (1974, p. 10, map 11) show that *C. jeffreysi* occurs in stations 2065, 2068 and 2072, SW of Punta del Este, mouth of the Rio de la Plata. These stations fall in a small near-shore area of their fluvio-marine zone characterized by bottom salinities ranging from about 30 to 35%, that is from slightly hyposaline to normal marine salinity. The surface salinity on the other hand is influenced by the influx of La Plata waters and ranges from 25 to 30%. The surface water temperature of this area ranges from a minimum of 10.56° C to a maximum of 24.15° C (BOLTOVSKOY and LENA, 1974, p. 5). BOLTOVSKOY (1970, p. 71) suggests that the area in which *C. jeffreysi* occurs is under the influence of the cold waters of the subantarctic Malvin (Falkland) current which flows in northern direction along the eastern South American coast up to about the Cabo Frio area of Brasil which is considered by BOLTOVSKOY (1959, p. 8 and in particular p. 12-16) as its northern limit. The depths of the stations 2065, 2068 and 2072 is 31.70 m, 20.73 m and 25.00 m respectively. These depths correspond well with those of the Campos shelf material. The stations (Nos. 52-53 and 54) with *C. jeffreysi* reported by ROETTGER (1970, p. 27, fig. 1, 2) from the shelf off Rio Grande do Sul, Brasil, occur within the 20 to 50 m depth zone. Also here the presence of *C. jeffreysi* appears to be due to the influx of cold subantarctic waters. PEREIRA (1969), p. 61) recorded *C. jeffreysi* from station 632 SE of Santos, Brasil, which falls in his bathymetric zone A from 50 to 70 m depth. Also the bottom waters of this area lie under the influence of the cold water Malvin (Falkland) current (PEREIRA, 1969, p. 42-44). Finally, BOLTOVSKOY (1958, p. 17) listed *C. jeffreysi* from the fresh waters of the Rio de la Plata where it is associated with thecamoebinas and a few rare and undersized foraminiferal species. This is the only record of *C. jeffreysi* from a fresh-water environment and needs to be checked by a restudy of BOLTOVSKOY's material. We may summarize this paragraph on the occurrence of *C. jeffreysi* on the eastern South American shelf as follows: *C. jeffreysi* is a typical shelf species and is known to live in temperate to cold waters at depths between 20 and 70 m. Its northernmost occurrence is defined by the northern limit of the cold water Malvin (Falkland) current somewhat to the north of Cabo Frio (Campos shelf), Brasil.

Cribrostomoides crassimargo (NORMAN), 1892

Pl. 3, Fig. 3, 7

Synonymy:

1884. *Haplophragmium canariense* (D'ORBIGNY). BRADY, p. 310, pl. 35, fig. 4 (not fig. 1-3, 5).

1892. *Haplophragmium crassimargo* NORMAN, pt. 8, p. 17.

1894. *Haplophragmium canariense* GOËS (part), not D'ORBIGNY, p. 20, pl. 5, fig. 92-96, 97, 98 ?, not 99-101 (fide HOEGLUND).
1910. *Haplophragmium crassimargo* NORMAN. HERON-ALLEN and EARLAND, p. 424, fig. 3, 4.
1913. *Haplophragmium crassimargo* NORMAN. HERON-ALLEN and EARLAND, p. 130, pl. 10, fig. 5, 6.
1920. *Haplophragmoides major* CUSHMAN, p. 39, pl. 8, fig. 6.
1931. *Haplophragmoides emaciata* (BRADY). WIESNER, p. 95, pl. 12, fig. 139.
1931. *Haplophragmoides latidorsata* (BORNEMANN). WIESNER, p. 95, pl. 12, fig. 140.
1936. *Alveolophragmium orbiculatum* var. *typica* STSCHEDRINA, p. 315, text-fig. 2*a*, *b* (fide LOEBLICH and TAPPAN, 1953).
1936. *Alveolophragmium orbiculatum* var. *ochotonensis* STSCHEDRINA, p. 316, text-fig. 2*a*, *b* (fide LOEBLICH and TAPPAN, 1953).
1936. *Alveolophragmium orbiculatum* var. *caraensis* STSCHEDRINA, p. 318, text-fig. 3*a*, *b* (fide LOEBLICH and TAPPAN, 1953).
1943. *Haplophragmoides canariensis* HESSLAND (not D'ORBIGNY), p. 262, 263, pl. 1, fig. 1.
1947. *Labrospira crassimargo* (NORMAN). HOEGLUND, p. 141, pl. 11, fig. 1, text-fig. 121-125.
1948. *Haplophragmoides major* CUSHMAN, p. 27, pl. 2, fig. 17.
1948. *Haplophragmoides major* CUSHMAN. PARKER, pl. 1, fig. 1.
1952. *Labrospira crassimargo* (NORMAN). PARKER, p. 300, pl. 2, fig. 16*a*, *b*.
1952. *Labrospira crassimargo* (NORMAN). PHLEGER, p. 85, pl. 13, fig. 11, 16.
1953. *Alveolophragmium crassimargo* (NORMAN). LOEBLICH and TAPPAN, p. 29-31, pl. 3, fig. 1-3.
?1961. *Cribrostomoides* cf. *jeffreysi* (WILLIAMSON). BOLTOVSKOY, p. 266, 267, pl. 2, fig. 18, 19.
1964. *Cribrostomoides crassimargo* (NORMAN). LOEBLICH and TAPPAN, p. C225, fig. 136, 3*a*, *b*.
1967. *Cribrostomoides crassimargo* (NORMAN). TODD and LOW, p. A15, pl. 1, fig. 24*a*, *b*.

