

Early Paleogene planktic foraminifera in thin-sections – an experiment on isolated specimens from the Fore-Magura Thrust Sheet (Polish Outer Carpathians)

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This paper describes results of an experiment aimed mainly at obtaining random thin-sections of isolated specimens of planktic foraminifera determined to a species level. Twenty species of uppermost Paleocene-Middle Eocene planktic foraminifera from pelagic variegated marls of the Fore-Magura Thrust Sheet have been chosen for this experiment. These planktic foraminifera belong to the genera *Chiloguembelina*, *Turborotalia*, *Acarinina*, *Morozovella*, *Muricoglobigerina*, *Subbotina* and *Parasubbotina*. Their SEM images, stereomicroscope photos of isolated specimens, and the experimental thin-sections along with their systematics and stratigraphic ranges are presented.

Key words: Paleocene-Middle Eocene planktic foraminifera, random thin-sections, experiment on isolated specimens, Fore-Magura Thrust Sheet.

INTRODUCTION

The study of planktic foraminifera in thin-sections is sometimes the only possible tool to date lithified pelagic sediments. In case of single rock samples of unknown provenance, it can be a very difficult task, particularly when cross-sections of microfossils are rare and accidental. This problem gave rise to an idea of preparing random sections across numerous and well-determined isolated specimens of planktic foraminifera that can be used in thin-section analyses of sedimentary rocks. The research required very rich assemblages of planktic foraminifera. Such assemblages were found in the Fore-Magura Unit deposits of the Polish Outer Carpathians (POC; Malata, 2013).

The Fore-Magura Unit (see Burtan and Sokółowski, 1956; Książkiewicz, 1972), or the Fore-Magura Thrust Sheet (F-MTS) according to Książkiewicz et al. (2011), occurs in a narrow belt in front of the Magura Nappe in the western part of the POC (Fig. 1). Its deposits display some facies affinities to both the Magura Basin expressed by the Upper Cretaceous flysch-type Biotite Beds, and the Silesian sedimentary domain indicated by the similar deposits of the uppermost Eocene and Oligocene (Fig. 2). The characteristic and distinguishing feature of the F-MTS is the presence of the Upper Cretaceous–Eocene deep-water pelagic marls.

MATERIAL AND METHODS

For the purpose of this work, 15 samples abundant in planktic foraminifera were chosen from five sections of Paleocene–Eocene marls of the F-MTS, SW of Ywiec (Fig. 1). The most numerous specimens of particular genera were selected from each of these 15 assemblages and then determined to a species level. Each taxon identified must have been represented by a considerable amount of specimens (at least 10 but usually 30–40). Those specimens, which best fitted to the descriptions of particular species, were photographed in reflected light using a Sony A330 digital camera mounted on a Nikon SMZ 1500 stereomicroscope. Then, scanning microphotographs were also taken using a Hitachi S-4700 Scanning Microscope. Approximately 500 specimens of planktic foraminifera were examined in our experiment.

After completing the photographic documentation of the specimens, thin-sections were prepared according to our experimental procedure. Several specimens of particular species were randomly put on the standard microscopic glass slide and then immersed in epoxy resin (*Araldite 1000-Struers*). Such a preparation was dried for a few hours at a temperature of ~50°C in the lab oven until it was completely hardened. In the next step, the slides were hand-ground using consecutively 1500, 2500 and 4000 abrasive papers, down to the thickness appropriate for the observations in the transmitted light microscope (*Nikon ECLIPSE 50*). Finally, they were mechanically polished to eliminate abrasive grooves. More than twenty microscopic slides were prepared in this way. Each of these slides consists of several cross-sections of particular species, displaying various and random orientations of specimens.

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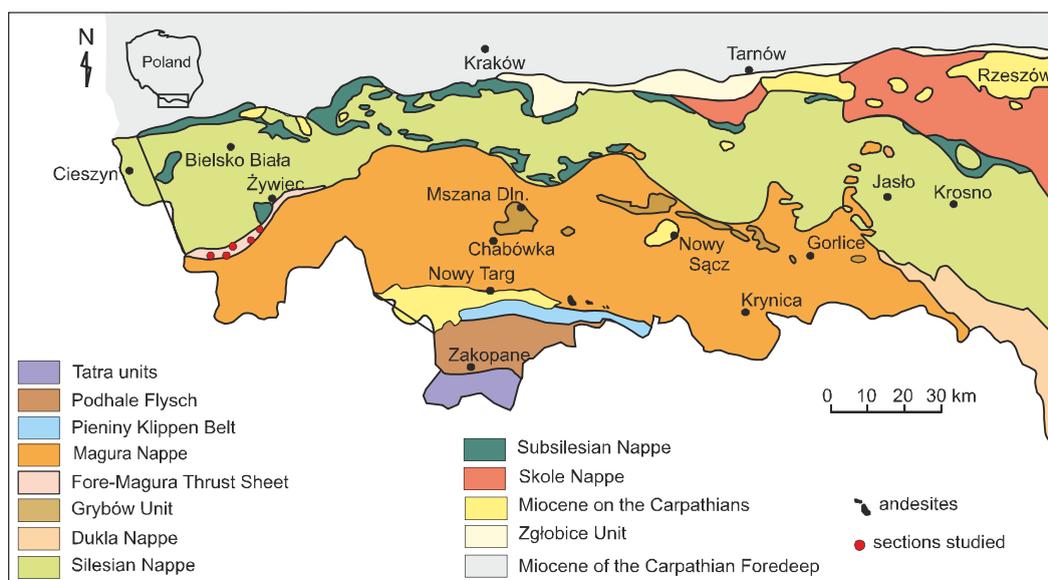


Fig. 1. Tectonic sketch-map of the western part of the Polish Outer Carpathians with the position of sections studied in the Fore-Magura Thrust Sheet (after Malata et al., 1996; Lexa et al., 2000, supplemented)

