

# A Late Cretaceous Flysch-type Agglutinated Foraminiferal Fauna from the *Trochamminoides proteus* Type Locality (Wien - Hütteldorf, Austria)

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## ABSTRACT

The agglutinated foraminifera species described by Karrer, 1866 from the Cretaceous Flysch of the Vienna Woods have been revised, and the accompanying assemblage from Karrer's original sediment sample has been studied. The most important form in his paper is *Trochammina proteus* Karrer, 1866, the type species of the genus *Trochamminoides* Cushman, 1910. By properly resolving the nature of its lectotype, designated by Brady, 1884 taxonomic stability of both the species and genus are achieved. The lectotype is characterized by an inner irregular coiling, beginning with an undivided tube; the outer 1-2 whorls are nearly planispirally coiled, multichambered. For the Recent species, placed in *T. proteus* by Brady, 1884, the new name *Trochamminoides challengerii* n. sp. is introduced here. Other specimens of the *T. proteus* type series belong to different species, described by Grzybowski from the Carpathian Flysch.

*Cornuspira Hörnesi* Karrer, 1866 is a junior synonym of *Ammodiscus cretaceus* (Reuss, 1845). Three additional species were described by Karrer: *Ataxophragmium arenaceum* n. sp., *Lagena globosa* Walk. var. *globosa asperella* n. ssp., and *Rosalina*?, are different preservational forms of the same species *Caudammina arenacea* related to *C. ovulum* (Grzybowski).

From the common tubular flysch forms the genera *Silicobathysiphon* Myatlyuk, 1966 and *Bogdanowiczia* Pishvanova & Vyalov, 1967 are considered as valid. These genera belong to the family Hippocrepinellidae Loeblich & Tappan, 1984. This family is emended here because of the very finely agglutinated siliceous wall structure, giving a translucent appearance.

The agglutinated foraminiferal assemblage of the Karrer sample is typical for Late Cretaceous flysch faunas. The age is determined by calcareous nannoplankton as late Campanian (- early Maastrichtian?). Some faunal elements mentioned by Karrer and found in his sample are contaminated from the Vienna Basin middle Miocene.

## INTRODUCTION

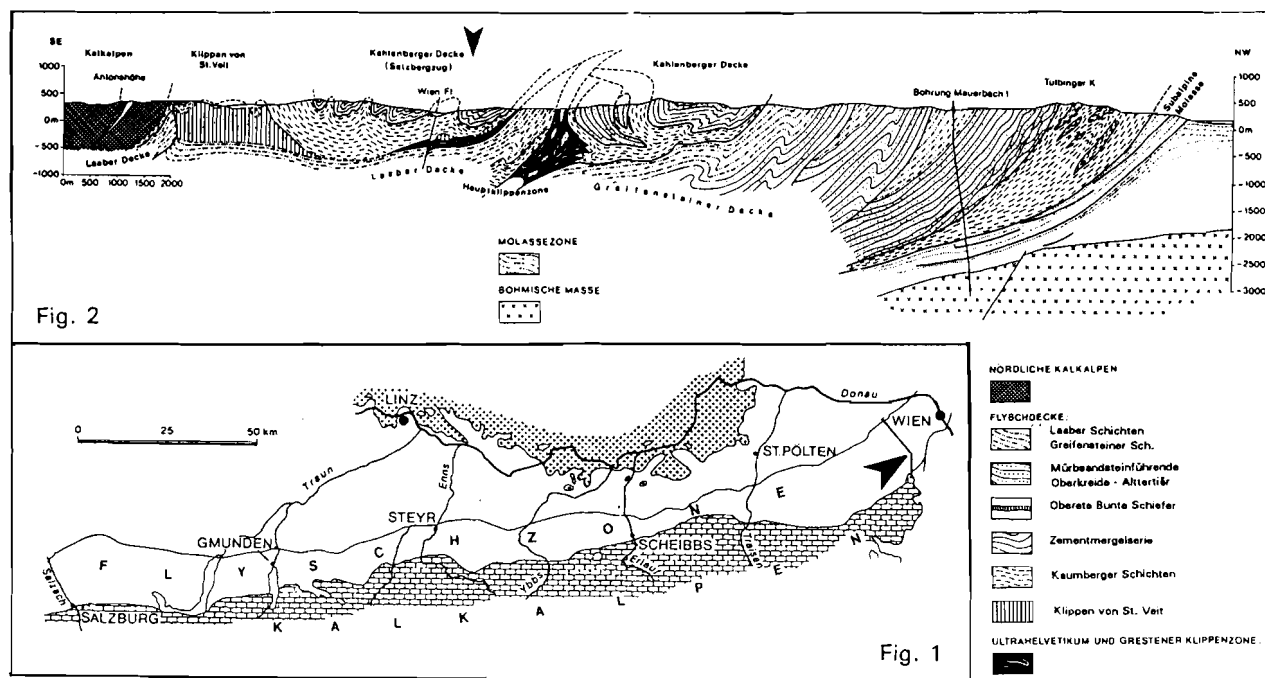
In one of the first papers studying flysch-type foraminifera assemblages Karrer (1866) described some important species of agglutinated foraminifera. From these, *Trochammina proteus* was selected as type species of the genus *Trochamminoides* by Cushman, 1910. In July 1932, J.A. Cushman had studied the original material during his visit in Vienna and had selected a series of specimens from the type series, which were most similar to the figures of Karrer. By accident this slide had not been returned to the museum but to the Geological Survey in Vienna, where it has been in the collection of R. Grill until 1991. Now that this slide has been returned to the museum, it is possible to solve the riddle of the *Trochammina proteus* lectotype.

To clarify the genus *Trochamminoides*, and some species described in the Karrer paper, the original specimens and the type sample have been restudied. Most of the forms included in the original definition of *T. proteus* have been reported later by Grzybowski as distinct species from the Carpathian

Flysch. The revisions of the Grzybowski collection by Liszka & Liszkowa (1981) and Kaminski & Geroch (1993) and the translations of the Grzybowski work by Kaminski *et al.* (1993) proved most valuable for this study. For synonymy only those works were used, which studied original material, or are important for determinations.

## GEOLOGICAL SETTING

The Rheno-Danubian Flysch is part of the Alpine nappe system. It is interpreted as the sheared-off younger sedimentary cover of the Penninic unit. The sediments are of deep water origin, dominated by turbidites, and generally Early Cretaceous to Eocene in age (comp. Janoschek & Matura, 1980; Müller A.W., 1987; Prey, 1980; Tollmann, 1985; Schnabel, 1992). In the region of the Vienna Woods the Flysch is tectonically subdivided into nappes of somewhat different sedimentary history: from north to south there are the Greifenstein nappe, the Laab nappe, and the Main Klippen belt. Overthrust onto them is the southernmost Flysch nappe, the Kahlenberg



**Figure 1-2.** Geological setting of the *Trochamminoides proteus* type locality in the Kahlenberg nappe at Wien - Hütteldorf (acc. Prey, 1980, p. 203, Fig. 43). 1. Extension of the Flysch zone in eastern Austria, north of the Calcareous Alps. Location of the section marked by a solid line; of the type locality by an arrow. 2. Geological section through the Flysch nappes in the Vienna Woods. The Flysch is overthrust on the Alpine foreland in the north. The type locality is marked by an arrow.

nappe. Further to the south lies the St. Veit Klippen Belt, which is presumed to be Flysch basement, and the overthrust Northern Calcareous Alps (Figs. 1-2).

