Eocene (Priabonian) agglutinated foraminiferal morphogroups from the Rashrashiyah Formation of Saudi Arabia: taxonomy and paleoenvironmental implications

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ABSTRACT: The Middle–Upper Eocene Rashrashiyah Formation of the Sirhan–Turayf Basin, northwestern Saudi Arabia, yields a diverse assemblage of deep-marine agglutinated benthic foraminifera representing the first well-documented assemblage from the Arabian Plate. Twenty-three species assigned to ten genera were identified from an ~11 m interval and correlated with planktonic foraminiferal Zone E14 (Priabonian). The fauna is dominated by *Haplophragmoides*, *Spiroplectammina*, *Plectina*, *Pavonitina*, *Karreriella,* and *Flabellogaudryina*, with *Pavonitina styriaca*, *Pavopsammia flabellum*, *Plectina* spp., *Karreriella arenasensis*, and *Clavulinoides alpina* reported for the first time from Saudi Arabia. Morphogroup and diversity trends reveal an upward transition within the upper Slope Marl Assemblage (SMA). The lower part of the studied succession corresponds to the lower subdivision of the upper SMA and is characterized by oxygen-stressed assemblages dominated by *Haplophragmoides* with *Psammosphaera* and *Saccammina*, whereas the upper part of the succession represents the upper subdivision of the upper SMA and is marked by communities dominated by *Karreriella*, *Plectina*, and pavonitinids (*Pavonitina*, *Pavopsammia*) associated with the Oxygen Minimum Zone (OMZ). The assemblage shows strong paleoecological and taxonomic affinity with OMZ-related Priabonian slope faunas from Hungary, Italy, and southern Bulgaria. These findings significantly extend the known southern Tethyan distribution of several agglutinated taxa and establish the Sirhan–Turayf Basin as a key reference locality for reconstructing Late Eocene benthic foraminiferal paleoecology and upper-slope environmental conditions along the southern margin of the Tethys.

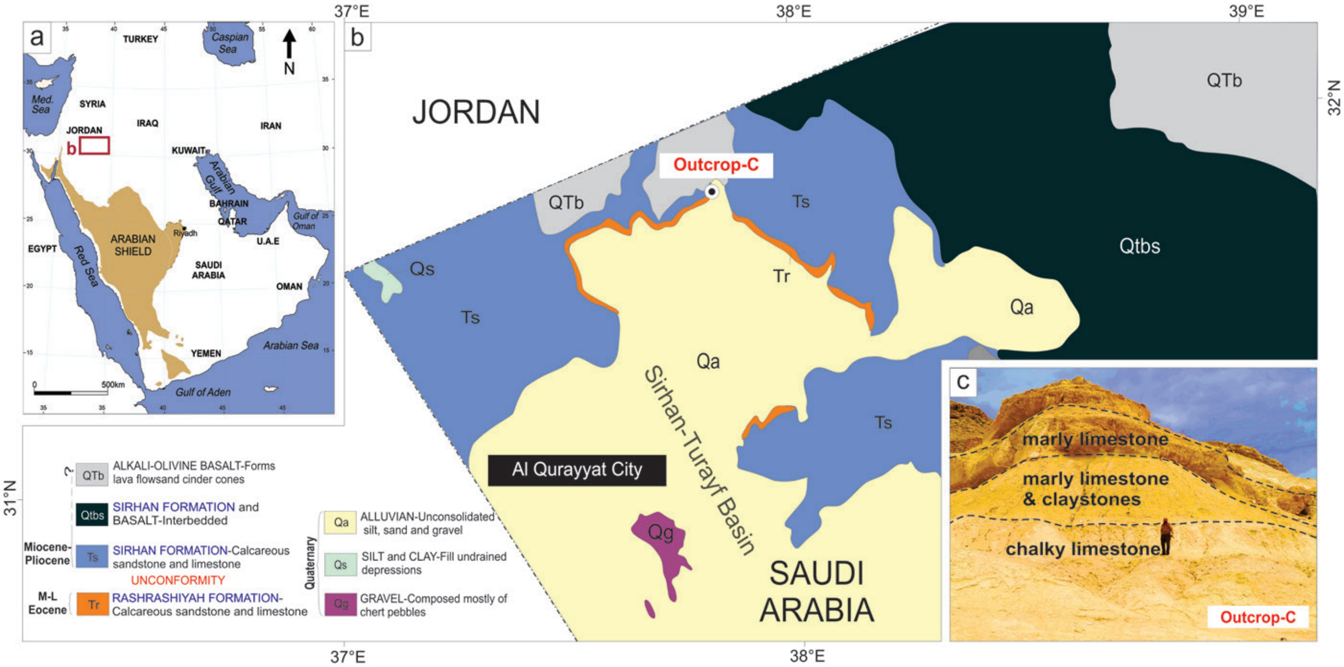
Keywords: Agglutinated foraminifera, morphogroups, taxonomy, Priabonian.

INTRODUCTION

Agglutinated benthic foraminifera represent one of the most important components of Paleogene deep-marine microfauna, particularly near or below the carbonate compensation depth (CCD), where calcareous taxa are rare or absent. Their stratigraphic and paleoenvironmental utility has long been established in classic flysch-type successions, where they provide a detailed record of bathymetric changes, substrate character, and redox fluctuations (Gradstein and Berggren 1981; Kaminski and Gradstein 2005; Murray 2006). Because their test morphology, wall composition, and microstructure directly reflect environmental conditions, agglutinated foraminifera are widely used to reconstruct deep-water depositional settings and to recognize paleoecological gradients (Kaminski and Gradstein 2005; Cetean and Kaminski 2011).

Beyond siliciclastic flysch facies, agglutinated assemblages are also characteristic of carbonate-bearing slope-marl successions deposited above the CCD in hemipelagic outer-shelf to upper-bathyal environments (Kuhnt and Kaminski 1990; Kaminski and Gradstein 2005). In these settings, agglutinated benthic foraminifera commonly occur together with calcareous planktonic and benthic taxa, forming mixed assemblages referred to as the Slope Marl Assemblage (SMA). Within such mixed carbonate–siliciclastic systems, agglutinated foraminifera remain sensitive indicators of organic-matter flux, oxygen availability, and substrate stability (Kuhnt and Kaminski 1988; Kaminski and Gradstein 2005; Setoyama et al. 2017; Benedetti 2017). Their morphologic diversity reflects different feeding strategies and microhabitats, making them essential for understanding slope paleoecosystems and the dynamics of the oxygen-minimum zone (Cetean and Kaminski 2011; Setoyama et al. 2017).

The Eocene epoch was a time of profound climatic and oceanographic reorganization, including the Middle Eocene Climatic Optimum followed by progressive cooling through the Bartonian–Priabonian transition (~40.5–37.8 Ma) (Bohaty and Zachos 2003; Wade et al. 2011). These events had a major impact on marine carbonate production and benthic community composition across the Tethyan realm. While planktonic foraminifera from this interval have been extensively studied for global correlation and paleoclimate reconstruction (Wade et al. 2011), detailed taxonomic and paleoecologic studies



TEXT-FIGURE 1
(a) General base structural map of Arabian Plate illustrating the Sirhan–Turayf region and the location of the study area (red rectangle), modified after Ziegler et al. (2001). (b) Simplified geological map showing the position of Outcrop-C southwest of Al Qurayyat City within the Sirhan–Turayf Basin. (c) Field photograph of Outcrop-C showing the lithological characteristics of the Rashrashiyah Formation (Middle–Late Eocene).

of agglutinated benthic foraminifera remain relatively scarce (Kaminski and Gradstein 2005; Waśkowska 2021; Kaminski et al. 2024a,b), particularly in carbonate-rich slope environments of the southern Tethys.

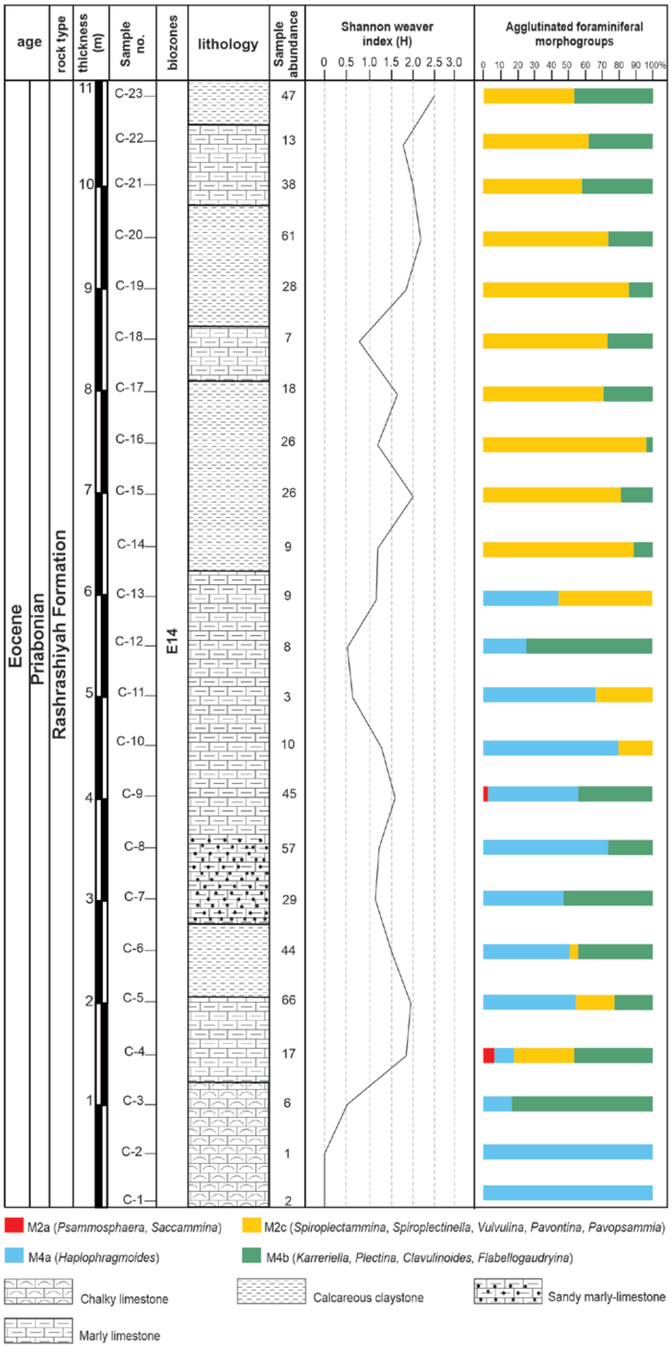
Within the Arabian Plate, thick Paleogene marine successions are widely developed, yet their agglutinated benthic foraminiferal assemblages remain poorly documented. The Sirhan–Turayf Basin in northwestern Saudi Arabia represents a structurally controlled depocenter that accumulated Cretaceous–Paleogene sediments within the southern Tethyan domain (Meissner et al. 1987; Abu-Jaber et al. 1989; Ahmed et al. 2022; Bamousa et al. 2023). The Eocene Rashrashiyah Formation consists of alternating marls and limestones deposited in outer-shelf to upper-bathyal settings (Aljahdali et al. 2020; Allam et al. 2025). Recent studies have documented its calcareous planktonic foraminiferal assemblages and established a Bartonian–Priabonian age (Korin et al. 2025a) and Priabonian correlation with the global planktonic foraminiferal zonation (Wade et al. 2021). Calcareous benthic foraminifera from the Rashrashiyah Formation are currently under investigation and will be treated in a separate contribution. However, its agglutinated benthic foraminiferal assemblage has not yet been systematically documented, and comprehensive regional datasets remain essential for refining bathymetric interpretations and biogeographic patterns of Paleogene deep-marine faunas.

