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LOWER PALEOCENE DEEP-WATER AGGLUTINATED FORAMINIFERA FROM THE CONTESSA HIGHWAY SECTION (UMBRIA-MARCHE BASIN, ITALY): TAXONOMY, STRATIGRAPHIC DISTRIBUTION AND ASSEMBLAGE TURNOVER ACROSS THE CRETACEOUS/PALEOGENE BOUNDARY

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Abstract. Deep-water agglutinated foraminifera (DWAF) are investigated from the lower Paleocene of the Contessa Highway Paleocene (CHP) section in the Umbria-Marche Basin in Italy. In the lowermost part of the Paleocene corresponding to the P0–Pα interval and lowermost P1 planktonic foraminifera zones, a total of 46 species of DWAF are identified. A comparison with the uppermost Maastrichtian DWAF assemblages documented by Cetean (2009) results in a combined total of 94 DWAF species over the Cretaceous/Paleogene boundary interval at Contessa Highway. Of these, 49 species are listed as extinction taxa, nine are survivor taxa, 19 are Lazarus taxa, and 17 taxa display first occurrences in the Paleocene. The record of DWAF in the Contessa Highway Paleocene section displays a moderate decrease in diversity across the K/Pg boundary, followed by a gradual recovery in the first meter of the Paleocene. The lower Paleocene record is characterized by blooms of opportunistic species belonging to the genera *Reophax*, *Subreophax, Repmanina,* and *Spiroplectinella*. The K/Pg boundary interval records a major change in the proportions of DWAF morphogroups, from a suspension-feeding community in the Maastrichtian to one dominated by epifaunal detritivores in the lower Paleocene, reflecting a fundamental change in marine primary productivity following the bolide impact.

Introduction

The Cretaceous/Paleogene boundary records a significant mass extinction event in the history of ocean biota (Raup & Sepkoski 1982). Over 90% of calcareous nannofossil and planktonic foraminiferal species went extinct over the interval (MacLeod et al. 1997). Most recently, ocean acidification has been suggested as a primary cause for the extinction of calcareous plankton (Henehan et al. 2019). Extinctions in the photic zone would have led to changes in export productivity and in the organic carbon flux to the seafloor (Hsu & MacKenzie 1985; Henehan et al. 2019). Changes in organic flux would in turn be reflected in the composition of the benthic foraminiferal community (Kuhnt & Kaminski 1993, 1996; Alegret et al. 2004). During the late Maastrichtian, the coccolithophores acted as primary ocean producers, but these organisms were affected by impact-darkness kill mechanisms during and after the impact event (Gibbs et al. 2020). Fortunately, the survivor species started to

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recover in early Danian, and blooms of opportunistic plankton are found in the sedimentary record (Gibbs et al. 2020). Consequently, primary productivity and the flux of carbon to the seafloor were likely to be quite variable in the early Paleocene (Hsu 1983). The pelagic-benthic coupling would have affected the benthic community trophic structure translating into the appearance of opportunistic species of benthic foraminifera. Initial studies by Kuhnt & Kaminski (1993, 1996) suggested that the agglutinated benthic foraminiferal community structure reacted to these changes in the food supply. The occurrence of opportunistic species of deep-water agglutinated foraminifera (DWAF) was reported by Kuhnt & Kaminski (1996) from the lowermost Paleocene in Italy, by Peryt et al. (1997) from the Rotwandgraben section in Austria, and by Kuhnt et al. (1998) from the lower Paleocene at ODP Site 959 on the Côte D'Ivoire-Ghana transform margin. A similar phenomenon among calcareous and agglutinated benthic foraminifera has been reported in the basal Danian of the Caravaca section in southeast Spain (Coccioni and Galeotti 1994), in the Aïn Settara section in Tunisia (Peryt et al. 2002), and in the Bidart section in southern France (Alegret et al. 2004).

The area near Gubbio contains a thick sequence of pelagic sediments that includes the K/Pg boundary (Luterbacher & Premoli Silva 1964; Alvarez et al. 1980). The pelagic limestones of the Scaglia Rossa Formation contain diversified assemblages of DWAF (Kaminski & Gradstein 2005; Cetean 2009), but their record across the boundary has only been studied in a preliminary manner (Kuhnt & Kaminski 1996), and these authors did not provide a detailed inventory or taxonomy for the early Paleogene DWAF. The Upper Cretaceous biostratigraphic record of DWAF was published by Kaminski et al. (2011) from the Contessa Highway section, but this data record ended at the K/Pg boundary. The goals of this research, therefore, are:

- to provide a complete documentation of the DWAF species occurring above the K/Pg boundary;
- to document quantitative changes in the community structure in the lowermost Paleocene, and to identify any opportunistic species that may have bloomed as a response to the event.

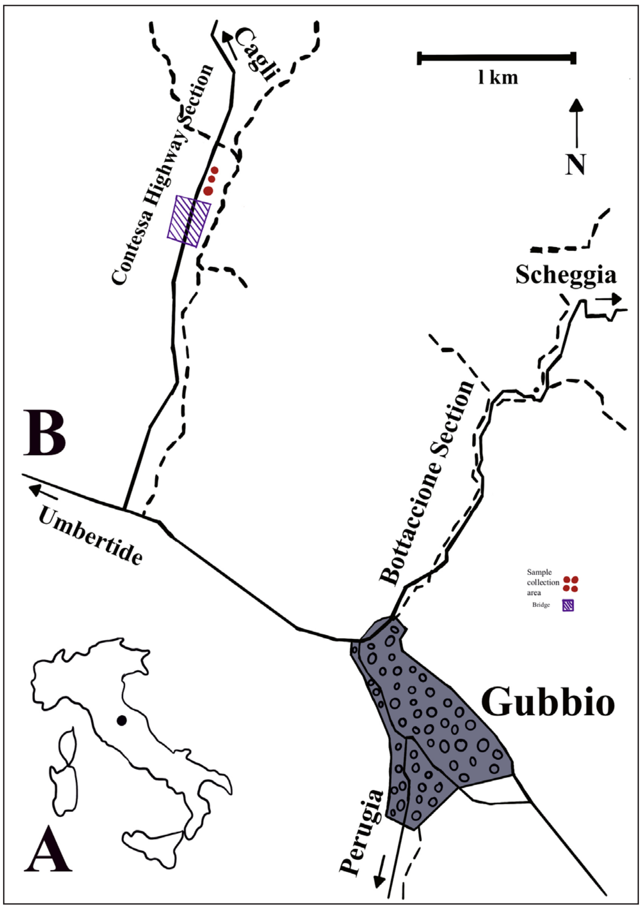

Fig. 1 - Location of the Contessa Highway section. A) Insert map; B) Sampled locality.

Study Area

In the Umbria-Marche basin of Central Italy, the lower Paleocene is mainly composed of pelagic limestones with marls deposited as a part of the Scaglia Rossa Formation. The Scaglia Rossa Formation (lower Turonian to lower Eocene) consists of pinkish and reddish pelagic micritic limestones with associated cherts in some levels. This formation was subdivided into four members by Alvarez & Montanari (1988), numbered R1–R4 from bottom to top. The R2 Santonian–Maastrichtian pink limestone with the terminal Maastrichtian white limestone and the Paleocene R3 dark red marly limestones are well-exposed in the Contessa Highway Paleocene (CHP) section (lat. 43°22'47"N; long. 13°33'49"E). This research is focused on the lowermost meter of the Danian of the R3 member (Fig. 1). The studied section is the best available section as it is accessible and undisturbed by faults (Fig. 2).

Fig. 2 - Exposure of the Scaglia Rossa Formation on the east side of the Contessa Highway. Paleocene, sampled in this study.

Methods

Twenty samples from the first meter of the Paleocene were collected for this study. The lowermost 50 cm of the Paleocene Scaglia Rossa Formation above the K/Pg boundary was collected bed-by-bed, and subsequently at a sampling resolution of 10 cm to a stratigraphic height of 1 m. In the lab, samples were first broken into small pieces of around 1-2 cm in size. The samples were then dissolved using the dilute hydrochloride acid method described by Kaminski et al. (2011). Specimens were picked from the >125μm fraction, mounted onto cardboard slides, and individual specimens were photographed using a NeoScope JCM-7000 scanning electron microscope in the College of Petroleum and Geosciences, KFUPM. The taxonomy follows Kaminski & Gradstein (2005), Kaminski et al. (2011, 2021). The systematics of the Deep Water Agglutinated Foraminifera is based on Kaminski (2014). Assemblage parameters (e.g., Shannon-Weaver diversity, H´) were calculated using the PAST software package (Hammer et al. 2001). Morphogroup analysis follows the model adopted by Kaminski & Gradstein (2005). Specimen slides are currently housed in the authors' collection, but they will be permanently archived in the European Micropalaeontological Reference Centre (Micropress Europe Foundation) at the AGH University of Science & Technology in Kraków, (Poland).

Results

The newly studied lower Paleocene samples from the CHP section were compared with the Upper Cretaceous record of Cetean (2009) to create a broader coverage of species distribution and abundance. The combined record yields a total of 94 species from the K/Pg boundary interval in Contessa (Fig. 3). Of these, 49 species are listed as extinction taxa, 9 are survivor taxa, 19 are Lazarus taxa, and 17 taxa display first occurrences in the Paleocene.

The species *Spiroplectinella israelskyi, Psammosiphonella cylindrica, Rhizammina* sp., *Repmanina charoides, Ammodiscus peruvianus, Bathysiphon* sp., *Ammosphaeroidina pseudopauciloculata, Saccammina grzybowskii,* and *Trochamminoides dubius* belong to the group of survivor taxa. These species are present in the first Paleocene sample overlying the boundary clay. The Shannon-Weaver diversity shows a moderate decrease across the boundary but displays a steady recovery in the first meter of the Paleocene. The turnover rate is at the highest between the highest Maastrichtian sample and the first bed of the Paleocene.

A number of species display acmes in the 1-m interval directly overlying the boundary clay (Figure 4). The genus *Reophax* is conspicuously present in the overlying interval and comprises as much as 24% of the assemblage. *Repmanina charoides* is a well-known survivor species that may even form acmes following environmental disturbances (Galeotti et al. 2004; Kaminski & Gradstein 2005; Arreguin-Rodriguez et al. 2014). *Spiroplectinella israelskyi* reacts differently, displaying low abundance in the Upper Cretaceous, and high abundance above the K/Pg boundary. *Subreophax scalaris, Glomospira irregularis, Recurvoides* spp., *Lituotuba lituiformis, Trochamminoides subcoronatus, Arthrodendron* sp., *Trochamminoides folius, Cribrostomoides subglobosus, Glomospira gordialis, Ammodiscus glabratus, Recurvoidella lamella, Subreophax splendidus, Glomospira glomerata, Caudammina ovula, Nothia* sp., *Remesella varians, Paratrochamminoides gorayskii, Bolivinopsis rosula,* and *Trochamminoides grzybowskii* are the members of the Lazarus taxa group – they disappear from the interval immediately overlying the boundary clay, but they reappear higher in the studied section. *Subreophax scalaris* and *Recurvoides* spp., show significant changes in relative abundance at the top of the sampled interval. *Reophax* sp. 3, *Spiroplectammina spectabilis, Rhizammina* sp. 2, *Paratrochamminoides olszewskii, Reo-*

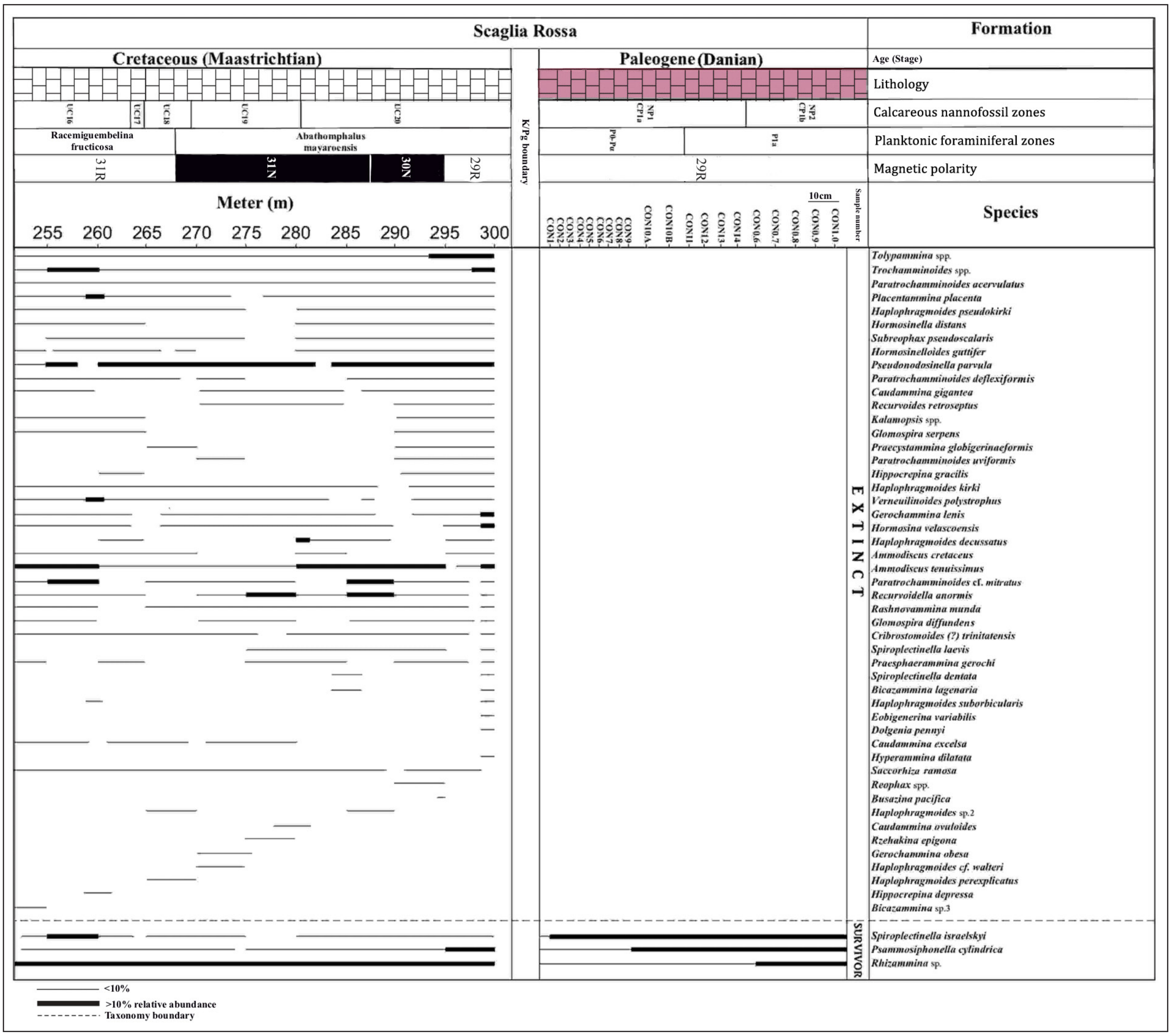

Fig. 3a - Stratigraphic ranges of DWAF species in the Contessa Highway section. Maastrichtian ranges are from Cetean (2009).