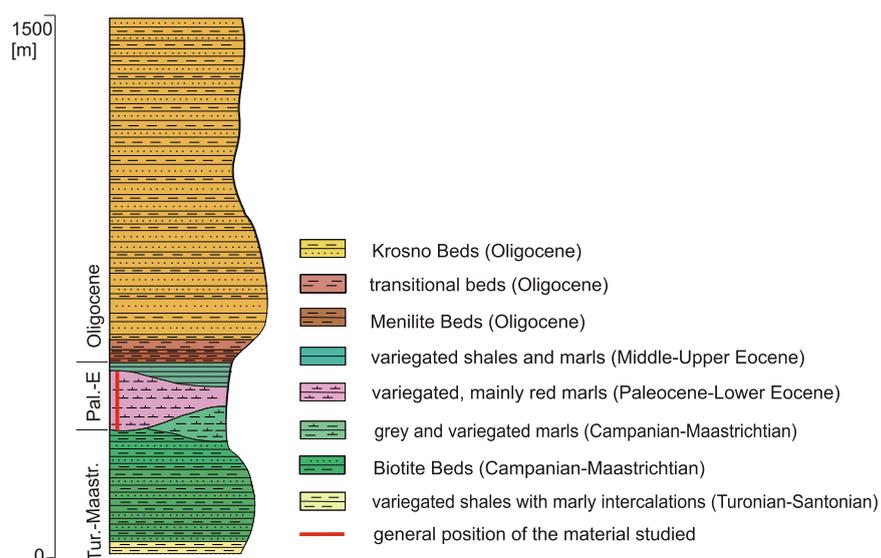


Fig. 2. Stratigraphic log of the Fore-Magura Thrust Sheet (northern zone according to Burtan and Sokołowski, 1956)

The selected planktic species represent two types of morphologies – multichambered biserial and multichambered trochospiral. The latter consists of genera displaying different shapes, i.e. *Acarinina* and *Morozovella* types as well as *Subbotina* type, including forms with globular chambers and more or less spherical tests. Drawings and names of different sections, used in the text, are presented in Figure 3.

foraminifera are presented in the form of scanning microscope images, stereoscope microscope photographs of isolated specimens, and several best cross-sections, chosen from the experimental slides prepared for each species (Figs. 4–23).

PRESENTATION OF RESULTS

Following the pattern of pioneering work of Postuma (1971) and Premoli Silva et al. (2003), twenty species of planktic

SYSTEMATICS AND REMARKS ON EXPERIMENTAL THIN-SECTIONS

Chiloguembelina trinitatensis
(Cushman and Renz, 1942)
(Fig. 4)

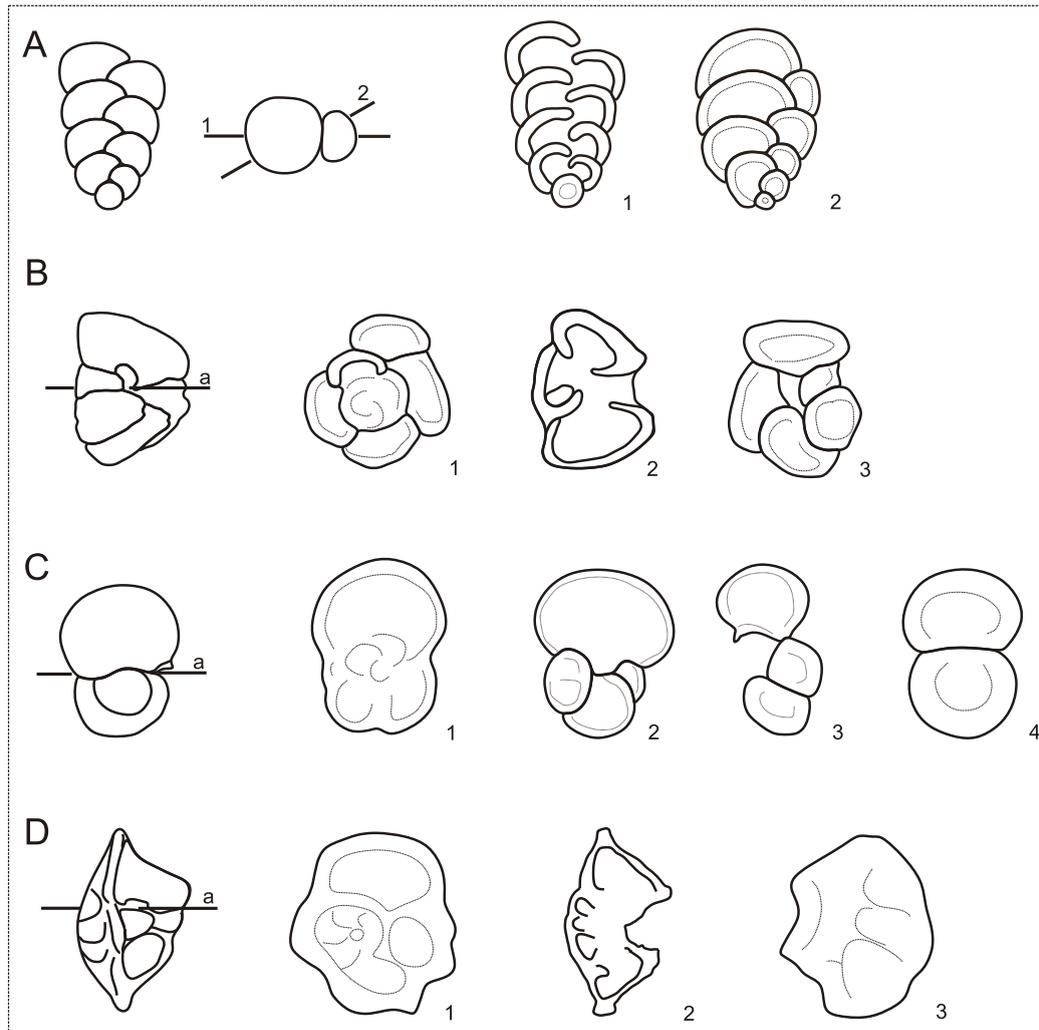


Fig. 3. Glossary to experimental sections through biserial and trochospiral morphology of foraminiferal growth (A – after Flügel, 2004)

A – biserial: 1 – axial sagittal, 2 – axial oblique; **B** – trochospiral (Acarinina type): 1 – transversal dorsal, 2 – axial, 3 – transversal oblique; **C** – trochospiral (Subbotina type): 1 – transversal ventral or dorsal, 2 – axial, 3 – relict axial, 4 – transversal oblique; **D** – trochospiral (Morozovella type): 1 – transversal ventral or dorsal, 2 – axial, 3 – transversal oblique; a – axis of chamber coil

Gümbelina trinitatis n. sp. – Cushman and Renz (1942): 4, pl. 2, figs. 8a, b.

Chilogumbelina trinitatis (Cushman and Renz) – D'Hondt and Huber (1999): 92, pl. 13, figs. 11, 16; pl. 70, figs. 8–10.