The type locality of *Trochamminoides proteus* (Karrer, 1866) is situated in the SE stripe (Satzberg range) of the Kahlenberg nappe. The stratigraphic succession in this part starts with mid-Cretaceous shales and sandstone layers, followed by the Reischelsberg sandstone (Cenomanian - Turonian), and the Kahlenberg formation. The Kahlenberg formation comprises 500-600 m of Santonian to lower Maastrichtian sediments; the lower Kahlenberg beds consist of light gray, layered marls and marly limestones, gray-green shales, and some calcareous sandstones; whereas the upper Kahlenberg beds contain thick limestone layers and increasing sand contents (Prey 1974; 1979; Müller, 1987). Nannoplankton determinations of Karrer's type sample (cordially contributed by H. Egger, Wien) have revealed a late Campanian (?early Maastrichtian) age.

Karrer's original sample originates from soft layers within a gray marly limestone sequence and was collected in 1865. It is labelled as "Hütteldorf, the 1st quarry at the road to Mariabrunn". The quarry is overbuilt today, but the sample has been preserved together with the described material in the collections of the Vienna museum. During the restudy of the sample some well preserved middle Miocene foraminifera have been observed, caused by contamination. This explains the remark of Karrer (p. 493) questioning some Vienna Basin species. The

flysch assemblage is purely agglutinated, of rather small dimensions and fine agglutination, dominated by tubiform, glomospirid, and trochamminoid specimens.

#### SYSTEMATIC DESCRIPTION

Order FORAMINIFERIDA Eichwald, 1835  
Suborder TEXTULARIINA Delage & Herouard, 1896  
Superfamily ASTORRHIZACEA Brady, 1881  
Family BATHYSIPHONIDAE Avnimelech, 1952  
Genus *Bathysiphon* M. Sars, 1872

#### *Bathysiphon* ? sp.

Pl. 1, Figs. 1-3

Tubes of different width (0.25-0.75 mm), compressed along the axis, straight to slightly bent, not branching. Wall rather thin (0.03-0.07 mm), agglutinated of very fine quartz grains and clay flakes, no transparent siliceous matrix; colour generally light gray; surface smooth. Tube filled with dark gray-green clayey material. In contrast to *Dendrophrya*, the wall contains more clay particles, is less silicified and thinner; sponge spicules are missing.

Occurrences: common.

Family RHABDAMMINIDAE Brady, 1884  
Genus *Psammosiphonella* Avnimelech, 1952.

The synonymy of Loeblich & Tappan (1987) between *Bathysiphon* and *Psammosiphonella* is not adopted

here. The wall of *Psammosiphonella* does not contain as many sponge spicules, and the surface is rough, not finely finished, more related to *Rhabdammina*. The tubes are straight, not branching.

*Psammosiphonella cylindrica* (Glaessner, 1937)

Pl. 1, Figs. 4-5

*Rhabdammina cylindrica* Glaessner, 1937, p. 354, pl. 1, fig. 1.  
*Psammosiphonella cylindrica* (Glaessner). - Pflaumann, 1964, p. 49, pl. 3, fig. 1; pl. 7, figs. 11-12.

*Psammosiphonella cylindrica* (Glaessner). - Grün et al., 1964, p. 246, pl. 3, fig. 4.

*Psammosiphonella cylindrica* (Glaessner). - Grün, 1969, p. 307, pl. 60, figs. 1-8.

Straight tubes of equal distance (0.15-0.27 mm in diameter), not compressed; slight constrictions or inflated short parts occur in some specimens. Wall thick, about one third of diameter; firmly cemented with medium sized, sharp angled quartz grains; translucent; rough surface. *Psammosiphonella cylindrica* is missing a branching central part, and contains no sponge spicules as wall material.

Occurrence: common.

Genus *Rhabdammina* M. Sars, 1869

*Rhabdammina?* sp.

Pl. 1, Fig. 6; textfigs. 3-4

Short, straight, unbranched tubes, similar to *P. cylindrica*. The difference is given by the wall texture. The surface in reflected light seems to be made of larger elongated components arranged in a pattern perpendicular to the long axis. In SEM it is observed that the firmly cemented wall consists of tightly packed small quartz crystals with few larger sand grains, and some particles of phyllosilicates. The surface itself is covered by deep transverse impressions of large sponge needles. Wall translucent; surface rough. The systematical position is uncertain; in contrast to *Psammosiphonella* originally sponge spicules have had part in the construction of the wall.

Occurrence: rare.

Genus *Rhizammina* Brady, 1879

*Rhizammina indivisa* Brady, 1884

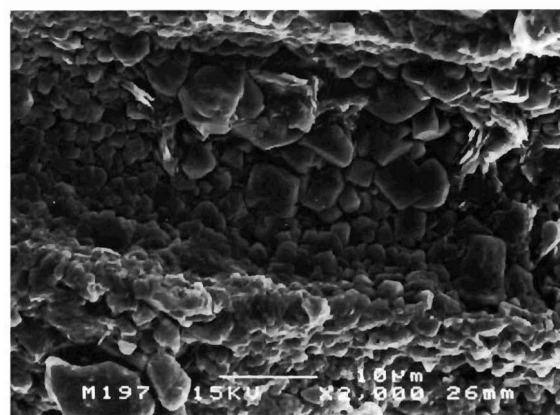
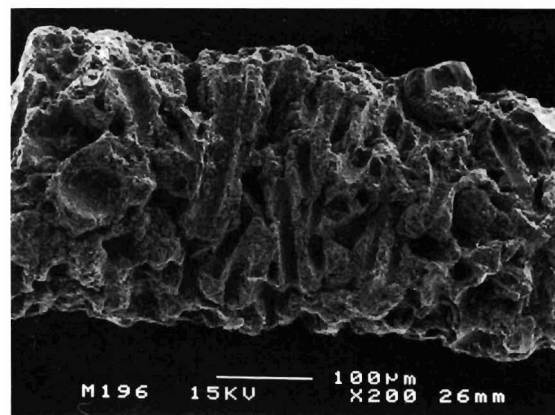
Pl. 1, Fig. 7

*Rhizammina indivisa* Brady, 1884, p. 277, pl. 29, figs. 5-7.

*Rhizammina* cf. *indivisa* Brady, 1884. - Samuel, 1977, p. 19, pl. 1, figs. 10-11; pl. 8, fig. 1.