phax sp. 2, *Subreophax aduncus, Paratrochamminoides heteromorphus, Paratrochamminoides* sp., *Paratrochamminoides draco, Glomospira* sp. 4, *Subreophax longicameratus, Kalamopsis grzybowskii, Rashnovammina munda, Jaculella* sp., *Glomospira demarginata,* and *Trochamminoides proteus* are the members of the new taxa group. *Reophax* sp. 3, *Spiroplectammina spectabilis, Paratrochamminoides olszewskii*, and *Subreophax aduncus* display high abundance in consecutive samples.

Discussion

Abundance and diversity of the agglutinated foraminifera

The record of DWAF from the Upper Cretaceous (Cetean 2009; Kaminski et al. 2011) shows high abundance, species richness and diversity, consisting of about 94 species. In the Contessa Highway section, a major turnover in species composition is observed at the K/Pg boundary. In our record, a total of 49 species are placed in the extinction group, nine species survive the boundary event, and 19 species reappear higher in the section as Lazarus taxa, and 17 taxa have their first occurrences in the first meter of the Paleocene. The turnover rate among DWAF appears to be comparatively high at Contessa, but a number of species that disappeared from our record at the boundary are known from the Paleocene in other parts of the world, such as Trinidad, IODP Site 1511 in the Tasman Sea, Site 959 on the Côte d'Ivoire Margin, and the Polish Carpathians (Kaminski & Gradstein 2005). The

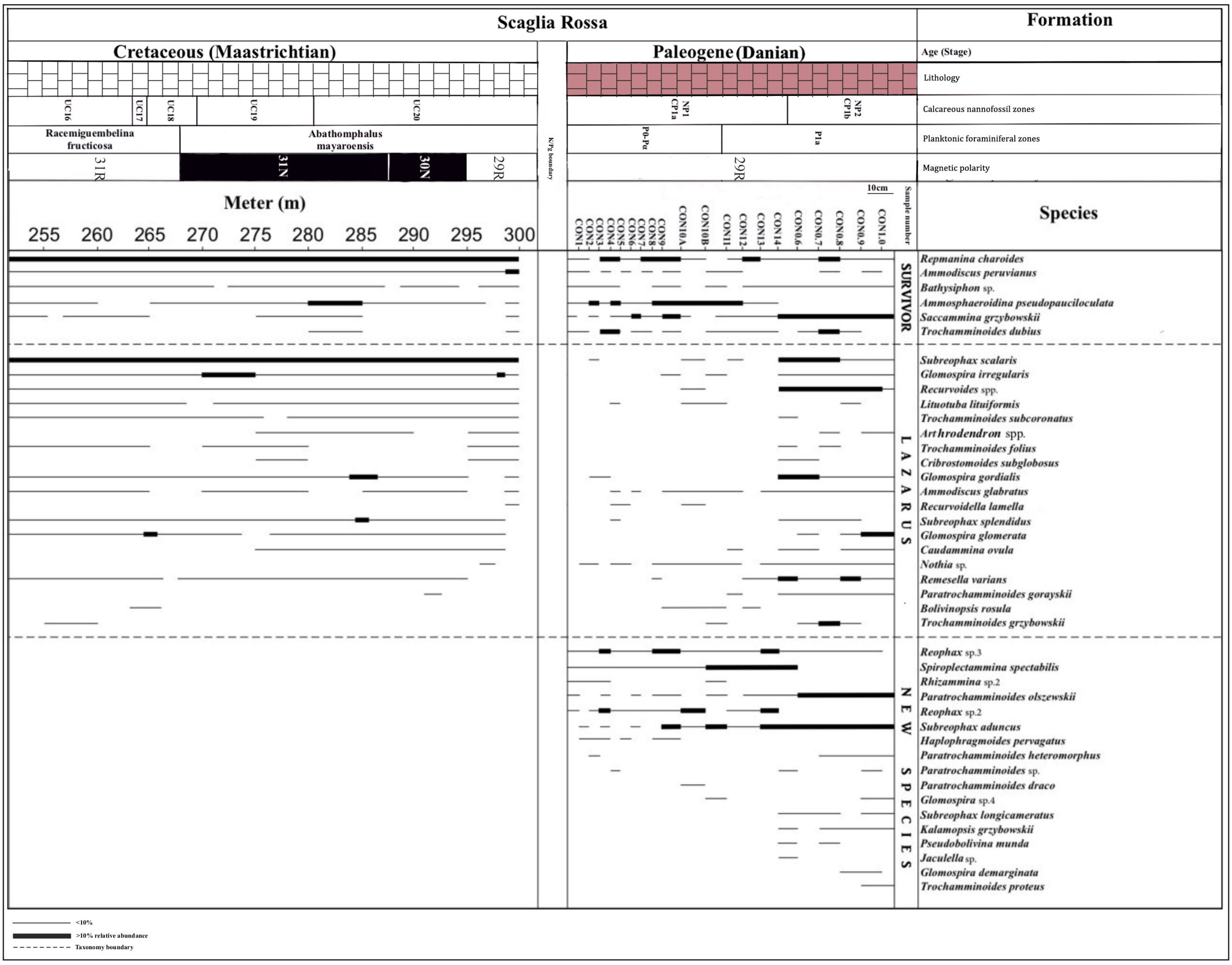

Fig. 3b - Stratigraphic ranges of DWAF species in the Contessa Highway section. Maastrichtian ranges are from Cetean (2009).

turnover rate observed at Contessa is likely a local response to the K/Pg boundary event, as globally very few DWAF species became extinct at the boundary. Moreover, it is reasonable to assume that some of the taxa listed in the extinction group may reappear as Lazarus taxa higher in the Paleocene. This question needs to be addressed by additional sampling of the Paleocene section.

Opportunists

Several species display increased relative abundance above the K/Pg boundary. Some of these forms are known to be opportunists, such as the genera *Reophax* and *Subreophax*. These genera recolonized the sea floor after the deposition of a volcanoclastic layer in the Campanian part of the Scaglia Rossa Formation (Galeotti et al. 2002), and their modern relatives have colonized the volcanic ash layer deposited by the 1991 eruption of Mt. Pinatubo in the South China Sea (Hess et al. 2001). The acme of *Spiroplectinella israelskyi* has also been observed above the K/Pg boundary in Austria, Spain, and in the south of France (Kuhnt & Kaminski 1993; Peryt et al. 1997; Alegret et al. 2004; Alegret 2007). The genera *Reophax* and *Spiroplectinella* are primarily infaunal types that are interpreted as detritivores (Kuhnt & Kaminski 1993). At Contessa, *Spiroplectinella israelskyi* displays increased abundance together with *Reophax* sp. 3 in the first bed of the Paleocene overlying the boundary clay. In the overlying beds, acmes of *Subreophax* spp. and *Spiroplectammina spectabilis* are observed. In the South China Sea, the genus *Subreophax* characterised the second stage of colonisers after the 1991 eruption of Mt. Pinatubo (Hess et al. 2001).

Morphogroups

The population dynamics of benthic foraminifera respond to environmental conditions, largely

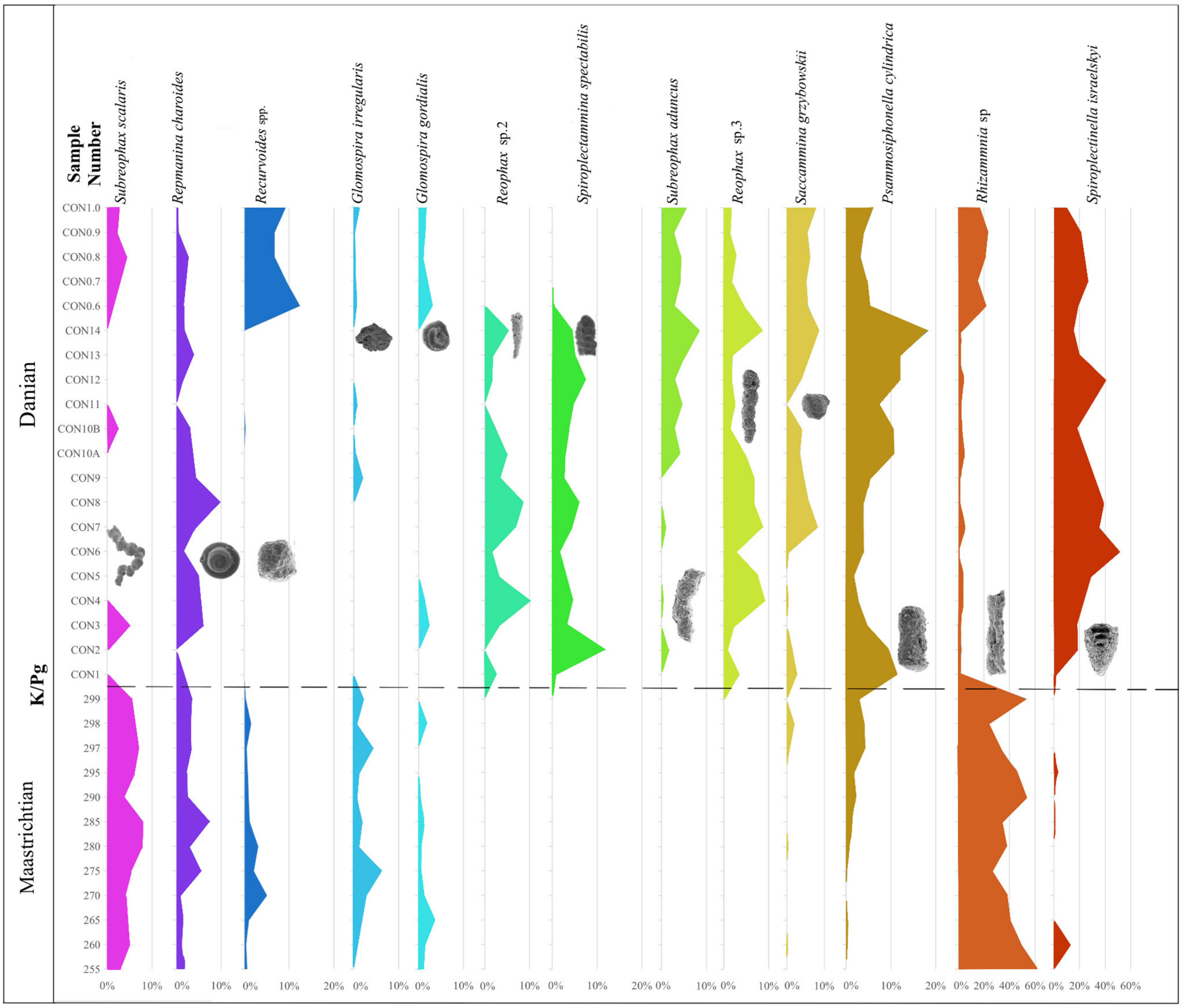

Fig. 4 - Blooms of opportunistic species in the Contessa Highway section.

reflecting the trophic continuum (Jorisson et al. 1995; Altenbach et al. 1999; Van Der Zwaan et al. 1999). For the purpose of this study, the DWAF genera were placed into morphogroups according to their gross morphology (Table 1). The morphogroup scheme used here follows the study of Cetean et al. (2011). Changes in environmental conditions can be assessed by analyzing the proportions of DWAF morphogroups (e.g., Kaminski & Gradstein 2005), which provide information about favored environments, microhabitats, and feeding strategies. The integration of morphogroup analysis can help delineate DWAF foraminiferal assemblages that provide information about the environmental conditions at the seafloor before and after the K/Pg boundary event (e.g., Kuhnt & Kaminski 1993, 1996; Peryt et al. 1997).