Chilogumbelina trinitatis (Cushman and Renz) – Huber et al. (2006): 475, 476, pl. 16.2, figs. 1–5.

Stratigraphic range. – Latest Paleocene–Early Eocene (P5–E3 zones; Berggren and Pearson, 2005; Pearson et al., 2006).

Remarks. – One of the characteristic features of this species is an arch-like aperture with a lip, symmetrically centered such as shown in Figure 4D. The characteristic features of the species are visible in most of the sections. In Figure 4I, almost all chambers are preserved in the section, but in the others, the initial parts of tests are missing. Figure 4K–M represents cuts that are axially shifted towards the edge of tests. Species identification can be based on the sections in Figure 4F, I.

Chilogumbelina wilcoxensis
(Cushman and Ponton, 1932)
(Fig. 5)

Gümbelina wilcoxensis n. sp. – Cushman and Ponton (1932): 63, Pl. 8, fig. 17.

Chilogumbelina wilcoxensis (Cushman and Ponton) – Olszewska et al. (1996): 105, pl. 35, fig. 5.

Stratigraphic range. – Late Paleocene–Early Eocene (P4b–E4 zones; Berggren and Pearson, 2005; Pearson et al., 2006); in the POC, reported from the late Early Eocene (Olszewska et al., 1996).

Remarks. – Figure 5A, B, D, E shows the apertures covered by small, additional chambers of slightly irregular shape. In Figure 5G, J, L, the elements of the additional chamber covering apertures are preserved. Figure 5F, N represents juvenile specimens.

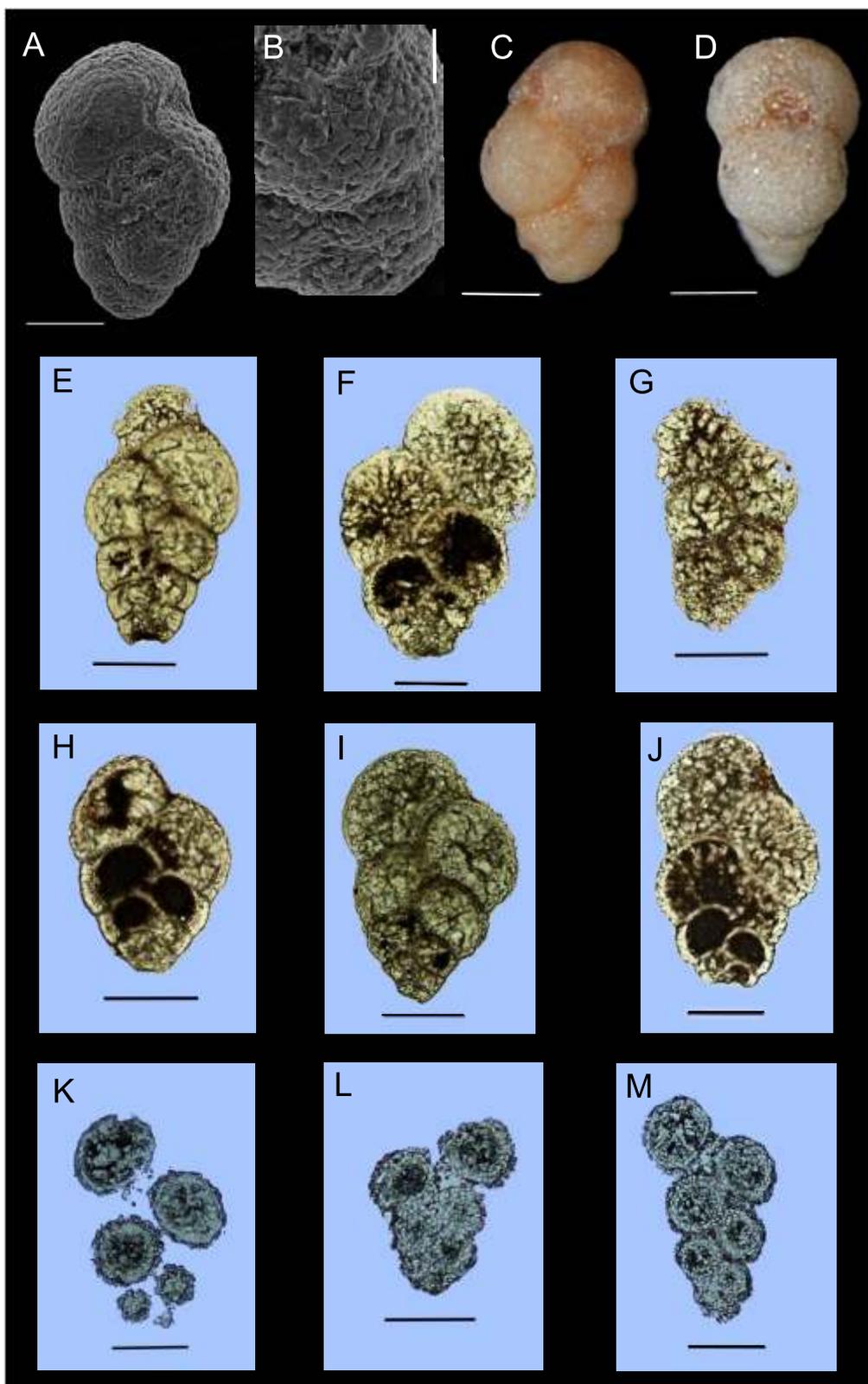


Fig. 4. *Chiloguembelina trinitatensis* (Cushman and Renz)

A – SEM image of isolated specimen; B – detail of surface of test A (scale bar = 25 μm); C, D – stereomicroscope photos of isolated specimens; E–M – transmitted light photos of experimental thin-sections of *Ch. trinitatensis*; scale bars = 100 μm