A very few specimens of a fairly large-sized *Cribrostomoides* in which the final chambers increase much in width and which show coarse agglutination have been placed into *C. crassimargo* (NORMAN).

Morphological description

The planispirally coiled test is free and oblong, higher than wide in side view. It is distinctly biumbilicate. The periphery is broadly rounded in oral view and only slightly to non-lobate in side view. The maximum diameters oscillate around 1 000 μ.

The enrollment is almost involute in its early stage and becomes in the final stage evolute (pl. 3, fig. 3, 7). The final whorl consists of about 8 chambers which increase considerably in width but not much in height as added. The radial sutures are normally straight and because of the relatively coarse agglutination not too well defined. The wall is single-layered and imperforate.

The aperture is an oblong areal opening placed across the base of the septal face. It is completely surrounded by a thin protruding lip similar to that in *C. jeffreysi.*

Remarks:

Cribrostomoides crassimargo differs from *C. jeffreysi* in the following aspects:

1. The chambers increase in the course of growth not much in height but strongly in width.
2. The chambers and the sutures are not too well defined and the ultimate and penultimate chambers do not make up half of the test.
3. The agglutination is very coarse.
4. The tests are normally larger than those of *C. jeffreysi.*

It is probable that the specimens described and illustrated by BOLTOVSKOY (1961, p. 266, 267, pl. 2, fig. 18, 19) from the shelf in front of the mouth of the Rio de la Plata under the name of *Cribrostomoides* cf. *jeffreysi* should be placed in *C. crassimargo*. They are larger, more coarsely agglutinated and more evolute than *C. jeffreysi.* These forms are from 3 stations M.2, M.16 and M.20 from a depth of 64 m, 60 m and 113 m respectively. No information is given about their number in above samples.

Cribrostomoides compactus BRÖNNIMANN and BEURLEN, n. sp.

Pl. 3, Fig. 1, 2, 8, 10-13

Holotype: The holotype of *Cribrostomoides compactus*, n. sp., is the specimen illustrated by the scanning photographs of the apertural side pl. 3, fig. 1, 2. Its maximum diameter is about 200 μ. The specimen is from a dredge sample station PM-3-6B, Campos shelf, Brasil (see location map, text-fig. 1 in Brönnimann and Beurlen, 1977). Depth 30 m.

Morphological description of the holotype

The test is small for the genus, axially thick and without umbilical depressions. The outline of the test, as seen in side view, is subcircular, somewhat longer than wide, and virtually non-lobate. In oral view it is thickly oblong with broadly rounded periphery. The enrollment is involute so that only the 5 chambers of the final whorl are visible from the outside. Due to the coarse agglutination of the walls, the sutures

between the chambers are not well defined. The aperture is a broadly oval interio-areal opening completely surrounded by a slightly protruding thin lip which is agglutinated by small foreign elements (pl. 3, fig. 1, 2).

The aperture is very close to the base of the septal face. The surface of the test is coarsely agglutinated by relatively large irregularly angular quartz grains and flakes. In the interstices between the quartz grains occurs a granular-spongy substance. The wall is imperforate and single-layered.

The holotype shows the following dimensions in microns:

Maximum diameter of test	200
Maximum thickness of test in oral view	120
Width of aperture	36
Height of aperture	14

Morphological remarks on illustrated paratypes

On pl. 3, fig. 12 and 13, 2 more specimens of *C. compactus*, n. sp., are illustrated by scanning photographs. Their maximum diameters in side view are 210 μ (fig. 12), 150 μ (fig. 13), and their axial thicknesses 80 μ and 100 μ respectively. The overall features of the paratypes agree well with those described from the holotype. In all specimens the aperture is a broadly oval areal opening very close to the base of the septum. The aperture is completely surrounded by a slightly protruding thin lip. In the specimen pl. 3, fig. 13 the aperture seems to be interiomarginal. This is, however, not the case and due to the position of the specimen. The 5 chambers of the involute final whorl are difficult to distinguish because of the coarse agglutination. A specimen photographed in immersion oil, pl. 3, fig. 11 shows a non-transparent axial portion representing the axial thickening and 3 transparent chambers characterized by thick walls. In another specimen the areal aperture is depicted (pl. 3, fig. 8, 10). The walls are relatively thick for the genus and throughout single-layered and imperforate. The paratype pl. 3, fig. 11 has a maximum diameter of 150 μ, an axial thickness of 100 μ and the walls of the final chamber are 7 to 15 μ thick. The paratype pl. 3, fig. 8, 10 has a maximum diameter of 200 μ, and the aperture is about 10 μ high. The total number of chambers of this paratype is 11 including the proloculus.

Remarks:

C. compactus, n. sp., is a rare species. It occurs associated with *C. jeffreysi*, *C. crassimargo* and *C. siphonapertus*, n. sp. It differs from *C. jeffreysi* and *C. crassimargo* by the small size, the axially thick, non-umbilicate involute test, the coarse agglutination and the broadly oval areal aperture. From *C. siphonapertus*, n. sp., it differs in the overall shape and by the form of the areal aperture which is subcircular and surrounded by a thickened rim in *C. siphonapertus*.

The association of *C. compactus* with *C. jeffreysi* and *C. crassimargo* suggests that also *C. compactus*, n. sp., is a species of temperate to cold water preference.

Cribrostomoides siphonapertus BRÖNNIMANN and BEURLEN, n. sp.

Pl. 3, Fig. 4, 5, 6, 9

Synonymy :

1971. *Ammoscalaria runiana* (HERON-ALLEN and EARLAND). MURRAY, p. 29, pl. 7, fig. 6-8.