In the Contessa Highway section, Kuhnt & Kaminski (1996) first noted that changes in the proportions of morphogroups were observed across the K/Pg boundary. The new record of DWAF morphogroups is presented in Fig. 5. At Contessa, we observe a major reduction in the M1 morphogroup and an increase in the M2 and M3 morphogroups coincident with the K/Pg boundary, signaling a shift from a Maastrichtian community dominated by epifaunal suspension-feeders, to one dominated by epifaunal detritivores in the lower Paleocene. The M4 group comprised chiefly of elongate tapered tests are interpreted as active deposit-feeders. Their trend was relatively stable in the Maastrichtian, but experienced a slight decrease to minimum values in the lowermost beds of the Paleocene, followed by a rapid recovery with stable values in the lower Paleocene. Because the

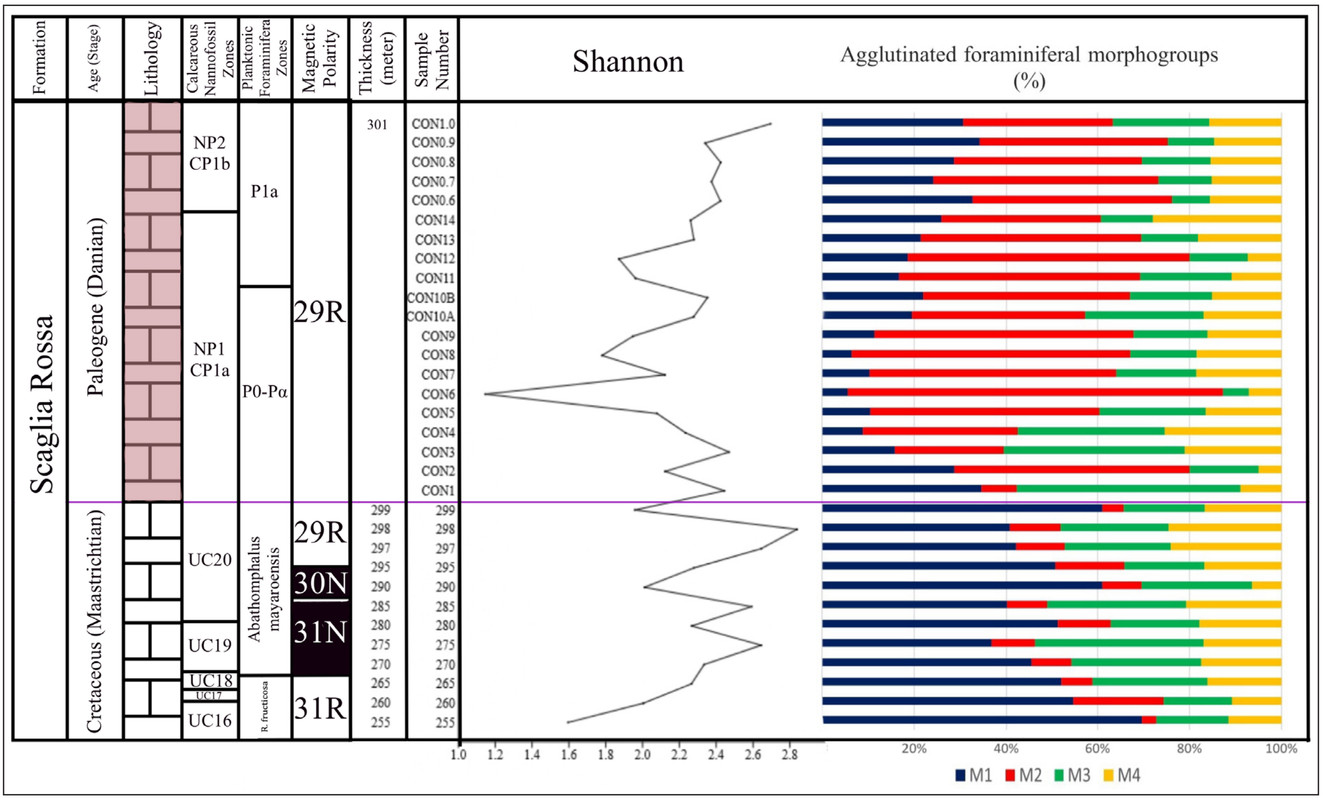

Fig. 5 - Shannon diversity and relative proportions of DWAF morphogroups across the K/Pg boundary in the Contessa Highway section.

proportion of the M4 morphogroup rapidly recovers to pre-Paleocene values, we conclude that the total flux of organic carbon to the sea floor did not "collapse" at the K/Pg boundary. Instead, the shift in the proportion of M1 and M2-M3 morphogroups provides evidence that the type of organic matter available to the benthos likely changed. Early authors who have studied the carbon isotope record across the K/Pg boundary have reported a "collapse" in productivity coincident with the boundary event, resulting in a "Strangelove Ocean" (Hsu & MacKenzie 1983). While the impact winter scenario may have resulted to a short-term reduction in productivity, this scenario cannot explain changes that took place in the longer term. Although calcareous nannoplankton display a major extinction at the boundary (MacLeod et al. 1997), the organic-walled dinoflagellates survived, and may even increase in abundance in the lowermost Paleocene (Hultberg 1986). The "productivity collapse" at the K/Pg boundary has been questioned by Alegret et al. (2012), who found an inconsistent geographical pattern in paleoproductivity proxies. Birch et al. (2016) examined the carbon and isotope record and concluded that the biological pump was weakened as a consequence of marine extinctions, but less severely and for a shorter duration than has previously been suggested. The flux of organic carbon to the sea floor may have been more variable in the early Paleocene as witnessed by the more extreme variability of the M4 morphogroup, but the total is only slightly reduced from the Late Cretaceous values (Paleocene average M4 =15%, vs. 17% for the Maastrichtian). The acme of *Glomospira charoides* in Sample CON0.8 suggests somewhat more oligotrophic conditions, as this species indicates oligotrophy in the modern Mediterranean (De Rijk et al. 1999, 2000). Our observations support the findings of Gibbs et al. (2020), who observed a reduction in the amount of productivity derived from photosynthetic calcareous plankton, but an increase in the amount of organic productivity derived from bacteria. M2 and M3 are interpreted as bacterial detritivores, and these groups dominate the DWAF record above the boundary.

Conclusions

A total of 46 species of deep-water agglutinated foraminifera are observed in the lowermost meter of the Paleocene in the Contessa Highway section, corresponding the P0–Pα interval, and lowermost P1 planktonic foraminiferal zones. A comparison with the uppermost Maastrichtian DWAF record documented by Cetean (2009) yields a combined total of 94 species over the Cretaceous/Paleogene boundary interval in Contessa.

Quantitative analysis of DWAF across the Cretaceous/Paleogene boundary in the Contessa Highway section shows that the assemblage experienced decrease in species diversity and abundance across the K/Pg boundary. About 52% of DWAF taxa disappeared at the K/Pg boundary, 10% survived, 20% reappeared in Danian, and 18% are identified as newly appearing taxa.

A significant increase in relative proportions is observed above the boundary for some species. The infaunal detritivores such as *Spiroplectinella israelskyi* and *Reophax* spp. display blooms above the boundary and dominate the assemblages. These species are known to be opportunists. The second wave of colonizers in Contessa is indicated by the high numbers of *Spiroplectammina spectabilis* and *Subreophax*.

The assemblage structure of DWAF is interpreted based on the morphogroup analysis. The relative proportions of DWAF morphogroups show declining (M1) (suspension feeding) morphogroup, interpreted as reflecting declining productivity in photosynthetic calcareous plankton. The concurrent increase in the (M2) and (M3) (epifaunal to shallow infaunal) morphogroups support the idea of organic productivity from bacteria. The (M4) (deep infaunal) morphogroup is relatively stable, which implies that the total flux of carbon to the sea floor did not change significantly. The benthic foraminiferal record does not support the idea of a "Strangelove Ocean" across the K/Pg boundary in Contessa.

Systematic Taxonomy

The classification of agglutinated foraminifera by Kaminski (2014) was used for the taxa listed below.

Class **FORAMINIFEREA** d'Orbigny, 1826
Subclass MONOTHALAMANA Pawlowski, Holzmann & Tyszka, 2013
Order **Astrorhizida** Lankester, 1885
Suborder **Astrorhizina** Lankester, 1885
Family Rhabdamminidae Brady, 1884
Subfamily Bathysiphoninae Avnimelech, 1952
Genus *Bathysiphon* Sars, 1872

Bathysiphon sp.

Pl. 1, fig. 1a-c

1988 *Bathysiphon* sp. – Kaminski et al., p. 182, pl. 1, figs. 2–3.
2000 *Bathysiphon* sp. 1 – Nagy et al., pl. 4, figs. 7–10.

Remarks. Test medium size, tubular fragments, with a thick and smooth wall.

Genus *Nothia* Pflaumann, 1964

Nothia excelsa (Grzybowski, 1898)

Pl. 1, fig. 2a-b

1898 *Dendrophrya excelsa* Grzybowski, p. 272, pl. 10, figs. 1-4.
1992 *Nothia excelsa* (Grzybowski) – Geroch & Kaminski, pl. 1, figs. 1-4, pl. 2, figs. 1-11
1993 *Nothia excelsa* (Grzybowski) – Kaminski & Geroch, p. 245, pl. 1, figs. 2-6.
1997 *Dendrophrya excelsa* Grzybowski – Peryt et al., pl. 1, fig. 10.
2005 *Nothia excelsa* (Grzybowski) – Kaminski & Gradstein, p. 106, pl. 2, figs. 1-9.
2019 *Nothia excelsa* (Grzybowski) – Bubík, pl. 1, fig. 1.
2021 *Nothia excelsa* (Grzybowski) – Kaminski et al., p. 342, pl. 1, fig. 3.

Remarks. Straight and robust test. Clear wall and thin, finely agglutinated, smooth surface.

Genus *Psammosiphonella* Avnimelich, 1952

Psammosiphonella cylindrica (Glaessner, 1937)

Pl. 1, figs. 3a-b, 4a-b and 5a-b

1937 *Rhabdammina cylindrica* Glaessner, p. 354, pl. 1, fig. 1.
1975 *Bathysiphon cylindrica* (Glaessner) – Webb, p. 834, pl. 1, fig. 6.
1997 *Rhabdammina* sp. – Peryt et al. pl. 1, fig. 14.
2005 *Psammosiphonella cylindrica* (Glaessner) – Kaminski & Gradstein, p. 119, pl. 5/6, figs. 9–13 (with synonymy).
2008 *Psammosiphonella cylindrica* (Glaessner) – Waśkowska-Oliwa, p. 250, pl. 1, fig. 1.
2011 *Psammosiphonella cylindrica* (Glaessner) – Setoyama, et al., p. 280, pl. 2, fig. 6a, b.
2015 *Psammosiphonella cylindrica* (Glaessner) – Setoyama & Kaminski, p. 242, pl. 1, fig. 5.
2021 *Psammosiphonella cylindrica* (Glaessner) – Kaminski et al., p. 342, pl. 1, fig. 3.

Remarks. Test is agglutinated, smooth to rough surface. Wall is thick. Tubular form, straight and clear aperture. The aperture is an opening at either end of the tube.

Family Rhizamminidae Wieser, 1931
Genus *Rhizammina* Brady, 1879

Rhizammina sp. 1

Pl. 1, fig. 6a-b

1879 *Rhizammina algaeformis* Brady, p. 20, pl. 4, figs. 16-17.
1975 *Rhizammina algaeformis* Brady – Webb, pl. 1, fig. 2.
2021 *Rhizammina* sp. 1 – Kaminski et al., p. 343, pl. 1, figs. 6-7.

Remarks. Test elongate, agglutinated with small size grains and a rough surface, slightly bent thin wall. The tubular fragments are constant in size.

Rhizammina sp. 2

Pl. 1, fig. 7

1879 *Rhizammina algaeformis* Brady, p. 20, pl. 4, figs. 16-17.
1990 *Rhizammina* cf. *algaeformis* Brady – Kuhnt, p. 324, pl. 1, fig. 1.
2011 *Rhizammina algaeformis* Brady – Kaminski et al., p. 101, pl. 1, figs. 2–3.
2021 *Rhizammina* sp. 2 – Kaminski et al., p. 344, pl. 1, figs. 23–24.

Remarks. Wall thin with smooth surface, straight with slightly bent tubular fragments, smoothly agglutinated, the diameter of the test smaller at the ends of the tube.

Suborder **Saccamminina** Lankester, 1885
Superfamily Saccamminoidea Brady, 1884
Family Saccamminidae Brady, 1884
Subfamily Saccammininae Brady, 1884
Genus *Saccammina* Carpenter, 1869

Saccammina grzybowskii (Schubert, 1902)

Pl. 1, figs. 8a-b and 9a-b

1902 *Reophax grzybowskii* Schubert, p. 20, pl. 1, fig. 13a-b.
1984 *Saccammina grzybowskii* (Schubert) – Hemleben & Troester, p. 522, pl. 1, fig. 14.
1990 *Saccammina grzybowskii* (Schubert) – Kuhnt, p. 325, pl. 2, fig. 3.
1997 *Saccammina grzybowskii* (Schubert) – Peryt et al. pl. 2, fig. 15.
2005 *Saccammina grzybowskii* (Schubert) – Kaminski & Gradstein, p. 132, pl. 10, figs. 1–9.
2008 *Saccammina grzybowskii* (Schubert) – Waśkowska-Oliwa, p. 251, pl. 2, figs. 2, 3, 5.
2011 *Saccammina grzybowskii* (Schubert) – Kaminski et al., p. 84, pl. 1, fig. 5.
2018 *Saccammina grzybowskii* (Schubert) – Waśkowska et al., pl. 6, figs. J–K.
2019 *Saccammina grzybowskii* (Schubert) – Wilson et al., p. 13, pl. 1, fig. 3.
2020 *Saccammina grzybowskii* (Schubert) – Waśkowska et al., p. 43, pl. 8, figs. A-D.
2021 *Saccammina grzybowskii* (Schubert) – Kaminski et al., p. 344, pl. 1, figs. 11–12.