This study provides the first detailed taxonomic and paleoecological documentation of benthic agglutinated foraminifera from the Eocene Rashrashiyah Formation in the Sirhan–Turayf Basin, northwestern Saudi Arabia. It aims to describe the composition, morphological characteristics, taxonomy, and ecological distribution of the assemblage and to use these data to reconstruct benthic habitats and depositional conditions in Paleogene deep-marine environments of the Arabian Plate.

MATERIALS AND METHODS

A total of 23 bulk samples were collected from an approximately 11 m-thick succession of the Rashrashiyah Formation exposed at Outcrop C with sample interval of 50 cm, southwest of Al-Qurayyat, during the 2024 field campaign, with logistical support from the Saudi Geological Survey (text-fig. 1). The sampled interval represents the upper part of the Rashrashiyah Formation, a Paleogene unit within the Sirhan–Turayf Basin of northwestern Saudi Arabia. The basin forms part of the larger Azraq–Sirhan depression, which extends into eastern Jordan and represents a long-lived marine depocenter that accumulated a continuous Late Cretaceous–Paleogene sedimentary sequence (Meissner et al. 1987). Near the Al-Qurayyat water well, the formation attains a thickness of about 75 m and is well exposed along erosional scarps and isolated hills. Lithologically, the succession consists of chalky limestones interbedded with bituminous calcareous marls in the lower part, grading upward into siliceous limestones and calcareous claystones (text-fig. 2). The succession exhibits lithologic features typical of Eocene marl–limestone alternations associated with mixed benthic and planktonic foraminiferal assemblages (Aljahdali et al. 2020; Wade et al. 2021; Allam et al. 2025; Kaminski and Korin 2025; Korin et al. 2025a, b).

Approximately 100 g of each sample was disaggregated in a mild detergent solution for about two hours, with treatment duration adjusted according to lithification. The residues were washed through a 63 µm sieve, oven-dried at ~60°C, and the foraminifera content picked under an Olympus SZX7 stereomicroscope. The present study focuses on agglutinated benthic foraminifera; calcareous benthic taxa were recorded but are not discussed in detail here, as they form part of an ongoing separate study. Imaging and Z-stacking were performed using a ZEISS Axio Zoom V16 system housed at the College of Petroleum Engineering and Geosciences, King Fahd University



TEXT-FIGURE 2
Vertical variation in agglutinated benthic foraminiferal morphogroups and diversity within the Rashrashiyah Formation (Outcrop C). An upward increase in diversity is accompanied by a shift from M2a–M4a dominance to M2c–M4b, reflecting an internal transition within the upper Slope Marl Assemblage (SMA) driven by increasingly persistent dysoxic conditions and enhanced organic-matter flux during the Priabonian (Zone E14), rather than progressive deepening.

of Petroleum and Minerals (KFUPM). Representative specimens are illustrated in Plates 1–3. Taxonomic identification followed Cushman (1937), Loeblich and Tappan (1987), Kaminski and Gradstein (2005), Kaminski et al. (2021, 2024a) and Kaminski and Korin (2025). Species abundance and vertical distribution data are presented in Table 1. Morphogroup classification, diversity, and paleo-bathymetric analyses were performed following the schemes of Kaminski and Gradstein (2005) and Setoyama and Kaminski (2015) and Setoyama et al. (2017), as summarized in text-figs. 3–4. The stratigraphic position of the studied interval was constrained using co-occurring planktonic foraminiferal assemblages defining the Priabonian Zone E14 of Wade et al. (2011, 2021) and correlated with the regional biostratigraphic framework of Korin et al. (2025a). All prepared slides and illustrated specimens will be permanently curated at the European Micropaleontological Reference Center, Kraków, Poland.

SYSTEMATIC TAXONOMY

The systematics of the agglutinated foraminifera follows Kaminski (2014).

Class FORAMINIFEREA d'Orbigny 1826
Subclass MONOTHALAMANA Pawlowski, Holzmann and Tyszka 2013
Order SACCAMMININA Lankester 1885
Suborder SACCAMMINOIDEA Brady 1884
Superfamily PSAMMOSPHAEROIDEA Haeckel 1894
Family PSAMMOSPHAERIDAE Haeckel 1894
Subfamily PSAMMOSPHAERINAE Haeckel 1894
Genus *Psammosphaera* Schultze 1875

Psammosphaera irregularis (Grzybowski 1896) emend Liszka and Liszkowa 1981
Plate 1, figure 1

Keramosphaera irregularis GRZYBOWSKI 1896, p. 273, pl. 8, figs. 12–13.
Psammosphaera scruposa (Berthelin 1880). – KAMINSKI et al. 1988, p. 182, pl. 2, fig. 5. *Psammosphaera irregularis* (Grzybowski) emend. Liszka and Liszkowa 1981 – KAMINSKI and GRADSTEIN 2005, p. 129, fig. 9, pl. 9, figs. 1–9. – KAMINSKI et al. 2024a, p. 272, pl. 1, fig. 1.

Material: 2 specimens.

Description: Test medium-large-sized, subspherical to irregular, with a coarse, uneven exterior (pl. 1, fig. 1). The outline is variable but generally globular to lobate, reflecting the irregular accumulation of agglutinated grains. Wall thick, composed of coarse to medium-sized quartz and lithic fragments bound in organic cement, producing a rough texture with grains often protruding from the surface. The aperture is simple, terminal, and irregular in outline, sometimes appearing as a single opening or multiple small pores.

Remarks: *Psammosphaera irregularis* is characterized by its irregular, massive test and coarse agglutination, which distinguishes it from more regularly spheroidal *Psammosphaera* species. Liszka and Liszkowa (1981) emended the species to include Paleogene forms. Kaminski et al. (1988) discussed its synonymy with *P. scruposa* (Berthelin 1880), but Kaminski and Gradstein (2005) maintained Paleogene occurrences under *P. irregularis.* The present material corresponds closely to the emended concept, showing the coarse, uneven wall structure and subspherical outline described in previous studies (Grzybowski 1896; Liszka and Liszkowa 1981; Kaminski and Gradstein 2005).

Distribution and occurrences: The species was originally described from the Eocene of the Polish Carpathians (Grzybowski 1896). It was subsequently reported by Liszka and Liszkowa (1981) from the Paleogene of Poland and by Kaminski et al.

(1988) from the Paleogene of the North Sea Basin. Kaminski and Gradstein (2005) provided additional illustrations in their global atlas of Paleogene deep-water agglutinated foraminifera. More recently, it has also been documented from the Paleocene–Eocene deep-water assemblages of IODP Site U1511 in the Tasman Sea (Kaminski et al. 2024a), confirming its broad paleogeographic distribution across both the Tethyan and Indo-Pacific realms. In this study, *Psammosphaera irregularis* is recorded from samples C-4 and C-9 within the lower part of E14 biozone.

Family SACCAMMINIDAE Brady 1884
Subfamily SACCAMMININAE Brady 1884
Genus *Saccammina* Carpenter 1869

Saccammina grzybowskii (Schubert 1902)
Plate 1, figure 2

Reophax grzybowskii SCHUBERT 1902, pl. 1, fig. 13.
Saccammina grzybowskii (Schubert 1902). – KAMINSKI and GRADSTEIN 2005, p. 132, pl. 10, figs. 1–7. – WAŚKOWSKA-OLIWA 2008, p. 251, pl. 2, figs. 2, 3, 5. – KAMINSKI et al. 2011, p. 84, pl. 1, fig. 5. – WAŚKOWSKA et al. 2018, pl. 6, figs. J–K. – WILSON et al. 2019, p. 13, pl. 1, fig. 3. – KAMINSKI et al. 2021, p. 344, pl. 1, figs. 11–12.

Material: 3 specimens.

Description: The test is small to medium-sized, subspherical to slightly flattened in outline (pl. 1, fig. 2). The wall is thin, finely agglutinated, and appears smooth to slightly granular under reflected light. The surface shows a compact texture with scattered larger grains embedded in the wall. The aperture is terminal, round to slightly irregular, without a distinct neck.

Remarks: Our material corresponds well with the original description of *Reophax grzybowskii* Schubert (1902) and subsequent descriptions under *Saccammina* (Kaminski and Gradstein 2005; Waśkowska-Oliwa 2008). The thin wall and rounded, unilocular outline distinguish this species from other agglutinated taxa in the assemblage. It differs from more robust *Saccammina* species by its smaller size, delicate wall, and smooth surface texture.

Distribution and occurrences: *Saccammina grzybowskii* was originally described from the Paleogene of northern Italy (Schubert 1902). It has been documented from the Paleocene of the Subsilesian rock unit in Poland (Waśkowska-Oliwa 2008), the Upper Cretaceous–Paleogene of the Umbria–Marche Basin, Italy (Kaminski et al. 2011), and the Paleocene–Eocene of the Magura Nappe, Outer Carpathians (Waśkowska et al. 2018). Additional records include the Paleogene of the Caribbean (Wilson et al. 2019) and the Paleocene of IODP Site U1511, Tasman Sea (Kaminski et al. 2021). In this study, *Saccammina grzybowskii* is recorded from samples C-4 and C-9 within the lower part of E14 biozone.

Suborder LITUOLINA Lankester 1885
Superfamily LITUOLOIDEA de Blainville 1827
Family HAPLOPHRAGMOIDIDAE Maync 1952
Genus *Haplophragmoides* Cushman 1910

Haplophragmoides* cf. *walteri (Grzybowski 1898)
Plate 1, figure 3–4

Trochammina walteri GRZYBOWSKI 1898, p. 290, pl. 11, fig. 31.
Haplophragmoides cf. *walteri* (Grzybowski). – KAMINSKI et al. 2011, p. 90, pl. 4, figs. 13–14. – SETOYAMA and KAMINSKI 2015, p. 246, pl. 2, fig. 16. – KAMINSKI et al. 2021, p. 352, pl. 4, figs. 16a, b.

Material: 46 specimens.

Description: Test medium-sized, planispiral, and slightly involute, with a distinctly flattened outline and an acute to subacute periphery (pl. 1, fig. 3a-c, 4a-c). Chambers are triangular to subrectangular, increasing gradually in size, with approximately eight in the final whorl. The test in axial view shows a compressed profile (pl. 1, fig. 3b). Sutures are weakly depressed, straight to slightly recurved. The wall is finely agglutinated, appearing smooth in texture. The aperture is interiomarginal, forming a low slit; in some specimens, a faint apertural lip is visible.

Remarks: The studied material is consistent with the morphology of *Haplophragmoides walteri* described by Grzybowski (1898) and later authors (Kaminski et al. 2011; Setoyama and Kaminski 2015). The specimens referred to as *Haplophragmoides* cf. *walteri* show the typical compressed, involute test with triangular chambers, although they are slightly smaller and more slender than the classical Eocene forms from Poland. Such variability has been noted in previous studies (Kuhnt et al. 1993; Kaminski et al. 2021). The taxon can be distinguished from *H. eggeri* by its less inflated chambers and from *H. nauticus* by its straighter sutures and more triangular chamber shape.

Distribution and occurrences: *Haplophragmoides walteri* was first described from the Paleogene of the Silesian Unit in the Polish Carpathians (Grzybowski 1898). The form designated as *H.* cf. *walteri* has since been documented from Upper Cretaceous to Paleogene deep-water deposits, including northern Spain (Kuhnt and Kaminski 1993), the Umbria–Marche Basin of Italy (Kaminski et al. 2011), the Cretaceous of the Norwegian Sea (Setoyama and Kaminski 2015), and the Paleocene of IODP Site U1511 in the Tasman Sea (Kaminski et al. 2021). In the present study, it is recognized from several samples (C-1 to C-11) within the E14 biozone.