Holotype : The holotype of *Cribrostomoides siphonapertus*, n. sp., is the specimen illustrated by the scanning photographs of the oral views pl. 3, fig. 5, 6. The maximum diameter of the holotype is about 195 μ. The specimen is from a dredge sample station PM-3-6B, Campos shelf, Brasil. Depth 30 m.

Morphological description of the holotype

The test is small for the genus, laterally flattened and slightly biumbilicate. The outline of the test as seen in side view is subcircular, longer than wide and non-lobate and in oral view it is axially compressed with parallel sides with broadly rounded periphery. The enrollment is involute and only the 5 chambers of the last volution are visible. Because of the coarse agglutination the sutures are indistinct. The agglutinated material consists essentially of large irregular quartz flakes and angular quartz grains. The aperture is a subcircular to somewhat oval areal opening in the middle of the apertural face and close to its base. It is surrounded by a thick rim.

The holotype shows the following dimensions in microns:

Maximum diameter of test	195
Maximum thickness of test	65
Maximum diameter of areal aperture including walls (rim)	16

Morphological remarks on illustrated paratypes

In addition to the holotype, 2 paratypes are illustrated. One is represented by the scanning photograph pl. 3, fig. 4 and the other by a photograph in immersion oil pl. 3, fig. 9. The features of the scanned paratype correspond well with those of the holotype, in particular the subcircular areal rimmed aperture and the laterally flattened shape of the coarsely agglutined test. It has a maximum diameter of about 225 μ and an axial thickness of about 70 μ. The maximum diameter of the oval-rounded aperture including the rims is 19 μ. The maximum diameter of the paratype, immersed in oil, is 175 μ. Its walls measure in the final chamber about 10 μ in thickness. The test consists of 7 chambers including the large proloculus which measures 55 μ in diameter, including the walls. The aperture is not visible in this

photograph. The walls are single-layered and rather thick for the genus and imperforate.

Remarks: *Cribrostomoides siphonapertus*, n. sp., occurs rarely but more frequently than *C. compactus*, n. sp., in the shallow water samples from the Campos shelf. It is associated with *C. jeffreysi*, *C. crassimargo* and *C. compactus*, n. sp. It differs from all other here described representatives of *Cribrostomoides* by its rounded and rimmed areal aperture, from *C. jeffreysi* and *C. crassimargo* also by its overall shape and involute enrollment, and from *C. compactus* also by its laterally flattened test. Its association with *C. jeffreysi* and *C. crassimargo* most probably suggests that *C. siphonapertus*, n. sp., is also a temperate to cold water species. MURRAY (1971, p. 29, pl. 7, fig. 6-8) described as *Ammoscalaria runiana* (HERON-ALLEN and EARLAND), 1916, from off Plymouth, depth 10-60 m, a small cribrostomoid which is identical with the here described *C. siphonapertus*. *Haplophragmium runianum* was proposed by HERON-ALLEN and EARLAND (1916, pl. 40, fig. 15-18) for a fairly large coarsely agglutinated lituolid with a simple terminal or interiomarginal aperture unlike that of *C. siphonapertus*. It was found in 3 fathoms depth at Loch Scresort, Rhum, W of Scotland. The optical section of *Cribrostomoides siphonapertus* shows a very few distinct chambers separated by fairly thick curved septa (pl. 3, fig. 9) whereas that of *Ammoscalaria runiana* (HERON-ALLEN and EARLAND) has more than 25 chambers of rectangular shape and very thin septa (HOEGLUND, 1947, p. 156, fig. 137).

Genus *Haplophragmoides* CUSHMAN, 1910
Type species *Nonionina canariensis* d'ORBIGNY, 1839
Haplophragmoides sp.?
Pl. 1, fig. 6, 11

With open nomenclature is here described a very rare lituolid species probably referable to *Haplophragmoides* CUSHMAN. As shown by the scanning photographs of the same specimen in side and oral view (pl. 1, fig. 6, 11) it is a very small, axially thick and peripherally broadly rounded test. The coiling is involute and the final volution consists only of 4 chambers which are separated by straight radial sutures. The aperture is difficult to be seen but seems to be a thin interiomarginal slit. The walls are coarsely agglutinated by angular quartz grains and flakes and other elements such as sponge spicules. The maximum diameter of the test is 200 μ, and its axial thickness 135 μ. The illustrated specimen is from station PM-4-12B, depth 50 m.

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4. TROCHAMMINA BRASILIENSIS BRÖNNIMANN AND BEURLEN, N. SP., FROM THE CAMPOS SHELF

ABSTRACT

Trochammina brasiliensis, n. sp., is described and illustrated from the near-shore shallow-water area of the Campos shelf, Brasil, and compared with *Trochammina quadriloba* HOEGLUND, 1948, the type species of *Trochamminopsis* BRÖNNIMANN, 1976, and with *Trochammina vesicularis* GOËS

sensu EARLAND, 1934. *Trochammina brasiliensis* is a typical shelf species and associated with the cold to temperate water *Cribrostomoides jeffreysi* (WILLIAMSON), *Polystomammina planulata* (MIKHALEVITCH) and other lituolids and trochamminids. *Trochamminopsis quadriloba* has been recorded in temperate to cold waters off Sweden, the Artic Sea, the Gulf of Maine and the Campos shelf. *Trochammina vesicularis* GOËS sensu EARLAND has been described from the cold waters of the Falklands area, Antarctic Sea, in a depth range from 278 to 3 264 m. *Trochammina vesicularis* GOËS, 1894, from the Arctic Sea, is considered to represent a *nomen non conservandum sine tipo* and should no longer be used.