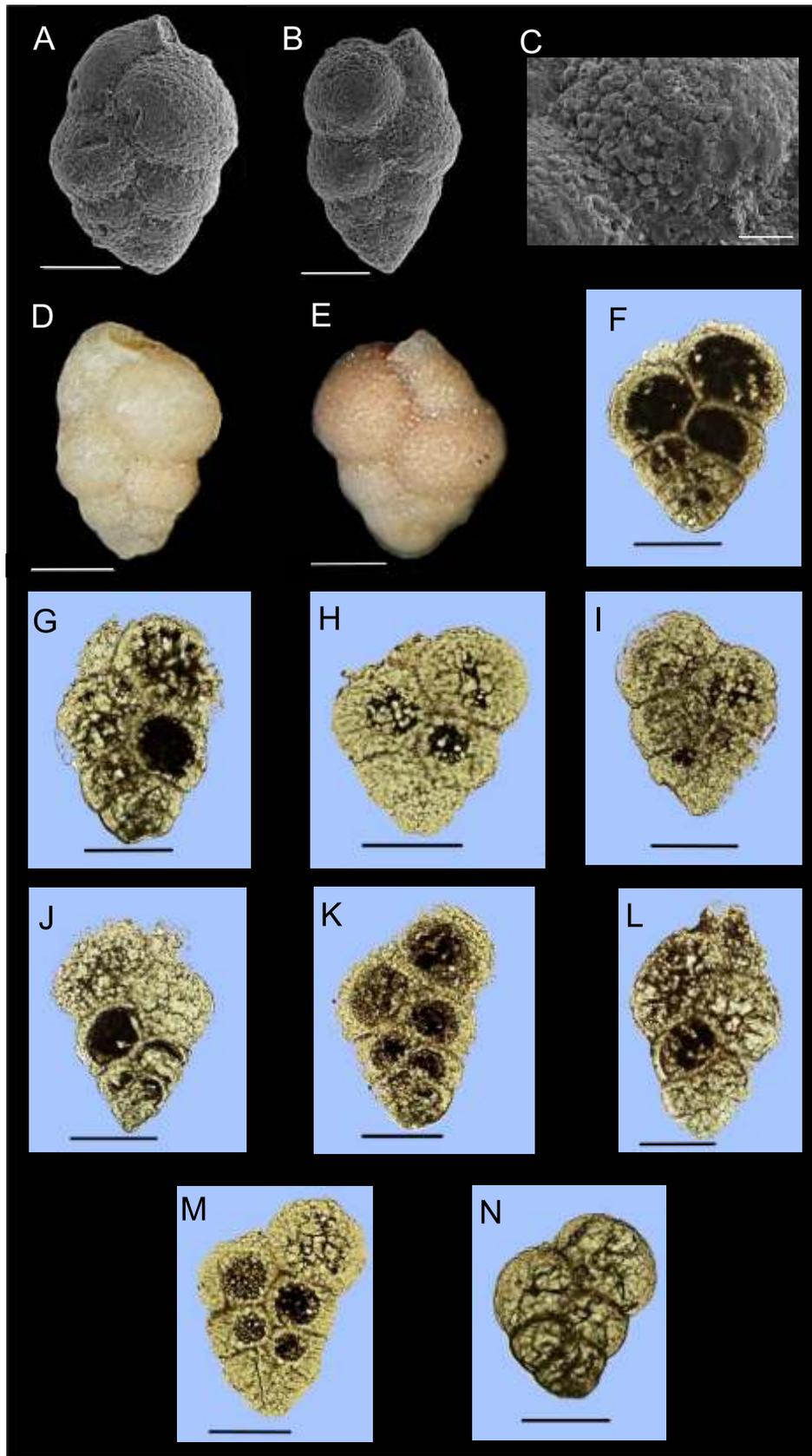


Fig. 5. *Chiloumbelina wilcoxensis* (Cuchman and Ponton)

A, B – SEM images of isolated specimens; C – detail of surface of test B (scale bar = 25 μm);
 D, E – stereomicroscope photos of isolated specimens; F–N – transmitted light photos
 of experimental thin-sections of *Ch. wilcoxensis*; scale bars = 100 μm

Species identification can be based on the sections in [Figure 5F, G, H](#).

The sections of both species of *Chiloguembelina* show great similarity, but chambers of *Ch. wilcoxensis* seem to increase more rapidly and the traces of this small additional aperture-covering chamber are usually preserved in most of its axial cuts.

Turborotalia frontosa (Subbotina, 1953)
([Fig. 6](#))

Globigerina frontosa n. sp. – Subbotina (1953): 84, pl. 12, fig. 3.
Turborotalia frontosa (Subbotina) – Olszewska et al. (1996): 112, pl. 40, figs. 13, 14.

Stratigraphic range. – Late Early–Middle Eocene (E7–E11 zones; [Berggren and Pearson, 2005](#); [Pearson et al., 2006](#)); in the POC: Middle–early Late Eocene ([Olszewska et al., 1996](#)).

Remarks. – This species is relatively easy to identify due to its general shape, number of chambers, and a characteristic extraumbilical aperture with a distinct lip ([Fig. 6B, D](#)), but the randomly-oriented sections do not reveal diagnostic features of the species. In [Figure 6G, H](#), remnants of aperture lips are visible; in [Figure 6H, I](#), the sections exhibit the test surface texture presented in a SEM image ([Fig. 6C](#)).

Acarinina bullbrooki (Bolli, 1957)
([Fig. 7](#))

Globorotalia bullbrooki n. sp. – Bolli (1957): 167, pl. 38, fig. 5.
Acarinina bullbrooki (Bolli) – Olszewska et al., 1996: 113, 114, pl. 36, figs. 10, 11.
Acarinina bullbrooki (Bolli) – Berggren et al. (2006): 269, 271, 272, 275, 276, pl. 9.6, figs. 1–16.

Stratigraphic range. – Latest Early–early Middle Eocene (E7–E11 zones; [Berggren and Pearson, 2005](#); [Pearson et al., 2006](#)); in the POC: latest Early Eocene–Middle Eocene ([Olszewska et al., 1996](#)).

Remarks. – The concept of this species has been applied in our study according to [Berggren et al. \(2006\)](#). Obtained cuts ([Fig. 7I–K](#)) are more or less transversal to the axis of chamber coil. [Figure 7J and H](#) shows the transverse dorsal ([Fig. 3](#)) and [Figure I](#) transverse ventral sections (see also [Flügel, 2004: fig. 10.23](#)). [Figure 7L](#) represents axial cutting, transversal or “meridional” in relation to trochospiral coil, displaying the flat spiral side and the final chamber convexity at the umbilical side. [Figure 7M](#) shows only remnants of the test without any characteristic features. Species identification can be based on the sections in [Figure 7H, J](#).

Acarinina cf. esnaensis (LeRoy, 1953)
([Fig. 8](#))

Globigerina esnaensis n. sp. – LeRoy (1953): 31, pl. 6, figs. 8–10 (*vide* Ellis et Messina, Cat. of Foram.).
Acarinina esnaensis (LeRoy) – Berggren et al. (2006): 286–289, pl. 9.11, figs. 1–12.