Haplophragmoides horridus (Grzybowski 1901)
Plate 1, figure 5

Haplophragmium horridum GRZYBOWSKI 1901, p. 270, pl. 7, fig. 12.
Haplophragmoides horridus (Grzybowski). – KAMINSKI and GEROCH 1993, p. 275, pl. 15, figs. 6–8. – KAMINSKI and GRADSTEIN 2005, p. 347, pl. 77, figs. 1–6. – BELDEAN and FILIPESCU 2011, p. 11, pl. 4, fig. 10.

Material: 27 specimens.

Description: The test is medium to large, planispiral, and involute, with a nearly circular to suboval outline. In axial view (pl. 1, fig. 5b), the test is somewhat inflated rather than compressed, giving a relatively thick axial profile. The last whorl consists of 4–5 triangular to subtriangular chambers that increase rapidly in size toward the periphery. Sutures are straight, distinct, and moderately depressed. The wall is finely to moderately agglutinate, with a smooth to slightly rough texture. The periphery is rounded to sublobate. The aperture is a low slit with a faint lip at the base of the final chamber.

Remarks: *Haplophragmoides horridus* is characterized by its lobate outline, triangular final chamber, and agglutinated wall. It differs from *H. walteri* by having fewer, coarser chambers and by lacking the compressed axial profile typical of that species, and from *H. eggeri* by its less inflated morphology. Specimens from the Sirhan–Turayf basin are consistent with published descriptions, though they tend to be smaller and exhibit finer wall textures than the classical Carpathian material.

Distribution and occurrences: *Haplophragmoides horridus* was originally described from the Paleogene of the Magura Unit in the Polish Carpathians (Grzybowski 1901). It has since been reported from additional Eocene deposits of the Outer Carpathians and discussed in subsequent taxonomic and stratigraphic treatments of Paleogene deep-water agglutinated foraminifera (Kaminski and Geroch, 1993; Kaminski and Gradstein, 2005). Additional records include the Neogene of the Transylvanian Basin, Romania (Beldean and Filipescu 2011). In the present study, *H. horridus* is recognized from several samples (C-5 to C-12) within the E14 biozone.

Haplophragmoides porrectus Maslakova 1955
Plate 1, figure 6

Haplophragmoides porrectus MASLAKOVA 1955, p. 47, pl. 3, figs. 5–6. – KAMINSKI and GRADSTEIN 2005, p. 353, pl. 79, figs. 1a–6. – BENEDETTI 2017, p. 40, fig. 18.20. – KAMINSKI et al. 2021, p. 352, pl. 4, figs. 13a–14b.

Material: 88 specimens

Description: Test small, free, rounded, planispirally coiled and involute, composed of two whorls. The first whorl is tightly coiled and minute, about one-third the diameter of the last whorl. The final whorl comprises 6–7 triangular chambers increasing gradually in size toward the periphery (pl. 6, figs. 6a–c). Sutures are straight to slightly curved and depressed. Wall finely agglutinated, smooth in texture. Aperture a narrow slit located at the base of the final chamber on the periphery.

Remarks: The studied specimens of *Haplophragmoides porrectus* display seven chambers in the final whorl (pl. 6, figs. 6a–c), a feature consistent with specimens from the Paleogene of the Labrador Margin (Kaminski and Gradstein 2005). This chamber arrangement represents the upper limit of variation within the species and has been interpreted as transitional toward *Recurvoidella lamella.*

Distribution and occurrences: *H. porrectus* was originally described from the Paleocene Jammenskaya Svita of the Ukrainian Carpathians (Maslakova 1955). It was later recorded from the Paleocene–Eocene of the North Atlantic and Labrador Sea (Kaminski and Gradstein 2005), and from the Paleogene of the Labrador Margin (Setoyama et al. 2017). Additional occurrences have been reported from the Eocene of Italy (Benedetti 2017). In this study, *H. porrectus* is identified from several samples (C-4 to C-10 and C-13) within the E14 biozone.

Superfamily SPIROPLECTAMMINOIDEA Cushman 1927
Family SPIROPLECTAMMINIDAE Cushman 1927
Subfamily SPIROPLECTAMMININAE Cushman 1927
Genus *Spiroplectammina* Cushman 1927

Spiroplectammina deperdita (d'Orbigny 1846)
Plate 1, figure 7

Textularia deperdita d'ORBIGNY 1846, p. 244, pl. 14, figs. 23–25. – OZSVÁRT 2007, p. 35, pl. 2, figs. 1–2.
Spiroplectammina deperdita (d'Orbigny). – KORECZ-LAKY and NAGY GELLAI 1985, p. 84, fig. 1. – DARAKCHIEVA et al. 2019, p. 11, pl. 1, fig. 6
Spiroplectammina (*Spiroplectinella*) *deperdita* (d'Orbigny). – CHARNOCK and JONES 1990, p. 182, pl. 9, fig. 14; pl. 21, fig. 4.

Material: 35 specimens.

Description: Test elongate, rectangular, and strongly compressed, with a small initial coil followed by 8–9 pairs of low, flattened biserial chambers. Sutures are straight to slightly oblique, distinctly depressed. Periphery sharp to knife-edged, wall finely agglutinated and smooth; aperture a low arch at the base of the final chamber.

Remarks: *Spiroplectammina deperdita* (d'Orbigny 1846) is readily identified by its slender, strongly compressed test, composed of low, flattened biserial chambers and a sharp, knife-edged periphery. It differs from *Spiroplectinella carinata* (d'Orbigny) in lacking a pronounced keel and inflated chambers, which give the latter a more robust appearance (Charnock and Jones 1990). The taxon has been treated inconsistently in the literature, being referred to as *Textularia deperdita* (Ozsvárt, 2007), *Spiroplectammina deperdita* (Darakchieva et al. 2019), and *Spiroplectinella deperdita* (Charnock and Jones, 1990). The morphology of our specimens, particularly the delicate biserial stage, elongate rectangular outline, and thin, knife-edged periphery, is most consistent with the concept of *Spiroplectammina*, and overall, more slender than typical S*piroplectinella.*

Distribution and occurrences: Originally described by d'Orbigny (1846) from the Vienna Basin as *Textularia deperdita.* The species has subsequently been reported under different generic assignments from a wide range of European localities. Charnock and Jones (1990) illustrated it from the Upper Eocene of the North Sea Basin as *Spiroplectammina* (*Spiroplectinella*) *deperdita*. It occurs in the middle to upper Eocene of Hungary (Ozsvárt 2007), and the middle Eocene to lower Oligocene of Bulgaria (Darakchieva et al. 2019). In this study, *S. deperdita* is documented from several samples (e.g., C-4, C-14, and C-23) along the E14 biozone.

Genus *Spiroplectinella* Kisel'man 1972

Spiroplectinella carinata (d'Orbigny 1846)
Plate 1, figure 10

Textularia carinata d'ORBIGNY 1846, p. 247, pl. 14, figs. 32–34.
Spiroplectammina carinata (d'Orbigny). – POPESCU and IVA 1971, p. 40, pl. 2, figs. 3–4. – SZCZECHURA and POŻARYSKA 1974, p. 31, pl. 3, figs. 16–17. – SZTRÁKOS 1979, pl. 3, fig. 3. – OZSVÁRT 2007, p. 32, pl. 1, figs. 10–11.
Spiroplectinella carinata (d'Orbigny). – PAPP and SCHMIDT 1985, p. 86, pl. 80, figs. 1–4. – DARAKCHIEVA JURANOV and VALCHEV 2019, p. 12, pl. I.7. – HASSAN and KORIN 2019, fig. 11.16.

Material: 23 specimens.

Description: The test is elongate with a small planispiral initial coil that transitions into a biserial arrangement. The biserial stage is composed of 7–8 pairs of broad chambers that are relatively low but strongly inflated, giving the test a robust appearance. Chambers increase gradually in size toward the apertural end. Sutures are distinct, slightly oblique, and moderately depressed. The periphery is acute, bearing a narrow keel. The wall is coarsely agglutinated, with grains visibly protruding at the surface. The aperture is a low, arch-shaped opening situated at the base of the final chamber.

Remarks: *Spiroplectinella carinata* (d'Orbigny 1846) is distinguished from *Spiroplectammina* by its acute keeled periphery and broad, low chambers that become inflated toward the aperture. The coarsely agglutinated wall and robust biserial portion support its placement in *Spiroplectinella* (Papp and Schmidt 1985; Darakchieva 1999; Ozsvárt 2007).

Distribution and occurrences: *Spiroplectinella carinata* (d'Orbigny, 1846) is well documented from Eocene deposits across Europe and adjacent regions. It was originally described from the Upper Eocene of Poland (d'Orbigny 1846) and has since been reported from the Upper Eocene of the Polish Carpathians (Popescu and Iva 1971). The species occurs in the Middle to Upper Eocene of Hungary (Sztràkos 1979; Ozsvárt 2007), the Upper Eocene of the Caucasus and Ukraine, and the Eocene of England (Papp and Schmidt 1985; Darakchieva 1999). Additional occurrences are known from the Middle to Upper Eocene of southern Bulgaria (Darakchieva 1999) and from the Upper Eocene of Egypt (Hassan and Korin 2019).

Spiroplectinella dentata (Alth 1850)
Plate 1, figure 8, 9

Textularia dentata ALTH 1850, p. 262, pl. 13, fig. 13.
Spiroplectammina dentata (Alth). – SLITER 1977, p. 675, pl. 1, fig. 9. – BECKMANN 1978, p. 769, pl. 1, figs. 4–5. – KUHNT 1990, p. 325, pl. 6, fig. 14.
Spiroplectammina sp. aff. *S. dentata* (Alth). – KAMINSKI et al. 1988, p. 74, pl. 7, figs. 10–11.
Spiroplectammina ex gr. *dentata* (Alth). – KUHNT and KAMINSKI 1993, p. 75, pl. 6, figs. 5–6.
Spiroplectinella dentata (Alth). – KAMINSKI and GRADSTEIN 2005, p. 439, pl. 106, figs. 1a–8.

Material: 55 specimens.

Description: Test elongate and biserial throughout, expanding gradually from the rounded initial end toward the apertural margin. The initial portion of the test exhibits a short planispiral coiling, which passes into the biserial stage. In the lateral view, the test is distinctly kite-shaped, with a rhomboidal cross-section. Periphery angular and dentate, bearing fine spine-like projections along the margins. Chambers are obliquely arranged; early chambers more closely appressed, later chambers increasing progressively in size. Sutures straight to slightly oblique and clearly defined. Wall agglutinated, composed of moderately coarse grains, well cemented. Aperture a low, simple arch situated at the base of the final chamber.

Remarks: *Spiroplectinella dentata* (Alth 1850) is readily distinguished from *Spiroplectammina deperdita* (d'Orbigny 1846) by its broader, flabellate to kite-shaped test with a rhomboidal cross-section, in contrast to the elongate, rectangular, and strongly compressed form of *S. deperdita.* The periphery in *S. dentata* is distinctly dentate, bearing fine spine-like projections, whereas *S. deperdita* possesses a sharp, knife-edged margin. The short initial planispiral coiling followed by a regular biserial stage in the present specimen conforms well to the descriptions of Alth (1850), Sliter (1977), and Kaminski and Gradstein (2005).

