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GLOMOSPIRA KAMINSKII SP. NOV., A NEW AGGLUTINATED FORAMINIFERA FROM THE PALEOCENE OF THE SCAGLIA ROSSA FORMATION, CONTESSA, ITALY

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Abstract: The new species *Glomospira kaminskii* is described from the Paleogene Scaglia-type assemblages in central Italy. The species is characterized by its initial glomospiral coiling, which changes during ontogeny to streptospiral or irregular. The undivided tubular chamber often meanders across the surface of the earlier test, and then may uncoil. The species also differs from other *Glomospira* species in possessing a finely agglutinated wall and a deeply incised coil suture. This discovery shows that the genus *Glomospira* may alter its coiling mode in the adult stage. The species, first reported from the Lower Eocene of the Labrador Sea, has a cosmopolitan distribution.

Key words: Foraminifera, new species, taxonomy, Paleogene, Italy.

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INTRODUCTION

The genus *Glomospira* was separated from the genus *Ammodiscus* by Rzehak (1885), by its "ganz abnormalen Bau", compared with *Ammodiscus tenuis* Brady. Rzehak used the term "glomospiral", in reference to the coiling of *Glomospira gordialis* (Jones and Parker). The description of the type species *Trochammina squamata* var. *gordialis* was made by Jones and Parker (1860). In Rzehak's understanding, the genus "*Ammodiscus*" was used for the planispiral disc-shaped forms, and "*Glomospira*" for abnormal forms that are coiled in a ball. Loeblich and Tappan (1987) used a narrower definition for the genus, stating that the proloculus is followed by a streptospiral coiled part, and then irregular coiling. Bender (1995) demonstrated that specimens of "*Glomospira charoides* forma *gordialis*" from west Africa actually possess an initial *Repmanina*-like initial stage (coiled in a ball), and a later glomospirally-coiled stage.

The new species *Glomospira kaminskii* sp. nov. shows a combination of coiling modes, initially glomospirally coiled, followed by streptospiral and/or irregular coiling. The new species therefore shows a combination of the coiling modes of two well-known species: *Glomospira gordialis* (Jones and Parker) and *Glomospira irregularis* (Grzybowski). Previously identified as '*Glomospira* sp. 4", this species has been documented at various locations, such as the Labrador Sea, Labrador Shelf, North Sea, and Tasman Sea, over the past three decades (Kaminski *et al*., 1989, 2021, 2024; Kaminski and Gradstein, 2005). Specimens illustrated in this study are from the Scaglia Rossa Formation, exposed in the Contessa Valley of central Italy.

A thick series of deep-water limestone formations, spanning from the Cretaceous to the Paleogene, can be found in the Umbria-Marche Basin near Gubbio, Italy. The area hosts the famous exposures of the Cretaceous/Paleogene (K/Pg) boundary, as first described by Alvarez *et al*. (1980), following their discovery of the iridium anomaly in the nearby Bottaccione Valley. Notably, the distribution and assemblages of deep-water agglutinated foraminifera underwent significant changes, as documented in the K/Pg boundary sections (Kuhnt and Kaminski, 1996; Hikmahtiar *et al*., 2022). Kaminski *et al*. (2011) studied the taxonomy and biostratigraphy of the Upper Cretaceous deep-water foraminiferal assemblages at Contessa, and a low-resolution study of the Paleogene was carried out by Kaminski and Gradstein (2005). The investigation by Hikmahtiar *et al*. (2022) focused on the Deep Water Agglutinated Foraminifera (DWAF) from the lowermost metre of the Paleocene at Contessa, based on high-resolution sampling. Subsequent sampling with a broader stratigraphic interval indicated a greater diversity of DWAF than initially

reported, necessitating further research (Hikmahtiar and Kaminski, 2022, 2023a, b; Hikmahtiar, 2023).

This study aims to enhance our understanding of Paleogene DWAF by documenting and providing the formal description of the species, formerly known as "*Glomospira* sp. 4" of Kaminski and Gradstein (2005). The recent discovery of this species in the Paleocene at Contessa represents the optimal choice for a type locality, owing to the public accessibility of the outcrop. All the previous reports of the species have been from boreholes. Furthermore, specimens extracted using the hydrochloric acid digestion method, display excellent preservation, enabling the resolution of their morphological features and their description as a new species.

