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Gilianelles (Microproblematics) from Late Cretaceous Deposits of Mount Polyus (Crimean Peninsula)

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Abstract—Gilianelles, calcareous microproblematics, representatives of the Late Campanian group of microfossils, were found for the first time in the Upper Cretaceous deposits of the interfluve of the Kacha and Belbek rivers in the Crimean Mountains. They come from deposits of the Polyus section, previously dated as Turonian–Santonian. It is proposed that the 50-m thick "calcisphere" limestones along the dirt road on the western slope of Mount Polyus to its summit (outcrop 3177) can be dated as Campanian.

Keywords: Gilianelles, calcareous microproblematics, Campanian Stage, Crimea, Russia

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INTRODUCTION

The purpose of this paper is to present a new group of microfossils from the Upper Cretaceous deposits of Crimea, well known from publications due to their stratigraphic continuity and similarity with sections of Western Europe (Baraboshkin et al., 2022). New calcareous microproblematics were found in the Upper Cretaceous limestones of the Polyus section in the valley of the Belbek River, previously dated as Turonian-Santonian (Klikushin, 1985).

For the first time, Gilianelles, enigmatic calcareous microproblematics, ranging in size from 100 to 250 μm, characterized by a distinct axial symmetry and currently conventionally classified as calcareous dinocysts, were recorded from the Upper Cretaceous deposits of Western Europe from a relatively narrow (Campanian–Maastrichtian) stratigraphic interval (Odin and Lethiers, 2006; Odin, 2008a, 2008b, 2011). Until now, their taxonomic affiliation is uncertain—incertae sedis. The homogeneity of this group of microfossils according to established criteria and the lack of described equivalent forms led to coining of the name Gilianelles. For a taxonomic treatment, a typical representative of these microproblematics was selected under the name of the type species *Gilianella stellata* Odin, 2007 (Odin and Lethiers, 2006; Odin, 2007).

The name Gilianelles for these calcareous microproblematics comes from the name of the author Gilles Serge Odin, who described more than 60 species of these microproblematics from the Campanian–Maastrichtian interval in France and Spain (Odin, 2009, 2011). Initially, microproblematics were divided into five morphological groups: discs, spheres, cupules, cones, kegs, and were described using the letters of the English alphabet from A to N with various serial numbers as individual codes (Odin and Lethiers, 2006). Recognized leading micropaleontologists of the world, including M. Caron (Friborg), P.O. Baumgartner (Lausanne), J.P. Bellier (Paris), and F. Robaszynski (Mons) confirmed the originality of the discovered forms and the difference from all previously known microfossils (Odin, 2007, 2008a). Gilianelles are characteristic of the Upper Campanian part of the stratotype of the Campanian–Maastrichtian Tercis section in southern Aquitaine in southwestern France (Odin, 2008a), the Campanian *Radotruncana calcarata* Zone interval in the Navarra section in northern Spain (Odin, 2008a, 2011), as well as the Upper Campanian *Bostrychoceras polyplocum* Zone of the Lägerdorf region of northwestern Germany (Willems, 1990; Bison et al., 2004; Wendler and Willems, 2004; Versteegh et al., 2009). These microproblematics differ from calcispheres (Krasheninnikov and Basov, 1983) in the general shape and structure of the skeleton, and from dinocysts in their size and lack of tabulation (Odin, 2011).

Gilianelles have not previously been found in Russia or the countries of the former USSR.

MATERIAL AND METHODS

Calcareous microproblematics were kindly provided to the author by I.P. Ryabov (Saratov State University) from samples collected in the section of Mount Polyus (Outcrop 3177) in the Crimean Mountains (Baraboshkin et al., 2022; Guzhikov et al., 2024) (Fig. 1).