Remarks. Unilocular test, circular shape, medium agglutinated. Aperture located at the periphery of the test.

Subclass TUBOTHALAMANA Pawlowski, Holzmann & Tyszka 2013
Order **Ammodiscida** Mikhalevich, 1980

Suborder **Hippocrepinina** Saidova, 1981
Superfamily Hippocrepinoidea Rhumbler, 1895
Family Hippocrepinidae Rhumbler, 1895
Subfamily Jaculellinae Mikhalevich, 1995
Genus *Jaculella* Brady, 1879

Jaculella sp.

Pl. 1, fig. 10

2021 *Jaculella* sp. (Brady) – Kaminski et al., p. 345, pl. 1, fig. 14.

Remarks. Thinner and more finely agglutinated than the modern species *Jaculella acuta* Brady, 1879.

Family Hormosinellidae Rauser & Reitlinger, 1986
Genus *Caudammina* Montanaro-Gallitelli, 1955

Caudammina ovula (Grzybowski, 1896)

Pl. 1, fig. 11

1896 *Reophax ovulum* Grzybowski, p. 276, pl. 8, figs. 19-21.
1975 *Hormosina ovulum* (Grzybowski) – Webb, p. 834, pl. 2, figs. 1-2.
1988 *Hormosina ovulum ovulum* (Grzybowski) – Kaminski et al., p. 186, pl. 2, fig. 10 (with synonymy).
1997 *Hormosina ovulum* (Grzybowski) – Peryt et al. pl. 2, fig. 8.
2005 *Caudammina ovula* (Grzybowski) – Kaminski & Gradstein, p. 233, pl. 41, figs. 1a-8 (with synonymy).
2011 *Caudammina ovula* (Grzybowski) – Kaminski et al., p. 102, pl. 2, fig. 3.
2013 *Caudammina ovula* (Grzybowski) – Holbourn et al., p. 146, figs. 1-2.
2015 *Caudammina ovula* (Grzybowski) – Setoyama & Kaminski, p. 243, pl. 1, figs. 12-13.
2021 *Caudammina ovula* (Grzybowski) – Kaminski et al., p. 346, pl. 2, fig. 3.

Remarks. Wall is thick, finely agglutinated with smooth to medium surface.

Genus *Subreophax* Saidova, 1975

Subreophax aduncus (Brady, 1882)

Pl. 1, fig. 12a-b

1882 *Reophax aduncus* Brady, p. 715 (type figure not given).
1975 *Subreophax aduncus* (Brady) – Saidova, p. 57.
1990 *Subreophax aduncus* (Brady) – Charnock & Jones, p. 165, pl. 4, fig. 20; pl. 15, fig. 18.
2011 *Subreophax aduncus* (Brady) – Kaminski & Cetean, p. 64, pl. 2, figs. 4-6 (lectotype).
2011 *Subreophax aduncus* (Brady) – Kaminski et al., p. 87, pl. 2, figs. 14–16.
2015 *Subreophax aduncus* (Brady) – Setoyama & Kaminski, p. 243, pl. 1, fig. 16.
2021 *Subreophax aduncus* (Brady) – Kaminski et al., p. 346, pl. 2, fig. 6.

Remarks. Test meandering with uniform size, beadlike pseudochambers.

Subreophax longicameratus Kaminski et al., 2011

Pl. 1, fig. 13a-b

2011 *Subreophax longicameratus* Kaminski et al., p. 87, pl. 2, figs. 17-21, pl. 3, figs. 1-5
2015 *Subreophax longicameratus* Kaminski et al. – Setoyama & Kaminski, pl. 1, fig. 17.
2021 *Subreophax longicameratus* Kaminski et al. – Kaminski et al., p. 346, pl. 2, fig. 7.

Remarks. First described from the Upper Cretaceous at Contessa.

Subreophax scalaris (Grzybowski, 1896)

Pl. 1, fig. 14a-b, 15

1896 *Reophax guttifera* (Brady, 1896) var. *scalaria* Grzybowski, p. 277, pl. 8, fig. 26a, b.
1988 *Subreophax scalaria* (Grzybowski) – Kaminski et al., p. 187, pl. 2, figs. 16-17.
2005 *Subreophax scalaris* (Grzybowski) – Kaminski & Gradstein, p. 278, pl. 55, figs. 1–7.
2005 *Subreophax* sp. 1. Kaminski et al., p. 392, pl. 3, fig. 1.
2008a *Subreophax scalaris* (Grzybowski) – Kender et al., p. 122, pl. 4, figs. 12-13.
2008b *Subreophax scalaris* (Grzybowski) – Kender et al., p. 497, pl. 3, figs. 3-4.
2011 *Subreophax scalaris* (Grzybowski) – Kaminski et al., p. 87, pl. 3, fig. 7.
2011 *Subreophax scalaris* (Grzybowski) – Setoyama et al., p. 286, pl. 4, fig. 15.
2015 *Subreophax scalaris* (Grzybowski) – Setoyama & Kaminski, p. 243, pl. 1, fig. 18.
2015 *Subreophax scalaris* (Grzybowski) – Waśkowska, pl. 10, figs. s, t.
2020 *Subreophax scalaris* (Grzybowski) – Waśkowska et al., p. 65, pl. 20, figs. A–D.
2021 *Subreophax scalaris* (Grzybowski) – Kaminski et al., p. 346, pl. 2, fig. 8.

Remarks. Thin test wall with medium agglutinated. The chambers deflated, untidy alignment, increasing gradually in size.

Subreophax splendidus (Grzybowski, 1898)

Pl. 1, fig. 16a-b

1898 *Reophax splendida* Grzybowski, p. 278, pl. 10, figs. 9-10.
1993 *Subreophax splendidus* (Grzybowski) – Kaminski & Geroch, p. 251, pl. 3, figs. 11a-12b.
2011 *Subreophax splendidus* (Grzybowski) – Kaminski et al., p. 103, pl. 3, fig. 8.

Remarks. Wall coarsely agglutinated, test large, aperture small. The outline is irregular. Flattened pseudochambers.

Suborder **Ammodiscina** Mikhalevich, 1980
Superfamily Ammodiscoidea Reuss, 1862
Family Ammodiscidae Reuss, 1862
Subfamily Ammodiscinae Reuss, 1962

Genus *Ammodiscus* Reuss, 1962

Ammodiscus glabratus Cushman & Jarvis, 1928

Pl. 1, fig. 17a-b

1928 *Ammodiscus glabratus* Cushman & Jarvis, p. 87, pl. 12, fig. 6a, b.
1962 *Ammodiscus glabratus* (Cushman & Jarvis) – Hillebrandt, p. 25, pl. 1, fig. 3.
1970 *Grzybowskiella glabrata* (Cushman & Jarvis) – Mjatliuk, p. 71-72, pl. 12, fig. 7a-b.
1977 *Ammodiscus glabratus* (Cushman & Jarvis) – Krashenninikov & Pflaumann, p. 569, pl. 2, figs. 8-9.
1988 *Ammodiscus glabratus* (Cushman & Jarvis) – Kaminski et al., p. 184, pl. 3, fig. 8a-b.
2005 *Ammodiscus glabratus* (Cushman & Jarvis) – Kaminski & Gradstein, p. 148, pl. 15, figs. 1a–6.
2011 *Ammodiscus glabratus* (Cushman & Jarvis) – Kaminski et al., p. 101, pl. 1, fig. 10.
2011 *Ammodiscus glabratus* (Cushman & Jarvis) – Setoyama et al., p. 266, pl. 2, fig. 11a, b.
2021 *Ammodiscus glabratus* (Cushman & Jarvis) – Kaminski et al., p. 347, pl. 2, fig. 14.

Remarks. Wall finely agglutinated, surface is smooth, the coil chamber steadily increase in size, planispiral, test free, involute coiling, minimum coil suture.

Ammodiscus peruvianus Berry, 1928

Pl. 1, figs. 18 and 19

1928 *Ammodiscus peruvianus* Berry, p. 403, pl. 27.
1959 *Ammodiscus cf. A. incertus* (d'Orbigny) – Mallory, p. 108, pl. 1, fig. 11a-b.
1967 *Ammodiscus* sp. (aff. *gorlicensis* Grzybowski) – Jurkiewicz, p. 58, pl. 2, figs. 10, 12.
1976 *Ammodiscus peruvianus* (Berry) – Rögl, pl. 2, fig. 23.
1981 *Ammodiscus peruvianus* (Berry) – Gradstein & Berggren, p. 241, pl. 2, figs. 14-15.
1988 *Ammodiscus peruvianus* (Berry) – Kaminski et al., p. 185, pl. 3, figs. 11-12.

Plate 1

Deep-water agglutinated foraminifera from the Danian of Contessa Highway, Gubbio, Italy.

1a-b) *Bathysiphon* sp., CON-1; 2a-c) *Nothia excelsa* (Grzybowski), CON-1; 3-5) *Psammosiphonella cylindrica* (Glaessner), 3 - CON-1; 4 - CON-10A; 5 - CON-14; 6a-b) *Rhizammina* sp. 1., CON-7; 7) *Rhizammina* sp. 2., CON-3; 8-9) *Saccammina grzybowskii* (Schubert), 8 - CON-9; 9 - CON-14; 10) *Jaculella* sp., CON-0.6; 11) *Caudammina ovula* (Grzybowski), CON-12; 12a-b) *Subreophax aduncus* (Brady), CON-14; 13a-b) *Subreophax longicameratus* Kaminski et al., CON-0.6; 14a-b) *Subreophax scalaris* (Grzybowski), CON-0.7; 15) *Subreophax scalaris* (Grzybowski), CON-0.6; 16a-b) *Subreophax splendidus* (Grzybowski), CON-2; 17a-b) *Ammodiscus glabratus* Cushman & Jarvis, CON-5; 18-19) *Ammodiscus peruvianus* Berry, 18 - CON-4; 19 - CON-11.

All scale bars 100 µm.

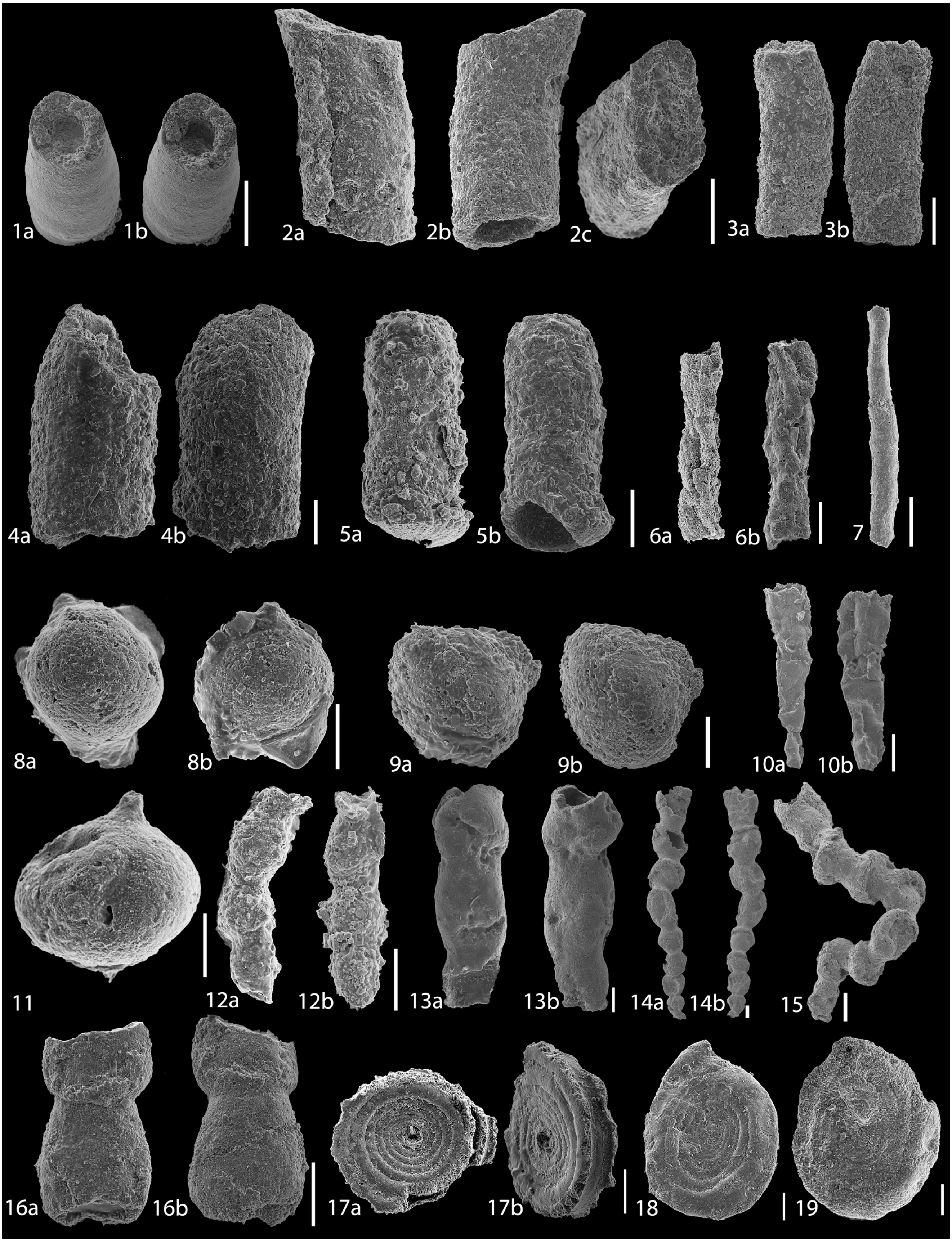
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PLATE 1

1997 *Ammodiscus peruvianus* (Berry) – Peryt et al., pl. 2, fig. 9.
2005 *Ammodiscus peruvianus* (Berry) – Kaminski & Gradstein, p. 157, pl. 18, figs. 1-6.
2011 *Ammodiscus peruvianus* (Berry) – Kaminski et al., p. 101, pl. 1, figs. 11-12.