Stratigraphic range. – Late Paleocene–Early Eocene (P4b–E5 zones; [Berggren and Pearson, 2005](#); [Pearson et al., 2006](#)).

Remarks. – The general shape of specimens corresponds to the description of the species and the picture of the holotype in [Berggren et al. \(2006\)](#). The characteristic texture of the test surface is not visible due to diagenetic obliteration. [Figure 8G, I, K, M and O](#) presents transverse dorsal sections, while the others are oblique. In general, the thin-sections display the

shape and morphology of isolated specimens. Species identification can be based on the sections in [Figure 8G, M, O](#).

Acarinina pentacamerata (Subbotina, 1947)
([Fig. 9](#))

Globorotalia pentacamerata n. sp. – Subbotina (1947): 128, pl. 7, figs. 15–17 (*vide* Ellis et Messina, Cat. of Foram.).
Acarinina pentacamerata (Subbotina) – Berggren et al. (2006): 296, 297, pl. 9.15, figs. 1–16.

Stratigraphic range. – Late Early Eocene (E5–E7 zones; [Berggren and Pearson, 2005](#); [Pearson et al., 2006](#)).

Remarks. – Most of the experimental sections point to the random position of the specimens, transversal to the trochospiral axis, resulting in more or less oblique cuttings. [Figure 9I](#) shows 52 chambers of the last coil on the spiral side; this is the most complete section. In [Figure 9L, K](#), the test surface texture is visible even in the incomplete “residual” section. Species identification can be based on the section in [Figure 9I](#).

Morozovella aragonensis (Nuttall, 1930)
([Fig. 10](#))

Globorotalia aragonensis n. sp. – Nuttall (1930): 288, pl. 24, figs. 6–8, 10, 11 (*vide* Ellis et Messina, Cat. of Foram.).
Morozovella aragonensis (Nuttall) – Olszewska et al. (1996): 118, 119, pl. 38, figs. 17, 18.

Stratigraphic range. – Early–Middle Eocene (E5–E9 zones; [Berggren and Pearson, 2005](#); [Pearson et al., 2006](#)); in the POC – late Early–Middle Eocene ([Olszewska et al., 1996](#)).

Remarks. – Most of the experimental sections display incomplete “residual character” with no diagnostic features of the species. [Figure 10H](#) shows an axial section of the conical, trochospiral test, and the sections in [Figure 10I, J, L](#) most probably reveal remnants of the spiral sides.

Morozovella cf. caucasica (Glaessner, 1937)
([Fig. 11](#))

Globorotalia aragonensis Nuttall var. *caucasica* – Glaessner, 1937: 31, 48, pl. 1, fig. 6a–c (*vide* Ellis et Messina, Cat. of Foram.).
Morozovella caucasica (Glaessner) – Berggren and Pearson, 2006: 354–358, pl. 11.4, figs. 1–16.

Stratigraphic range. – Late Early–earliest Middle Eocene (E6–E8 zones; [Berggren and Pearson, 2005](#); [Pearson et al., 2006](#)).

Remarks. – The protruding part of the last chamber on the umbilical side is a characteristic feature of the species. Most of the sections display random cuts but more or less transverse to the axis of trochospiral coil. [Figure 11H, K, R](#) shows transversal sections of the flattened spiral side; [Figure 11H, R](#) displays a thick marginal keel. [Figure 11N](#) shows an axial section with the distinctly high last chamber. Species identification can be based on the sections in [Figure 11H, K, R](#).

Morozovella gracilis (Bolli, 1957)
([Fig. 12](#))

Globorotalia formosa ssp. *gracilis* – Bolli (1957): 75, pl. 18, figs. 4–6 (*vide* Ellis et Messina, Cat. of Foram.).
Morozovella gracilis (Bolli) – Berggren et al. (1999): 61, 62, pl. 54, figs. 13–15.
Morozovella gracilis (Bolli) – Berggren and Pearson (2006): 366, pl. 11.8, figs. 1–16.