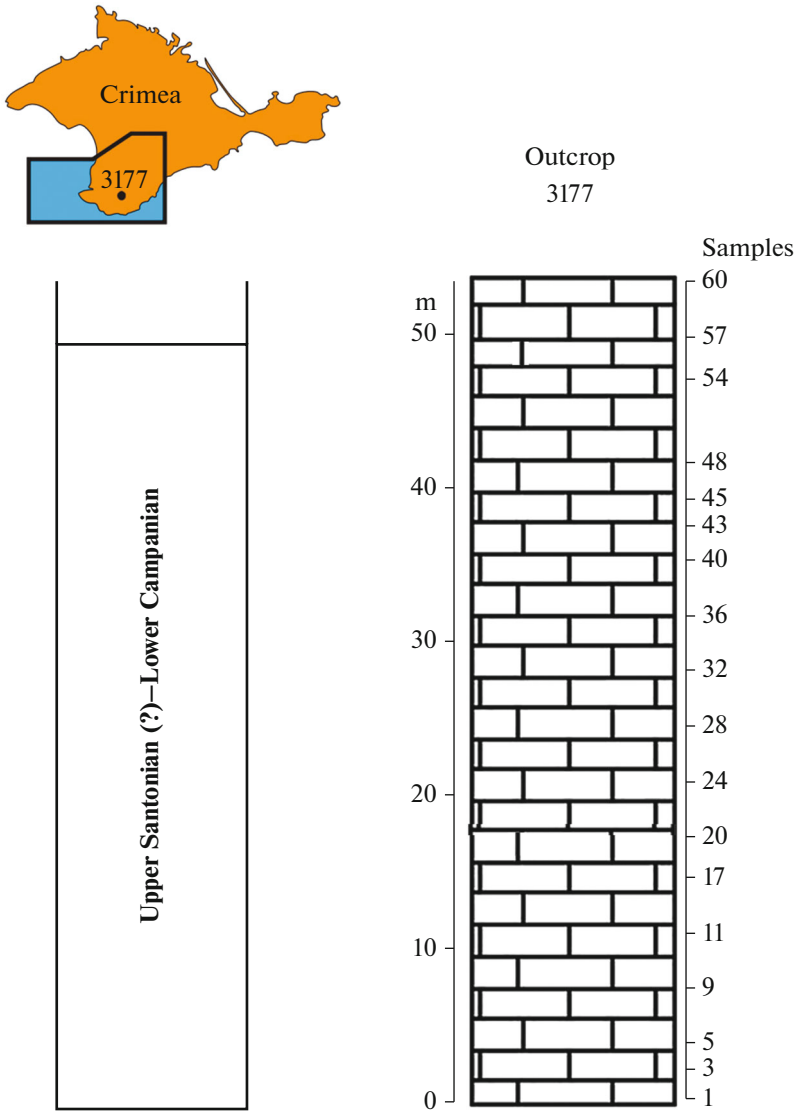


Fig. 1. Section of Mount Polyus near the village of Vysokoe, Bakhchisarai Region of the Crimean Mountains. Outcrop 3177 is a studied section along a dirt road leading through the forest along the western slope of Mount Polyus to its summit. Lines with numbers show the levels with Gilianellids. Long horizontal strokes and numbers correspond to the levels of samples with calcareous microproblematics taken "sample by sample" with paleomagnetic specimens (modified after Guzhikov et al., 2024).

To extract calcareous microproblematics, we used a technique usually used for washing foraminiferal tests, namely the dissociation method by acetolysis—treatment with concentrated acetic acid (Baraboshkin et al., 2024).

Skeletons of Gilianelles extracted from the sediments were mounted on three stubs and photographed using a TESCAN electron microscope at the Borissiak Paleontological Institute of the Russian Academy of Sciences, supervised by E.A. Zhegallo.

Collections nos. 2022-1, 2022-2 and 2022-4 "Calcareous microproblematics of Crimea" are housed in the Geological Institute of the Russian Academy of Sciences (GIN RAS).

GEOLOGY OF THE POLUS SECTION

Our record of Gilianelles comes from the Upper Cretaceous deposits of the Mount Polyus section (in many works this mountain is referred to as "Chuku") in southwestern Crimea (Fig. 1). These deposits exposed in the Belbek River valley were previously considered as Turonian–Santonian (Klikushin, 1985) or Turonian–Coniacian (Bragina and Bragin, 2007), but, according to the latest data, they are late Santonian and, possibly, part of the early Campanian (Guzhikov et al., 2024). Alekseev (1989) wrote that Santonian deposits in southwestern Crimea only occasionally crop out.