Remarks. Wall finely agglutinated, test medium, surface is smooth, the coil is planispiral, coiling involute. The chambers increase in size, not fully rounded, slightly elliptical.

Subfamily Usbekistaniinae Vialov, 1968
Genus *Glomospira* Rzehak, 1885

Glomospira demarginata (Grzybowski, 1898)
Pl. 2, fig. 1a-b

1898 *Ammodiscus demarginatus* Grzybowski, p. 284, pl. 10, fig. 34.
1993 *Glomospira demarginata* (Grzybowski) – Kaminski & Geroch, p. 300, pl. 6, fig. 1.

Remarks. Test finely agglutinated, coiling circular, ending in an uncoiling tube.

Glomospira glomerata (Grzybowski, 1898)
Pl. 2, figs. 2-3

1898 *Ammodiscus glomeratus* Grzybowski, p. 285, pl. 11, fig. 4.
1898 *Ammodiscus serpens* Grzybowski, pl. 10, fig. 32, 33.
1970 *Tolypammina prava*, Mjatliuk, p. 74, pl. 1 & 17, fig. 15 & 2.
1977 *Glomospira glomerata* (Grzybowski) – Samuel, p. 28, pl. 23, figs. 1-2.
1988 *Glomospira glomerata* (Grzybowski) – Kaminski et al., p. 185, pl. 3, fig. 16.
2005 *Glomospira glomerata* (Grzybowski) – Kaminski & Gradstein, p. 178, pl. 24, figs. 1-6.

Remarks. Extensive, meandering s-shaped coils, wall is thick and coarsely agglutinated. Aperture at the open end of the tube

Glomospira gordialis (Jones & Parker, 1860)
Pl. 2, fig. 4

1860 *Trochammina squamata* Jones & Parker, var. *gordialis* Jones & Parker, p. 304.
1928 *Glomospira gordialis* (Jones & Parker) – Cushman & Jarvis, p. 87, pl. 12 fig. 7.
1967 *Glomospira gordialis* (Jones & Parker) – Jurkiewicz, p. 59-60, pl. 2, fig. 23; textfigure 8a-d.
1988 *Glomospira gordialis* (Jones & Parker) – Kaminski et al., p. 185, pl. 3, fig. 17.
1990 *Glomospira gordialis* (Jones & Parker) – Berggren & Kaminski, p. 73, pl. 1, fig. 1.
2005 *Glomospira gordialis* (Jones & Parker) – Kaminski & Gradstein, p. 181, pl. 25, figs. 1-8.
2011 *Glomospira gordialis* (Jones & Parker) – Kaminski et al., p. 101, pl. 1, fig. 14.

Remarks. Test finely agglutinated with smooth surface. Outline is circular. The coil is streptospiral in the center. Aperture at the top bottom of the tube.

"Glomospira" irregularis (Grzybowski, 1898)
Pl. 2, fig. 5a-c

1898 *Ammodiscus irregularis* Grzybowski, p. 285, pl. 11, figs. 2, 3.
1937 *Glomospira irregularis* (Grzybowski) – Glaessner, p. 359, pl. 1, fig. 7.
1955 *Glomospira irregularis* (Grzybowski) – Maslakova, p. 45-46, pl. 3, fig. 3.
1967 *Glomospira irregularis* (Grzybowski) – Jurkiewicz, p. 61-62, pl. 2, figs. 18-19; text figure 9a-c.
1981 *Glomospira irregularis* (Grzybowski) – Gradstein & Berggren, p. 246, pl. 3, figs. 1-4.
1982 *Glomospira irregularis* (Grzybowski) – Miller et al., p. 19, pl. 1, fig. 12.
1984 *Glomospira irregularis* (Grzybowski) – Hemleben & Troester, p. 519, pl. 1, fig. 22.
1988 *Glomospira irregularis* (Grzybowski) – Kaminski et al., p. 185, pl. 3, figs. 20-21.
1990 *Glomospira* (*Tolypammina*?) *irregularis* (Grzybowski). – Kuhnt, p. 311, pl. 1, fig. 12.
1993 *Glomospira irregularis* (Grzybowski) – Kaminski & Geroch, p. 256, pl. 6, figs. 6–8b.
2005 *"Glomospira" irregularis* (Grzybowski) – Kaminski & Gradstein, p. 185, pl. 26, figs. 1a–7 (with synonymy).
2011 *"Glomospira" irregularis* (Grzybowski) – Setoyama et al., p. 272, pl. 3, fig. 20; pl. 7, fig. 1.
2011 *"Glomospira" irregularis* (Grzybowski) – Kaminski et al., p. 85, pl. 1, fig. 15.
2015 *"Glomospira" irregularis* (Grzybowski) – Setoyama & Kaminski, p. 243, pl. 2, figs. 6-7.
2021 *"Glomospira" irregularis* (Grzybowski) – Kaminski et al., p. 347, pl. 3, fig. 3.

Remarks. Streptospiral coiling, wall thick with medium agglutinated, rough surface, undivided tube of fairly constant diameter. The tube coiled with small whorls in irregular direction.

Glomospira sp. 4
Pl. 2, fig. 6a-c

2005 *Glomospira* sp. 4 Kaminski & Gradstein, p. 198, pl. 30, figs. 1-9.
2021 *Glomospira* sp. 4 Kaminski & Gradstein – Kaminski et al., p. 348, pl. 3, figs. 4-5.

Remarks. Coiling is glomospiral, becoming irregular. The species was first reported from the Paleogene of the North Sea.

Genus *Repmanina* Suleymanov, in Arapova & Suleymanov, 1966

Repmanina charoides (Jones & Parker, 1860)
Pl. 2, figs. 7a-c and 8a-c

1860 *Trochammina squamata* var. *charoides* Jones & Parker, p. 304 (type figure not given).
1990 *Glomospira charoides* (Jones &Parker). – Berggren & Kaminski, p. 60, pl. 1, fig. 2 (lectotype).
1990 *Glomospira charoides* (Jones &Parker) – Kuhnt, p. 311, pl. 1, figs. 9, 10.
2001 *Repmanina charoides* (Jones & Parker) – Alegret & Thomas, p. 201, pl. 10, fig. 11.
2005 *Glomospira charoides* (Jones &Parker) – Kaminski & Gradstein, p. 168, pl. 22, figs. 1–16 (with synonymy).
2011 *Repmanina charoides* (Jones & Parker) – Kaminski et al., p. 86, pl. 1, fig. 17a, b.
2011a *Repmanina charoides* (Jones & Parker) – Setoyama et al., p. 283, pl. 3, figs. 22-23.
2013 *Glomospira charoides* (Jones & Parker) – Holbourn et al., p. 268, fig. 1.
2021 *Repmanina charoides* (Jones & Parker) – Kaminski et al., p. 348, pl. 3, fig. 6.

Remarks. Aperture is small and indistinct.

Superfamily Lituotuboidea Loeblich & Tappan, 1984
Family Lituotubidae Loeblich & Tappan, 1984
Genus *Lituotuba* Rhumbler, 1895

Lituotuba lituiformis (Brady, 1879)

Pl. 2, fig. 9a-c

1879 *Trochammina lituiformis* Brady, p. 59, pl. 5, fig. 16.
1928 *Lituotuba lituiformis* (Brady) – Cushman & Jarvis p. 90, pl. 12, fig. 15a-b.
1967 *Trochammina lituiformis* (Brady) – Jurkiewicz, p. 65-67, pl. 3, figs. 2-3; text figure 12a-g.
1988 *Lituotuba lituiformis* (Brady) – Kaminski et al., p. 190, pl. 4, figs. 14-15.
1990 *Lituotuba lituiformis* (Brady) – Kuhnt, p. 318, pl. 1, figs. 17, 18.
2005 *Lituotuba lituiformis* (Brady) – Kaminski & Gradstein, p. 287, pl. 58, figs. 1–8.
2008a *Lituotuba lituiformis* (Brady) – Kender et al., p. 123, pl. 5, fig. 17.
2011 *Lituotuba lituiformis* (Brady) – Kaminski et al., p. 88, pl. 3, fig. 12.
2013 *Lituotuba lituiformis* (Brady) – Holbourn et al., p. 340, fig. 1.
2015 *Lituotuba lituiformis* (Brady) – Setoyama & Kaminski, p. 245, pl. 2, fig. 8.
2021 *Repmanina charoides* (Jones & Parker) – Kaminski et al., p. 348, pl. 3, fig. 6.

Remarks. Streptospiral tube with 3-4 whorls, uncoiling in the latter part. The coiled part is initially undivided and later develops chambers (or pseudochambers). Wall finely agglutinated, medium and imperforate.

Genus *Paratrochamminoides* Soliman 1972

Paratrochamminoides draco (Grzybowski, 1901)

Pl. 2, fig. 10a-b

1901 *Trochammina draco* Grzybowski, p. 280, pl. 8, fig. 10.
1993 *Paratrochamminoides draco* (Grzybowski) – Kaminski & Geroch, p. 277, pl. 16, fig. 5a-c.
1995 *Paratrochamminoides draco* (Grzybowski) – Bubík, p. 84, pl. 3, fig. 2.

Remarks. Coiling initially glomospiral, wall thick and finely agglutinated.

Paratrochamminoides gorayskii (Grzybowski, 1898)

Pl. 2, fig. 11a-c

1898 *Ammodiscus gorayskii* Grzybowski, p. 283, pl. 11, fig. 5.
1993 *Paratrochamminoides gorayskii* (Grzybowski) – emend. Kaminski & Geroch, pl. 2, fig. 7a-c.
1993 *Paratrochamminoides gorayskii* (Grzybowski) – Kaminski & Geroch, p. 255, pl. 5, fig. 8a–d.
2005 *Paratrochamminoides gorayskii* (Grzybowski) – Kaminski & Gradstein, p. 297, pl. 61, figs. 1a–5.
2008a *Paratrochamminoides gorayskii* (Grzybowski) – Kender et al., p. 123, pl. 6, fig. 9.
2011a *Paratrochamminoides gorayskii* (Grzybowski) – Setoyama et al., p. 278, pl. 5, figs. 9, 10.
2011 *Paratrochamminoides gorayskii* (Grzybowski) – Kaminski et al., p. 89, pl. 4, figs. 1, 2.
2015 *Paratrochamminoides gorayskii* (Grzybowski) – Setoyama & Kaminski, p. 245, pl. 2, fig. 9.
2021 *Paratrochamminoides gorayskii* (Grzybowski) – Kaminski et al., p. 348, pl. 2, fig. 12.

Remarks. Test relatively small, slightly oval outline, coiling triloculine, wall thick, medium to finely agglutinated, medium to rough surface.

Paratrochamminoides heteromorphus (Grzybowski, 1898)

Pl. 2, fig. 12

1898 *Trochammina heteromorpha* Grzybowski, p. 286, pl. 11, fig. 16.
1990 *Paratrochamminoides heteromorphus* (Grzybowski) – Kuhnt, p. 320, pl. 5, fig. 18.
1993 *Paratrochamminoides heteromorphus* (Grzybowski) – Kaminski & Geroch, p. 258, pl. 7, figs. 4, 5.
2004 *Paratrochamminoides heteromorphus* (Grzybowski) – Kaminski & Kuhnt, p. 281, (no figure given).
2005 *Paratrochamminoides heteromorphus* (Grzybowski) – Kaminski & Gradstein, p. 298, pl. 62, figs. 1–10 (with synonyms).

Remarks. Test glomospiral to irregular trochospiral. Coiling in three whorls and uncoiling in the terminal part. Chambers are the same size. Wall is medium agglutinated, rough surface.

Paratrochamminoides olszewskii (Grzybowski 1898)

Pl. 2, fig. 13a-c

1898 *Trochammina olszewskii* Grzybowski, p. 298, pl. 11, fig. 6.

1993 *Paratrochamminoides olszewskii* (Grzybowski) – Kaminski & Geroch, p. 257, pl. 7, figs. 1, 2.
2004 *Paratrochamminoides olszewskii* (Grzybowski) – Kaminski & Kuhnt, p. 282, (no figure given).
2005 *Paratrochamminoides olszewskii* (Grzybowski) – Kaminski & Gradstein, p. 305, pl. 64, figs. 1a–7.
2008a *Paratrochamminoides olszewskii* (Grzybowski) – Kender et al., p. 123, pl. 6, figs. 10-11.
2008b *Paratrochamminoides olszewskii* (Grzybowski) – Kender et al., p. 499, pl. 4, fig. 3.
2011 *Paratrochamminoides olszewskii* (Grzybowski) – Kaminski et al., p. 104, pl. 3, fig. 4.

Remarks. Glomospiral coiling and long tubular chambers in the whorls, inside and outer part. Test is rounded slightly oval. Wall is finely agglutinated with rough surface. Aperture at the opening end of the tube. The species *Paratrochamminoides kaminskii* Zerfass et al. 2022 described from Barremian shallow-water sediments in Brazil differs in possessing low trochospiral coiling. This species may be the ancestral form of the group of Late Cretaceous to Paleogene forms with sausage-shaped chambers.

Paratrochamminoides sp.

Pl. 2, fig. 14a-b

Remarks. Test is small to medium, glomospirally coiled. Wall medium to finely agglutinated. Aperture indistinct.