Trochamminids belong to the more common arenaceous foraminifera of the shallow-waters of the Campos shelf area, Brasil, Lat. S. 21° 30′/22° 30′ and Long. W 40° 30′/41° 30′ (see location map, text-fig. 1 in BRÖNNIMANN and BEURLEN, 1977). *Trochammina brasiliensis*, n. sp., which will be described below, has been commonly found on the Campos shelf which was sampled down to a depth of 50 m. The species is most frequently represented in the dredge samples PM-4-12B and PM-14A-26B, both depth 50 m.

Trochamminidae Schwager, 1877
Trochammininae Schwager, 1877
Trochammina Parker and Jones, 1859
Trochammina brasiliensis BRÖNNIMANN and BEURLEN, n. sp.
Pl. 4, Fig. 1-8

Holotype: The holotype of *Trochammina brasiliensis*, n. sp., is the specimen illustrated pl. 4, fig. 3.

It shows the trochamminine interiomarginal, umbilical-extraumbilical aperture. The specimen is from the dredge sample taken at station PM-4-12B, 50 m depth. Its maximum umbilical diameter is 240 μ.

Morphological description

a. *Holotype*

The holotype of *Trochammina brasiliensis*, n. sp., is a small, spirally bluntly pointed trochospire. The test is made up of about 4 volutions of subglobular chambers. The early volution consists of 5 perhaps 6 and the final volution of 4 chambers. The chambers increase gradually in size as added and the final volution makes up the major portion of the test. The periphery of the final volution is lobate as seen from the illustrated umbilical view (pl. 4, fig. 3). The subglobular chambers surround on the umbilical side a shallow axial depression. The chambers are, at least in the final whorls, well separated and the spiral and

radial sutures are distinct. The early chambers are small and their sutures are not much depressed hence they are difficult to recognize.

The aperture is an elongate slit-like interiomarginal umbilical-extraumbilical opening. It is throughout its extension of 70 to 80 μ more or less of the same height of about 10 μ. There is no lip or lip-like structure. There are no supplementary apertures.

The thin wall is agglutinated, non-calcareous and single-layered. Its examination in immersion oil showed it to be devoid of perforations and internal structures. It does not form subdivisions of the chamber lumina. The foreign elements are essentially quartz flakes which produce the irregular but relatively smooth mosaic of the surface. There are also agglutinated organic derived elements such as sponge spicules. The surface is somewhat coarser than in *Cribrostomoides jeffreysi* (WILLIAMSON) and in *Polystomammina planulata* (MIKHALEVITCH) with which *T. brasiliensis* is normally associated. The color of the test is brown to red brown.

The maximum umbilical diameter of the holotype is about 240 μ and its axial height, measured from the apex to the base of the ultimate chamber, is about 230 μ. The trochospire is therefore almost as high as it is wide across its base. The maximum diameter of the final chamber is about 150 μ.

b. *Paratypes*

Umbilical and spiral views of paratypes of *T. brasiliensis*, n. sp., are illustrated on pl. 1, fig. 1, 2, 4-8. They exhibit the same overall features as described for the holotype. In all cases the final whorl is composed of 4 subglobular chambers. The maximum umbilical diameters of the tests range from 120 to 380 μ. The axial height is throughout more or less the same as the umbilical diameter. The wall measured in the final chamber of a large specimen is about 4 to 6 μ thick. In immersion oil brownish granular substance is seen between the foreign elements similar to that described in *Cribrostomoides jeffreysi* (WILLIAMSON). The walls are single-layered, imperforate and non-calcareous. The color of the tests is brown to red brown. The final chambers are usually lighter colored than the early ones. In diluted HCl the brown to red brown walls change to colorless. As in the case of *Cribrostomoides jeffreysi* the color seems to be fixed to a calcareous component. The earliest chambers of the trochospire do not loose their brownish color in HCl.