The section of Mount Polyus (Outcrop 3177) is composed of alternating foraminiferal and "calci-

sphere" limestones with rare lenses and chert nodules. The thickness of the sediments ranges from 55 in outcrop 3177 (Fig. 1) to 140 m (Guzhikov et al., 2024). From A.S. Alekseev's collection of ammonites assembled by V.G. Klikushin from the Upper Cretaceous deposits at Mount Polyus, E.Yu. Baraboshkin (Baraboshkin et al., 2023) identified the ammonites *Pseudoxybeloceras (Parasolenoceras) splendens* Collignon, 1969 (early Campanian, rarely late Santonian), *Hauericeras (Gardeniceras) gardeni* (Baily, 1855) (middle Coniacian–early Campanian), *Saghalinites nuperus* (van Hoepen, 1921) and *Baculites* cf. *incurvatus* Dujardin 1837 (middle Coniacian–early Campanian).

Publications concerning the area of the Polyus section (*Atlas*..., 1997) contain images of the ammonites *Nowakites*? cf. *savini* (Grossouvre, 1894) and *Eupachydiscus* cf. *sayni* (Grossouvre, 1894) (late Santonian–Campanian). Based on benthic foraminifera in the section of Upper Cretaceous deposits on the steep eastern slope of Mount Polyus (Outcrop 3176), the presence of the Upper Turonian (sample 3176-3) and Upper Santonian was established, confirmed by the discovery of the Late Santonian–Early Campanian ammonite *Eupachydiscus* cf. *isculensis* (Redtenbacher, 1873) (Baraboshkin et al., 2023). Due to the presence of nannoplankton *Zeugrhabdotus scutula* (Bergen, 1994) Rutledge et Bown, 1996 and *Eprolithus moratus* Stover, 1966, the middle part of the section (samples 3176/4–3176/14) is assigned to the Santonian and based on the appearance of the genus *Arkhangelskiella* (samples 3176/15–3176/18) the overlying beds are dated as the late Santonian–Campanian (Guzhikov et al., 2024).

In search of a stratigraphic interval corresponding to the Coniacian and Lower Santonian, a team led by A.Yu. Guzhikov and E.Yu. Baraboshkin studied rocks exposed along a dirt road leading through the forest along the western slope of Mount Polyus to its summit (Outcrop 3177) (Fig. 1). At the very base of the Mount Polyus section, starting with Sample 3177/1, a typically Late Santonian species of benthic foraminifera, *Gavelinella stelligera* (Marie, 1941), was identified. The upper part of Outcrop 3177 (starting from the level of Sample 3177/40), based on the appearance of the benthic species *Heterostomella praefoveolata* Myatlyuk in Akimets, 1961 and the presence of the planktonic foraminifer *Sigalia decoratissima* (De Klasz, 1953) (Sample 3177/57), is also proposed to be attributed to the upper Santonian (Guzhikov et al., 2024).

GILIANELLES FROM LATE CRETACEOUS DEPOSITS OF MOUNT POLYUS

Since this is the first discovery in Crimea of numerous and so diverse calcareous microproblematics Gilianelles (Vishnevskaya, 2023a; Vishnevskaya et al., 2023), some of the species have so far been identified by us in an open nomenclature. The identified taxa are somewhat different from the Campanian holotypes and require additional systematic study.

At the base of the section (Samples 3177/3, 3177/5, 3177/9, 3177/11) the species *Azymella cannabinata* Odin, 2008, *Gilianella tenuibrachialis* Odin, 2008 (Campanian distribution) were identified, and three meters higher (Samples 3177/17 and 3177/20) discoid forms of the species *Gilianella tenuibrachialis* Odin, 2008, *Gilianella terbrachialis mutata* Odin, 2008, *Scutellella (Tetratropis) terrina* Bison, Wendler, Versteegh et Willems, 2004 (Campanian), *Numismella tarbellica* Odin, 2008 (Campanian–Maastrichtian) and spherical forms of *Pilella reticulata* Odin, 2008 (Campanian–Maastrichtian) were found (Plates 13, 14).

In the lower middle part of the section (Samples 3177/24 and 3177/28) only the species *Gilianella tenuibrachialis* Odin, 2008 (Campanian) was identified.