Distribution and occurrences: *Spiroplectinella dentata* (Alth 1850) has a long stratigraphic range extending from the Late Cretaceous to the early Paleogene. It was originally described from the Upper Cretaceous deposits of Europe (Alth 1850) and subsequently reported from Maastrichtian to Danian sediments at DSDP Site 527 in the South Atlantic (Sliter 1977). The species has also been documented from Paleocene to Eocene bathyal to outer neritic settings of the North Atlantic, Tethyan, and Western Indian Ocean regions (Kaminski and Gradstein 2005). In the present study, *S. dentata* is identified from several samples (C-6 to C-15 and C-23) within the E14 biozone.

Spiroplectinella subhaeringensis (Grzybowski 1896)
Plate 2, figure 1

Textularia subhaeringensis GRZYBOWSKI 1896, p. 285, pl. 9, fig. 16.
Spiroplectammina subhaeringensis (Grzybowski). – SZCZECHURA and POŻARYSKA 1974, p. 31, pl. 3, figs. 16–17. – KUHNT and COLLINS 1996, p. 214, pl. 2, fig. 12.
Spiroplectinella subhaeringensis (Grzybowski). – DARAKCHIEVA 1999, p. 9. – KAMINSKI and GRADSTEIN 2005, p. 444, text-fig. 108-1, pl. 108, figs. 1–5– DARAKCHIEVA et al. 2019, p. 12, pl. 1, fig. 9.

Material: 19 specimens.

Description: The test begins with a small planispiral initial coil, followed by a biserial stage composed of four to five pairs of chambers that increase rapidly in size. The final chambers are strongly inflated and overlap the earlier ones. The periphery is subacute, bearing a narrow keel. Sutures are slightly depressed; the wall is finely agglutinated. The aperture is an interomarginal fissure.

Remarks: The species is readily recognized by its rapidly enlarging, strongly inflated chambers that overlap earlier ones, producing a stout biserial test. A subacute periphery with a narrow keel and a finely agglutinated wall further distinguishes it from the more slender *Spiroplectammina*. These diagnostic features support its assignment to *Spiroplectinella* (Darakchieva 1999; Kaminski and Gradstein 2005; Darakchieva et al. 2019).

Distribution and occurrences: *Spiroplectinella subhaeringensis* (Grzybowski 1896) was originally described from the Eocene of the Polish Carpathians (Grzybowski 1896) and later documented from Paleogene strata of the same region (Szczechura and Pożaryska 1974). The species has been reported from Paleogene deep-sea deposits of the Atlantic Ocean (Kuhnt and Collins 1996; Kaminski and Gradstein 2005) and from the Middle Eocene to Lower Oligocene successions of southern Bulgaria (Darakchieva 1999; Darakchieva et al. 2019). It is recorded within E14 biozone in this study.

Subfamily VULVULININAE Saidova 1981
Genus *Vulvulina* d'Orbigny 1826

Vulvulina spinosa Cushman 1927
Plate 2, figure 2

Vulvulina spinosa CUSHMAN 1927, p. 111, pl. 23, fig. 1. – CUSH-

MAN 1932, p. 79, pl. 10, fig. 15. – KRAEVA and ZERNETSKIJ 1969, p. 28, pl. 9, fig. 3. – REISER 1987, p. 60, pl. 2, figs. 6, 8. – BELLAGAMBA and COCCIONI 1990, p. 903, pl. 2, figs. 7–9. – DARAKCHIEVA 1999, p. 10. – SZÉKELY and FILIPESCU 2015, p. 32, Figs. 5.3a-b, 5.6. – DARAKCHIEVA et al. 2019, p. 13, pl. 1, fig. 11.

Material: one specimen.

Description: Test elongate, with a small initial planispiral coil followed by a biserial stage. The biserial portion consists of 4–5 pairs of low, broad chambers with peripheral spinose projections. Final chambers curve slightly backward, numbering 2–3, separated by distinct, depressed sutures. The wall is finely agglutinated, with a smooth to slightly rough texture. Periphery irregular due to the presence of spines. Aperture terminal, narrow, slit-like.

Remarks: *Vulvulina spinosa* is recognized by its elongate test with a biserial stage bearing peripheral spines and backward-curved final chambers. The spinose outline distinguishes it from smoother species of *Vulvulina* (Reiser 1987; Darakchieva 1999). It differs from *V. jarvisi* in having less inflated chambers (Cushman 1932) and from *Spiroplectammina spinosa* by its more robust morphology (Bellagamba and Coccioni 1990).

Distribution and occurrences: Originally described from the upper Eocene Alazan clay of Mexico (Cushman 1927), *V. spinosa* has since been reported from the Eocene of the Carpathians and South Bulgaria (Reiser 1987; Darakchieva 1999). Additional records occur in the Eocene of Italy and Germany (Bellagamba and Coccioni 1990) and the Oligocene of the Transylvanian Basin, Romania (Székely and Filipescu 2015). In this study, the species is identified from the E14 biozone.

Vulvulina eocaena Montagne 1941
Plate 2, figure 3

Vulvulina eocaena MONTAGNE 1941, p. 44, pl. 6, figs. 3, 4. – OLSZEWSKA et al. 1996, p. 77, pl. 25, figs. 7, 8. – BALINIAK 2018, p. 379, pl. 1, figs. 1, 2.

Material: 3 specimens.

Description: Test elongate and compressed, with a small indistinct initial planispiral coil followed by a biserial stage. The biserial portion consists of 4–5 pairs of low, broad chambers that gradually increase in size. Final chambers become slightly uniserial, curving backward. Sutures are distinct and slightly depressed. Wall finely agglutinated, smooth to somewhat rough in texture. Aperture terminal, narrow, and slit-like.

Remarks: This species is readily recognized by its elongate form, well-developed biserial portion, and uniserial final chambers. It differs from *V. spinosa* Cushman 1927 by lacking peripheral spines and from *V. pennatula* (Batsch 1791) by its more slender and less robust outline (Montagne 1941; Olszewska et al. 1996; Baliniak 2018).

Distribution and occurrences: First described from the Eocene of France (Montagne 1941). Reported subsequently from the Upper Eocene of the Polish Outer Carpathians (Olszewska et al. 1996) and Paleocene–Eocene slope marls of the Fore-Magura Thrust Sheet, Polish Outer Carpathians (Baliniak 2018). In the present study, *Vulvulina eocaena* is recorded from the upper part of E14 biozone.

Superfamily PAVONITINOIDEA Loeblich and Tappan 1961
Family PAVONITINIDAE Loeblich and Tappan 1961
Subfamily PAVONITININAE Loeblich and Tappan 1961
Genus *Pavonitina* Schubert 1914

Pavonitina styriaca Schubert 1914
Plate 2, figure 4

Pavonitina styriaca SCHUBERT 1914, p. 143, pl. 4, figs. 1–8. – CIMERMAN 1969, p. 112, pl. 1, figs. 1–7. – SEIGLIE and BAKER 1983, fig. 9. – SZTRÀKOS 1987, p. 131, pl. 2, fig. 5, pl. 3, fig. 8. – ŁUCZKOWSKA 1990, pl. 5, fig. 9. – POPESCU 1999, p. 413, pl. II, figs. 6, 7, 10. – BOUDAGHER-FADEL 2008, p. 299, pl. 6.1, fig. 8. – KORIN et al. 2025b, p. 144, fig. 2A–FF.

Material: 29 specimens.

Description: Test medium-sized, elongate, thin, and palmate with a leaf-like outline. The initial portion shows a short, slightly coiled stage, which passes into a biserial arrangement and finally a uniserial stage in the adult form. Chambers is semi-triangular in the early part, later moderately compressed, and aligned in a linear series. Sutures are distinct, slightly depressed, and curved in the early stages, becoming strongly inverted and V-shaped in later growth. Wall is finely agglutinated, composed of fine- to medium-grained particles, with sharply defined margins. Aperture terminal, poorly preserved, subcircular, situated on a low, weakly developed neck. Internal oblique septula are present in both the biserial and uniserial portions, though sometimes faint.

Remarks: *Pavonitina styriaca* is the type species of the genus, first described from the Miocene Schlier Formation in Austria (Schubert 1914). Later studies (Cimerman 1969; Seiglie and Baker 1983; Sztràkos 1987; Łuczkowska 1990; Popescu 1999; BouDagher-Fadel 2008) confirmed its diagnostic features, especially the transition from initial coiling to biserial and then uniserial growth, together with oblique septula. The presence of septula in both biserial and uniserial stages is a key feature distinguishing this species from other members of the Pavonitininae.

Distribution and occurrences: Originally reported from the Miocene Schlier Formation of Austria, the species is now documented from Priabonian (upper Eocene, Biozone E14) deposits of the Rashrashiyah Formation, Sirhan–Turayf Basin, northwestern Saudi Arabia (Korin et al. 2025b). Its occurrence in fine-grained marls and calcareous claystones indicates outer neritic to upper bathyal settings, consistent with adaptation to low-energy, oxygen-poor environments.

Pavonitina biarritzensis Sztràkos 1987
Plate 2, figure 5

Pavonitina biarritzensis SZTRÀKOS, 1987, p. 129, pl. 1, figs 1–3, pl. 3, figs 1–3. – CIMERMAN et al., 2006, p. 16, pl. 1, figs. 7-8. – KORIN et al., 2025b, p. 144, fig. 3A–D.

Material: 4 specimens.

Description: Test elongate and laterally compressed, leaf-shaped in outline. The early stage consists of a short initial coil, followed by a biserial chamber arrangement that transitions into a uniserial adult portion. Biserial chambers are semi-triangular to subrectangular, moderately compressed, and increase gradually in height toward the apertural end. Sutures are distinct, slightly depressed, and curved. The wall is finely agglutinated, composed of well-selected fine to medium grains, and sharply defined along the margins. The aperture is terminal, low-arched to subcircular, positioned on a short, weakly developed neck. In some specimens, faint flabelliform (fan-shaped) septula are visible within the final chambers.

Remarks: *Pavonitina biarritzensis* was originally described by Sztràkos (1987) from the Priabonian deposits of the Biarritz region (France). It is readily recognized by its flattened, elongate form and the progressive change from a short, coiled early stage to biserial and finally uniserial chamber arrangement. The species closely resembles *Phyllopsammia adanula* Małecki (1954) in its overall shape and fan-like septula, but as Cimerman (1969) and Sztrákos (1987) noted, *Phyllopsammia* is invalid; these forms are properly assigned to *Pavonitina*. The present specimens agree closely with those described and illustrated by Korin et al. (2025b) from the Rashrashiyah Formation of Saudi Arabia.

Distribution and occurrences: The species is known from the Priabonian strata of the Biarritz region (France) (Sztràkos 1987) and the Upper Eocene successions of the Rashrashiyah Formation in the Sirhan–Turayf Basin of Saudi Arabia (Korin et al. 2025b). Its association with deep-marine agglutinated assemblages suggests an outer-neritic to upper-bathyal habitat within low-energy, below-wave-base environments.

Pavonitina kiscelliana (Sztràkos 1987)
Plate 2, figure 6

Ammospirota kiscelliana SZTRÀKOS 1979, p. 59, pl. 3, fig. 6.
Ammospirota kiscelliana (Sztràkos). – SZTRÀKOS 1982, p. 21, fig. 6.
Pavonitina kiscelliana (Sztràkos). – SZTRÀKOS 1987, p. 130, pl. 1, figs. 4–8, pl. 3, figs. 4–6. – CICHA et al. 1998, p. 116, pl. 6, figs. 2–4. – KORIN et al. 2025b, p. 146, fig. 3E-L.

Material: 2 specimens.

Description: Test thin, laterally compressed, and broadly fan-shaped to palmate in outline. The early portion begins with a short, planispiral initial coil that transitions into a biserial chamber arrangement, gradually becoming uniserial as it approaches the adult stage. Chambers are slightly arcuate, overlapping gently, and separated by distinct, depressed sutures. The wall is finely agglutinated, composed of well-sorted grains, and externally smooth. Internally, the chambers exhibit weakly developed vertical septula descending from the chamber roof in a radial or fan-like pattern. The aperture is terminal, subcircular, and located within a shallow depression, though commonly poorly preserved.