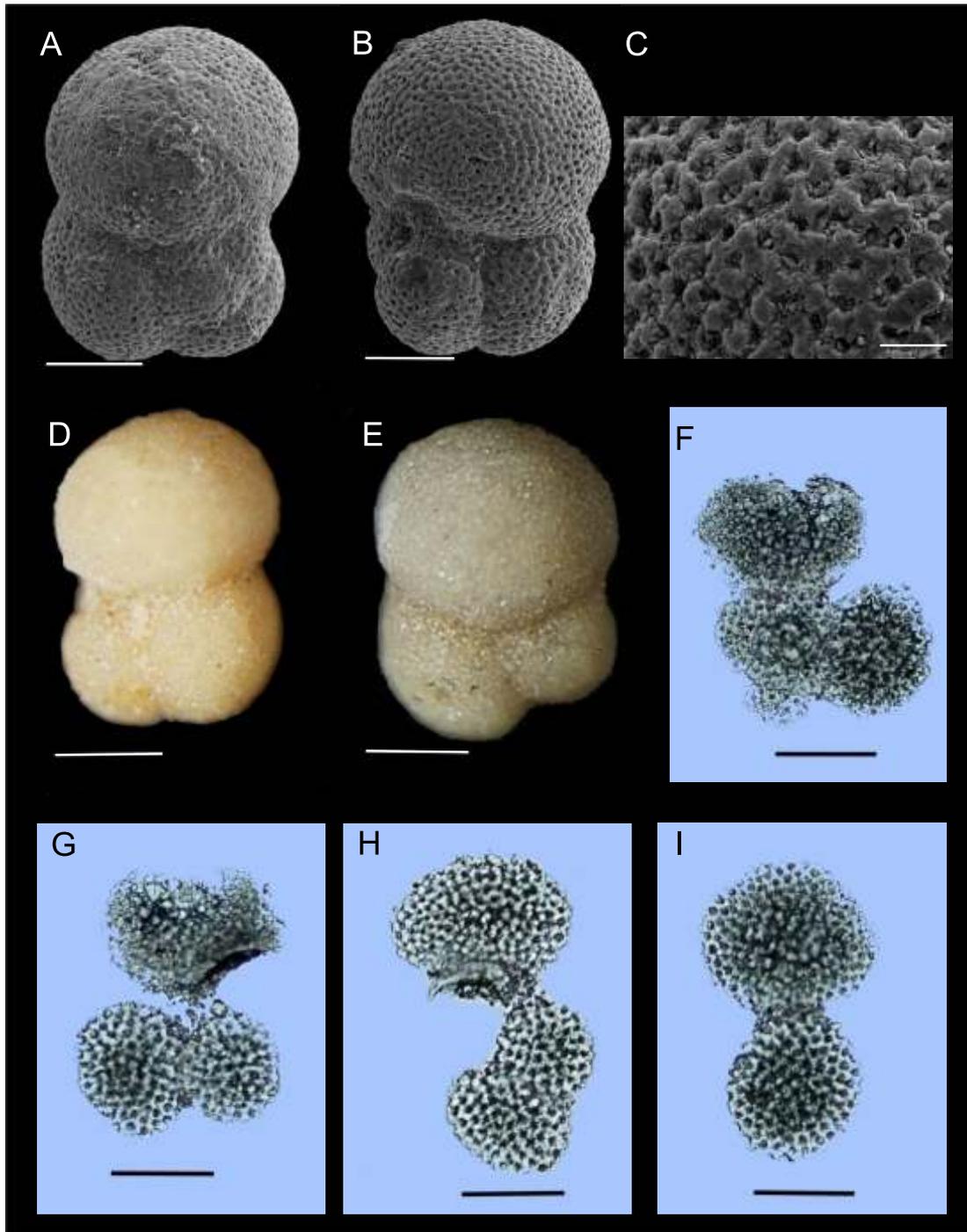


Fig. 6. *Turborotalia frontosa* (Subbotina)

A, B – SEM images of isolated specimens; C – detail of surface of test B (scale bar = 25 μm); D, E – stereomicroscope photos of isolated specimens; F–I – transmitted light photos of experimental thin-sections of *T. frontosa*; scale bars = 100 μm

Stratigraphic range. – Late Paleocene–Early Eocene (top P5–E5 zones; Berggren and Pearson, 2005; Pearson et al., 2006); in the POC – late Early Eocene (Olszewska et al., 1996).

Remarks. – The sections display all the chambers of the last coil on the umbilical side and the marginal keel. Figure 12G and H shows slightly oblique axial sections. Figure 12N illustrates transverse dorsal cut. In Figure 12G and I, the specimens are obliquely cut, but all the chambers of the last coil are

visible due to the convexity of the older (inner) coils. Species identification can be based on the sections in Figure 12G, M.

Morozovella lensiformis (Subbotina, 1953)
(Fig. 13)

Globorotalia lensiformis n. sp. – Subbotina, 1953: 214, pl. 18, fig. 4, 5.
Morozovella lensiformis (Subbotina) – Olszewska et al., 1996: 119, pl. 37, figs. 15, 16.

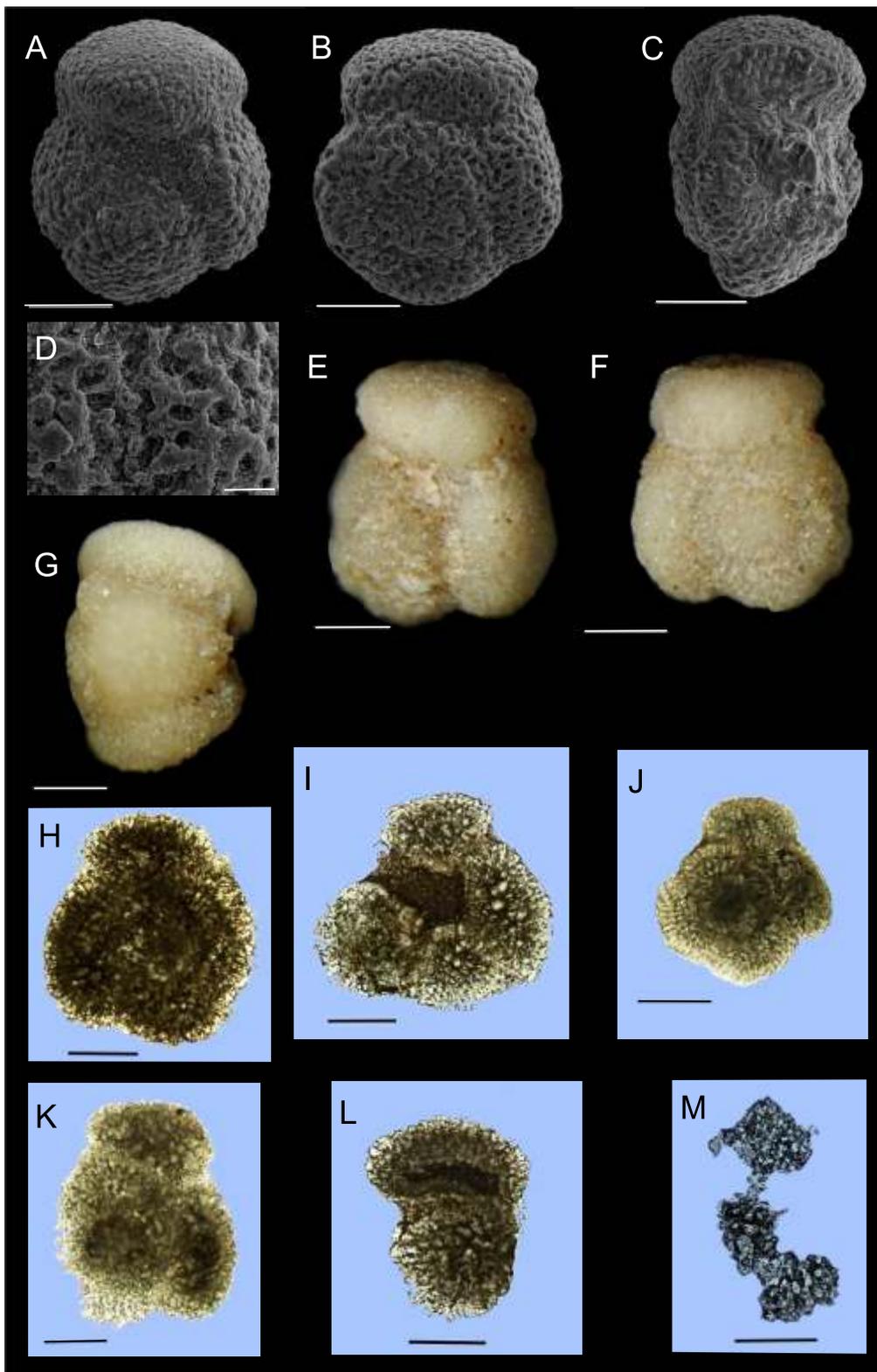


Fig. 7. *Acarinina bullbrooki* (Bolli)