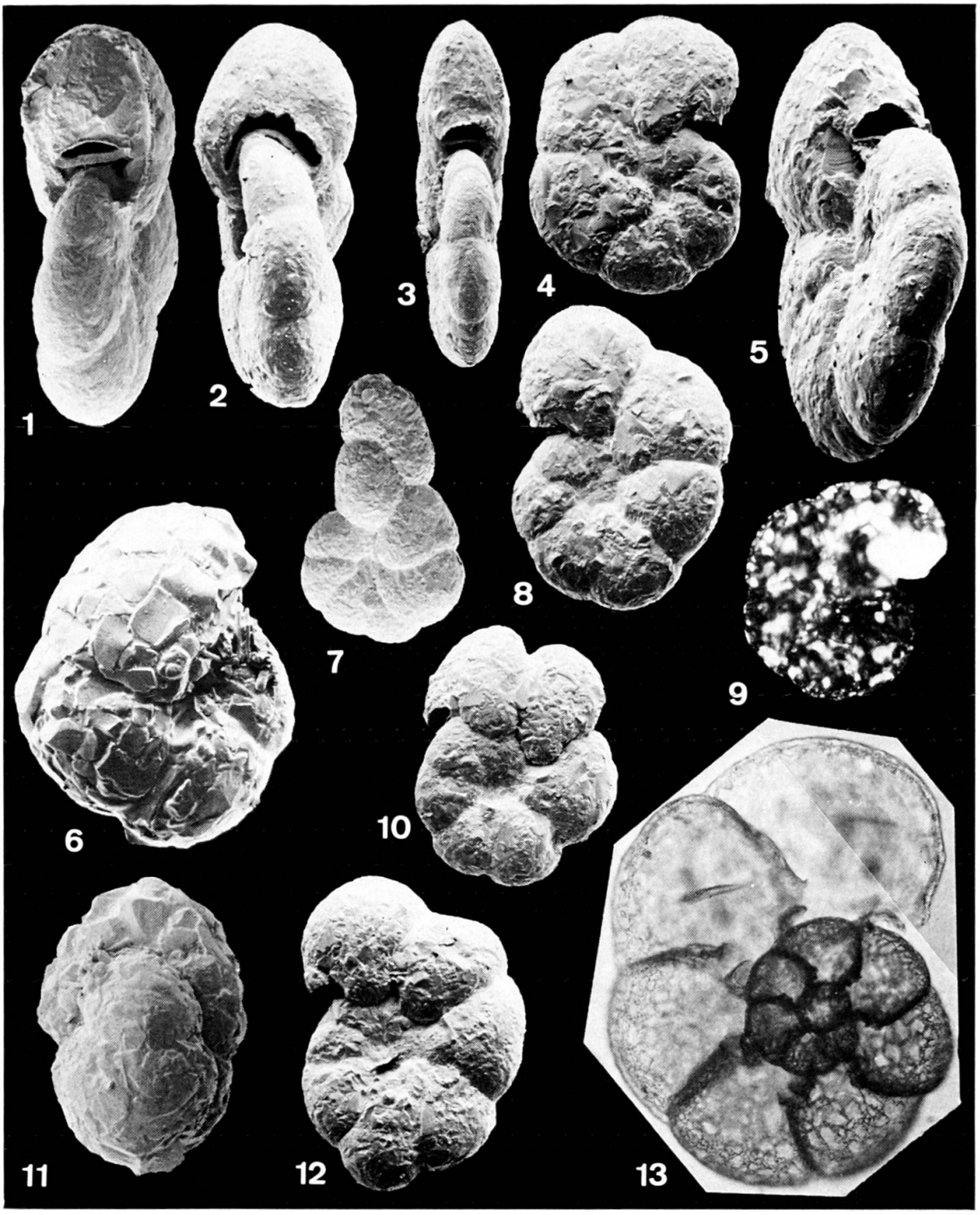
c. *Other specimens*

In dredge sample PM-14-24, depth about 40 m, occur specimens with an umbilical diameter of up to 600 μ.

Comparison with *Trochamminopsis quadriloba* (HOEGLUND) and *Trochammina vesicularis* GOËS sensu EARLAND

At first glance *Trochammina brasiliensis*, n. sp., is very close in dimensions and gross morphological features to *Trochamminopsis quadriloba* (HOEGLUND) (HOEGLUND 1947, pl. 4, fig. 4*a-c*). This also bluntly pointed trochospiral species is invariably quadriserial in the final volution. HOEGLUND (1947) described it from the Skagerak (83 to 700 m depth) and Koster Chanel (ca. 200 m depth) under the name of *Trochammina pusilla*. In 1948 he proposed the new trivial name *quadriloba* because *pusilla* was preoccupied by *Trochammina pusilla* (GEINITZ), 1848. Thanks to the kindness of Dr. ROY OLERÖD of the Naturhistoriska Riksmuseet, Stockholm, Sweden, the senior author was able to examine topotypes of *Trochammina quadriloba* HOEGLUND from the Koster Channel, depth about 200 m, type collection No. 2083, and to have scanning photographs of the apertural features made. These photographs show that the aperture of HOEGLUND'S species is an umbilically situated very small crescent-like opening quite different from that of *Trochammina brasiliensis*, n. sp., and of *Trochammina inflata* (MONTAGU), 1808, the type species of *Trochammina* PARKER and JONES, 1859, which is an interiomarginal umbilical-extraumbilical elongate slit as shown by BRADY'S illustration (1884, pl. 41, fig. 4*c*). On the basis of the different apertural features BRÖNNIMANN proposed for trochamminids of the type of *Trochammina quadriloba* the genus *Trochamminopsis* with *Trochammina quadriloba* HOEGLUND as type species (BRÖNNIMANN, 1976). Further, the agglutination of *Trochamminopsis quadriloba* is much coarser than that of *T. brasiliensis* and does not consist essentially of quartz platelets but of relatively large angular quartz grains. A single but typical specimen of *Trochamminopsis quadriloba* was encountered in the dredge sample PM-14-24B, Campos shelf. Also PHLEGER (1952, p. 86, pl. 13, fig. 33, 34) reported and illustrated a typical specimen of *Trochamminopsis quadriloba* from the Canadian and Greenland Artic seas. The same author recorded it also from numerous stations in the southwest Gulf of Maine.

In his "Synopsis of the Artic and Scandinavian Recent Marine Foraminifera", GOËS introduced in 1894 a new trochamminid which he named *Trochammina vesicularis* (1894, p. 31, pl. 6, fig. 235-237). This rare, conical species of 400 μ diameter was encountered by GOËS in the Spitzbergen Sea at about 350 m depth. According to GOËS' very brief description and line drawings the test is made up of about 4 volutions of axially somewhat compressed subglobular chambers. It does not possess an umbilical depression. The final whorl consists of 5 chambers. Nothing is said about the apertural features. Apart from GOËS' description and drawings nothing is known about *T. vesicularis*. In fact, HOEGLUND (1947, p. 202-203) who was faced with the problem to compare his *T. pusilla* (= *quadriloba*) with *T. vesicularis*, stated that "regrettably, [GOËS] made no type collection and his original material from Spitzbergen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EXPLANATION TO THE PLATES

PLATE 1

FIG. 1-5, 7-10, 12, 13. — *Cribrostomoides jeffreysi* (WILLIAMSON)
FIG. 1-3, 5, 8-10, 12, 13 Sample PM-4-12B. Depth 50 m.
FIG. 4, 7 Sample PM-8-10B. Depth 50 m.