MATERIALS AND METHODS

For this paper, 44 samples were collected from the lower Paleocene of the Contessa Highway section. The measured interval begins at the K/Pg boundary. Samples were collected with a sampling resolution of 10 cm between 1 m and 2 m and 20 cm between 2 m and 4.8 m above the K/Pg boundary. Dilute hydrochloric acid (HCl) was used to dissolve the samples, which were then washed through a 63-µm sieve to extract the agglutinated foraminifera. Specimens from the >125 µm fraction were selected and mounted on cardboard microslides. The holotype and paratype specimens were placed in single-hole slides, and are deposited in the European Micropalaeontological Reference Centre in Kraków, Poland. The specimens were photographed at the College of Petroleum and Geosciences, KFUPM, using a Neoscope JCM-7000 scanning electron microscope (SEM).

SAMPLE LOCATION

The Contessa Highway Section (N43°22′47.0″, E13°33′′49.0″) is located in the Umbria-Marche Basin of Central Italy (Fig. 1). It is part of a pelagic limestone sequence, extending from the Cenomanian to the Eocene, with interbedded marls in the lower Paleocene. The Scaglia Rossa Formation comprises reddish-pinkish pelagic micritic limestones and some cherts (Alvarez and Montanari, 1988). The section sampled for this study is the lower part of the Danian (0.0 m to 4.8 m above the K/Pg boundary) of the Scaglia Rossa Formation's R3 Member (Fig. 2).

RESULTS

The lowermost samples, collected from the Danian in the Contessa Highway Section, contain no specimens of *Glomospira kaminskii* sp. nov. However, at a stratigraphic height of 0.38 m above the K/Pg boundary, assemblages