Remarks: *Pavonitina kiscelliana* was originally described by Sztràkos (1979) as *Ammospirota kiscelliana* from the Kiscell Clay Formation of Hungary and later reassigned to *Pavonitina* (Sztràkos 1987) based on the presence of fine, radially arranged flabelliform septula. The species is characterized by its thin, laterally compressed, fan-shaped morphology and chamber sequence that progresses from a short coiled initial stage to biserial and finally uniserial growth. The present specimens from Saudi Arabia correspond closely to those illustrated by Sztràkos (1987) and Korin et al. (2025b). Juvenile forms may superficially resemble *P. biarritzensis*, but *P. kiscelliana* exhibits a more advanced uniserial stage and more distinct internal septation.

Distribution and occurrences: The species occurs in outer-neritic to upper-bathyal settings, typically within fine-grained, low-oxygen muds and marls. It has been reported from the upper Eocene to lower Oligocene Kiscell Formation in Hungary, correlative units in Spain, and the central Paratethys region (Poignant and Sztràkos 1986). In Saudi Arabia, *Pavonitina kiscelliana* occurs in the lower Priabonian interval of the Rashrashiyah Formation (Korin et al. 2025b), indicating deposition below storm-wave base under calm hemipelagic conditions.

Genus *Pavopsammia* Seiglie and Baker 1983

Pavopsammia flabellum Seiglie and Baker 1983
Plate 2, figure 7

Pavopsammia flabellum SEIGLIE and BAKER 1983, p. 393, pl. 1, figs. 6a–8. – LOEBLICH and TAPPAN 1987, p. 119, pl. 127, figs. 7–9 – BOUDAGHER-FADEL 2008, p. 299, pl. 6.1, fig. 9; KORIN et al. 2025b, p. 146, fig. 3M-FF.

Material: 56 specimens.

Description: Test compressed, fan-shaped to subpalmate in outline, with a flattened and broadly rounded periphery. Chamber arrangement triserial in the early growth stage, passing into biserial and finally uniserial configuration toward the adult stage. Chambers are subrectangular to crescentic in shape, increasing gradually in size toward the apertural end. Sutures are distinct, slightly depressed, and often coarsely agglutinated. The wall is composed of fine agglutinated grains, and the interior of the chambers shows vertical septula arranged in a radial or flabelliform pattern. Aperture terminal, semi-rounded, and located at the end of the final chamber, often within a shallow depression.

Remarks: *Pavopsammia flabellum* was established by Seiglie and Baker (1983) as the type species of the genus *Pavopsammia* based on Oligocene material from offshore West Africa. It is characterized by a triserial to biserial and finally uniserial chamber arrangement, representing a transitional morphology between *Flabelloglandulina* and *Pavonitina*. The fan-shaped septula are a distinctive internal feature supporting its generic placement. The Saudi specimens show excellent preservation, matching well with the morphology illustrated by Seiglie and Baker (1983), Loeblich and Tappan (1987), and Korin et al. (2025b), and confirm the occurrence of the genus in the late Eocene.

Distribution and occurrences: *Pavopsammia flabellum* is known from the Oligocene of offshore West Africa (Seiglie and Baker 1983) and the upper Eocene to lower Oligocene deep-water successions of Europe and the Middle East (Loeblich and Tappan 1987; BouDagher-Fadel 2008). Its occurrence in the upper Eocene Rashrashiyah Formation (Korin et al. 2025b) represents the first record of the species from Saudi Arabia. The species typically occurs in outer neritic to upper bathyal environments characterized by low-energy, oxygen-depleted conditions.

Order TEXTULARIIDA Delage and Hérouard 1896
Suborder TEXTULARIINA Delage and Hérouard 1896
Superfamily EGGERELLOIDEA Cushman 1937

Family EGGERELLIDAE Cushman 1937
Subfamily PSEUDOGAUDRYINAE Loeblich and Tappan 1985
Genus *Flabellogaudryina* Kaminski and Korin 2025

Flabellogaudryina sirhanensis Kaminski and Korin 2025
Plate 2, figure 8

Flabellogaudryina sirhanensis KAMINSKI and KORIN 2025, p. 95, pl. 1, figs. 1a–4c; pl. 2, figs. 1a–4c; text-fig. 2

Material: 88 specimens.

Description: Test medium-sized, elongate, and distinctly flattened, flabelliform in outline. Early stage triserial and triangular, later becoming biserial with strongly compressed, laterally expanded chambers. Sutures flush to slightly depressed, strongly arched in the biserial stage. Wall coarsely agglutinated, canaliculated, with calcareous cement; fragments of other foraminiferal tests are occasionally incorporated. Aperture terminal, oval to subcircular, areal, surrounded by a low rim or collar.

Remarks: This species is readily distinguished from other pseudogaudryinids by its distinctly flattened biserial chambers and characteristic flabelliform outline. The presence of a finely canaliculated wall surface clearly differentiates it from *Spiroplectammina* Cushman 1927, and related genera. It also differs from *Pseudogaudryina* in having more laterally expanded biserial chambers and a broader, fan-shaped test. Despite its superficial resemblance to some flaring forms, the combination of a compressed test and canaliculated wall structure justifies its assignment to the new genus *Flabellogaudryina* by Kaminski and Korin (2025).

Distribution and occurrences: *Flabellogaudryina sirhanensis* was first identified from the Bartonian–Priabonian succession of the Rashrashiyah Formation, Sirhan–Turayf Basin, northwestern Saudi Arabia (Kaminski and Korin, 2025).

Flabellogaudryina sp.
Plate 1, figure 9

Material: 3 specimens.

Remarks: *Flabellogaudryina* sp. is distinguished from *Flabellogaudryina sirhanensis* by its more elongate and slender outline, narrower biserial portion, and less laterally expanded chambers. The test is more compressed in the lateral view, with chambers that are higher and more regularly arranged.

Suborder VERNEUILININA Mikhalevich and Kaminski 2004
Superfamily VERNEUILINOIDEA Cushman 1911
Family PROLIXOPLECTIDAE Loeblich and Tappan 1985
Genus *Plectina* Marsson 1878

Plectina cubensis Cushman and Bermúdez 1936
Plate 2, figures 10, 11

Plectina cubensis CUSHMAN and BERMÚDEZ 1936, p. 57, pl. 10, figs. 7–9. – CUSHMAN 1937, p. 108, pl. 12, figs. 9–11. – BERGGREN 1972, pl. 12, fig. 22.

Material: 9 specimens.

Description: Test small, comparatively short and broad, subconical, with the greatest breadth near the apertural end and tapering proximally toward the initial end. Adult portion distinctly biserial; early chambers indistinct, later chambers ovate to subglobular, inflated, and increasing gradually in size. Sutures oblique and moderately depressed. Wall coarsely agglutinated with firmly cemented grains. Aperture terminal, circular to subcircular, positioned slightly above the inner margin of the final chamber.

Remarks: *Plectina cubensis* is characterized by its short, subconical test with inflated biserial chambers and a terminal circular aperture. Compared with *P. dalmatina* (Schubert), it is smaller and less elongate, with broader chambers and a less lobulate outline.

Distribution and occurrences: *Plectina cubensis* was originally described from the Eocene (lower Principe Formation) of Cuba (Cushman and Bermúdez 1936) and later recorded from the Eocene of Trinidad (Cushman 1937) and the North Atlantic region (Berggren 1972). In the present study, *P. cubensis* is recorded within the upper part of the E14 biozone.

Plectina* cf. *cubensis Cushman and Bermúdez 1936
Plate 3, figure 1

Material: 1 specimen.

Remarks: Our specimens resemble *Plectina cubensis* but differ in exhibiting a more compact biserial arrangement, less basal tapering, and final chambers that appear slightly deformed or collapsed, probably as a result of taphonomic preservation.

Plectina dalmatina (Schubert in Liebus 1911)
Plate 3, figure 2

Gaudryina dalmatina SCHUBERT 1911, p. 75, pl. 3, fig. 5.
Plectina dalmatina (Schubert). – LIEBUS 1927, p. 349. – CUSHMAN 1937, p. 107, pl. 12, fig. 8. – PROTO-DECIMA and BOLLI 1978, p. 795, pl. 1, fig. 13. –SZTRÁKOS 1987, pl. 3. fig. 7. – CIMERMAN et al. 2006, p. 16, pl. 1, figs. 9-10. – OZSVÁRT 2007, p. 34, pl. 1. fig. 15.– BOSCOLO-GALAZZO 2014, p. 34, pl. 1, fig. 1.

Material: 8 specimens

Description: Test elongate and subtriangular in general shape. The initial portion is initially coiled or triserial-arrangement, consisting of small, closely arranged chambers that gradually transition into a biserial arrangement in the middle part and occasionally become weakly uniserial in the final stage. Chambers are ovate to subglobular, moderately inflated, and increase progressively in size toward the apertural end. Sutures are distinct, oblique, and slightly depressed, giving the test a gently lobate outline in lateral view. The wall is coarsely agglutinated, with fine quartz grains set in a calcareous matrix, resulting in a compact and relatively smooth surface. aperture is rounded to slightly ovate, in a slight depression of the apertural face.

Remarks: *Plectina dalmatina* differs by its more elongate, subtriangular test with a smoother wall texture and more regular chamber arrangement. The chambers are generally less inflated than in *P. cubensis*, except for its last chamber, and increase more gradually in size toward the apertural end.

Distribution and occurrences: The species was originally described from the Eocene of Dalmatia (Schubert 1911) and subsequently reported from the Eocene of Central and Southern Europe, including Italy and Hungary (Proto-Decima and Bolli 1978; Sztrákos 1987; Ozsvárt 2007; Boscolo-Galazzo 2014). *P. dalmatina* is found within the E14 biozone in the area under consideration.

Plectina eocenica Cushman 1936
Plate 3, figure 3

Plectina eocenica CUSHMAN 1936, p. 32, pl. 5, fig. 5. – CUSHMAN 1937, p. 108, pl. 12, figs. 5–7. – OZSVÁRT 2007, p. 34, pl. 1, fig. 16.

Material: 5 specimens

Description: Test elongate and subcylindrical, composed of an initial triserial stage that passes into a biserial arrangement, with a slight tendency toward uniserial growth in adult forms. Chambers are distinct, inflated, and increase gradually in size toward the apertural end. Sutures are moderately depressed and oblique in the biserial stage. Wall coarsely agglutinated. Aperture terminal, rounded to subcircular, without a defined neck.

Remarks: *Plectina eocenica* differs from *P. dalmatina* (Schubert) by its more elongate form, coarser agglutination, and more lobulate outline.

Distribution and occurrences: *Plectina eocenica* was first described from the Eocene of Biarritz, France (Cushman 1936) and later illustrated from the Eocene of Trinidad (Cushman 1937). The species has also been recorded from the Eocene of Hungary (Ozsvárt 2007). In the present study, *P. eocenica* is identified from the Priabonian of the Rashrashiyah Formation, within the upper part of Biozone E14.

Superfamily TEXTULARIOIDEA Ehrenberg 1838
Family EGGERELLIDAE Cushman 1937
Subfamily EGGERELLINAE Cushman 1937
Genus *Karreriella* Cushman 1933

Karreriella halkyardi Cushman 1936
Plate 3, figure 4

Karreriella halkyardi CUSHMAN 1936, p. 36, pl. 5, fig. 16. – CUSHMAN 1937, p. 124, pl. 14, fig. 33.– GRÜNIG 1985, p. 258, pl. 3, figs. 21–22. – CIMERMAN et al., 2006, p. 18, pl. 2, figs. 3–4.