FIG. 1. — 105 × (see also pl. 2, fig. 3)
FIG. 2. — 75 × (see also pl. 2, fig. 2)
FIG. 3. — 160 ×
FIG. 4. — 72 ×
FIG. 5. — 110 ×
FIG. 7. — 44 ×
Fig. 8. — 70 ×
FIG. 9. — 77 × (in immersion oil under crossed nicols)
FIG. 10. — 70 ×
FIG. 12. — 75 ×
FIG. 13. — 115 × (in immersion oil)

FIG. 6, 11. — *Haplophragmoides* sp. ?
Sample PM-4-12B. Depth 50 m.
The same specimen in side view (fig. 6, 225 ×), and in oral view (fig. 11, 220 ×).

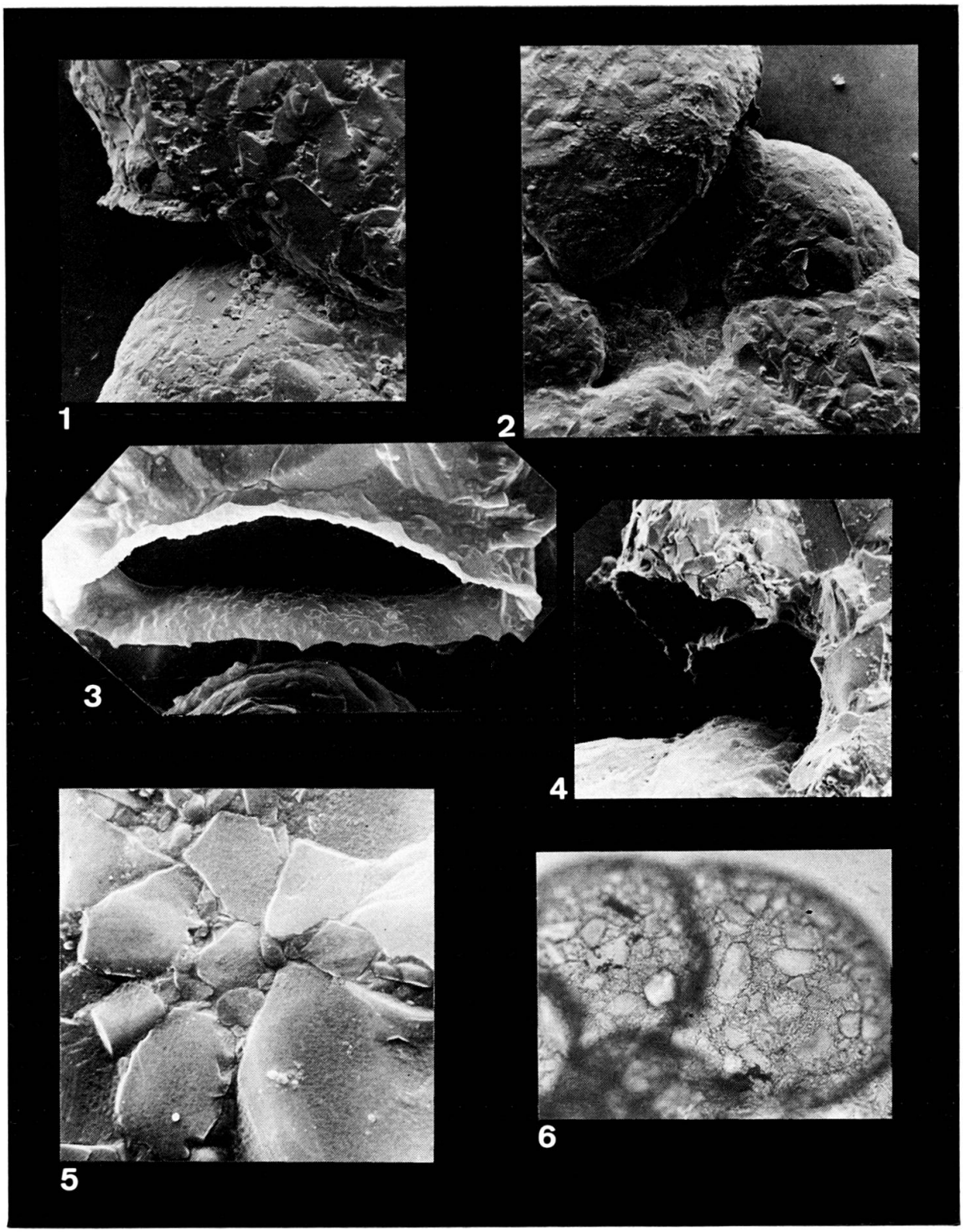
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PLATE 2

FIG. 1-6. — *Cribrostomoides jeffreysi* (WILLIAMSON)
All sample PM-4-12B. Depth 50 m.

FIG. 1. — 420 ×
FIG. 2. — 155 × (see also pl. 1, fig. 2)
FIG. 3. — 725 × (see also pl. 1, fig. 1)
FIG. 4. — 610 ×
FIG. 5. — 1 600 ×
FIG. 6. — ca. 235 ×