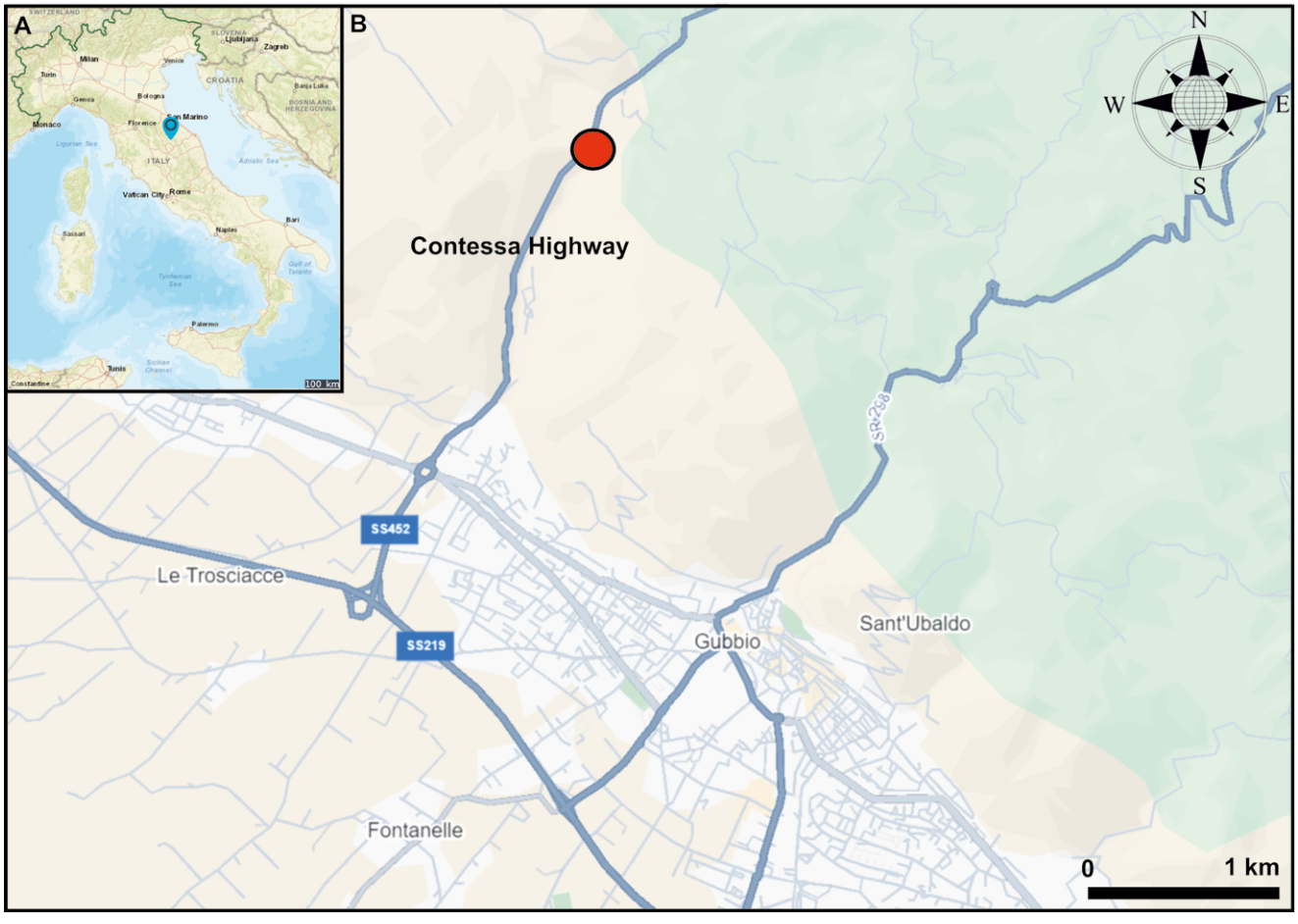

Fig. 1. **A**. Location of the studied area in Italy (blue marker). **B**. Detail location of Site Contessa Highway section, Italy (red dot). Map of Italy is adopted and modified from Istituto Superiore per la Protezione e la Ricerca Ambientale (ISPRA).