A–C – SEM images of isolated specimens; D – detail of surface of test B (scale bar = 25 μm);
 E–G – stereomicroscope photos of isolated specimens; H–M – transmitted light photos
 of experimental thin-sections of *A. bullbrooki*; scale bars = 100 μm

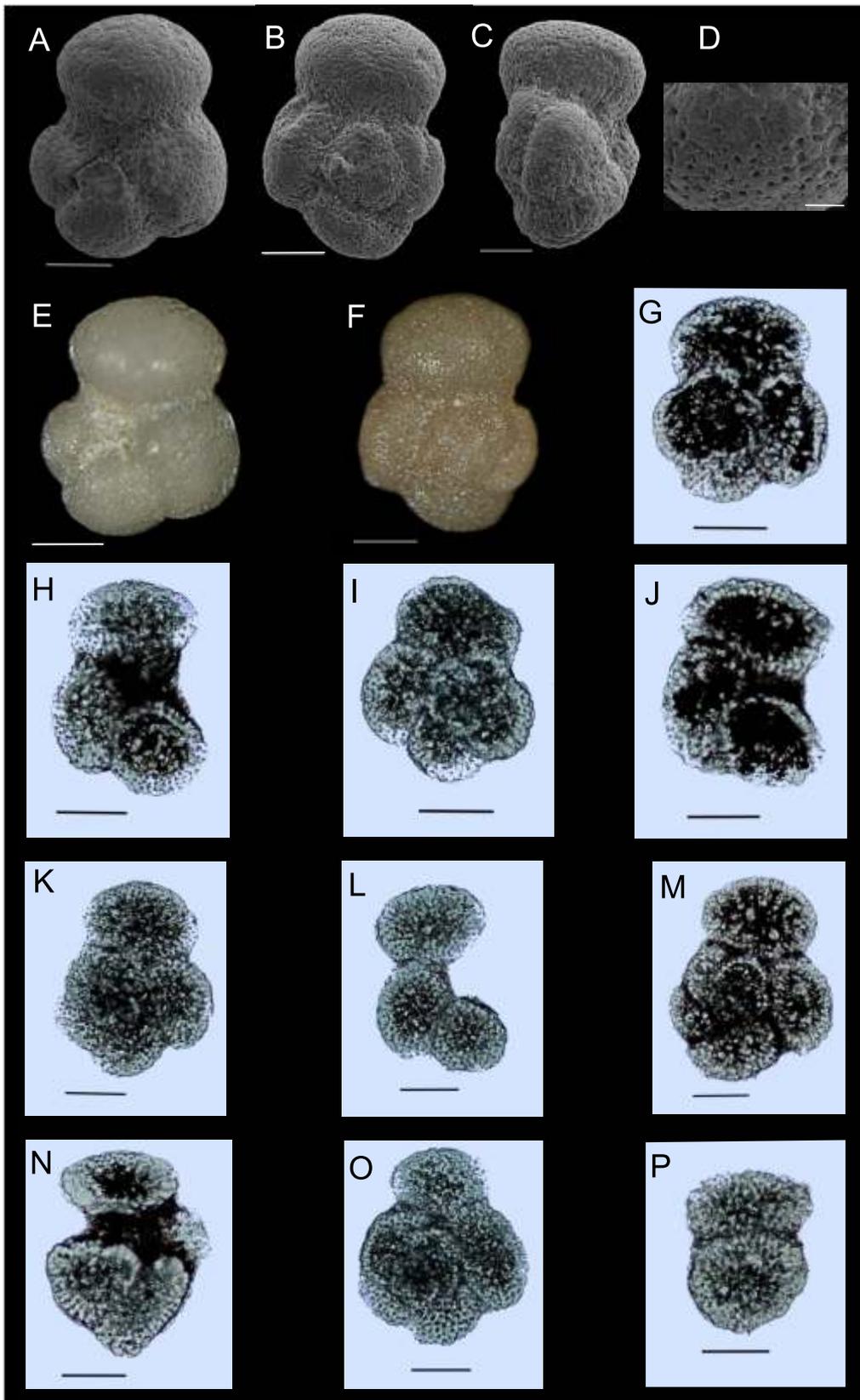


Fig. 8. *Acarinina* cf. *esnaensis* (LeRoy)

A–C – SEM images of isolated specimens; D – detail of surface of test A (scale bar = 25 μm);
 E, F – stereomicroscope photos of isolated specimens; G–P – transmitted light photos
 of experimental thin-sections of *A. cf. esnaensis*; scale bars = 100 μm