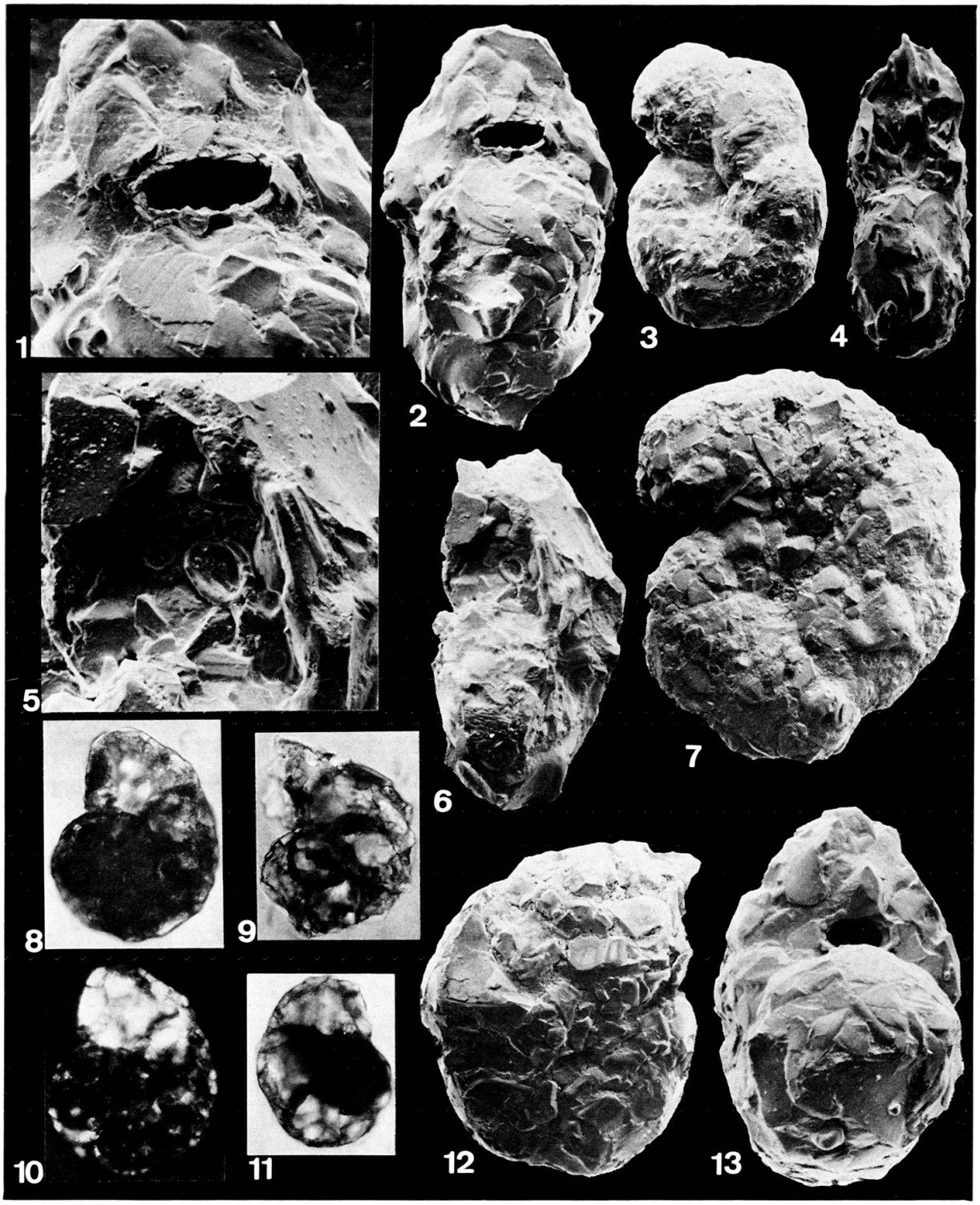
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PLATE 3

FIG. 1, 2, 8, 10-13. — *Cribrostomoides compactus* BRÖNNIMANN and BEURLEN, n. sp.

FIG. 1, 2 Holotype. Sample PM-3-6B. Depth 30 m.

FIG. 1. — 540 ×

FIG. 2. — 260 ×

FIG. 8, 10-13 Paratypes

FIG. 8, 10, 11. Sample PM-3-6B. Depth 30 m.

FIG. 8. — 140 ×

FIG. 10. — 140 × (under crossed nicols)

FIG. 11. — 150 ×

FIG. 12, 13. Sample PM-3-3B. Depth 15 m.

FIG. 12. — 210 ×

FIG. 13. — 325 ×

FIG. 4, 5, 6, 9. — *Cribrostomoides siphonapertus* BRÖNNIMANN and BEURLEN, n. sp.

FIG. 5, 6 Holotype. Sample PM-3-6B. Depth 30 m.

FIG. 5. — 660 ×

FIG. 6. — 240 ×

FIG. 4, 9 Paratypes. Sample PM-3-6B. Depth 30 m.

FIG. 4. — 190 ×

FIG. 9. — 145 ×

FIG. 3, 7. — *Cribrostomoides crassimargo* (NORMAN).

FIG. 3. — 37,5 ×. Sample PM-8-8B. Depth 45 m.

FIG. 7. — 49 ×. Sample PM-4-11B. Depth 50 m.