Short broken pieces of irregularly bent tubes with round to slightly compressed diameter. Wall thick, heavily agglutinated, with angular quartz grains. The determination is rather questionable as the Recent species has a soft wall composed mainly of organic cement with loosely agglutinated sand grains.

Occurrence: common.



Figures 3-4. *Rhabdammina?* sp. Fig. 3: detail of the test with impressions of sponge spicules; a larger sand grain on the upper right rim; Fig. 4: surface of the wall consisting of densely packed small quartz crystals.

Family HIPPOCREPINELLIDAE Loeblich & Tappan, 1984, emended herein.

**Emendation:** Test elongate, tubiform, open at both ends, non-septate. Commonly with transverse growth wrinkles or constrictions. Wall silicified, very finely agglutinated (maybe with larger amount of secreted cement), translucent; including more or less cemented wall structures; surface smooth, shiny. Apertures at both ends of open tubes, sometimes constricted. Differs from *Bathysiphonidae* in its translucent, siliceous wall texture. Stratigraphic occurrence: Pennsylvanian to Holocene.

Genus *Silicobathysiphon* Myatlyuk, 1966

The genus *Silicobathysiphon* has been synonymized with *Bathysiphon* by Loeblich & Tappan, 1987, because the wall structure of this genus has been neglected. It is a very significant difference, that the wall consists to a large part of cryptocrystalline siliceous material, probably secreted. In comparison Loeblich & Tappan, 1987 have held as valid the

genus *Silicotuba* Vyalov, 1966 with a similar wall structure but a morphotype as *Hyperammina*. The type species of *Silicotuba*, *Hyperammina grzybowskii* Dylańska, 1923 has turned out to be a *Kalamopsis* (Berggren & Kaminski, 1990) and *Silicotuba* is therefore invalid.

*Silicobathysiphon longolocus* Myatlyuk, 1970

Pl. 1, Fig. 8

*Silicobathysiphon* cf. *dubia* (White) *longolocus* subsp. n. Myatlyuk, 1970, p. 48, pl. 1, fig. 14. (fide Ellis & Messina).

Broken pieces of secondarily flattened tubes (width 0.2-0.4 mm); with an indentation along the axis caused by compaction; growth constrictions in short irregular distances; non-septate. Wall rather thin, siliceous, translucent; surface smooth, shiny. Forms like these have been reported as *Hyperammina nodata* Grzybowski, which has a segmentation at constant distances according to the author. Occurrence: rare.

Genus *Bogdanowiczia* Pishvanova & Vyalov, 1967

This genus is different from *Bathysiphon* in its wall composition. The wall is silicified, very finely agglutinated (secreted?) as in *Silicobathysiphon*. From the latter genus it is different by constrictions of the tube, showing as internal narrowing of the hollow space (pseudoseptae), occurring in irregular distances.

*Bogdanowiczia* sp.

Pl. 1, Figs. 9-10

*Bathysiphon*? sp. Geroch, 1960, p. 37(120), pl. 1, figs. 16-19; pl. 10, figs. 4, 10.

Secondarily compressed tubes with an indentation along the axis; width about 0.4-0.7 mm; no filling of dark material as in *Bathysiphon*. Wall rather thick (0.03-0.07 mm), very finely agglutinated, silicified, transparent; surface smooth, often with fine striae along or perpendicular to the axis. Superficially it compares to *Bathysiphon microrhaphidus* Samuel, 1977 by this pattern, but is missing sponge spicules. Constrictions at the place of internal pseudoseptae. The form is similar to the Miocene species *Bogdanowiczia pocutica* Pishvanova in Vyalov & Pishvanova (1967), described from bedding planes of flysch-type sandstones.

Occurrence: common.

Family PSAMMOSPHAERIDAE Haeckel, 1894

Genus *Psammosphaera* Schulze, 1875

*Psammosphaera fusca* Schulze, 1875

Pl. 1, Fig. 11

*Psammosphaera fusca* Schulze, 1875, p. 113, pl. 2, figs. 8 a-f.

Single, globose chambers, secondarily compressed discs; agglutinated wall, rough surface; no apparent aperture.

Occurrence: rare.

Family Saccamminidae Brady, 1884

Genus *Saccammina* Carpenter, 1869

*Saccammina placenta* (Grzybowski, 1898)

*Reophax placenta* Grzybowski, 1898, p. 276, pl. 10, figs. 9-10.

*Saccammina placenta* (Grzybowski). - Geroch, 1960, p. 37, 121, pl. 2, figs. 1-6.

*Saccammina placenta* (Grzybowski). - Kaminski & Geroch, 1993, p. 249, pl. 2, figs. 5-7.

Unicameral spheres, compressed to discs as in *Psammosphaera*, but with elevated round opening.

Occurrence: very rare.

Superfamily AMMODISCACEA Reuss, 1862

Family AMMODISCIDAE Reuss, 1862

Genus *Ammodiscus* Reuss, 1862

*Cornuspira Hörnesi* Karrer, 1866

Pl. 1, Figs. 12-13; textfig. 5

Valid name: *Ammodiscus cretaceus* (Reuss, 1845)

*Operculina cretacea* Reuss, 1845, p. 35, pl. 13, figs. 64-65.

*Cornuspira cretacea* Reuss. - Reuss, 1860, p. 177, pl. 1, fig. 1.

*Cornuspira Hörnesi* n.sp. - Karrer, 1866, p. 495, pl. 1, fig. 10.

*Ammodiscus cretacea* (Reuss). - Cushman, 1934, p. 45.

?*Ammodiscus cretaceus* (Reuss). - Noth, 1954, pl. 7, fig. 13.

*Ammodiscus cretaceus* (Reuss). - Gradstein & Berggren, 1981, p. 241, pl. 2, figs. 12-13.

**Original material:** type series, 3 specimens; acqu.no. 1866-XXXVII-3, type inv. MI-161.

Additionally selected from the type sample: 2 specimens.

**Lectotype:** Karrer, 1866, Pl. 1, Fig. 10, left specimen.

**Description of lectotype:** Textfig. 5.

Circular test, planispirally coiled, slightly biumbonate; non-septate tube; somewhat embracing coils; about 10 whorls, innermost whorls and proloculus not clearly visible because of recrystallization. Final whorl somewhat distorted by compaction. Wall non-calcareous, agglutinated of very fine quartz grains, with cryptocrystalline siliceous matrix; surface smooth.

**Dimensions:** max. diameter 0.67 mm; thickness 0.10 mm.

**Paralectotype 1:** Karrer, 1866, Pl. 1, Fig. 10, right specimen.

Test oval elongate by lateral compression, biumbonate; outline not smooth but with irregular growth constrictions. Number of whorls not distinguishable. Wall as in the lectotype.