Family Trochamminoidae Haynes & Nwabufo-Ene, 1998

Genus *Trochamminoides* Cushman, 1910

Trochamminoides dubius (Grzybowski)

Pl. 3, fig. 1a-c

1901 *Ammodiscus dubius* Grzybowski, p. 274, pl. 8, figs. 12, 14.
1970 *Trochamminoides dubius* (Grzybowski) – Neagu, p. 38, pl. 2, fig. 20.
1988 *Trochamminoides dubius* (Grzybowski) – Kaminski et al., p. 191, pl. 4, figs. 16-17.
1990 *Trochamminoides dubius* (Grzybowski) – Kuhnt, p. 326, pl. 5, fig. 11.
1993 *Trochamminoides dubius* (Grzybowski) – Kaminski & Geroch, p. 275, pl. 15, fig. 9.
2005 *Trochamminoides dubius* (Grzybowski) – Kaminski & Gradstein, p. 308, pl. 65, figs. 1–8.
2011 *Trochamminoides dubius* (Grzybowski) – Kaminski et al., p. 89, pl. 3, figs. 13-14.
2021 *Trochamminoides dubius* (Grzybowski) – Kaminski et al., p. 349, pl. 3, fig. 18.

Remarks. Test small, planispiral to slightly glomospiral with four or five chambers in the last whorl. Wall coarsely agglutinated with a rough surface, Aperture interiomarginal.

Trochamminoides folius (Grzybowski, 1898)

Pl. 3, fig. 2a-b

1898 *Trochammina folium* Grzybowski, p. 288, pl. 11, figs. 7-9.
1993 *Trochamminoides folius* (Grzybowski) – Kaminski & Geroch, p. 71-116, pl. 11, fig. 5.
1995 *Trochamminoides folius* (Grzybowski) – Bubík, p. 326, pl. 5, fig. 11.
2020 *Trochamminoides folius* (Grzybowski) – Waśkowska et al., p. 77, pl. 25, fig. A.

Remarks. Test finely agglutinated, flattened with oval in outline. The coiling is triloculine followed by planispiral. The final stage starts to uncoil. Chambers are large, oval, and elongated in the coiling direction.

Trochamminoides proteus (Karrer, 1866)

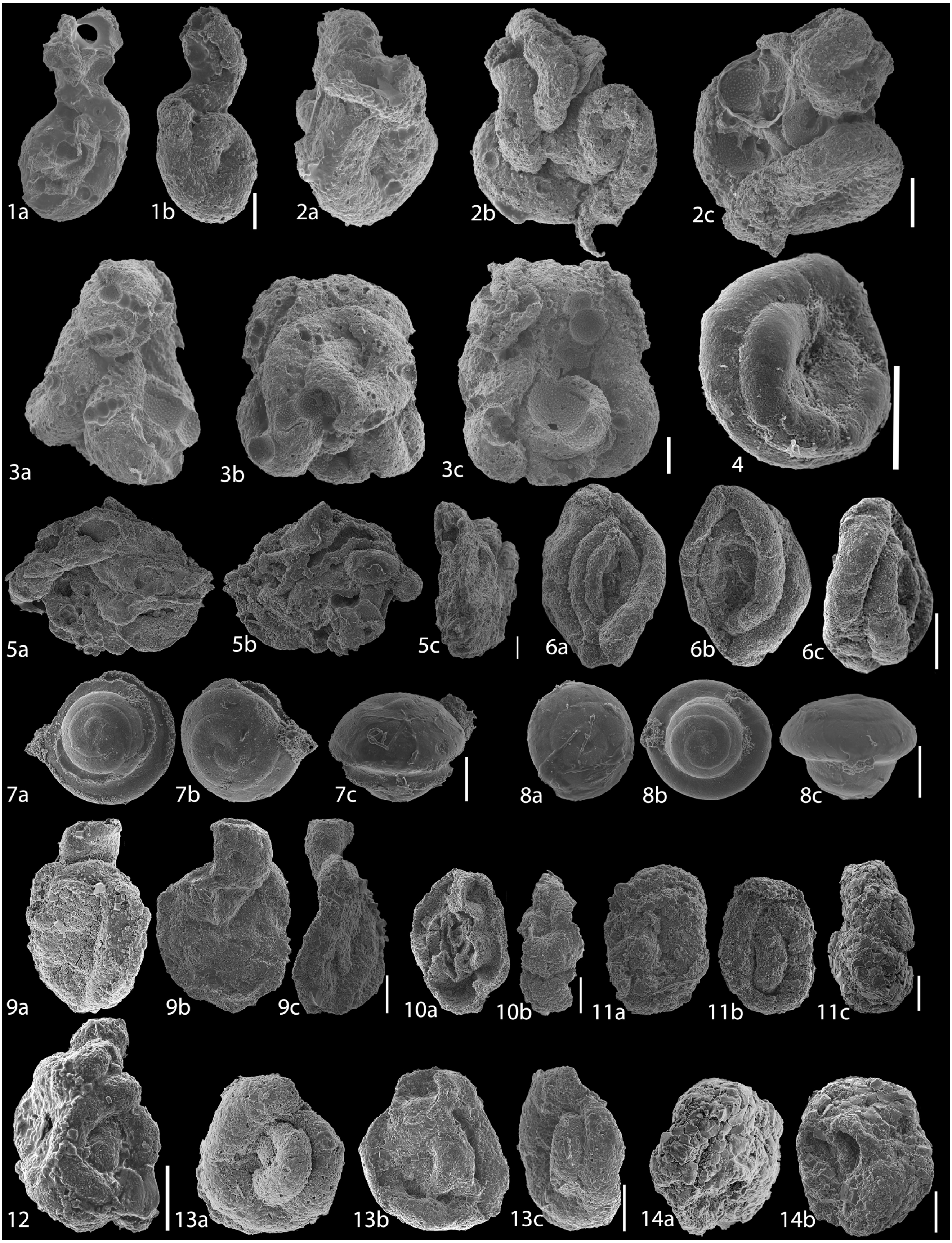
Pl. 3, fig. 3a-c

1866 *Trochammina proteus* Karrer, p. 494, pl. 1, fig. 8.
1928 *Trochamminoides proteus* (Karrer) – White, p. 308, pl. 5, fig. 5a-b.
1977 *Trochamminoides proteus* (Karrer) – Samuel, p. 46-47, pl. 4, fig. 20.
1988 *Trochamminoides proteus* (Karrer) – Kaminski et al., p. 192, pl. 4, fig. 20.
1995 *Trochamminoides proteus* (Karrer) – Rögl, p. 255, pl. 25, figs. 1-6.
2005 *Trochamminoides proteus* (Karrer) – Kaminski & Gradstein, p. 314, pl. 67, figs. 1–5.
2021 *Trochamminoides proteus* (Karrer) – Kaminski et al., p. 349.

Remarks. Test planispiral, oval in outline with inline part coiled more sporadic. Chambers globular, rounded and increase in size gradually. Chambers around 6 for small specimens, and more than 10 chambers for large specimens. Wall finely agglutinated.

Plate 2

Deep-water agglutinated foraminifera from the Danian of Contessa Highway, Gubbio, Italy.
1a-b) *Glomospira demarginata* (Grzybowski), CON-1.0; 2-3) *Glomospira glomerata* (Grzybowski), CON-1.0; 4) *Glomospira gordialis* (Jones & Parker), CON-3; **5a-c.** "*Glomospira*" *irregularis* (Grzybowski), CON-9; 6a-c) *Glomospira*(?) sp. 4, CON-11; 7-8) *Repmanina charoides* (Jones & Parker), 7. CON-1; 8. CON-8; 9a-c) *Lituotuba lituiformis* (Brady), CON-10B; 10a-b) *Paratrochamminoides draco* (Grzybowski), CON-10B; 11a-c) *Paratrochamminoides gorayskii* (Grzybowski), CON-12; 12) *Paratrochamminoides heteromorphus* (Grzybowski), CON-3; 13a-c) *Paratrochamminoides olszewskii* (Grzybowski), CON-13; 14a-b) *Paratrochamminoides* sp., CON-5.
All scale bars 100 μm.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13a
13b
13c
14a
14b

Plate 2

Trochamminoides subcoronatus (Grzybowski 1896)

Pl. 3, figs. 4a-c and 5

1896 *Trochammina subcoronata* Grzybowski, p. 287, pl. 11, fig. 3.
1898 *Trochammina subcoronata* Grzybowski, p. 290, pl. 11, figs. 26-27.
1967 *Trochamminoides subcoronatus* (Grzybowski) – Jurkiewicz, p. 71-72, pl. 3, fig. 15; textfigure 14.
1988 *Trochamminoides subcoronatus* (Grzybowski) – Kaminski et al., p. 192, pl. 4, fig. 19.
1997 *Trochamminoides subcoronatus* (Grzybowski) – Peryt et al., pl. 1, figs. 4, 12.
2005 *Trochamminoides subcoronatus* (Grzybowski) – Kaminski & Gradstein, p. 318, pl. 68, figs. 1-6.
2017 *Trochamminoides subcoronatus* (Grzybowski) – Setoyama et al., p. 197, pl. 1, fig. 26.
2020 *Trochamminoides subcoronatus* (Grzybowski) – Waśkowska et al., p. 84, pl. 28, figs. A-D.

Remarks. Test finely agglutinated, oval in outline, coiled in an irregular planispire.

Trochamminoides sp.

Pl. 3, fig. 6a-c

Remarks. Test near planispiral, long elongated outline coiled. 6-7 chambers. Wall finely agglutinated with a smooth surface.

Subclass GLOBOTHALAMANA Pawlowski, Holzmann & Tyszka 2013
Order **Lituolida** Lankester, 1885
Suborder **Hormosinina** Mikhalevich, 1980
Superfamily Hormosinoidea Haeckel, 1894
Family Aschemocellidae Vialov, 1966
Genus *Arthrodendron* Ulrich 1904

Arthrodendron sp.

Pl. 3, figs. 7-9

Remarks. species based on broken fragments with a preserved aperture, consisting of multiple openings each with a short neck, in a circular or rectangular pattern.

Genus *Kalamopsis* de Folin 1883

Kalamopsis grzybowskii (Dylążanka, 1923)

(Pl. 3, fig. 10a-b)

1923 *Hyperammina grzybowskii* Dylążanka, p. 65-66.
1950 *Bathysiphon nodosariaformis* Subbotina, p. 67, pl. 4, figs. 1-7.
1964 *Bathysiphon nodosariaformis* (Subbotina) – Bulatova & Subbotina, p. 87, pl. 3, figs. 1-8.
1964 *Kalamopsis grzybowskii* (Dylążanka) – Pflaumann, p. 79-80, pl. 10, figs. 14-15.
1972 *Kalamopsis grzybowskii* (Dylążanka) – Hanzliková, p. 36, pl. 2, fig. 8.
1975 *Kalamopsis grzybowskii* (Dylążanka) – Webb, p. 834, pl. 1, figs. 18-19.
1984 *Kalamopsis grzybowskii* (Dylążanka) – Hemleben & Troester, p. 550, pl. 2, figs. 3-5.
1988 *Kalamopsis grzybowskii* (Dylążanka) – Kaminski et al., p. 186, pl. 1, figs. 18-20.
1990 *Kalamopsis grzybowskii* (Dylążanka) – Kuhnt, p. 318, pl. 2, fig. 15.
2005 *Kalamopsis grzybowskii* (Dylążanka) – Kaminski & Gradstein, p. 252, pl. 47, figs. 1-12 (with synonymy).
2008 *Kalamopsis grzybowskii* (Dylążanka) – Waśkowska-Oliwa, p. 249-250, pl. 4, figs. 3-5.
2011 *Bathysiphon nodosariaformis* (Subbotina) – Setoyama et al., p. 269, pl. 1, fig. 4.
2011 *Kalamopsis grzybowskii* (Dylążanka) – Setoyama et al., p. 277, pl. 4, figs. 18-19.
2013 *Kalamopsis grzybowskii* (Dylążanka) – Holbourn et al., p. 316, figs. 1-2.
2015 *Bathysiphon nodosariaformis* (Subbotina) – Setoyama & Kaminski, p. 241, pl. 1, fig. 2.
2015 *Kalamopsis grzybowskii* (Dylążanka) – Setoyama & Kaminski, p. 245, pl. 2, fig. 12.
2017 *Bathysiphon nodosariaformis* (Subbotina) – Setoyama et al., p. 187, pl. 1, fig. 2.
2021 *Kalamopsis grzybowskii* (Dylążanka) – Kaminski et al., p. 349, pl. 4, fig. 6.

Remarks. Test cylindrical, long tubular chambers separated by internal membrane tissue. Chamber is tubular, straight form, bloated in the middle part. Test wall is thin, finely agglutinated. Aperture at the end of the tube.

Family Reophacidae Cushman, 1927
Genus *Reophax* de Montfort, 1808

Reophax sp. 2

Pl. 3, figs. 11a-b and 12a-b

Plate 3

Deep-water agglutinated foraminifera from the Danian of Contessa Highway, Gubbio, Italy.
1a-c) *Trochamminoides dubius* (Grzybowski), CON-4; 2a-b) *Trochamminoides folius* (Grzybowski), CON-0.8; 3a-c) *Trochamminoides proteus* (Karrer), CON-1.0; 4a-c) *Trochamminoides subcoronatus* (Grzybowski), CON-1.0; 5) *Trochamminoides subcoronatus* (Grzybowski), CON-0.6; 6a-c) *Trochamminoides* sp., CON-0.7; 7-9) *Arthrodendron* sp., 7 - CON-0.8; 8 - CON-0.8; 9 - CON-1.0; 10a-b) *Kalamopsis grzybowskii*, CON-0.6; 11-12) *Reophax* sp. 2., 11 - CON-1; 12 - CON-10A; 13-14) *Reophax* sp. 3., 13 - CON-3; 14 - CON-8.
All scale bars 100 µm.