Higher up the section (Samples 3177/32, 3177/36 and 3177/40) the following taxa were identified (Plates 13, 14): *Azymella cannabinata* Odin, 2008 (Campanian), *Gilianella tenuibrachialis* Odin, 2008 (Campanian), *Numismella tarbellica* Odin, 2008 (Campanian–Maastrichtian), *Pilella reticulata* Odin, 2008 (Campanian–Maastrichtian), *Scutellella pulchrevelifera* Odin, 2008 (Campanian), *Scutellella (Tetratropis) terrina* Bison, Wendler, Versteegh et Willems, 2004 (Campanian), *Scutellella (Tetratropis)* ? *patina* Willems, 1990 (Middle Coniacian–Lower Campanian; Wendler and Willems, 2004), *Pocillella grandicula* Odin, 2008 (Campanian), *Tercensella globosa* Odin, 2008 (Campanian–Maastrichtian), *Tercensella* aff. *doliolum* Odin, 2008.

Explanation of Plate 13

Calcareous microproblematics Gilianelles (Microproblematica) from the Polyus section, Outcrop 3177. Scale bar 100 μm.

Figs. 1, 10. *Gilianella tenuibrachialis* Odin, 2008: (1) specimen GIN, no. 2022-4-42/3177/45, (10) specimen GIN, no. 2022-4-58/3177/45.

Fig. 2. *Gilianella terbrachialis mutata* Odin, 2008, specimen GIN, no. 2022-4-105/3177/20.

Fig. 3. *Tercensella* aff. *doliolum* Odin, 2008, specimen GIN, no. 2021-1-52/3177/36.

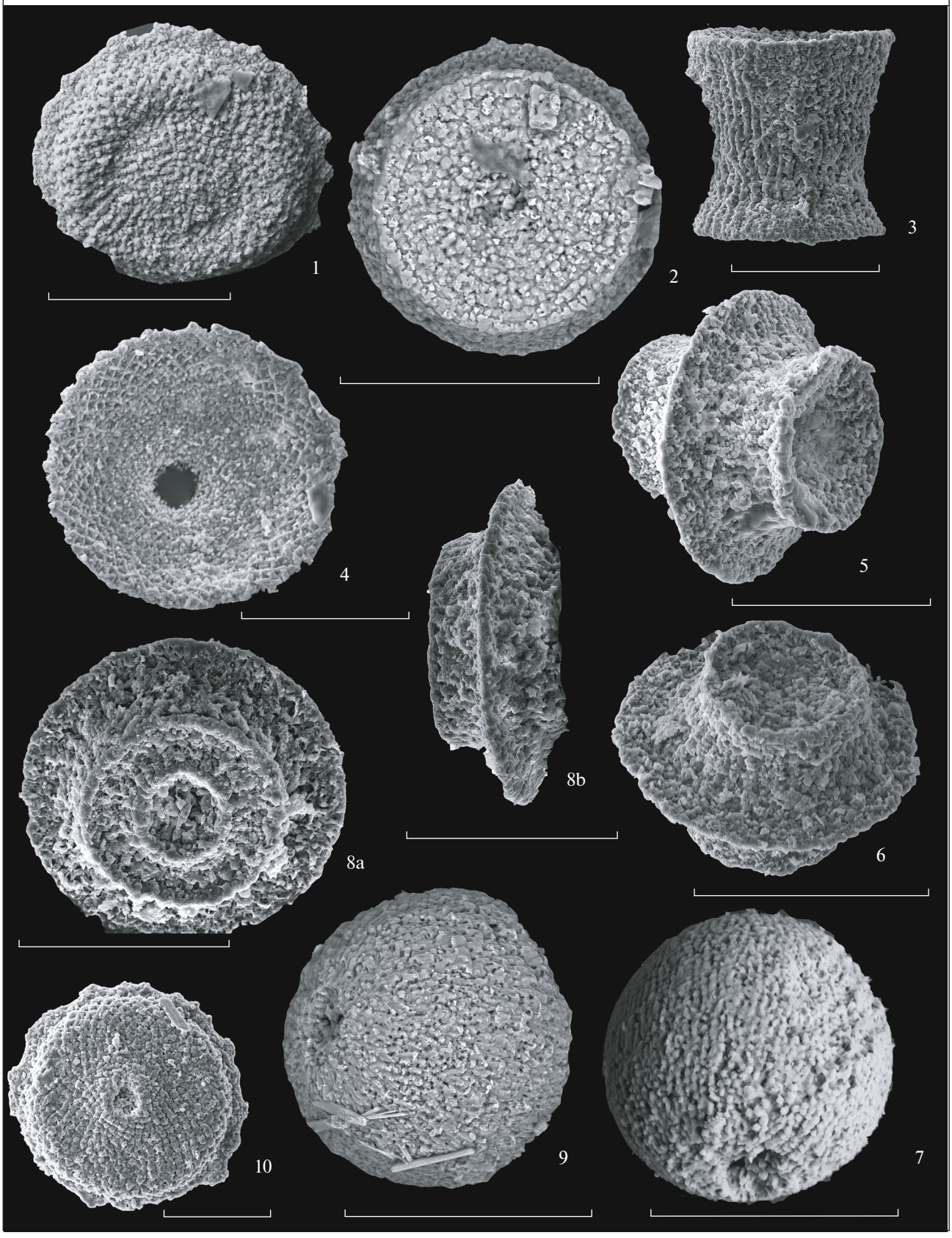
Fig. 4. *Azymella cannabinata* Odin, 2008, specimen GIN, no. 2022-4-75/3177/43.