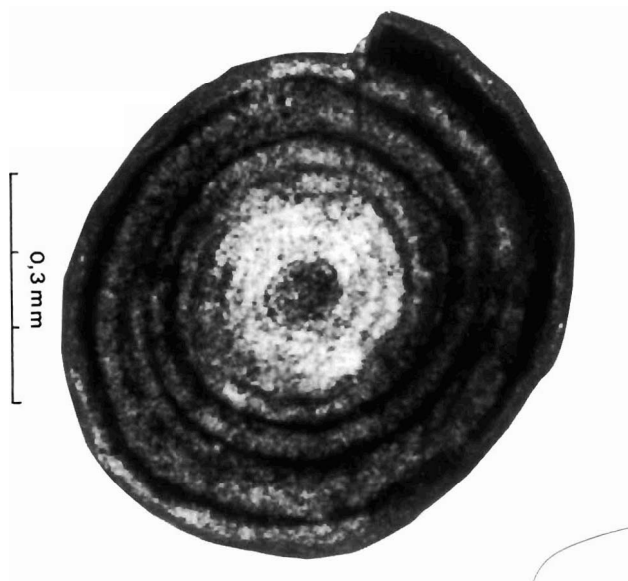
**Dimensions:** length 0.69 mm; width 0.33 mm; thickness 0.12 mm.

**Paralectotype 2:** SEM-Figs. 12-13 at Pl. 1

Broad oval in outline, planispirally coiled, biumbonate; innermost coils somewhat irregular; surface smooth.

**Dimensions:** length 0.65 mm; width 0.54 mm; thickness 0.10 mm.

**Remarks:** *Cornuspira Hörnesi* is a junior synonym of *Operculina cretacea* Reuss. A lectotype of *O. cretacea* will be designated by Kaminski *et al.* (in prep.). According to the wall structure, both the



**Figure 5.** *Cornuspira Hörnesi* Karrer, 1866. Correct name *Ammodiscus cretaceus* (Reuss, 1845). Transmitted light micrograph of the lectotype.

holotype and lectotype are very finely agglutinated and strongly silicified. They are at the moment included in *Ammodiscus* sensu Loeblich & Tappan (1961). Reuss himself never considered this species to be agglutinated. Later Cushman (1934) tested this species from different Cretaceous localities (including type localities of Reuss) to be non-calcareous, the test wall composed of fragmentary material with a predominance of cement.

Genus *Glomospira* Rzehak, 1885

*Glomospira serpens* (Grzybowski, 1898)

Pl. 1, Fig. 14

*Ammodiscus serpens* Grzybowski, 1898, p. 285, pl. 10, figs. 31-33.

*Glomospira serpens* (Grzybowski). - Kaminski & Geroch, p. 256, pl. 6, figs. 2-5.

Outline oval; undivided tube arranged in long half-coils, changing coiling directions along the axis; inner part irregularly coiled. The tubes are somewhat irregular along their axis by small growth changes. Wall agglutinated with fine to medium coarse quartz grains; surface with some roughness.

Occurrence: rare.

*Glomospira irregularis* (Grzybowski, 1898)

Pl. 1, Figs. 15-17

*Ammodiscus irregularis* Grzybowski, 1898, p. 285, pl. 11, figs. 2-3.

*Glomospira irregularis* (Grzybowski). - Kaminski & Geroch, p. 256, pl. 6, figs. 6-8b.

Test compact, globose to disc-shaped; consisting of an undivided tube with a strong irregular coiling; tubes with some growth irregularities. Wall coarsely agglutinated, surface rough.

Occurrence: common.

Superfamily HORMOSINACEA Haeckel, 1894

Family ASCHEMOCELLIDAE Vyalov, 1966

Genus *Kalamopsis* de Folin, 1883

*Kalamopsis grzybowskii* (Dyląganka, 1923)

Pl. 1, Fig. 18

*Hyperammina grzybowskii* Dyląganka, 1923, p. 65.

*Kalamopsis grzybowskii* (Dyląganka). - Kaminski & Geroch, 1993, p. 281, pl. 17, figs. 5a-8.

Typically broken pieces of round tubes, sometimes slightly flattened; with constrictions at the position of septae. Wall thick, finely agglutinated, silicified, somewhat transparent; surface smooth, shiny.

Occurrence: rare.

Family HORMOSINIDAE Gooday & Haynes, 1983

Genus *Subreophax* Saidova, 1975

*Subreophax scalaris* (Grzybowski, 1896)

*Reophax guttifera* Brady, var. *scalaris* Grzybowski, 1896, p. 277, pl. 8, figs. 26a-b.

*Reophax scalaris* Grzybowski. - Liszka & Liszkowa, 1981, p. 168, pl. 1, fig. 15.

*Subreophax scalaris* (Grzybowski). - Kaminski *et al.*, 1988, p. 187, pl. 2, figs. 16-17.

Broken fragments; uniserially arranged globose, but secondarily strongly compressed chambers; chambers not very distinctly separated. Wall agglutinated with fine quartz grains; surface rough.

Occurrence: very rare.

*Subreophax pseudoscalaris* (Samuel, 1977)

*Reophax pseudoscalaria* Samuel, 1977, p. 36, pl. 3, figs. 4a-b.

*Subreophax pseudoscalaria* (Samuel). - Kaminski *et al.*, 1988, p. 187, pl. 3, figs. 5-6.

Broken pieces; uniserially arranged chambers; chambers distinctly larger than those of *S. scalaris*, broader than high; compressed by diagenesis; only weakly separated. Wall agglutinated with rather coarse grains; surface rough.

Occurrence: very rare.

*Subreophax splendida* (Grzybowski, 1898)

Pl. 1, Fig. 19

*Reophax splendida* Grzybowski, 1898, p. 278, pl. 10, fig. 16.

*Subreophax splendida* (Grzybowski). - Kaminski & Geroch, 1993, p. 251, pl. 3, figs. 11-12.

Broken pieces; oval chambers uniserially arranged, weakly separated. Wall agglutinated with fine grained quartz; surface rather smooth.

Occurrence: rare.

Genus *Caudammia* Montanaro-Gallitelli, 1955

The genus *Caudammia* has been considered as dubious by Loeblich & Tappan (1987, p. 696). In the revision of the North Sea Paleogene faunas (Charnock & Jones, 1990, p. 161) this genus has been discussed and re-evaluated. Considering the original description it is a valid genus. Montanaro-Gallitelli (1955, p. 178) validly described a new species without figures, *Saccammia? caudata*. In the discussion of the species he emphasizes the basal projection not known in *Saccammia*, and is proposing therefore the new genus *Caudammia*. The description in 1955 and the later given figures (Montanaro-Gallitelli, 1958) are directly comparable with the flysch species "*Hormosina*" *ovulum* s.l. The holotype (1958, Pl. 1, Fig. 3) has a dimension of 0.36 mm length and 0.35 mm width; it is a flat compressed specimen with nearly circular outline, and narrow neck and basal tube. It may be the group called as *C. ovulum* ssp. in the following morphometric discussion. The paratype (Pl. 1, Figs. 4 a-c) has a length of 0.27 mm, and a width of 0.21 mm. The shape of the test is slender elongate pear-shaped as in typical *C. ovulum ovulum*. The genus *Hormosina* has globose overlapping chambers; the wall of the type species *H. globulifera* consists of rather coarse quartz grains agglutinated by organic material.