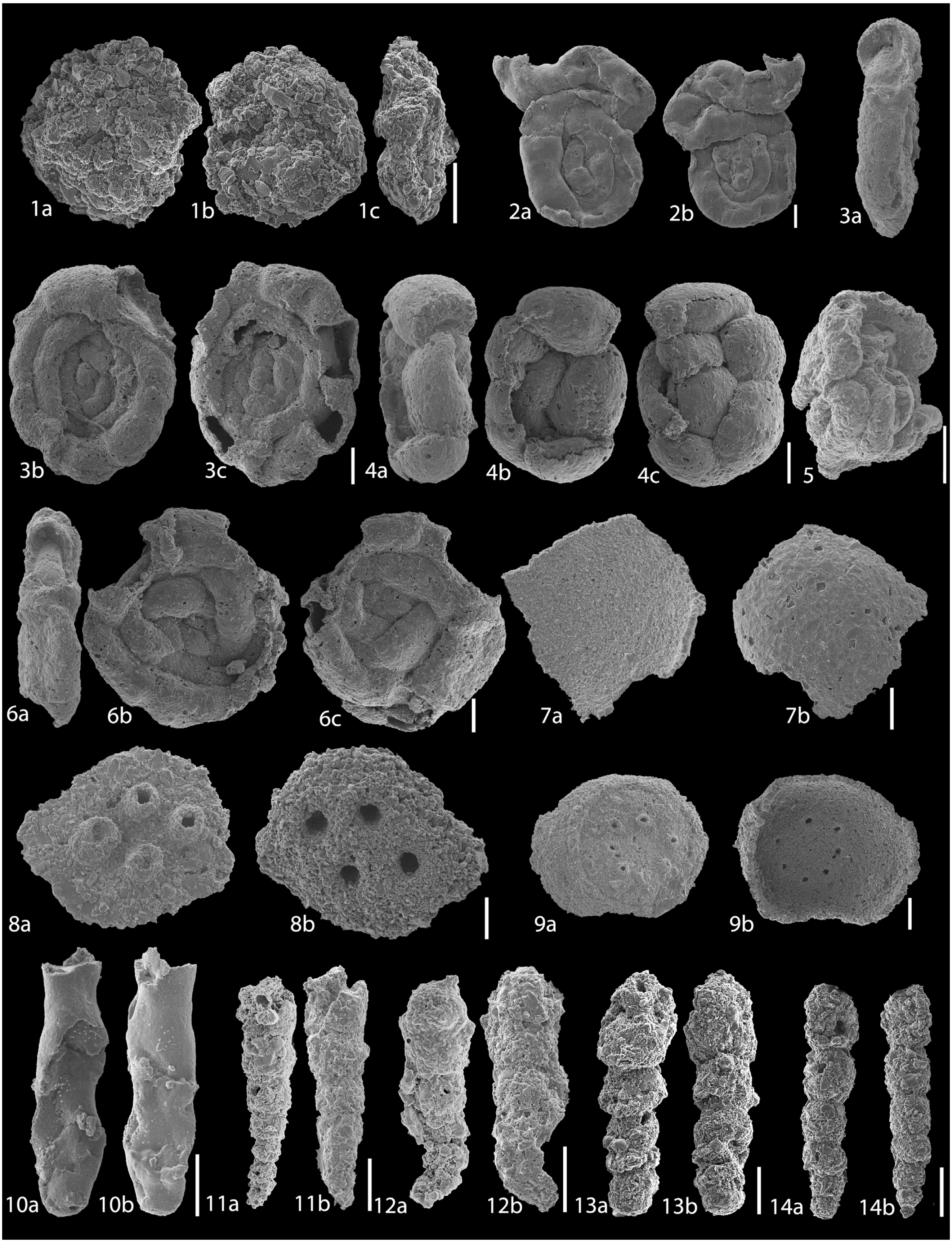
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Plate 3

Remarks. Test is straight to curved, with enlarging globular chambers; wall coarse, large grains.

Reophax sp. 3

Pl. 3, figs. 13a-b and 14a-b

1990 *Reophax* sp. 3 Kuhnt, p. 324, pl. 3, fig. 10.
2011 *Reophax* sp. 3 (Kuhnt) – Kaminski et al, p. 88, pl. 3, fig. 10.

Remarks. Test large, uniserial, straight, consisting of 5-6 chambers increasing in size. Wall coarsely agglutinated. Aperture terminal, rounded.

Suborder **Lituolina** Lankester, 1885
Superfamily Lituoloidea de Blainville, 1827
Family Haplophragmoididae Maync, 1952
Genus *Haplophragmoides* Cushman, 1910

Haplophragmoides pervagatus Krasheninnikov, 1973

Pl. 4, figs. 1a-b and 2a-b

1973 *Haplophragmoides pervagatus* Krasheninnikov, p. 215, pl. 1, fig. 7.
2011 *Haplophragmoides pervagatus* Krasheninnikov – Kaminski et al., p. 90, pl. 4, fig. 11.

Remarks. Test coarsely agglutinated, coiling planispiral, round in outline, chambers about the same size, around 3 whorls.

Superfamily Recurvoidoidea Alekseychik-Mitskevich, 1973
Family Ammosphaeroidinidae Cushman, 1927
Subfamily Ammosphaeroidininae Cushman, 1927
Genus *Ammosphaeroidina* Cushman, 1910

Ammosphaeroidina pseudopauciloculata (Mjatliuk, 1966)

Pl. 4, fig. 3a-b

1966 *Cystamminella pseudopauciloculata* Mjatliuk, p. 246, pl. 1, figs. 5–7; pl. 2, fig. 6; pl. 3, fig. 3.
1988 *Ammosphaeroidina pseudopauciloculata* (Mjatliuk) – Kaminski et al., p. 193, pl. 8, figs. 3a–5.
2005 *Ammosphaeroidina pseudopauciloculata* (Mjatliuk) – Kaminski & Gradstein, p. 376, pl. 87a, figs. 1a–5; pl. 87b, figs. 1a–10 (with synonymy).
2008 *Ammosphaeroidina pseudopauciloculata* (Mjatliuk) – Waśkowska-Oliwa, p. 247, pl. 8, figs. 5–6.
2008a *Ammosphaeroidina pseudopauciloculata* (Mjatliuk) – Kender et al., p. 501, pl. 6, fig. 7.
2011 *Ammosphaeroidina pseudopauciloculata* (Mjatliuk) – Kaminski et al., p. 91, pl. 4, fig. 16.
2011a *Ammosphaeroidina pseudopauciloculata* (Mjatliuk) – Setoyama et al., p. 268, pl. 11, figs. 2, 3.
2015 *Ammosphaeroidina pseudopauciloculata* (Mjatliuk) – Setoyama & Kaminski, p. 246, pl. 3, fig. 4.
2021 *Ammosphaeroidina pseudopauciloculata* (Mjatliuk) – Kaminski et al., p. 354. pl. 5, fig. 1.

Remarks: Test medium, finely agglutinated with smooth surface, flattened. Coiling streptospiral, chambers oval in outline. Wall thin, the chambers increase rapidly in size.

Ammosphaeroidina sp.

Pl. 4, fig. 4

Remarks. Test involute and three chambers shows in the whorl with coiling streptospiral, wall finely agglutinated with a smooth surface, chambers are spherical.

Superfamily Recurvoidoidea Alekseychik-Mitskevich, 1973
Family Ammosphaeroidinidae Cushman, 1927
Subfamily Recurvoidinae Alekseychik-Mitskevich, 1973
Genus *Cribrostomoides* Cushman, 1910

Cribrostomoides subglobosus Cushman, 1910

Pl. 4, fig. 5a-b

1869 *Lituola subglobosa* M. Sars, p. 250
1910 *Haplophragmoides subglobosum* (Sars) – Cushman, p. 105, figs. 162-164.
1993 *Cribrostomoides subglobosus* (Cushman) forma *subglobosus* – Jones et al., pl. 1, figs. 1–5; pl. 2, figs. 6–8; pl. 3, figs. 1–7.
2005 *Cribrostomoides subglobosus* (Cushman) – Kaminski & Gradstein, p. 391, pl. 92, figs. 1–3.
2008a *Cribrostomoides subglobosus* (Cushman) – Kender et al., p. 126, pl. 9, fig. 8.
2008b *Cribrostomoides subglobosus* (Cushman) – Kender et al., p. 502, pl. 6, fig. 9.

Plate 4

Deep-water agglutinated foraminifera from the Danian of Contessa Highway, Gubbio, Italy.
1-2) *Haplophragmoides pervagatus* Krasheninnikov, 1- CON-3; 2 - CON-4; 3a-b) *Ammosphaeroidina pseudopauciloculata* (Mjatliuk), CON-1; 4a-c) *Ammosphaeroidina* sp., CON-0.6; 5a-b) *Cribrostomoides subglobosus* Cushman, CON-0.6; 6a-b) *Recurvoidella* sp., CON-6; 7a-c) *Recurvoides* spp., CON-10B; 8-9) *Bolivinopsis rosula* (Ehrenberg), 8 - CON-11; 9 - CON-13; 10-11) *Spiroplectinella israelskyi* Hillebrandt, 10 - CON-9; 11 - CON-12; 12a-b) *Spiroplectammina spectabilis* (Grzybowski), CON-6; 13a-b) *Rashnovammina munda* Krasheninnikov, CON-0.6.
All scale bars 100 μm.

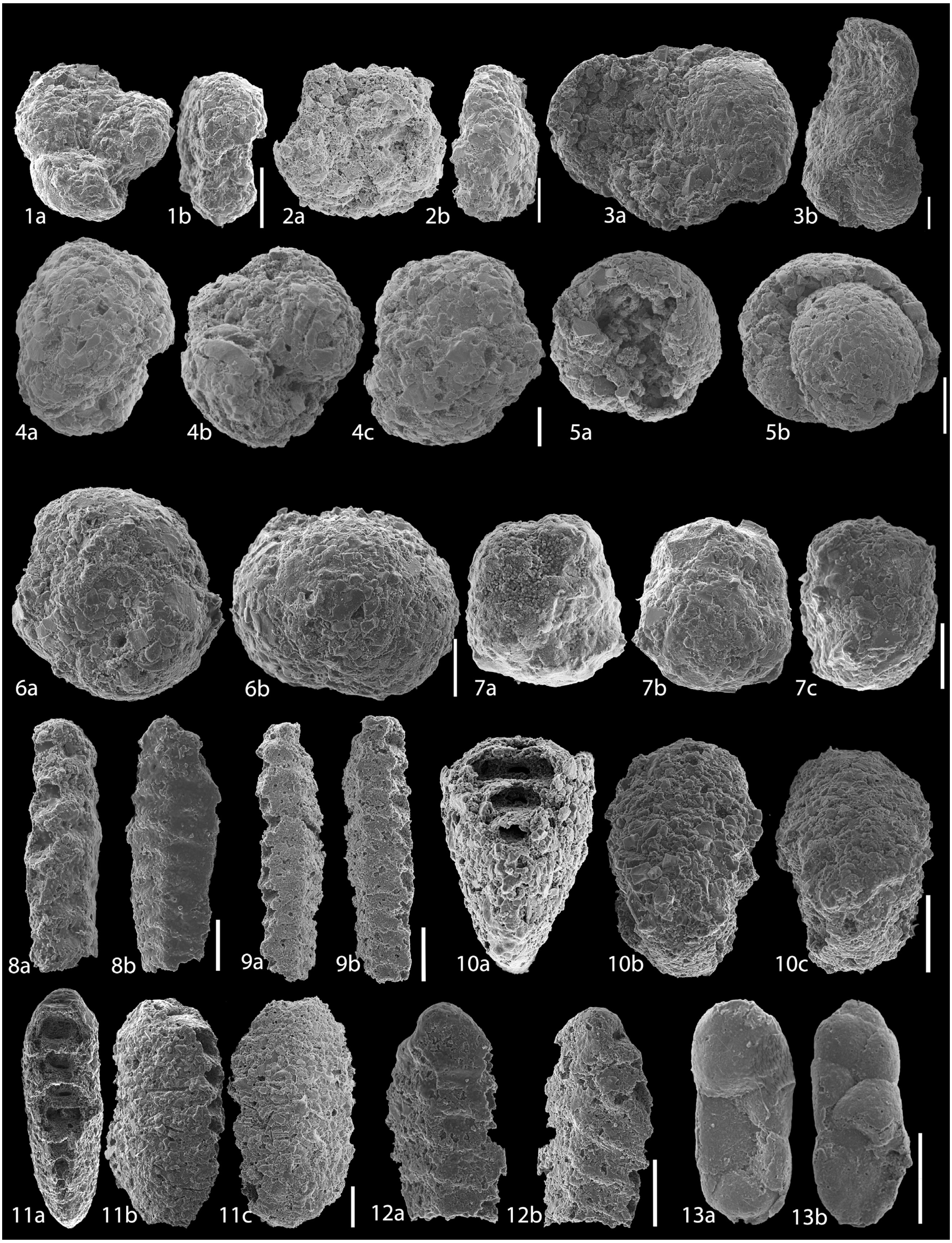
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Plate 4

2013 *Cribrostomoides subglobosus* (Cushman) – Holbourn et al., p. 220, pl. 6, figs. 1-2.
2017 *Cribrostomoides subglobosus* (Cushman) – Setoyama et al., p. 188, pl. 2, figs. 7.
2021 *Cribrostomoides subglobosus* (Cushman) – Kaminski et al., p. 354. pl. 5, fig. 3a-b.