Material: 15 specimens.

Description: Test elongate and tapering, with greatest breadth near the apertural end; periphery broadly rounded. The initial portion consists of four to five chambers arranged triserially, passing into a biserial or slightly twisted adult stage. Chambers are distinct, slightly inflated, and increase gradually in size toward the aperture. Sutures are horizontal, distinct, and slightly depressed. The wall is coarsely agglutinated, with a roughened surface texture. Aperture elongate, with a distinct lip positioned above the base of the last-formed chamber, occasionally nearly terminal in mature individuals.

Remarks: *Karreriella halkyardi* is distinguished by its tapering, elongate test, triserial early stage, and slightly twisted biserial adult portion.

Distribution and occurrences: Originally described from the Eocene Blue Marl of Biarritz, France (type locality). Also reported from the Eocene of Gassino near Turin and the Bartonian Eocene of Val di Lonte, Italy (Cushman 1936), and from the upper Eocene of the Sočka–Dobrna area, Slovenia (Cimerman et al. 2006). In the present study, *K. halkyardi* is identified from several samples (C-20 to C-23) within the E14 biozone.

Karreriella* cf. *halkyardi Cushman, 1936
Plate 3, figure 5

Material: 11 specimens.

Remarks: This form closely resembles *Karreriella halkyardi* Cushman 1936 in its general elongate, tapering outline and triserial-to-biserial chamber arrangement. However, it differs by having a more irregular apertural end, with the final chambers appearing partially collapsed and less inflated. The wall surface is also slightly rougher and more coarsely agglutinated than in the typical *K. halkyardi*, suggesting either diagenetic modification or minor morphological variability within the species group.

Karreriella* cf. *ovata Hussey 1943
Plate 3, figure 6

cf. *Karreriella ovata* HUSSEY 1943, p. 161, pl. 26, fig. 5.

Material: 8 specimens.

Description: Test elongate and gently tapering, slightly curved throughout its length, giving an overall inclined appearance. The periphery is rounded to slightly compressed, producing an ovate to subovate cross-section. Chambers distinct, moderately inflated, and increase gradually in size toward the apertural end. Sutures distinct, slightly depressed, and nearly horizontal. Wall finely agglutinated, composed of well-sorted, firmly cemented grains. Aperture terminal, situated near the center of the apertural face, surrounded by a short tubular neck.

Remarks: *Karreriella* cf. *ovata* closely resembles *Karreriella ovata* Hussey 1943 in general outline and the presence of a central tubular aperture. However, *Karreriella* cf. *ovata* from our study area is characterized by a distinctly curved and inclined test with less inflated adult chambers. The wall exhibits a comparatively rough and irregular surface texture, which may reflect minor diagenetic modification or inherent intraspecific variability.

Distribution and occurrences: Originally described from the Eocene Cane River Formation of Louisiana (Hussey 1943). The present specimens occur in the Middle–Upper Eocene carbonate–marl succession of the Sirhan–Turayf Basin within the upper part of E14 biozone, suggesting an extended paleogeographic range of the *Karreriella ovata* group across the Tethyan region.

Karreriella arenasensis Cushman and Bermúdez 1937
Plate 3, figure 8

Karreriella arenasensis CUSHMAN and BERMÚDEZ 1937, p. 5, pl. 1, figs. 20–21.– CUSHMAN 1937, p. 125, pl. 14, fig. 24.

Material: 6 specimens.

Description: Test elongate, slender, and cylindrical throughout, tapering gradually from a subacute initial end toward the apertural region. The periphery is broadly rounded and only slightly compressed, giving the test a nearly uniform cylindrical outline. Chambers distinct, moderately inflated, increasing regularly in size as added; early chambers are small and subglobular, while adult chambers are more elongated and uniform. Sutures straight, depressed, and oriented nearly perpendicular to the test axis. Wall finely agglutinated, well cemented, and smooth. Aperture low and broad, situated slightly above the base of the final chamber.

Remarks: The Saudi specimens resembles *Karreriella arenasensis* Cushman and Bermúdez (1937) in their cylindrical, elongate test and finely agglutinated wall. They differ from *Karreriella* cf. *ovata* by their straight, non-curved outline and more cylindrical overall shape, whereas *K.* cf. *ovata* shows a distinctly inclined and curved test. Minor variation in chamber inflation is attributed to intraspecific or diagenetic factors.

Distribution and occurrences: Originally described from the Eocene of Arroyo Arenas, Havana Province, Cuba (Cushman and Bermúdez 1937). The present material represents the first record of this species from the Middle–Upper Eocene of the Sirhan–Turayf Basin, northwestern Saudi Arabia, extending its paleogeographic range within the Tethyan realm within the upper part of E14 biozone.

Family PSEUDOGAUDRYINIDAE Loeblich and Tappan 1985
Subfamily PSEUDOGAUDRYININAE Loeblich and Tappan 1985
Genus *Clavulinoides* Cushman 1936

Clavulinoides alpina Cushman 1936
Plate 3, figure 9

Clavulinoides alpina CUSHMAN 1936, p. 22, pl. 3, fig. 16. – CUSHMAN 1937, p. 127, pl. 18, figs. 13–15. – OZSVÁRT 2007, p. 37, pl. 2, figs. 15–16.

Material: 13 specimens.

Description: Test small, subtriangular in outline, with the initial portion triserial and the upper part becoming uniserial. Chambers gradually enlarge and become more compressed toward the apertural end, resulting in a distinctly triangular cross-section. Sutures are faint to slightly depressed. The wall is finely agglutinated and smooth with minor surface irregularities. Aperture terminal, circular to subcircular, positioned at the end of the final chamber.

Remarks: *Clavulinoides alpina* is characterized by its subtriangular outline, with an early triserial stage transitioning into a uniserial adult portion. It differs from *Clavulinoides trilatera* (Cushman 1926) by possessing a shorter test, more compressed and broader chambers, and a distinctly triangular cross-section with indistinct sutures.

Distribution and occurrences: Originally described from the Eocene of the Swiss Alps (Cushman 1936) and subsequently reported from the Eocene of Hungary (Oszvárt 2007). The species has also been recorded from the Upper Eocene of the northeastern Desert, Egypt (Hassan and Korin 2019). In the present study, *Clavulinoides alpina* occurs within the Middle–Upper Eocene marl and carbonate succession of the Sirhan–Turayf Basin, northwestern Saudi Arabia, within biozone E14, where it is associated with other outer-shelf to upper-bathyal agglutinated foraminifera.

RESULTS AND DISCUSSION

The ~11 m interval of the Rashrashiyah Formation at Outcrop C yields a diverse and well-preserved assemblage of agglutinated benthic foraminifera, reported here for the first time from Saudi Arabia, which provides a detailed record of environmental conditions during the Priabonian (planktonic Zone E14). Twenty-three species assigned to ten genera were identified (pls. 1–3). Their distribution and abundance across the section are summarized in Table 1, which forms the basis for the quantitative paleoecological analyses that follow. The assemblage is dominated by *Haplophragmoides* (*H.* cf. *walteri*, *H. horridus*, *H. porrectus*), *Spiroplectammina* (*S. deperdita*), *Spiroplectinella* (*S. carinata*, *S. dentata*, *S. subhaeringensis*), *Plectina* (*P. cubensis*, *P. dalmatina*, *P. eocenica*), *Karreriella* (*K. halkyardi*, *K.* cf. *halkyardi*, *K.* cf. *ovata*, *K. arenasensis*), and members of the Pavonitininae (*Pavonitina styriaca*, *P. biarritzensis*, *P. kiscelliana*, *Pavopsammia flabellum*). Additional components include simple monothalamous forms (*Psammosphaera irregularis*, *Saccammina grzybowskii*), *Flabellogaudryina sirhanensis*, *Flabellogaudryina* sp., *Vulvulina spinosa*, *V. eocaena*, and *Clavulinoides alpina.*

Species distribution data (Table 1) show a pronounced upward increase in taxonomic richness and abundance throughout the section, with deep-infaunal taxa becoming progressively dominant toward the top. The Shannon–Wiener diversity index (text-fig. 2) documents this trend quantitatively, increasing from <1.0 in the basal samples (C-1–C-4, 0–2 m) to >2.5 in the uppermost levels (C-20–C-23, 9–11 m). This increase reflects a shift within the upper Slope Marl Assemblage (SMA) sensu Kuhnt and Kaminski (1989), which is defined as a mixed plankton-dominated marl assemblage characteristic of continental-slope settings at water depths of approximately 200–500 m, characterized by high taxonomic diversity, abundant calcareous planktonic foraminifera, and calcareous-cemented agglutinated benthic taxa. The studied interval records a transition from the lower part of the upper SMA, dominated by low-diversity assemblages with simple monothalamous morphotypes, to the upper part of the upper SMA, marked by increased diversity and the dominance of deep-infaunal morphogroups associated with the Oxygen Minimum Zone (OMZ) (Kaminski and Gradstein 2005; Setoyama et al. 2017; Benedetti 2017; Baliniak 2018). This transition is expressed by the proliferation of morphologically complex triserial–biserial and canaliculated forms, particularly among the Pavonitininae, consistent with increasingly persistent dysoxic conditions at the sediment–water interface.

The morphogroup distribution patterns shown in text-figs. 2–3 document a systematic reorganization of the agglutinated assemblage through the studied interval. In the lower part of the succession (samples C-1–C-9), the assemblage is dominated by morphogroup M4a, represented primarily by planispiral Haplophragmoides, while morphogroup M2a, composed of simple monothalamous forms (*Psammosphaera irregularis*, *Saccammina grzybowskii*), occurs only intermittently and with low relative abundance (text-fig. 2). This association corresponds to the lower subdivision of the upper Slope Marl Assemblage, reflecting stressed conditions on the continental slope characterized by unstable substrates and episodic oxygen limitation. Above this interval, beginning around sample C-10, a pronounced and persistent increase in morphogroups M2c and M4b is observed,