*Ataxophragmium arenaceum* Karrer, 1866

Pl. 1, Figs. 20-23

**Valid name:** *Caudammia arenacea* (Karrer)*Ataxophragmium arenaceum* Karrer, 1866, p. 495, pl. 1, fig. 9.non *Reophax ovulum*. - Grzybowski, 1896, p. 276, pl. 8, figs. 19-21.*Hormosina ovulum* (Grzybowski) var. *gigantea* n. var. - Geroch, 1960, p. 43(124), pl. 2, figs. 18-19.*Hormosina ovulum gigantea* Geroch, 1960. - Kuhnt & Kaminski, 1990, p. 474, pl. 1, figs. a-b.

**Original material:** 1 specimen, holotype; acqu.no. 1866-XXXVII-2; type inv. no. MI-189. Additionally selected from type sample: 19 specimens.

**Description of holotype:** Test consists of one bulbous ovate, pear-shaped chamber, strongly inflated in the upper (correctly lower) part, where there are furrows by deformation of the test. Those have been mistaken by Karrer as sutures of chambers in *Ataxophragmium*. The connecting tube of uniserially arranged chambers is preserved in the upper part as a short neck, sitting in a groove; at the other side of the test the tube is broken off, showing a little tip at the conical end of the chamber. The wall is agglutinated with very fine grains and a large amount of siliceous cement; the surface is smooth.

**Dimensions:** length 0.58 mm; width 0.50 mm.

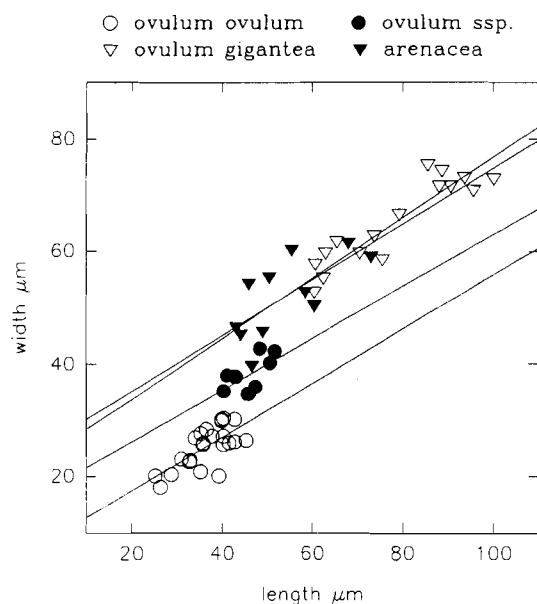
**Remarks:** Most specimens are deformed and compressed, but show the inflated oval-shaped chamber form with open, pointed endings or slender necks. The wall is non-calcareous, very finely aggluti-

nated, siliceous. The size is sometimes influenced by deformation, and has lengths of 0.43 to 0.73 mm, and largest diameters of 0.40 to 0.64 mm.

The deformation has been the reason that Karrer included some specimens in *Rosalina* or *Lagena*. Otherwise the incorrect description of the holotype has been the reason that this species has not been recognized by later authors. Only the younger synonym *Reophax ovulum gigantea* Geroch has been a used and well accepted species.

By the kindness of Prof. Geroch I have received a sample from the upper Senonian of Rudnik near Kraków. It is from non-calcareous red clays of the Silesian unit in the Polish Carpathians. The very rich agglutinated foraminiferal fauna contained many specimens of "*Hormosina*" *ovulum* s.l. By this fauna it was possible to decide on validity of the species name *arenacea* in comparison with the other forms of the *ovulum* group. A morphometric approach, comparing the length and width of the single chambers (Fig. 6) exhibits a three-folded pattern of the *ovulum* group:

*Caudammia ovulum ovulum* (Grzybowski) is distinctly smaller as the other investigated forms. It has maximum lengths of 0.25 - 0.45 mm, and maximum width of 0.18 - 0.30 mm (number of specimens 25). The shape of the chamber is more elongated pear-shaped to oval as the other groups; therefore in the scatter diagram the cluster of this species is positioned in the lower left corner. The regression line has the same slope as the other types, but is lying distinctly apart.



**Figure 6.** Scatter diagram and regression lines of *Caudammia* species in the Late Cretaceous Silesian flysch (locality Rudnik near Kraków) in relation to *Caudammia arenacea* (Karrer, 1866).

*Caudammia ovulum gigantea* (Geroch) is characterized by the large size and thick walls. The maximum length is 0.58 - 1.0 mm, the width 0.50 - 0.74 mm (number of specimens 25). In the scatter dia-

gramm this species lies apart from *C. ovulum ovulum* in the pattern of the specimens as well as in the position of the regression line. The regression line has a parallel slope but is not coinciding with that of *C. ovulum ovulum*.

All specimens of *Caudammina arenacea* (Karrer) fall near the cluster of *C. ovulum gigantea*. The difference is the somewhat smaller size, but the cluster shows the same regression. The maximum length is 0.43 - 0.73 mm, the width 0.40 - 0.64 mm (number of specimens 22, many deformed and not suitable for morphometry). The thickness of the wall and the shape of the test is comparable. It is shown by the diagram (Fig. 6) that both species are synonymous.

In the assemblage from Rudnik a third morphologic group has been observed: *C. ovulum* ssp. The specimens are smaller than in *gigantea/arenacea*, and larger as *ovulum* s.str. The shape is globose-ovate, somewhat broader in the lower part of the test; the connecting necks are slender; the wall is thick. Generally it is similar to *gigantea*, but the analysis demonstrates a different morphogroup. It has a distinct cluster with a regression line intermediate between the others. The slope of regression is parallel to both other species. This form-group may be synonymous with *Caudammina caudata* Montanaro Galitelli; this can be solved by statistical analysis only.

The species name *ovulum* is a diminutive of the Latin word ovum (egg), and has to be used as a noun with neutral ending also in the combination with the genus *Caudammina*.

*Lagena globosa* Walk. var. *globosa asperella*  
Karrer, 1866

Correct name: *Caudammina asperella* (Karrer)

Valid name: *Caudammina arenacea* (Karrer, 1866)

*Lagena globosa* Walk. var. *globosa asperella* Karrer, 1866, p. 496, pl. 1, fig. 11.  
*Ataxophragmium arenaceum* n. sp. - Karrer, 1866, p. 495, pl. 1, fig. 9.

**Original material:** One specimen, holotype; acqu.no. 1866-XXXVII-4; type inv. no. MI-191.

**Description of holotype:** Spherical, non-deformed test, with short protruding broken necks at both ends; chamber at the upper end conical. At this end the smooth surface shows numerous light furrows (growth ornamentations) coming down from the apertural neck. This has been misinterpreted by Karrer as the radial pattern common in lagenid apertures. Wall smooth, finely agglutinated as in *C. arenacea*.