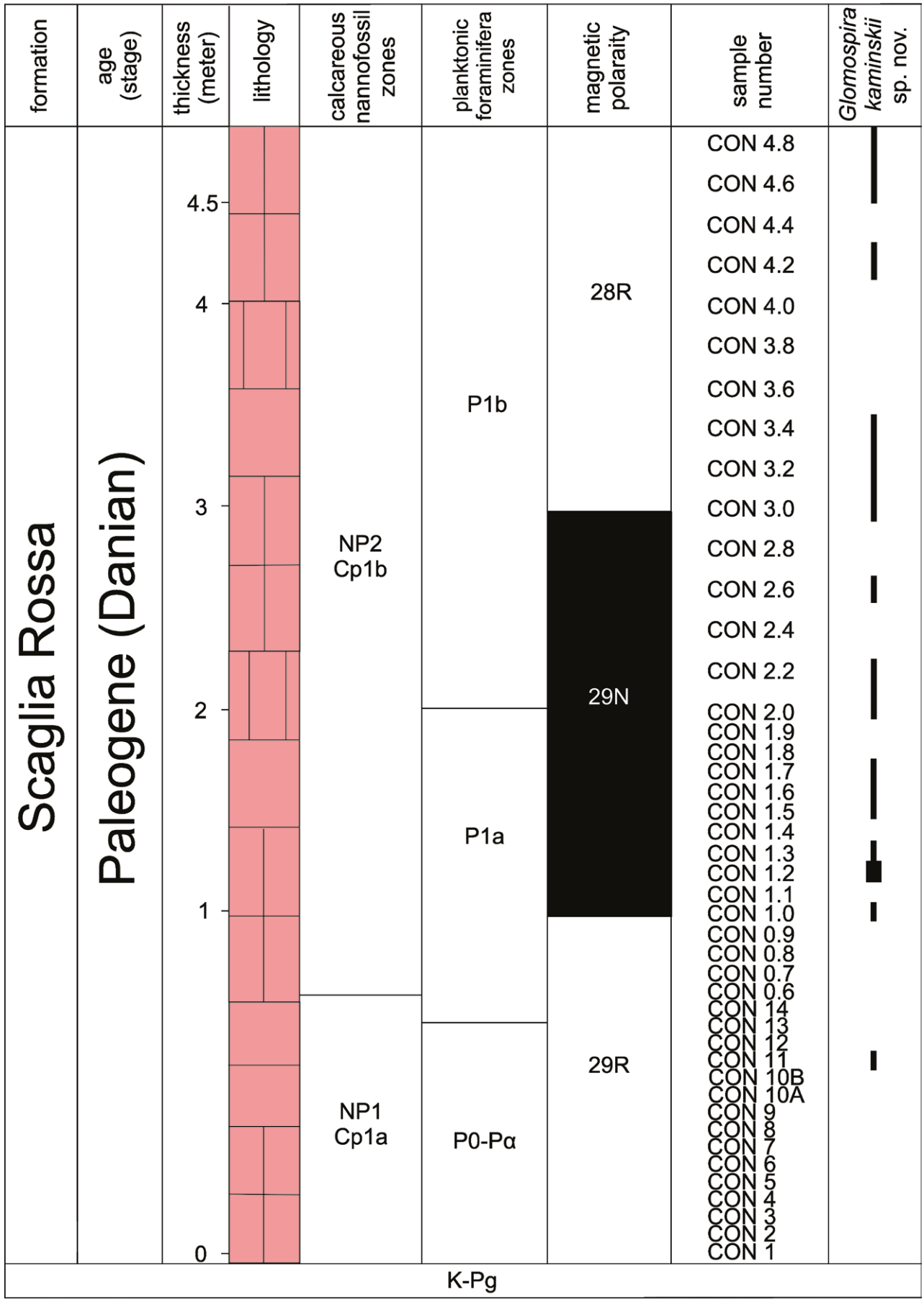

Fig. 2. Lithostratigraphic column of the studied section, showing the position of the samples with *Glomospira kaminskii* sp. nov. Calcareous nannofossil zones are from Monechi and Thierstein, (1985), planktonic foraminiferal zones are from Premoli Silva and Sliter (1995), and the geomagnetic-polarity time scale from Gradstein *et al*. (2012).

containing *Glomospira kaminskii* sp. nov. were found. Specimens are numerous and well-preserved, with their characteristic shape. A total of 51 specimens were recovered from the samples of the author, collected at different stratigraphic heights above the K/Pg boundary clay. At Contessa, the number of species in each sample is relatively low, with an average of three specimens per sample.

SYSTEMATIC PALAEONTOLOGY

Suborder Ammodiscina Mikhalevich, 1980
Superfamily Ammodiscoidea Reuss, 1862
Family Ammodiscidae Reuss, 1862
Subfamily Usbekistaniinae Vyalov, 1968
Genus *Glomospira* Rzehak, 1885

Type species: *Trochammina squamata* Jones and Parker var. *gordialis* Jones & Parker, 1860.
Diagnosis: An ammodiscid with glomospiral to streptospiral or irregular coiling.

Glomospira kaminskii sp. nov.
(Figs 3, 4)

1989 *Glomospirella* sp. – Kaminski, Gradstein and Berggren, pl. 2, fig. 6.

1989 *Glomospira irregularis* (Grzybowski) – Kaminski, Gradstein and Berggren, pl. 2, fig. 7.

2005 *Glomospira* (?) sp. 4 – Kaminski and Gradstein, p. 198, pl. 30, figs 1–9.

2021 *Glomospira* sp. 4 Kaminski and Gradstein – Kaminski, Alegret, Hikmahtiar and Waśkowska, p. 348, pl. 3, figs 4, 5.

2022 *Glomospira* sp. 4 Kaminski and Gradstein – Hikmahtiar, Kaminski and Cetean, p. 730, pl. 2, fig. 6.

Derivation of name: Named in honour of Prof. Michael A. Kaminski, who first discovered this species at ODP Site 647, in the Labrador Sea.
Type specimens: Deposited in the European Micropalaeontological Reference Centre in Kraków, Poland. The holotype and paratypes are housed in Cabinet 7, drawer 27. Catalog number 7/27–1; Fig. 4.1 (holotype). Catalog number 7/27–2; Figure 4.2–8 (paratypes).
Additional material: 51 specimens, currently housed in the author's collection at KFUPM.
Diameter/Dimensions of holotype: Diameter = 372–463 μm, thickness = 103 μm.
Diameter/Dimensions of paratypes: Diameter length horizontal = 253–700 μm, thickness = 113–319 μm.
Type level: Danian, lower Paleocene, at a stratigraphic height of 0.38 m above the K-Pg boundary clay, with the highest abundance at 1.2 m above the boundary.
Type locality: R3 member of the Scaglia Rossa Formation, Contessa Highway, Gubbio, Italy.
Diagnosis: A *Glomospira* species, characterized by its finely agglutinated wall and glomospiral to irregular coiling. Coiling may become more irregular with ontogeny.