Figs. 5, 6. *Scutellella (Tetratropis) terrina* Bison, Wendler, Versteegh et Willems, 2004: (5) specimen GIN, no. 2022-4-109/3177/20, (6) specimen GIN, no. 2022-1-42/3177/36.

Figs. 7, 9. *Pilella reticulata* Odin, 2008: (7) specimen GIN, no. 2022-4-41/3177/45, (9) specimen GIN, no. 2022-4-115/3177/36.

Fig. 8. *Numismella* cf. *tarbellica* Odin, 2008, specimen GIN, no. 2022-1-20/3177/32: (8a) upper view, (8b) lateral view.

Plate 13



According to M.A. Ustinova in the middle part of the section (Sample 3177/32) found nannoplanktonic species *Arkhangelskiella cymbiformis* Vekshina, 1959 (the very end of the Santonian–Maastrichtian), *Reinhardtites anthophorus* (Deflandre, 1959), limited in distribution to the Turonian–late Campanian (Burnett, 1998).

In the upper part of the section (Samples 3177/43, 3177/45 and 3177/48), in addition to previously encountered species, *Aturella altodepressa* Odin, 2008, *Aturella aequilatera* Odin, 2008, *Gilianella major* Odin, 2008, found in the Campanian–Maastrichtian, appear.

At the very top of the section (Samples 3177/48, 3177/54 and 3177/57) only Campanian species *Azymella cannabinata* Odin, 2008 and *Gilianella tenuibrachialis* Odin, 2008 were identified.

Thus, virtually all established Gilianelles species come from Campanian deposits. The species encountered are very close to the forms described from a relatively narrow stratigraphic interval of the Campanian stage, namely: from the Upper Campanian part of the stratotype of the Campanian–Maastrichtian Tercis section of southwestern France (Odin, 2008a, 2009); from the Upper Campanian *Bostrychoceras polyplocum* Zone of the Lägerdorf region of northwestern Germany (Bison et al., 2004); in the interval of the Campanian *Radotruncana calcarata* Zone of the Navarre section in northern Spain, where the marker species of planktonic foraminifera are the Campanian *Schackoina multispinata* (Cushman et Wickenden, 1930), *Globotruncana elevata* (Brotzen, 1934), *Globotruncana ventricosa* White, 1928 (Odin, 2008b, 2011).

Planktonic foraminifera similar to species from the Navarra section are present in the reference section of the Campanian Kudrino Stage of the Southwestern Crimea, member XVII (Kopaevich and Vishnevskaya, 2016): *Globotruncana ventricosa* appears for the first time in sample 22, and *Schackoina multispinus* appears in Sample 20. In Sample 20, *Aturella angulata* Odin, 2008, *Scutellella crassa* Odin, 2008 and *Azymella cannabinata* Odin, 2008 were identified, and in Sample 24, *Numismella tarbellica* Odin, 2008 was identified (Baraboshkin et al., 2024).

The species *Azymella cannabinata* (code A7) is known from sediments in the Tercis and Navarre sections, whose age ranges from 77.5 to 75 million years (Odin, 2008a, b), and the appearance of *Aturella altodepressa* (code A4a), *Aturella aequilatera* (code A4b), *Aturella angulata* (code A4b') was recorded at the end of this time interval (Odin, 2009). Only the species *Tetratropis patina* occurs in the narrower stratigraphic interval of the Middle Coniacian and Early Campanian (Willems, 1990).