**Dimensions:** length 0.45 mm; width 0.40 mm.

*Rosalina?*

Valid name: *Caudammina arenacea* (Karrer)

*Rosalina?* Karrer, 1866, p. 497, pl. 1, fig. 13.  
*Ataxophragmium arenaceum* n. sp. - Karrer, 1866, p. 495, pl. 1, fig. 9.

**Original material:** Five specimens; acqu.no. 1866-XXXVII-6.

**Description:** Strongly deformed specimens of pear-shaped to ovate test, compressed in both directions. Openings or necks at both sides of the test; typical *Caudammina arenacea*. Karrer has mistaken similarities with *Rosalina obtusa* d'Orbigny from the Nussdorf locality (middle Miocene, Badenian), and could not solve the problem by thin-sections. This error is understandable by the occurrence of contaminated Badenian faunas in his sample.

Superfamily LITUOLACEA de Blainville, 1827  
Family LITUOTUBIDAE Loeblich & Tappan, 1984  
Genus *Trochamminoides* Cushman, 1910

*Trochammina proteus* Karrer, 1866  
Pl. 2, Figs. 1-6; textfigs. 7-9

Valid name: *Trochamminoides proteus* (Karrer)

*Trochammina proteus* n.sp. Karrer, 1866, p. 494, pl. 1, figs. 1-8.  
non *Trochammina proteus* Karrer. - Brady, 1884, p. 341, pl. 40, figs. 1-3.  
non *Trochamminoides proteus* (Karrer). - Cushman, 1910, p. 98, figs. 142-144.  
*Trochamminoides proteus* (Karrer) p.p. - Pflaumann, 1964, p. 94, pl. 12, figs. 1 a-c (non 2 a-d).

**Original material:** acqu.no. 1866-XXXVII-1; type inv. no. MI-162. Nine specimens selected by Cushman, 1932 during his visit to Vienna, most of them figured by Karrer; 17 specimens remaining in the phial of the collection (1 specimen lost at SEM); Nine specimens additionally selected from the type sample.

**Description of lectotype,** designated by Brady, 1884, and Cushman, 1910 as the figure 8 of Karrer (1866); see textfigs. 7-9: Test oval-elongate in outline, biumbonate, laterally compressed by compaction. The coiling is planispiral in the outer whorl, the inner coiling is irregular. The proloculus is not visible; the innermost part consists of an undivided tube (textfig. 7), followed by a chambered irregularly coiling part (textfig. 9). The outer planispiral coil consists of 12 (penultimate whorl 9) nearly equidistant chambers; the last three chambers are damaged. The wall is firmly agglutinated with rather fine quartz grains; surface smooth.

**Dimensions:** max. length 0.69 mm; width 0.48 mm; thickness 0.23 mm.

**Paratypes:** The remaining 18 specimens consist of different species:

Karrer Pl. 1, Figs. 2-4: *Glomospira irreglularis* (Grzybowski)

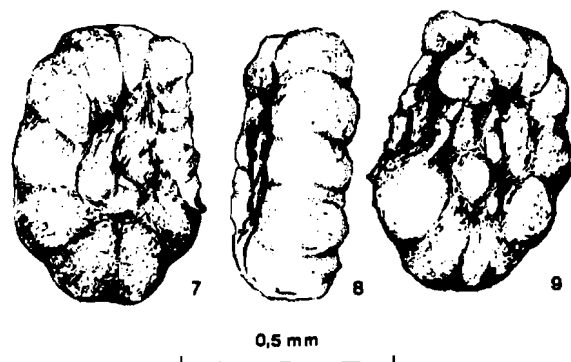
Pl. 1, Fig. 5: *Paratrochamminoides deformis* (Grzybowski)

Pl. 1, Fig. 6: "*Trochammina*" sp.

Pl. 1, Fig. 7: *Paratrochamminoides olszewskii* (Grzybowski);

Some, non-figured specimens belong also to *Trochamminoides variolarius* and *Thalmanmina turbinata*.

**Remarks:** The species is characterized by a discoidal test, starting with an irregular inner coiling, and an undivided innermost tube. The nearly planispiral outer coils consist of one to two, some-



Figures 7-9. *Trochammina proteus* Karrer, 1866. Correct name *Trochamminoides proteus*. Drawing of the lectotype (Karrer, pl. 1, fig. 8).

what embracing whorls. The whorl is subdivided in equidistant chambers of about the same length as the diameter of the tube. The maximum diameter is about 0.5 mm with a thickness of about 0.15 mm in average; one broken specimen (Pl. 2, Fig. 3) has a larger diameter of 1.4 mm.

The problems connected with the taxonomy of *T. proteus* have been discussed in the literature since Brady's time. By the re-appearance of the lectotype it has been possible to clarify the status of the genus *Trochamminoides*. Cushman (1910, p. 98) designated *T. proteus* as the type species of his new genus. He was using for description and comparison Recent material from the North Pacific and the comments of Brady (1884). Brady had already restricted the use of the species *proteus* to Karrer's figure 8, which was followed by Cushman. However, both incorrectly synonymized these Recent forms with the Cretaceous flysch species.

Some specimens of Brady's form have been studied from the Vienna comparative Brady collection (Challenger Station 276, South Pacific, 2350 fathoms). They compare well with his figures. The three specimens, partly damaged, have diameters up to 1.5 mm. But not only the general size is different; more important is the size of the single strongly inflated chamber with a length of about 0.65 and a width of 0.45 mm in the final whorl. A complete specimen of *Trochamminoides proteus* s.str. can be hidden in a single chamber of the modern form. *T. proteus* is distinctly more strongly compressed laterally. The other difference is the agglutination of fine grained quartz and sponge spicules by organic brownish matter in the Recent form; the surface is quite smooth, but dull. Because of these differences a new species name is proposed here.

***Trochamminoides challenger* n.sp.**

*Trochammina proteus*, Karrer. - Brady, 1884, p. 341, pl. 40, figs. 1-2 (not fig. 3).

*Trochamminoides proteus* (Karrer). - Cushman, 1910, p. 98, figs. 142-144.

Brady's figures exhibit a large test with an internally irregular coiling, but an outer planispiral whorl. The outer planispiral whorl consists of a number of elongate, inflated chambers. According to figures and description the maximum diameter is 1.00 - 1.25 mm.

As has been explained under *Trochammina proteus* this is an entirely different species. According to the coiling pattern it belongs to *Trochamminoides*. The new species name *challenger* is proposed here. The specimen figured by Brady (Pl. 40, Fig. 2) is designated as lectotype (Challenger Station 120, Atlantic off Pernambuco, 675 fathoms; British Museum (Natural History), inv. no. ZF2510; Paratype 1, Pl. 40, Fig. 1, juvenile specimen, inv.no. ZF5012; Paratype 2, not figured, inv.no. ZF5013).