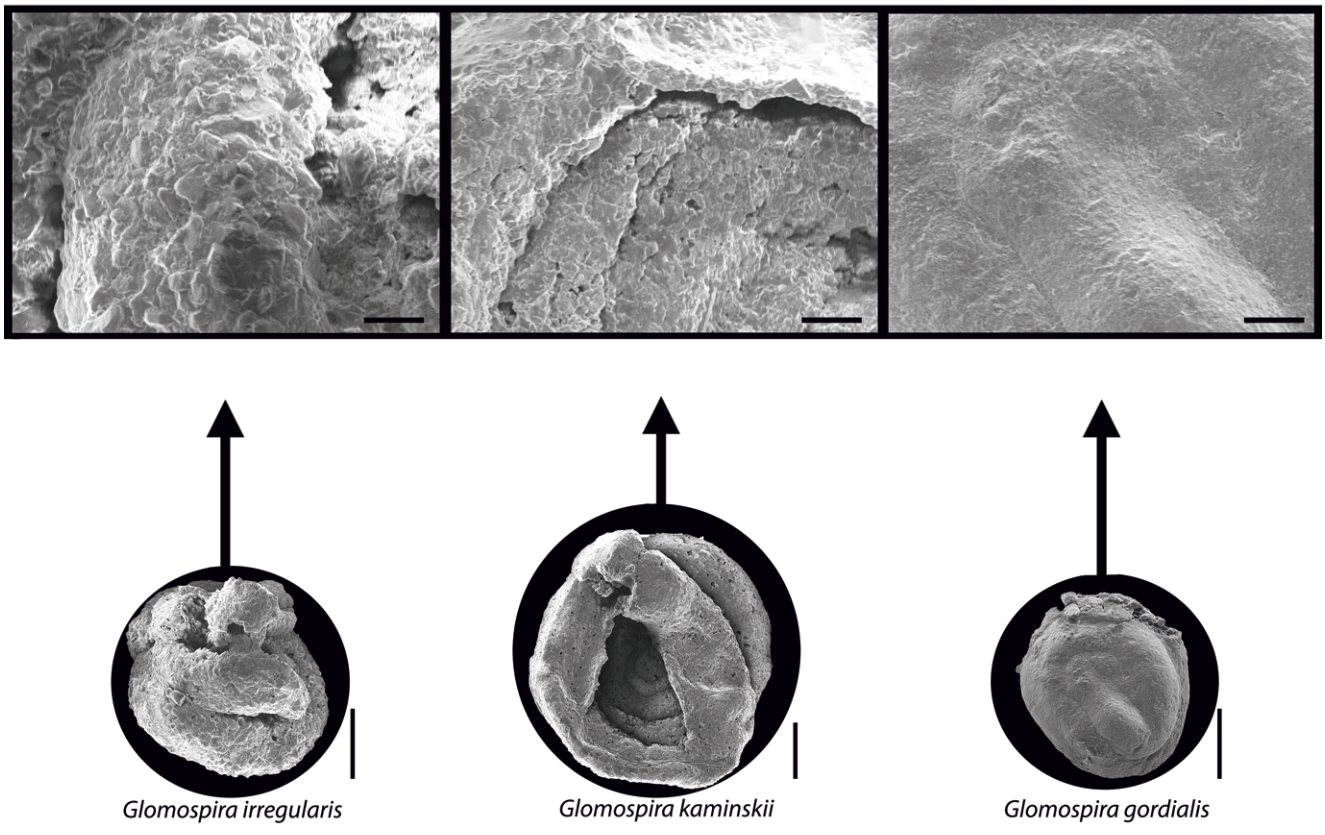

Fig. 3. Comparison of morphological details and grain size of agglutinated particles in *Glomospira irregularis, Glomospira kaminskii* sp. nov. and *Glomospira gordialis.* Top images (scale bar = 20 μm), bottom images (scale bar = 100 μm).