Remarks. Test globular and involute with rounded periphery. Streptospiral coiling becoming planispiral. Small chambers and straight sutures. Coarsely agglutinated wall.

Genus *Recurvoidella* Uchio, 1960

Recurvoidella sp.

Pl. 4, fig. 6a-b

1898 *Recurvoidella lamella* Grzybowski, p. 290, pl. 11, fig. 25.
1993 *Recurvoidella lamella* Grzybowski – Kaminski, p. 239-323, pl. 10, fig. 8a-c.

Remarks. Test slightly streptospiral, comprised of four globular chambers increasingly with the size. Periphery rounded, lobate. Sutures depressed, straight, extending to umbilicus. Umbilicus slightly depressed. Wall medium to finely agglutinated.

Genus *Recurvoides* Earland, 1934

Recurvoides spp.

Pl. 4, fig. 7a-c

1970 *Recurvoides anormis* Mjatliuk, p. 84, pl. 18, fig. 4, pl. 19, figs. 1-4.
1970 *Recurvoides* (?) *nadvornensis* Mjatliuk, p. 87, pl. 23, fig. 4a-d, 5a-d.
1988 *Recurvoides* sp. 2. Kaminski, p. 191, pl. 6, fig. 10a-11b.
2005 *Recurvoides anormis* Mjatliuk – Kaminski & Gradstein, p. 403, pl. 95, figs. 4-5.

Remarks. Test coarsely agglutinated with thick wall, with a broadly rounded periphery. Coiling is involute, streptospiral, with at least one abrupt change in coiling direction. Chambers broad, 5 visible on the exterior, with straight sutures.

Suborder **Spiroplectamminina** Mikhalevich, 1992
Superfamily Spiroplectamminoidea Cushman, 1927
Family Spiroplectamminidae Cushman, 1927
Subfamily Spiroplectammininae Cushman, 1927
Genus *Bolivinopsis* Yakovlev, 1891

Bolivinopsis rosula (Ehrenberg, 1854)

Pl. 4, figs. 8a-b and 9a-b

1854 *Spiroplecta rosula* Ehrenberg, p. 24, pl. 32, fig. 26.
1946 *Bolivinopsis rosula* (Ehrenberg) – Cushman, p. 101, pl. 44, figs. 4-8.
1995 *Spiroplectammina rosula* (Ehrenberg) – Bubík, p. 87, pl. 14, fig. 11.
2009 *Bolivinopsis rosula* (Ehrenberg) – Kaminski & Lazarus, p. 189, figs. 1-2.
2011 *Bolivinopsis rosula* (Ehrenberg) – Kaminski et al., p. 92, pl. 5, fig. 8.

Remarks. Test elongate, narrow, wall finely agglutinated, imperforate, with calcareous cement. Aperture an interiomarginal arch.

Genus *Spiroplectammina* Cushman, 1927

Spiroplectammina spectabilis (Grzybowski, 1898)

Pl. 4, fig. 12a-b

1898 *Spiroplecta spectablis* Grzybowski, p. 293, pl. 12, fig. 12.
1975 *Bolivinopsis spectabilis* (Grzybowski) – Webb, p. 835, pl. 3, figs. 1-3.
1984 *Spiroplectammina spectabilis* (Grzybowski) – Kaminski, p. 31, pl. 12, figs. 1–9; pl. 13, figs. 1–8 (with synonymy).
1988 *Spiroplectammina spectabilis* (Grzybowski) – Kaminski et al., p. 193, pl. 7, figs. 16-18.
1997 *Spiroplectammina spectabilis* (Grzybowski) – Peryt et al., pl. 3, fig. 12.
2005 *Spiroplectammina spectabilis* (Grzybowski) – Kaminski & Gradstein, p. 435, pl. 104, figs. 1a–6b (with synonymy).
2008 *Spiroplectammina spectabilis* (Grzybowski) – Waśkowska-Oliwa, p. 252, pl. 9, figs. 1–3.
2011 *Spiroplectammina spectabilis* (Grzybowski) – Setoyama et al., p. 285, pl. 11, figs. 8, 9.
2014 *Spiroplectammina spectabilis* (Grzybowski) – Waśkowska & Cieszkowski, pl. 8, figs. g–i.
2017 *Spiroplectammina spectabilis* (Grzybowski) – Setoyama et al., p. 196, pl. 2, fig. 11.
2020 *Spiroplectammina spectabilis* (Grzybowski) – Waśkowska et al., p. 117, pl. 45, figs. A-B.
2021 *Spiroplectammina spectabilis* (Grzybowski) – Kaminski et al., p. 354. pl. 5, fig. 3a-b.

Remarks. Test free, planispiral and then biserial with around 10 chambers. Wall imperforate, finely agglutinated medium-coarse surface. Aperture narrow.

Plate 5

Deep-water agglutinated foraminifera from Danian age; Contessa Highway, Gubbio, Italy.
1a-b) *Karrerulina horrida* (Mjatliuk), 1- CON-0.8; 2-3) *Remesella varians* (Glaessner), 2 - CON-13; 3 - CON-14; 4-11) Internal moulds (*Rhizammina*) 4 - CON-3; 5 - CON-6; 6 - CON-5; 7 - CON-10A; 8 - CON-9; 9 - CON-6; 10 - CON-13; 11 - CON-9.
All scale bars 100 µm.

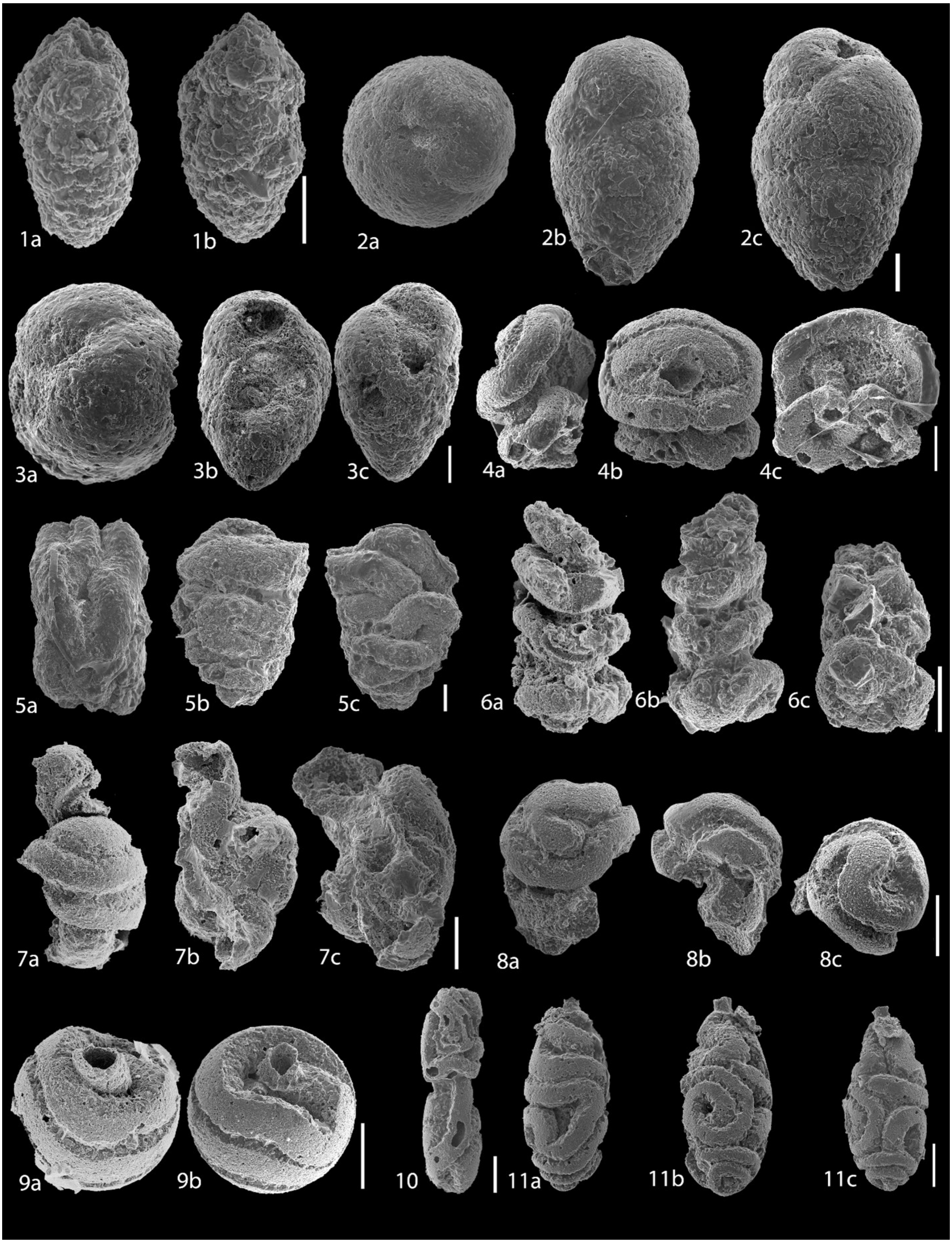
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Plate 5

Genus *Spiroplectinella* Kisel'man, 1972

Spiroplectinella israelskyi (Hillebrandt, 1962)

Pl. 4, figs. 10a-c and 11a-c

1951 *Spiroplectammina* sp. A – Israelsky, p. 13, pl. 3, figs. 17-19.
1962 *Spiroplectammina israelskyi* Hillebrandt, p. 30, pl. 1, figs. 5a-7b.
1990 *Spiroplectammina israelskyi* Hillebrandt – Kuhnt, p. 235, pl. 6, figs. 16–17.
1997 *Spiroroplectammina israelskyi* Frizzel – Peryt et al., pl. 3, figs. 1, 5.
2005 *Spiroplectinella israelskyi* (Hillebrandt) – Kaminski & Gradstein, p. 442, pl. 107, figs. 1–11.
2008 *Spiroplectinella israelskyi* (Hillebrandt) – Kaminski et al., p. 247, pl. 8, figs. 5–6.
2011 *Spiroplectinella israelskyi* (Hillebrandt) – Kaminski et al., p. 92, pl. 5, fig. 9.

Remarks. Test is planispiral, later biserial, lanceolate in outline, rhomboidal in cross-section. The spiral portion around 4-5 chambers.

Family Pseudobolivinidae Wiesner, 1931
Genus *Pseudobolivina* Wiesner, 1931

Rashnovammina munda Krasheninnikov, 1974

Pl. 4, fig. 13a-b

1973 *Pseudobolivina munda* Krasheninnikov, p. 210, pl. 2, figs. 10-11.
1990 *Pseudobolivina* cf. *munda* Krasheninnikov – Kuhnt, p. 324, pl. 6, figs. 1-2.
2011 *Rashnovammina munda* (Krasheninnikov) – Kaminski et al., p. 105, pl. 5, fig. 16.

Remarks. Test smooth-walled agglutinated. Oval outline with straight form.

Suborder **Verneuilinina** Mikhalevich and Kaminski, 2004
Superfamily Verneuilinoidea Cushman, 1911
Family Prolixoplectidae Loeblich and Tappan, 1985
Genus *Karrerulina* Finlay, 1940

Karrerulina horrida (Mjatliuk, 1970)

Pl. 5, figs. 1a-b

1970 *Karreriella horrida* Mjatliuk, p. 114-115, pl. 5 & 33 figs. 9, 15-16.
2005 *Karrerulina horrida* (Mjatliuk) – Kaminski & Gradstein, p. 473, pl. 117, figs. 1-11.
2020 *Karrerulina horrida* (Mjatliuk) – Waśkowska et al., p. 125, pl. 50, figs. A-D.

Remarks. Test comprised of a short initial trochospiral part of several whorls with 4-6 chambers per whorl, followed by an elongate triserial stage of about 3-4 whorls. Wall medium to finely agglutinated.

Suborder **Ataxophragmiina** Fursenko, 1958
Superfamily Ataxophragmioidea Schwager, 1877
Family Ataxophragmiidae Schwager, 1877
Subfamily Liebusellinae Saidova, 1981
Genus *Remesella* Vašíček, 1947

Remesella varians (Glaessner, 1937)

Pl. 5, figs. 2a-c and 3a-c

1937 *Matanzia varians* Glaessner, p. 366, pl. 2, fig. 15
1947 *Remesella mariae* Vašíček, p. 247, textfig. 3, pl. 2, fig. 14a-b.
1990 *Remesella varians* (Glaessner) – Kuhnt, pl. 6, figs. 19-21.
1995 *Remesella varians* (Glaessner) – Bubík, p. 86, pl. 15, fig. 11.
2005 *Remesella varians* (Glaessner) – Kaminski & Gradstein, p. 511, pl. 129, figs. 1-7.
2011 *Remesella varians* (Glaessner) – Kaminski et al., p. 94, pl. 5, fig. 20.

Remarks. Test coiled in high trochospire, initially with 4 chambers per whorl, reducing to biserial.

Internal moulds (*Rhizammina*)

Pl. 5, figs. 4a-11c

2004 Internal moulds (*R. indivisa*?) – Galeotti et al. p. 95, pl. 1, figs. 6, 12, 13.

Remarks. We recognized various specimens of tubular agglutinated foraminifera, possibly a species of *Rhizammina*, (Pl. 5, figs. 4–11), that apparently grew into and occupied the interiors of calcareous benthic or planktonic foraminifera. Because the limestone samples were processed using hydrochloric acid, these tubular agglutinated foraminifera that form "internal moulds" have been revealed.

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