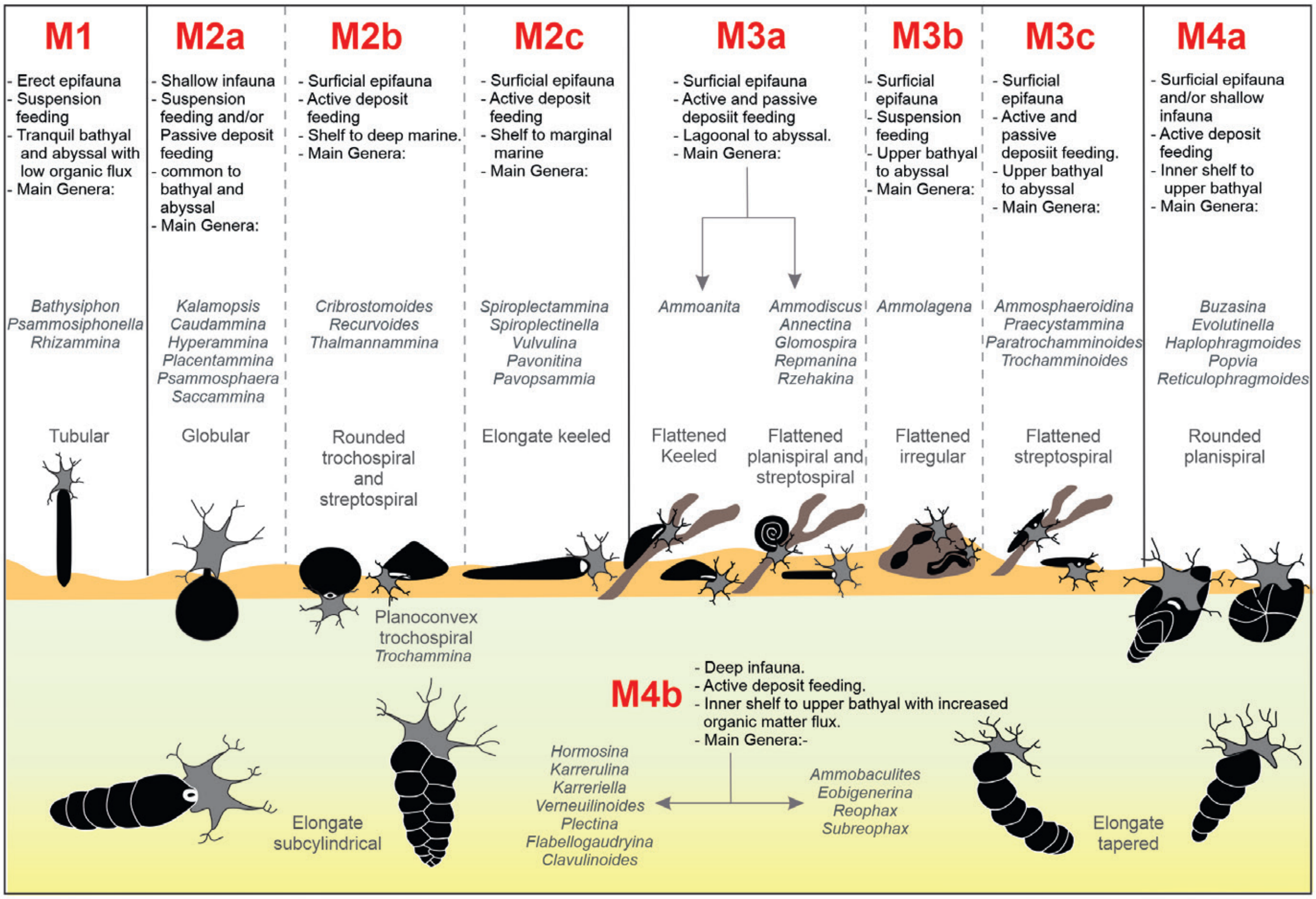
TABLE 1
Distribution and abundance of agglutinated benthic foraminiferal species in samples C-1 to C-23 from the Rashrashiyah Formation, Outcrop C, Sirhan–Turayf Basin, northwestern Saudi Arabia.

	Psammosphaera irregularis	*Saccammina grzybowskii*	*Haplophragmoides* cf. *walteri*	*Haplophragmoides horridus*	*Haplophragmoides porrectus*	*Spiroplectammina deperdita*	*Spiroplectinella dentata*	*Spiroplectinella carinata*	*Spiroplectinella subhaeringensi*	*Vulvulina spinosa*	*Vulvulina eocaena*	*Pavonitina styriaca*	*Pavonitina biarritzensis*	*Pavonitina kiscelliana*	*Pavopsammia flabellum*	*Flabellogaudryina sirhanensis*	*Flabellogaudryina* sp.	*Plectina cubensis*	*Plectina* cf. *cubensis*	*Plectina dalmatina*	*Plectina eocenica*	*Karrerielia halkyardi*	*Karreriella* cf. *halkyardi*	*Karreriella* cf. *ovata*	*Karreriella* sp.	*Karreriella arenasensis*	*Clavulinoides alpina*
C-23	0	0	0	0	0	2	2	3	3	1	2	11	1	0	0	0	0	2	1	1	2	3	7	1	2	3	0
C-22	0	0	0	0	0	1	2	0	0	0	0	4	0	0	1	0	0	1	0	0	0	1	1	0	2	0	0
C-21	0	0	0	0	0	0	4	3	0	0	1	14	0	0	0	0	0	1	0	1	0	4	1	2	4	3	0
C-20	0	0	0	0	0	6	21	7	5	0	0	0	0	0	6	0	0	1	0	2	1	7	2	2	1	0	0
C-19	0	0	0	0	0	3	8	3	1	0	0	0	1	0	8	0	0	0	0	2	0	0	0	0	0	0	2
C-18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	1	0	0	1	0	0	0	0	0	0
C-17	0	0	0	0	0	4	2	0	0	0	0	0	0	0	7	0	0	1	0	2	1	0	0	1	0	0	0
C-16	0	0	0	0	0	3	4	1	1	0	0	0	0	0	16	0	0	1	0	0	0	0	0	0	0	0	0
C-15	0	0	0	0	0	1	2	3	1	0	0	0	2	2	10	0	0	1	0	0	0	0	0	2	1	0	1
C-14	0	0	0	0	0	5	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
C-13	0	0	0	0	4	1	1	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0
C-12	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0
C-11	0	0	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C-10	0	0	2	2	4	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C-9	1	2	8	6	9	0	0	0	0	0	0	0	0	0	0	18	1	0	0	0	0	0	0	0	0	0	0
C-8	0	0	14	8	20	0	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	0	0	0	0	0
C-7	0	0	2	2	12	0	0	0	0	0	0	0	0	0	0	11	2	0	0	0	0	0	0	0	0	0	0
C-6	0	1	3	3	16	0	2	0	0	0	0	0	0	0	0	17	0	0	0	0	0	0	0	0	0	0	2
C-5	0	0	10	4	22	5	3	2	5	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	5
C-4	1	0	1	0	1	1	3	0	2	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	2
C-3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0
C-2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C-1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

accompanied by a high diversity values (text-fig. 2). These morphogroups are represented by taxa such as *Spiroplectammina deperdita*, *Spiroplectinella carinata*, *S. dentata*, *Plectina cubensis*, *Karreriella halkyardi*, *Pavonitina styriaca*, *P. biarritzensis*, *P. kiscelliana*, *Pavopsammia flabellum*, and *Flabellogaudryina sirhanensis*, and define the upper subdivision of the upper Slope Marl Assemblage sensu Kaminski and Gradstein (2005). Their dominance indicates stabilization of fine-grained substrates under persistently reduced oxygen availability, consistent with development of an Oxygen Minimum Zone–influenced assemblage. The vertical shift from M4a-dominated assemblages to those dominated by M2c–M4b therefore reflects a change in bottom-water oxygenation and organic-matter flux within a stable upper-slope setting, rather than a response to progressive deepening.

The lithological succession exhibits a close correspondence with the observed faunal trends, indicating a progressive shift in depositional conditions through the studied interval. The lower part of the section (0–4 m) is characterized by chalky limestones interbedded with bituminous calcareous marls, whereas the upper interval (7–11 m) is dominated by sandy limestones and calcareous claystones (text-fig. 2). Although bituminous layers occur in the lower interval, they most likely record episodic organic enrichment under unstable depositional conditions rather than sustained anoxic bottom waters. The upward lithological change indicates increasing hemipelagic input accompanied by a shift toward more clay-rich facies, consistent with progressive shallowing of the basin and/or intensification of the oxygen minimum zone (OMZ). The accumulation of fine-grained, organic-rich facies in the upper part of the section favored M2c–M4b morphogroups, specialized pavonitinids (*Pavonitina*, *Pavopsammia*), and canaliculated pseudogaudryinids (*Flabellogaudryina*), which are diagnostic of OMZ-influenced assemblages in upper-slope settings (text-fig. 4).

Planktonic foraminiferal evidence from the same stratigraphic interval from Korin et al. (2025a) and Allam et al. (2025) provides independent constraints on bathymetry. Within the upper part of Outcrop C (C-18–C-23, 8–11 m), a rich *Hantkenina assemblage* was recovered, *including H. compressa*, *H. primitiva*, *H. alabamensis*, and *H. nanggulanensis*. The occurrence of these taxa within the same stratigraphic interval as the agglutinated assemblage confirms a Priabonian (Zone E14) age and deposition in an open-marine, outer shelf setting below the storm-wave base. *Hantkenina* typically inhabits thermally stratified, warm surface waters with relatively low-oxygen bottom waters (Coxall and Pearson 2006); its association with high-diversity M2c–M4b morphogroups suggests enhanced organic-matter flux sustaining benthic life under suboxic to dysoxic conditions. The taxonomic composition of the Rashrashiyah assemblage shows strong affinity with Priabonian slope faunas across the Tethyan realm, including the Outer Carpathians, the Alps, and the central Paratethys (Cushman 1936, 1937; Kaminski and Gradstein 2005; Ozsvárt 2007; Benedetti 2017). Cosmopolitan species such as *Haplophragmoides porrectus*, *Spiroplectammina deperdita*, *Spiroplectinella carinata*, *S. dentata*, *Plectina dalmatina*, *Karreriella halkyardi*, *Vulvulina eocaena*, and *Clavulinoides alpina* reflect broad paleoceanographic continuity and similar ecological regimes across the Tethys during the late



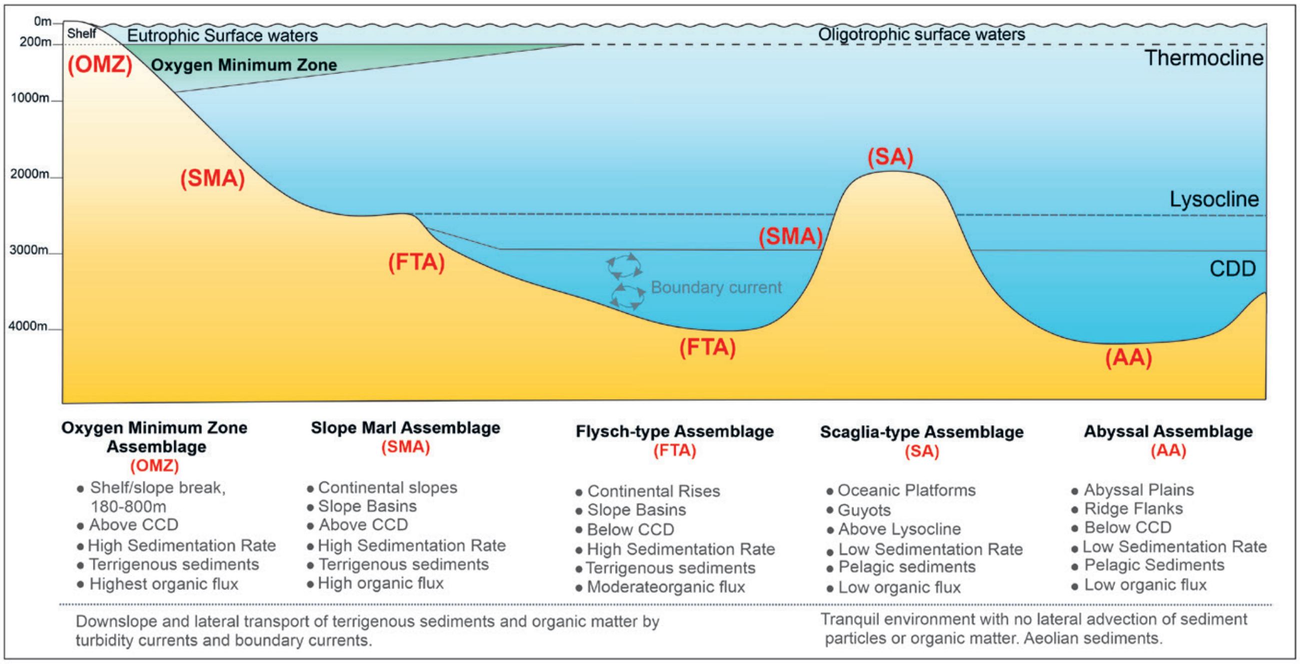
TEXT-FIGURE 3
Schematic illustration of agglutinated benthic foraminiferal morphogroups (M1–M4) and their inferred microhabitats and feeding strategies (after Kaminski and Gradstein 2005; Setoyama et al. 2017; Benedetti 2017). Morphogroups M2a, M2c, M4a, and M4b recorded in the Rashrashiyah Formation indicate upper Slope Marl Assemblage conditions characterized by oxygen-stressed to dysoxic environments during the Priabonian.