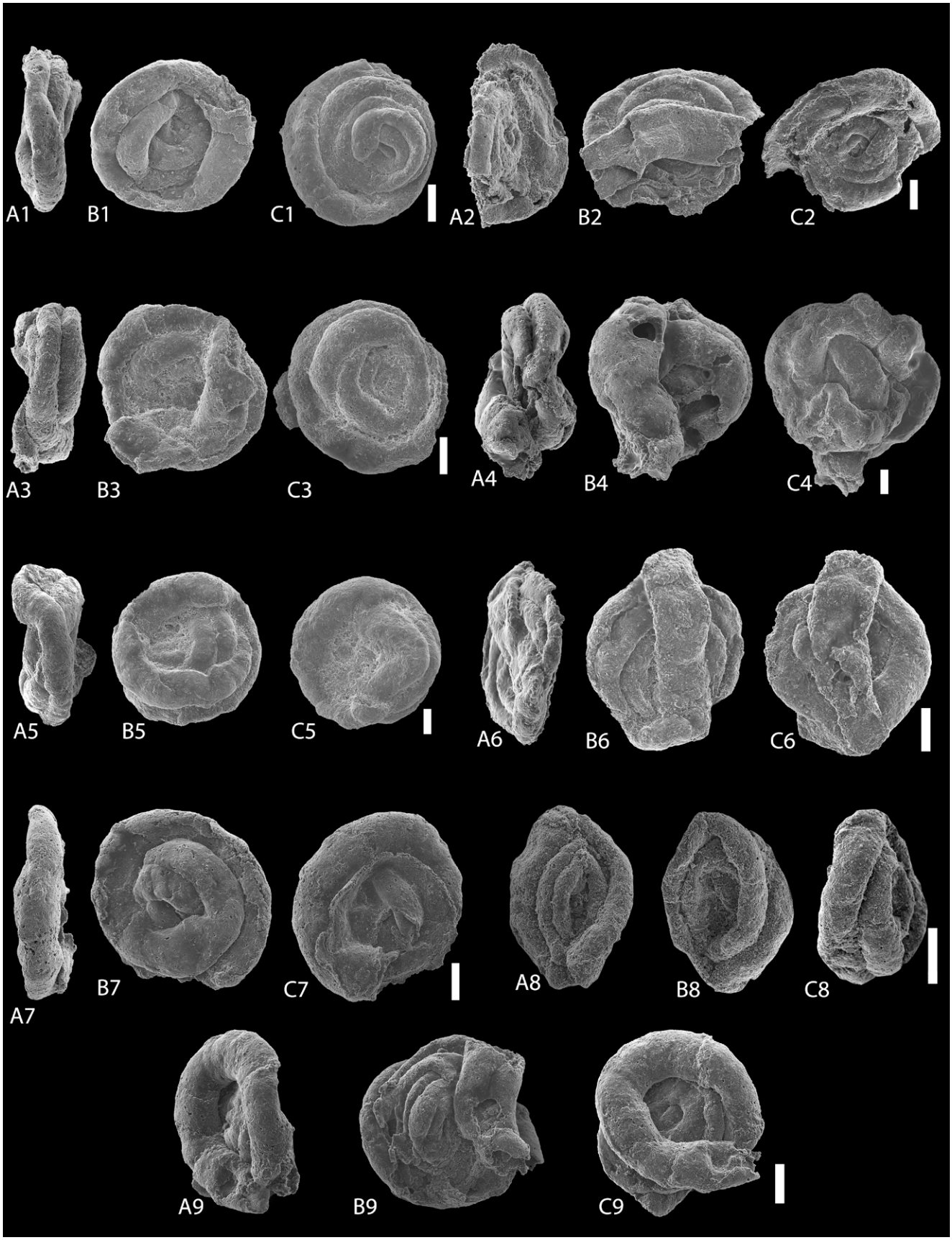

Fig. 4. *Glomospira kaminskii* sp. nov. from the Danian of Contessa Highway section, Italy. **A1–C1.** Holotype, sample CON-1l(40 cm). **A2–C2.** Paratypes, sample CON-1.0 (100 cm). **A3–C3.** Paratype, sample CON-1.2 (120 cm). **A4–C4.** Paratype, sample CON-1.3 (130 cm). **A5–C5.** Paratype, sample CON-1.5 (150 cm). **A6–C6.** Paratype, sample CON-2.2 (220 cm). **A7–C7.** Paratype, sample CON-2.6 (260 cm). **A8–C8.** Paratype, sample CON-3.2 (320 cm). **A9–C9.** Paratype, sample CON-4.8 (480 cm). All scale bars equal 100 μm. (A – edge; B – umbilical; C – spiral).

Description: The test consists of a proloculus, followed by an undivided tubular chamber, initially coiled in an irregular planispiral or glomospiral manner about a common plane, later inclining to the original plane of coiling or becoming highly irregular. The initial portion of the test is coiled in 4 or 5 whorls. The tubular chamber may then double back upon itself, meander across the surface of the earlier portion of the test or continue to coil in a second plane, inclined to the original plane of coiling. Coiling in the final portion of the test is more irregular. Some specimens may also uncoil. Coil suture is distinct, depressed, and the wall consists of finely agglutinated mineral grains with minimal cement. Aperture at the open end of the tube.