Consequently, the age of the microproblematic assemblage in the section of Mount Polyus can be tentatively determined as Campanian, possibly Middle Campanian.

GILIANELLES PALEOENVIRONMENTS

According to the literature, the presence of Gilianelles is associated with paleoenvironments at depths from 50 to 150 m. Such depths have been postulated for European Cretaceous basins in general, and were also inferred from a study of sea urchins from the Tersis-les-Bains section (Odin, 2001). Observations in southwestern France and northern Spain (Odin, 2008a, 2008b) suggest that Gilianelles were restricted to clear seas without clastic material.

Gilianelles cysts show different morphological adaptations, which indicate that these organisms likely occupied different ecological niches. Most are clearly planktonic, but some may have been benthic (Odin and Lethiers 2006; Odin, 2009). Adaptation to a planktonic lifestyle, as suggested by Odin and Lethiers (2006), is confirmed by the development of projections of cyst orientation along the axis of symmetry with the formation of an aboral continuation, which acts as a ballast keel that holds the diaphragm at the top.

Perpendicular to the major axis of symmetry there are general features indicating a preferred direction of movement relative to the water. Keelless cysts without projections and, in particular, those, in which the oral surface is clearer than the aboral one, are better adapted to a benthic lifestyle. Other cysts, such as simple discs, do not show obvious bathymetric adaptations and do not indicate a range of depths in the water.

Explanation of Plate 14

Calcareous microproblematics Gilianelles (Microproblematica) from the Polyus section, Outcrop 3177. Scale bar 100 μm.

Figs. 1–3, 5, 6. *Gilianella terbrachialis* Odin, 2008: (1) specimen GIN, no. 2022-1-76/3177/43, (2) specimen GIN, no. 2022-1-44/3177/36, (3) specimen GIN, no. 2022-1-32/3177/32, (5) specimen GIN, no. 2022-1-38/3177/45, (6) specimen GIN, no. 2022-2-86/3177/43.

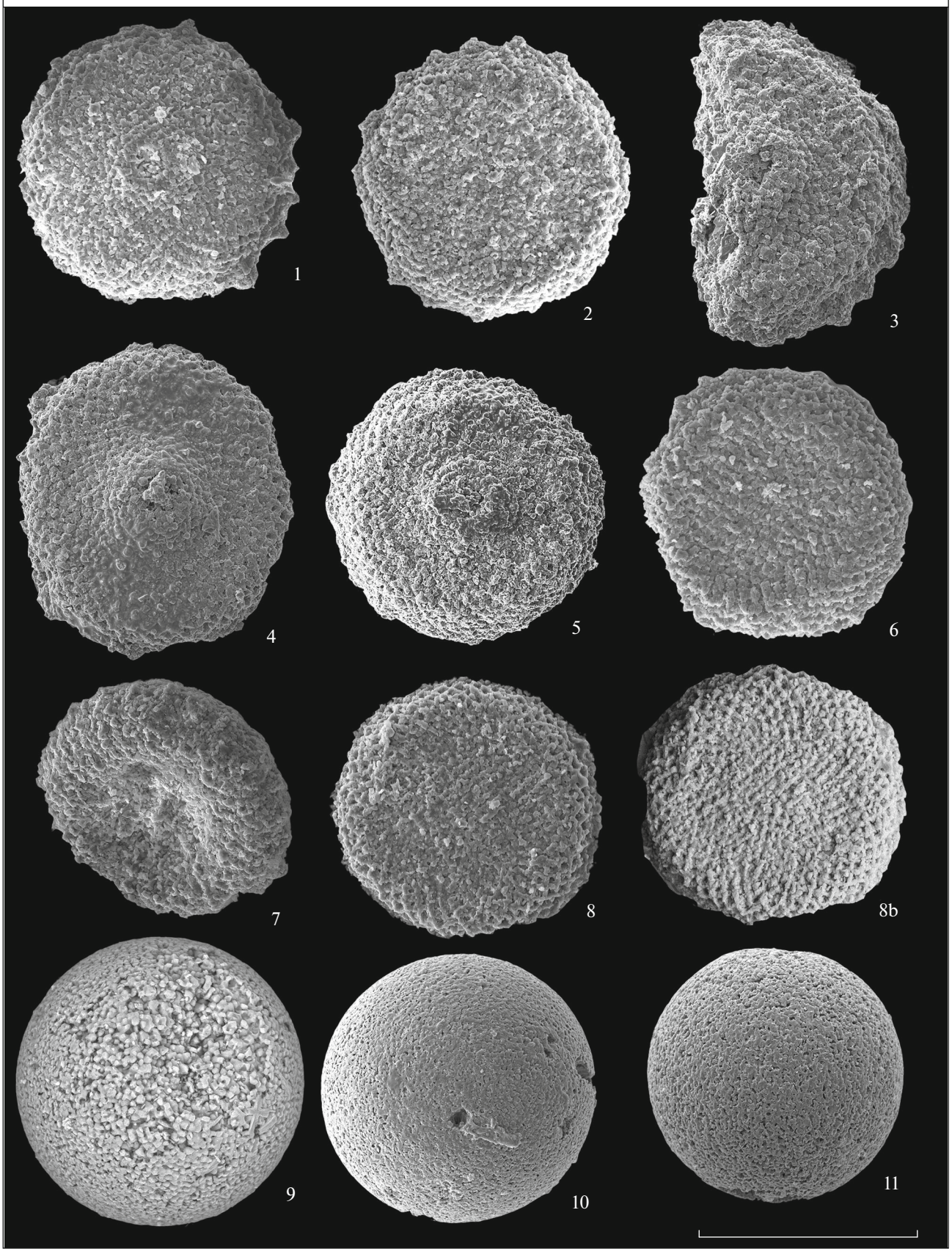
Fig. 4. *Gilianella major* Odin, 2008, specimen GIN, no. 2022-2-25/3177/45.