Eocene. The identification of *Karreriella arenasensis* and *Pavopsammia flabellum* extends their known range from the Atlantic and West African margins into the Arabian Plate, confirming the Sirhan–Turayf Basin as an important southern-Tethyan depocenter for deep-marine agglutinated faunas.

Integration of faunal data (Table 1), morphogroup trends (text-figs. 2–3), lithological changes, and planktonic assemblages establishes a coherent paleoenvironmental framework. During the Priabonian, the Sirhan–Turayf Basin represents an outer-shelf to upper-bathyal slope environment, with increasing organic-matter flux through time. The agglutinated assemblage at Outcrop C best corresponds to the upper part of the Slope Marl Assemblage (SMA), specifically the suboxic to dysoxic Oxygen Minimum Zone (OMZ) portion. The lack of tubular agglutinated taxa suggests that bottom-water environments were affected by low and variable oxygenation, probably linked to dynamic OMZ expansion and contraction, rather than being primarily controlled by depositional depth. The combined benthic and planktonic data therefore confirm that the Rashrashiyah Formation provides a key archive of Priabonian upper-slope paleoenvironmental conditions along the southern margin of the Tethys.

CONCLUSIONS

This study provides the first comprehensive documentation of Late Eocene (Priabonian) agglutinated benthic foraminiferal assemblages from the Rashrashiyah Formation in the Sirhan–Turayf Basin, northwestern Saudi Arabia, significantly improving the record of Paleogene slope-marl faunas from the Arabian Plate. The assemblage comprises 23 species assigned to 10 genera and dominated by *Haplophragmoides*, *Spiroplectammina*, *Plectina*, *Karreriella*, and members of the Pavonitininae, records a well-defined ecological gradient within the outer-shelf depositional setting. Morphogroup distributions and diversity trends demonstrate a clear internal subdivision of the upper Slope Marl Assemblage (SMA). The lower part of the succession is characterized by low-diversity, oxygen-stressed assemblages dominated by Haplophragmoides, with subordinate contributions from monothalamous taxa (*Psammosphaera*, *Saccammina*), reflecting unstable substrates and episodic oxygen limitation. The upper part of the succession is marked by elevated taxonomic diversity and dominance of morphologically complex taxa, including pavonitinids (*Pavonitina*, *Pavopsammia*) and pseudogaudryinids (*Flabellogaudryina*), corresponding to an Oxygen Minimum Zone–influenced assemblage. This vertical faunal reorganization is interpreted as reflecting progressive intensification of dysoxic conditions and increased organic-matter flux at the sediment–water interface rather than significant changes in water depth. The association with Hantkenina-bearing planktonic assemblages supports a Late Eocene age and confirms deposition in an open-marine slope environment. Comparison with coeval Tethyan successions reveals strong faunal similarities to Priabonian OMZ-related slope as-



TEXT-FIGURE 4
Conceptual cross-section illustrating the principal deep-marine assemblages – Oxygen Minimum Zone Assemblage (OMZ), Slope Marl Assemblage (SMA), Flysch-type Assemblage (FTA), Scaglia-type Assemblage (SA), and Abyssal Assemblage (AA) – in relation to water depth, lysocline, and the carbonate compensation depth (CCD). The model summarizes the depositional gradients, sedimentation rates, oxygenation, and organic-matter flux across the continental slope to abyssal settings (modified after Kaminski and Gradstein 2005).

semblages from the Carpathians, the Alps, and the central Paratethys and highlights the Sirhan–Turayf Basin in Saudi Arabia as a key reference area for Late Eocene benthic foraminiferal paleoecology and paleobiogeography.

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PLATE 1

All specimens are from the Rashrashiyah Formation, Sirhan–Turayf Basin, northwestern Saudi Arabia. Scale bars = 100 microns.

1 *Psammosphaera irregularis* (Grzybowski 1896), Outcrop C, Sample C-9.

2 *Saccammina grzybowskii* (Schubert 1902), Outcrop C, Sample C-6.

3–4 *Haplophragmoides* cf. *walteri* (Grzybowski 1898), Outcrop C, Sample C-8.

5 *Haplophragmoides horridus* (Grzybowski 1901), Outcrop C, Sample C-12.

6 *Haplophragmoides porrectus* Maslakova 1955, Outcrop C, Sample C-8.

7 *Spiroplectammina deperdita* (d'Orbigny 1846), Outcrop C, Samples C-20.

8–9 *Spiroplectinella dentata* (Alth 1850), Outcrop C, Sample C-19.

10 *Spiroplectinella carinata* (d'Orbigny 1846), Outcrop C, Sample C-23.


1
2
3a
3b
3c
4c
4b
4c
5a
5b
5c
6a
6b
6c
7a
7b
8a
8a
9a
9a
10a
10b

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PLATE 2

All specimens are from the Rashrashiyah Formation, Sirhan–Turayf Basin, northwestern Saudi Arabia. Scale bars = 100 microns.

1 *Spiroplectinella subhaeringensis* (Grzybowski 1896), Outcrop C, Sample C-19.

2 *Vulvulina spinosa* Cushman 1927, Outcrop C, Sample C-23.

3 *Vulvulina eocaena* Montagne 1941, Outcrop C, Sample C-21.

4 *Pavonitina styriaca* Schubert 1914, Outcrop C, Sample C-22.

5 *Pavonitina biarritzensis Sztràkos 1987,* Outcrop C, Sample C-19.

6 *Pavonitina kiscelliana* (Sztràkos 1987), Outcrop C, Samples C-15.

7 *Pavopsammia flabellum* Seiglie and Baker 1983, Outcrop C, Sample C-15.

8 *Flabellogaudryina sirhanensis* Kaminski and Korin 2025, Outcrop C, Sample C-9.

9 *Flabellogaudryina* sp. Kaminski and Korin 2025, Outcrop C, Sample C-7.

10–11 *Plectina cubensis* Cushman and Bermúdez 1936, Outcrop C, Sample C-20.


1a
1b
2a
2b
3a
3b
4a
4b
5a
5b
6a
6b
7a
7b
8a
8b
9a
9b
10a
10b
10c
11a
11b
11c

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PLATE 3

All specimens are from the Rashrashiyah Formation, Sirhan–Turayf Basin, northwestern Saudi Arabia. Scale bars = 100 microns.

1 *Plectina* cf. *cubensis* Cushman and Bermúdez 1936, Outcrop C, Sample C-23.

2 *Plectina dalmatina* (Schubert in Liebus 1911), Outcrop C, Sample C-19.

3 *Plectina eocenica* Cushman 1936, Outcrop C, Sample C-23.

4 *Karrerielia halkyardi* Cushman, 1936, Outcrop C, Sample C-22.

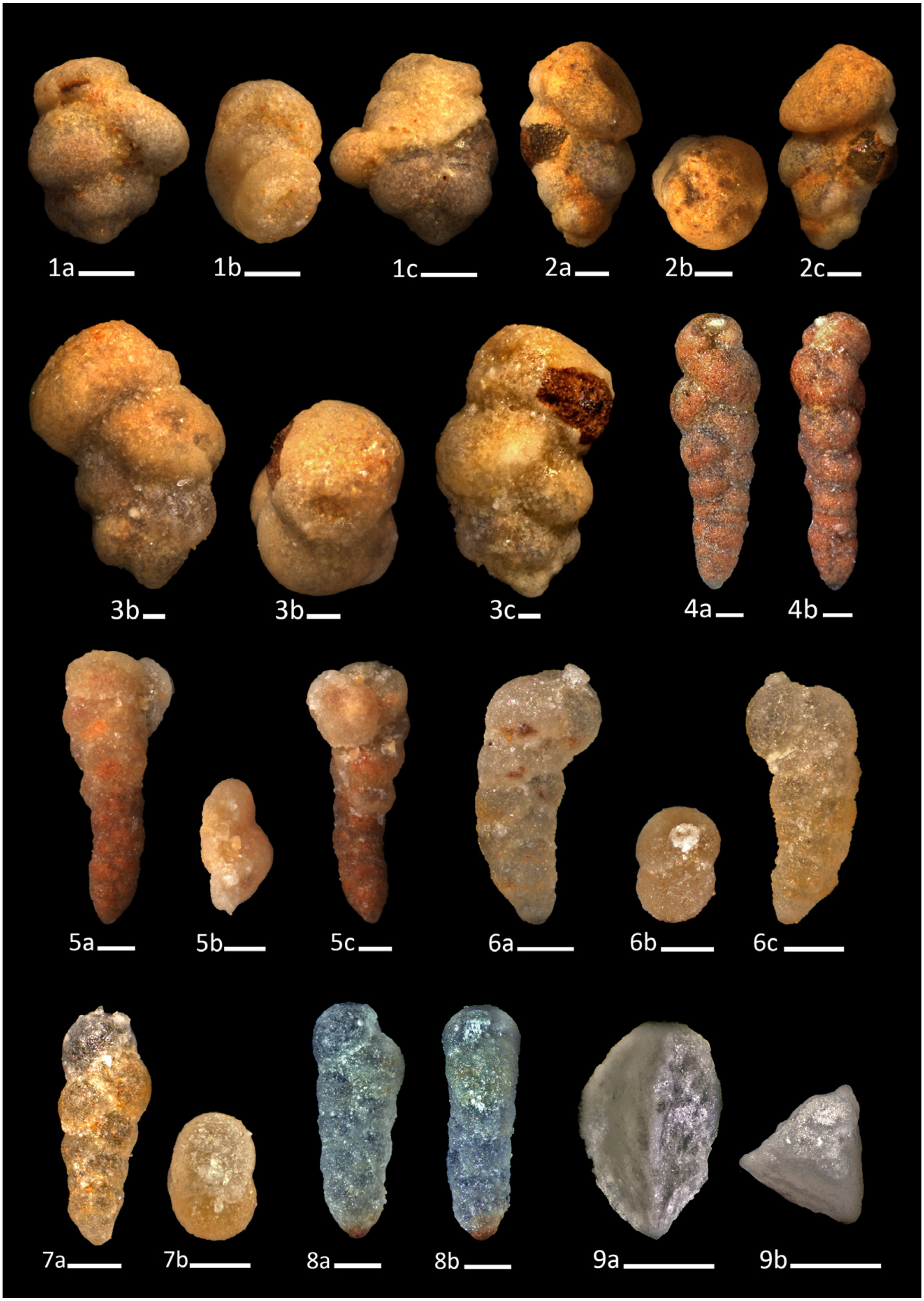
5 *Karrerielia* cf. *halkyardi* Cushman 1936, Outcrop C, Sample C-20.

6 *Karrerielia* cf. *ovata* Hussey 1943, Outcrop C, Sample C-21.

7 *Karrerielia* sp. Cushman 1933, Outcrop C, Sample C-23.

8 *Karreriella arenasensis* Cushman and Bermúdez 1937, Outcrop C, C-21.

9 *Clavulinoides alpina* Cushman 1936, Outcrop C, C-4.


1a
1b
1c
2a
2b
2c
3b
3b
3c
4a
4b
5a
5b
5c
6a
6b
6c
7a
7b
8a
8b
9a
9b

Cuba. *Contributions from the Cushman Laboratory for Foraminiferal Research*, 13: 1–29.

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