Remarks: *Glomospira kaminskii* sp. nov. exhibits superficial resemblance to both *Glomospira irregularis* and *Glomospira gordialis*. Its initial portion generally displays a glomospiral coil, similar to that of *G. gordialis*, with some specimens approaching planispiral coiling. Specimens from exploration wells in the Labrador and North Seas are strongly silicified, while those from ODP Site 647 have a somewhat roughened surface texture. The wall contains less cement than *G. gordialis*, and as a result the specimens lack the smooth, glossy appearance of the latter species. The character of the wall resembles that of *G. irregularis*, but the Contessa specimens selected finer agglutinated particles. This mode of coiling of the latter part of the test is closer to the genus *Ammovertellina* than to *Glomospira*, with Lower Eocene specimens bearing some resemblance to the species *Ammovertellina prima* Suleymanov from the Paleocene of Uzbekistan (Suleymanov, 1959).

Distribution: *Glomospira kaminskii* sp. nov. exhibits a broad bathymetric distribution across western Tethyan and North Atlantic regions, occurring in samples from both the continental shelf and the abyssal plain. Additionally, it is found within Scaglia-type assemblages in central Italy. It is reported from the Central North Sea and Labrador Sea, the Silesian Unit of the Polish Carpathians (Kaminski *et al*., 1989; Kaminski and Gradstein, 2005), and at IODP Site U1511 in the Tasman Sea (Kaminski *et al*., 2021, 2024). Additionally, the species is present in the Scaglia Rossa Formation in the Contessa Valley, Italy (Hikmahtiar *et al*., 2022).

Glomospira kaminskii sp. nov. has been observed at a number of localities worldwide in sediments ranging in age from early Paleocene to early Middle Eocene: in red sediments associated with Lower Eocene tuffs in the Central North Sea, Zone P7–P8; Lower Eocene at ODP Site 647 in the southern Labrador Sea; Zone LGR2B, Lower Eocene in the Flying Foam well on the Grand Banks; in the *Reticulophragmium amplectens* Zone, Lower to Middle Eocene from Djebel Moussa, Strait of Gibraltar, northern Morocco; in Middle Eocene green clays from the Silesian Unit of the Carpathians at Biecz, Poland (Kaminski and Gradstein, 2005); in the upper Paleocene in IODP Hole U1511B in the Tasman Sea (Kaminski *et al*., 2021, 2024); and in the Paleocene R3 Member of the Scaglia Rossa Formation in Italy (Hikmathiar *et al*., 2022).

DISCUSSION AND CONCLUSIONS

Glomospira kaminskii sp. nov. exhibits similarities to both *Glomospira diffundens* Cushman and Renz and *Glomospira gordialis*, particularly in its regular coiling pattern, known as glomospiral coiling. However, it differs in the grain size of its agglutinated particles and the manner in which it is coiled. Unlike the other two species, *Glomospira kaminskii* sp. nov. appears to be more poorly cemented and possesses a less glossy appearance.

The species starts its coiling pattern as glomospiral, before transitioning into an irregular form. This species displays a combination of the characteristics observed in *Glomospira gordialis* and *Glomospira irregularis*. Notably, *Glomospira irregularis* may not necessarily belong to the genus *Glomospira*; rather, its categorization into this genus is primarily based on tradition and its association with other species that have been referred to *"Glomospira"*. With the identification of *Glomospira kaminskii* sp. nov., a blending of traits and features emerges from both *Glomospira gordialis* and *Glomospira irregularis* (Fig. 3). *Glomospira kaminskii* sp. nov. is glomospiral-streptospiral with irregular coiling in varying amounts. The grain size of agglutinated particles contained in the outer wall of the coiled chamber is largest in *G. irregularis,* and smallest in *G. gordialis.* In this comparison, *Glomospira kaminskii* sp. nov. occupies an intermediate position between the rough surface texture of *G. irregularis* and the smooth (glossy) texture of *G. gordialis*. The discovery of *Glomospira kaminskii* sp. nov. at IODP Site U1511 in the Tasman Sea and now in the Contessa Highway Section shows that this species was widely distributed in the Paleogene ocean (Atlantic, Pacific and Tethys).

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