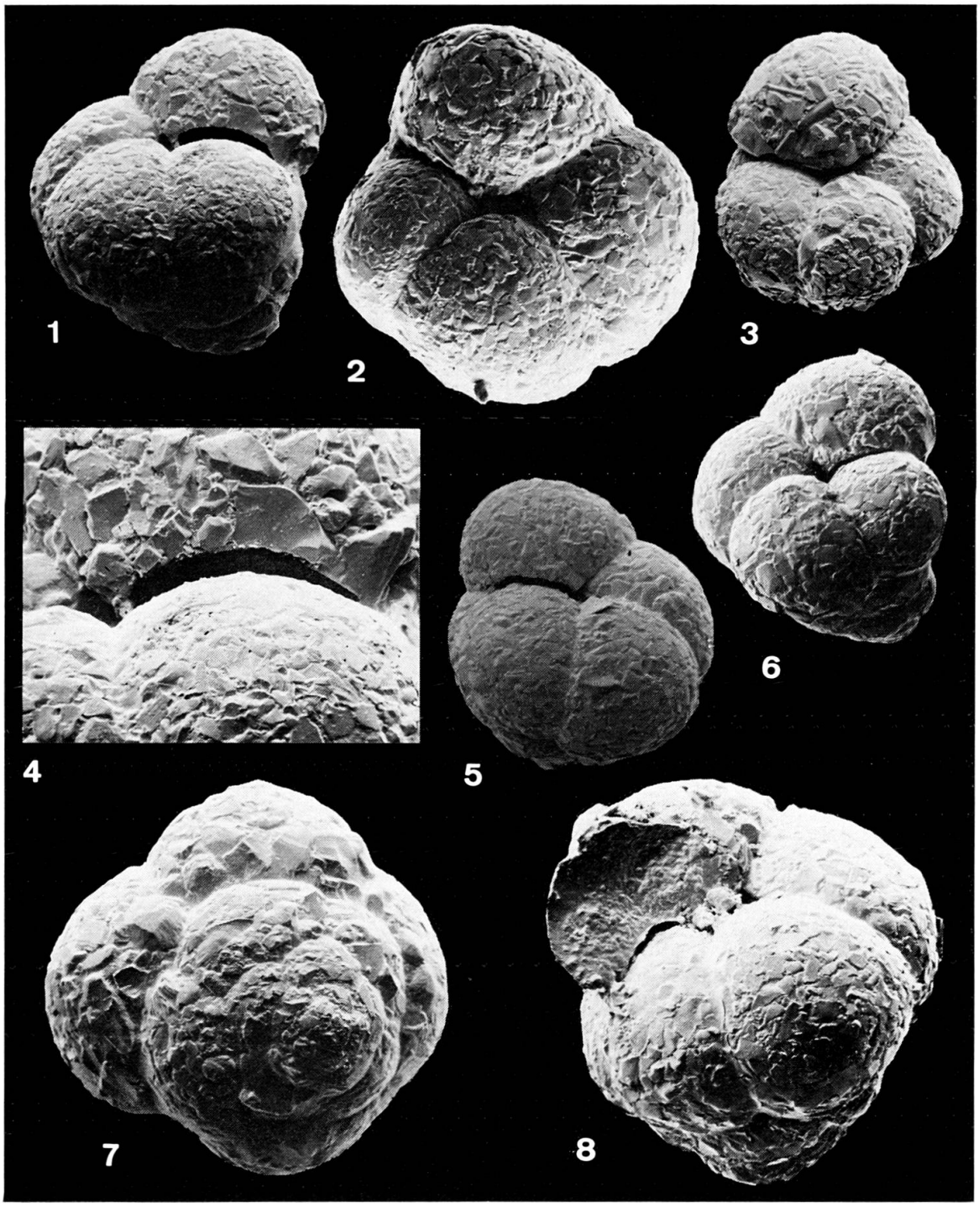
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PLATE 4

FIG. 1-8. — *Trochammina brasiliensis* BRÖNNIMANN and BEURLEN, n. sp.

FIG. 1. — 170 ×
FIG. 2. — 250 ×
FIG. 3. — 160 × (Holotype)
FIG. 4. — 420 × (detail of same specimen as fig. 1)
FIG. 5. — 100 ×
FIG. 6. — 155 ×
FIG. 7, 8. — 220 ×

All specimens are from dredge sample PM-4-12B. Depth 50 m.

is not to be found in the collections of the State Museum of Natural History. It is true that in those collections there are three tubes containing, according to the labels, the species in question. But my examination of the contents, which comprise a mixture of widely separate species, has resulted in no single specimen being found that even approximately corresponds to GOËS' description. It should be added that the contents of the three tubes were neither gathered nor examined by GOËS personally. They originate, in fact, from the Swedish Greenland Expedition of 1899, and at that date GOËS had already been dead two years." HOEGLUND then came to the conclusion that judging from GOËS' data his *T. pusilla* could not be identical with *T. vesicularis*. EARLAND (1934), p. 103-104, pl. 3, fig. 44-46), on the other hand, apparently did not hesitate to identify a trochamminid encountered in the Falkland area of the Antarctic Sea with *T. vesicularis* GOËS from the Arctic Sea. In fact, he wrote that "The specimens appear to comply almost exactly both with the figure and description of GOËS, but are more solidely constructed, a good deal of ferruginous cement being employed, and there is a very slight umbilical depression."

In view of the fact that GOËS' original material of *T. vesicularis* seems to be lost and also considering the incompleteness of GOËS' description we do not know whether the trochamminid reported by EARLAND from the Antarctic is identical with *T. vesicularis* from the Artic. In the writer's opinion *Trochammina vesicularis* GOËS, 1894, should be considered a nomen non conservandum sine tipo and the trochamminid described by EARLAND under this name should be renamed. For the time being it is here referred to as *Trochammina vesicularis* GOËS sensu EARLAND. In a forthcoming note a detail description of EARLAND's form will be published and a new trivial name proposed for it.

The senior writer examined during a visit to the British Museum (Nat. Hist.), EARLAND's material of *Trochammina vesicularis* GOËS sensu EARLAND. It contains 20 specimens of a conical, bluntly pointed trochamminid of 4 to 5 whorls with 4 or 5 subglobular, axially somewhat compressed chambers in the final whorl. The height of the test is usually slightly less than its umbilical diameter which varies from about 200 to 300 μ. The aperture is a small crescent-like interiomarginal opening, about halfway between umbilicus and periphery. The agglutination is smooth with some larger quartz flakes and the color of the single-layered imperforate walls is light brown. Even if in its overall appearance and dimensions *T. vesicularis* sensu EARLAND is quite similar to *T. brasiliensis* it clearly differs from the Campos form by its apertural features hence cannot be identified with the latter (text-fig. 1).

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