Fig. 7. *Gilianella terbrachialis mutata* Odin, 2008, specimen GIN, no. 2022-4-122/3177/9.

Fig. 8. *Gilianella tenuibrachialis* Odin, 2008, specimen GIN, no. 2022-4-59/3177/45: (8a) sharpness to the edge of the disc, (8b) sharpness to the central part of the disc.

Figs. 9–11. *Pilella reticulata* Odin, 2008: (9) specimen GIN, no. 2022-4-117/3177/3, (10) specimen GIN, no. 2022-4-60/3177/32, (11) specimen GIN, no. 2022-4-28/3177/45.

Plate 14



The short-term stratigraphic distribution of species from the genus *Tetratropis* Willems, 1990 is proposed to be interpreted (Wendler and Willems, 2004) as the emergence of morphotypes formed during short-term paleoceanographic events, most likely associated with impulses in the global cooling of the Late Cretaceous.

CONCLUSIONS

Since this is the first discovery of numerous and so diverse calcareous Gilianelles in the Crimea, while some of the species differ from the Campanian holotypes and are still defined in open nomenclature, the estimated age of these microfossils is Campanian. This is in good agreement with previous dates based on studies of planktonic foraminifers (Baraboshkin et al., 2024), but contradicts the Santonian age obtained from benthic foraminifers (Baraboshkin et al., 2022).

The use of calcareous microproblematics Gilianelles has enormous potential not only for the purposes of stratigraphy, but also in deciphering paleogeography, since most sections of the Crimea and the Caucasus (Vishnevskaya, 2023b) present a wide range of Gilianelles, presumably attributed to calcareous dinocysts, which were previously repeatedly noted as "calcispheres."

In addition, among the calcareous microproblematics of Gilianelles there are the species *Aturella angulata* Odin, *Aturella aequilatera* Odin and *Aturella altodepressa* Odin, which show evolutionary changes within the late Campanian–early Maastrichtian, and species of a narrow stratigraphic distribution have been established, which is of great stratigraphic interest.

The presence of clearly related forms, replacing each other in time (A4a, A4b, A4b' according to Odin, 2008 a, 2008b) of short-lived taxa of calcareous microproblematics Gilianelles in sections of Crimea (Kudrino and Polyus sections) will undoubtedly bring valuable additional information to modern knowledge.

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ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This work does not contain any studies involving human or animal subjects.

CONFLICT OF INTEREST

The author of this work declares that she has no conflict of interest.

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