***Trochamminoides dubius* (Grzybowski, 1901)**

Pl. 2, Figs. 7-10

*Ammodiscus dubius* Grzybowski, 1901, p. 274, pl. 8, figs. 12, 14.

*Trochamminoides dubius* (Grzybowski). - Kaminski & Geroch, 1993, p. 275, pl. 15, figs. 9-12.

Test relatively large, oval in outline, flat; inner whorls glomospiral, outer whorls planispiral; chambers elongate in coiling direction, 3-4 per whorl, often strongly compressed. Wall rather coarsely agglutinated (demonstrated also in the figures of Kaminski & Geroch, 1993); surface rough.

Occurrence: rare.

***Trochamminoides variolarius* (Grzybowski, 1896)**

Pl. 2, Figs. 11-14

*Trochammina variolaria* Grzybowski, 1898, p. 288, pl. 11, fig. 15.

*Trochamminoides variolarius* (Grzybowski). - Kaminski & Geroch, 1993, p. 261, pl. 9, figs. 5-6.

Test pseudoplanispiral; outline oval to rectangular, generally strongly compressed; only few whorls; 4-5 chambers in the final whorl; chambers elongate ovate of regular size. Wall very finely agglutinated; surface smooth.

Occurrence: common.

**Genus *Paratrochamminoides* Soliman, 1972**

The genus *Paratrochamminoides* differs from *Trochamminoides* only by the continuous streptospiral coiling, also in the final growth stage.

***Paratrochamminoides deformis* (Grzybowski, 1898)**

Pl. 2, Figs. 15-19

*Trochammina deformis* Grzybowski, 1898, p. 288, pl. 11, figs. 20-22.

*Paratrochamminoides deformis* (Grzybowski). - Kaminski & Geroch, 1993, p. 262, pl. 9, fig. 7a-c.

Test compact, tightly coiled, streptospirally throughout; chambers elongate, somewhat irregular



in width, commonly flattened. Wall very finely agglutinated; surface smooth.

Occurrence: common.

*Paratrochamminoides olszewskii* (Grzybowski, 1898)

Pl. 2, Figs. 20-25

*Trochammina olszewskii* Grzybowski, 1898, p. 286, pl. 11, fig. 6.

*Paratrochamminoides olszewskii* (Grzybowski). - Kaminski & Geroch, 1993, p. 257, pl. 7, figs. 1-2.

Test irregular-oval in outline; streptospirally coiled; 2-3 long, tubiform chambers per whorl with deformations along the axis. Wall rather coarsely agglutinated; surface rough.

Occurrence: rare.

*Paratrochamminoides* sp.

Pl. 2, Figs. 26-29

Test subglobular with tight coiling; whorls strongly changing directions; chambers elongate-ovate tubes; about 4 in one whorl. Wall finely agglutinated; surface somewhat rough.

Occurrence: rare.

Superfamily HAPLOPHRAGMIACEA Eimer & Fickert, 1899

Family AMMOSPHAEROIDINAE Cushman, 1927

Genus *Thalmannammina* Pokorný, 1951

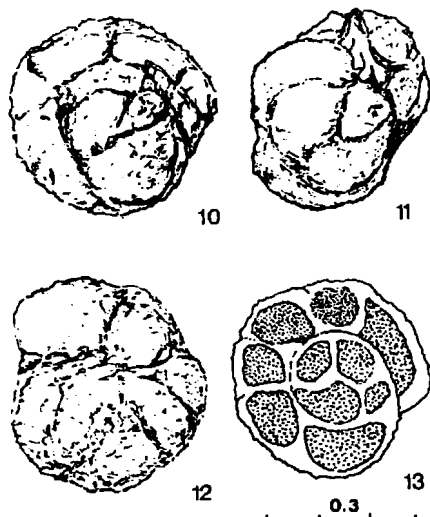
*Thalmannammina subturbinata* (Grzybowski, 1898)

Pl. 1, Figs. 24-26; textfigs. 10-13

*Haplophragmium subturbinatum* Grzybowski, 1898, p. 280, pl. 10, fig. 23.

*Thalmannammina subturbinata* (Grzybowski, 1898). - Pokorný, 1951, p. 470(477), figs. 1-2.

*Thalmannammina subturbinata* (Grzybowski) emend. Pokorný. - Kaminski & Geroch, 1993, p. 252, pl. 4, fig. 5 a-d, textfig. 5.



Figures 10-13. *Thalmannammina subturbinata* (Grzybowski, 1898). Coils strongly changing direction, with cuneate chambers at the point of turning coils. Final chamber showing smooth apertural face with apertural-like, basal structure.

Test subglobular with tight coiling; whorls are strongly changing directions (up to 180°); chambers globose to elongate-ovate, but at the backward bend of the coil triangular, cuneate; sutures not depressed but broad dark bands, visible only after immersion. Aperture indistinct; according to Kaminski & Geroch (1993) areal; the specimen of textfig. 11 exhibits a smooth apertural face with a lobate border at the suture to the preceeding whorl, somehow looking like an apertural slit, as described and figured by Pokorný (1951). Chamber connections have not been visible in transmitted light. Wall finely agglutinated; surface somewhat rough.

Occurrence: common.

Suborder LAGENINA Delage & Hérouard, 1896  
Superfamily NODOSARIACEA Ehrenberg, 1838  
Family POLYMORPHINIDAE d'Orbigny, 1839  
Genus *Globulina* d'Orbigny, 1839

*Polymorphina globosa* Münster

Valid name: *Globulina gibba* d'Orbigny, 1846

*Globulina gibba* d'Orbigny, 1826, p. 265, no. 20 (nomen nudum).

*Globulina gibba* - d'Orbigny, 1846, p. 227, pl. 13, fig. 13-14.

*Polymorphina globosa* Münster. - Karrer, 1866, p. 497, pl. 1, fig. 12.

One specimen; acqu.no. 1866-XXXVII-5.

Typical ovate specimen with smooth surface and calcareous test. Contaminated from middle Miocene.

# ACKNOWLEDGMENTS

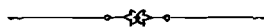
To carry out this revision I have had valuable discussions with Prof. S. Geroch (Kraków) and M.A. Kaminski (London), to whom I want to express my gratitude, also for reviewing the manuscript and contributing comparative material. Further I have to thank H. Egger (Wien) for his nannoplankton determinations of the Karrer type sample. The SEM micrographs were made through the cordial help of Mrs. A. Schumacher and F. Brandstätter, who helped also in mineralogical determinations and statistical methods. The material is deposited in the micropaleontological collection of the Naturhistorisches Museum in Vienna.

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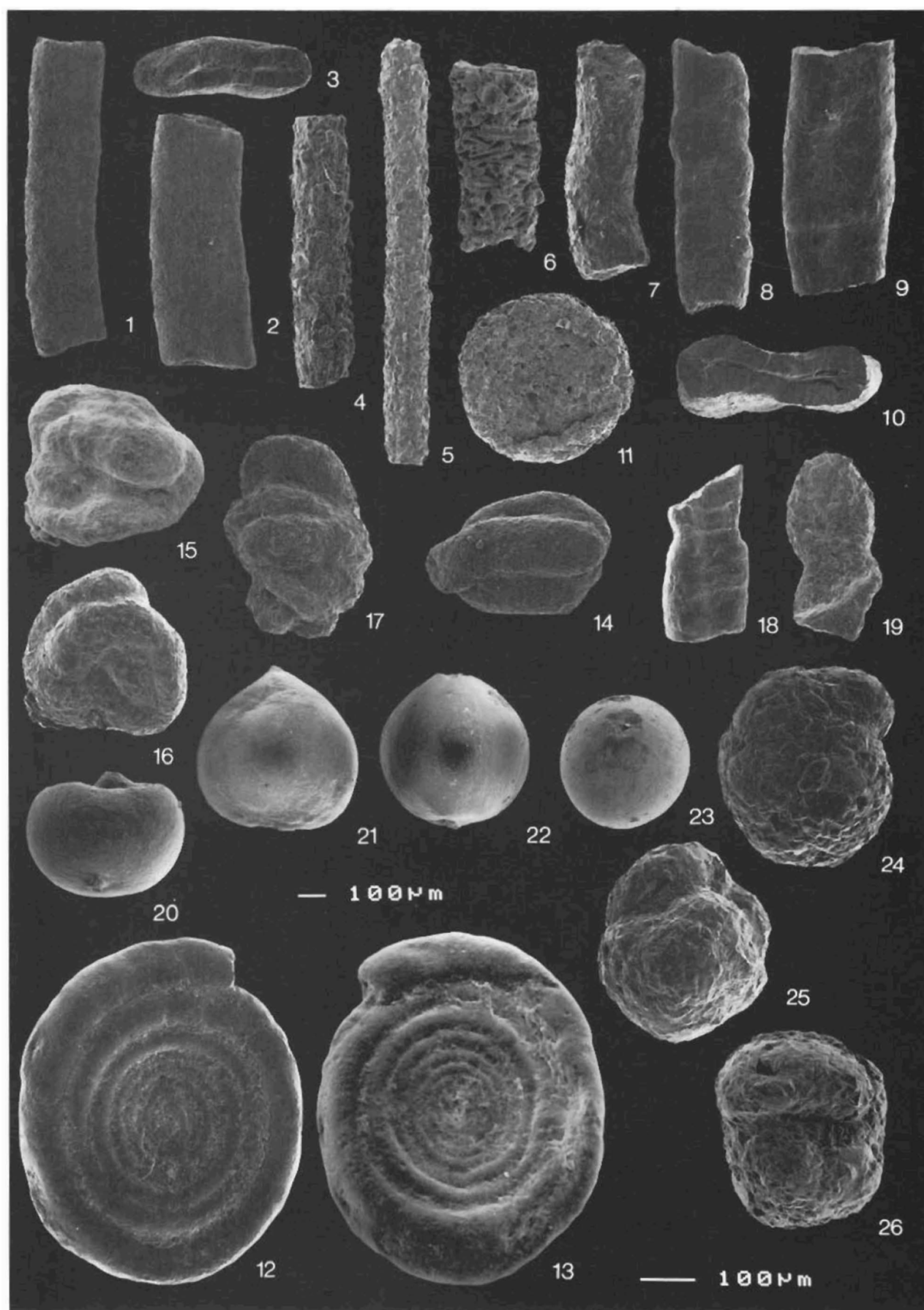
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## PLATE 1

- Figs. 1-3.** *Bathysiphon* sp. Compressed tubes; smooth surface, agglutinated of fine particles; no sponge spicules.
- Figs. 4-5.** *Psammosiphonella cylindrica* (Glaessner, 1937). Straight, thick-walled tubes with wall of angular quartz grains.
- Fig. 6.** *Rhabdammina?* sp. Short straight tubes, agglutinated of small quartz crystals, with impressions of sponge spicules.
- Fig. 7.** *Rhizammina indivisa* Brady, 1884. Irregular tubes with a circular cross-section, and rough surface.
- Fig. 8.** *Silicobathysiphon longoloculus* Myatlyuk, 1970. Tubes of transparent, siliceous material with irregular constrictions.
- Figs. 9-10.** *Bogdanowiczia* sp. Thick-walled tubes of transparent, siliceous material with stronger indentations at the position of pseudoseptae.
- Fig. 11.** *Psammosphaera fusca* Schulze, 1875.
- Figs. 12-13.** *Cornuspira Hörnesi* Karrer, 1866. Paratype no.2. Valid name: *Ammodiscus cretaceus* (Reuss, 1845).
- Fig. 14.** *Glomospira serpens* (Grzybowski, 1898).
- Figs. 15-17.** *Glomospira irregularis* (Grzybowski, 1898).
- Fig. 18.** *Kalamopsis grzybowskii* (Dyląganka, 1923).
- Fig. 19.** *Subreophax splendidus* (Grzybowski, 1898).
- Figs. 20-23.** *Ataxophragmium arenaceum* Karrer, 1866. Valid name: *Caudammia arenacea* (Karrer). Fig. 20 compares to *Rosalina?*; Fig. 21 is similar to the holotype of *Ataxophragmium arenaceum*; 22-23, two views of a specimen similar to *Lagena globosa asperella* Karrer.
- Figs. 24-26.** *Thalmanammia subtrubinata* (Grzybowski, 1898); same specimen. The side view in Fig. 25 shows some kind of an opening, but this is caused by a broken off larger sand grain.



## PLATE 2

- Figs. 1-6.** *Trochammina proteus* Karrer, 1866. Valid name: *Trochamminoides proteus* (Karrer). 1-2, same specimen, similar to the holotype, showing the innermost undivided tube; 3, large, broken specimen, but similar equidistant chambers as in smaller tests; 4-5, different views of the same specimen.
- Figs. 7-10.** *Trochamminoides dubius* (Grzybowski, 1901). 7-8, same young specimen, showing the inner glomospiral coiling.
- Figs. 11-14.** *Trochamminoides variolarius* (Grzybowski, 1898). Different stages of compression of the pseudoplanispiral test. 12 & 13, from the type series of *T. proteus*.
- Figs. 15-19.** *Paratrochamminoides deformis* (Grzybowski, 1898). Figs. 16-17, same specimen, with distinct streptospiral coiling of the upper side.
- Figs. 20-25.** *Paratrochamminoides olszewskii* (Grzybowski, 1898). Each pair of figures shows both sides of one specimen; constrictions between chambers are sometimes not well defined.
- Figs. 26-29.** *Paratrochamminoides* sp. Each pair (Figs. 26/27, Figs. 28/29) shows both sides of one specimen.