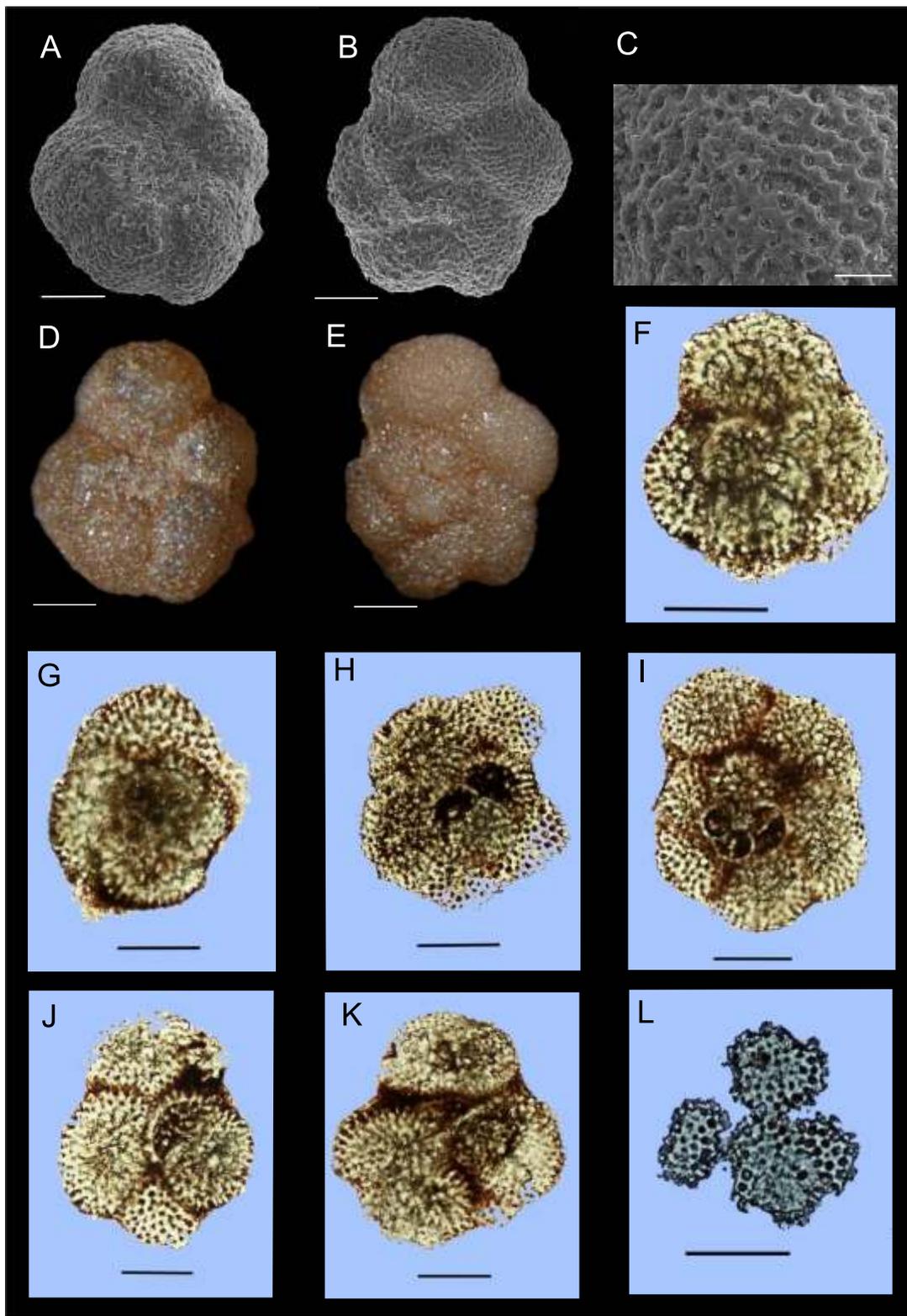


Fig. 9. *Acarinina pentacamerata* (Subbotina)

A, B – SEM images of isolated specimens; **C** – detail of surface of test B (scale bar = 25 μm);
D, E – stereomicroscope photos of isolated specimens; **F–L** – transmitted light photos of experimental thin-sections of *A. pentacamerata*; scale bars = 100 μm

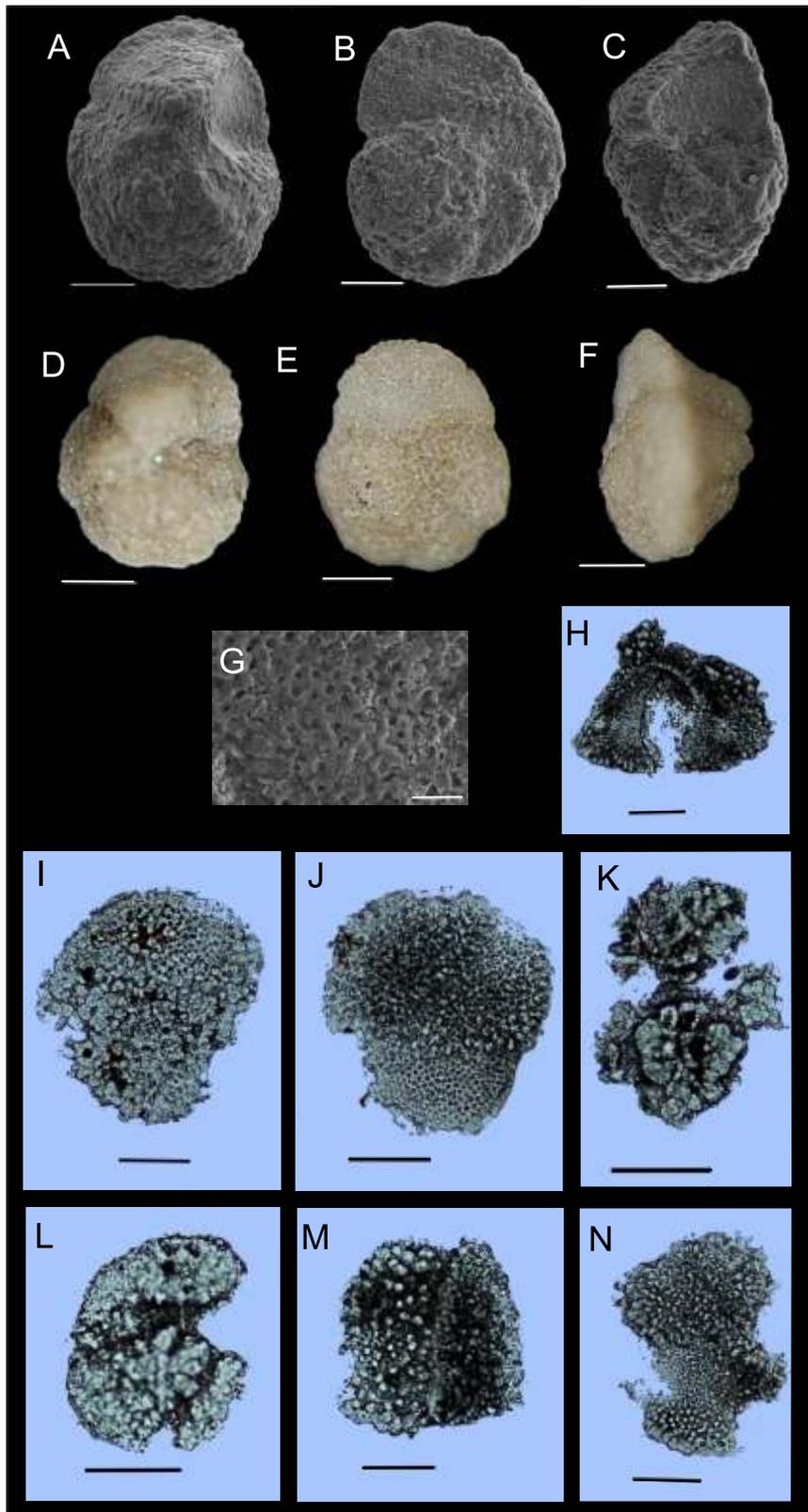


Fig. 10. *Morozovella aragonensis* (Nuttal)

A–C – SEM images of isolated specimens; **D–F** – stereomicroscope photos of isolated specimens; **G** – detail of surface of test C (scale bar = 25 μm); **H–N** – transmitted light photos of experimental thin-sections of *M. aragonensis*; scale bars = 100 μm

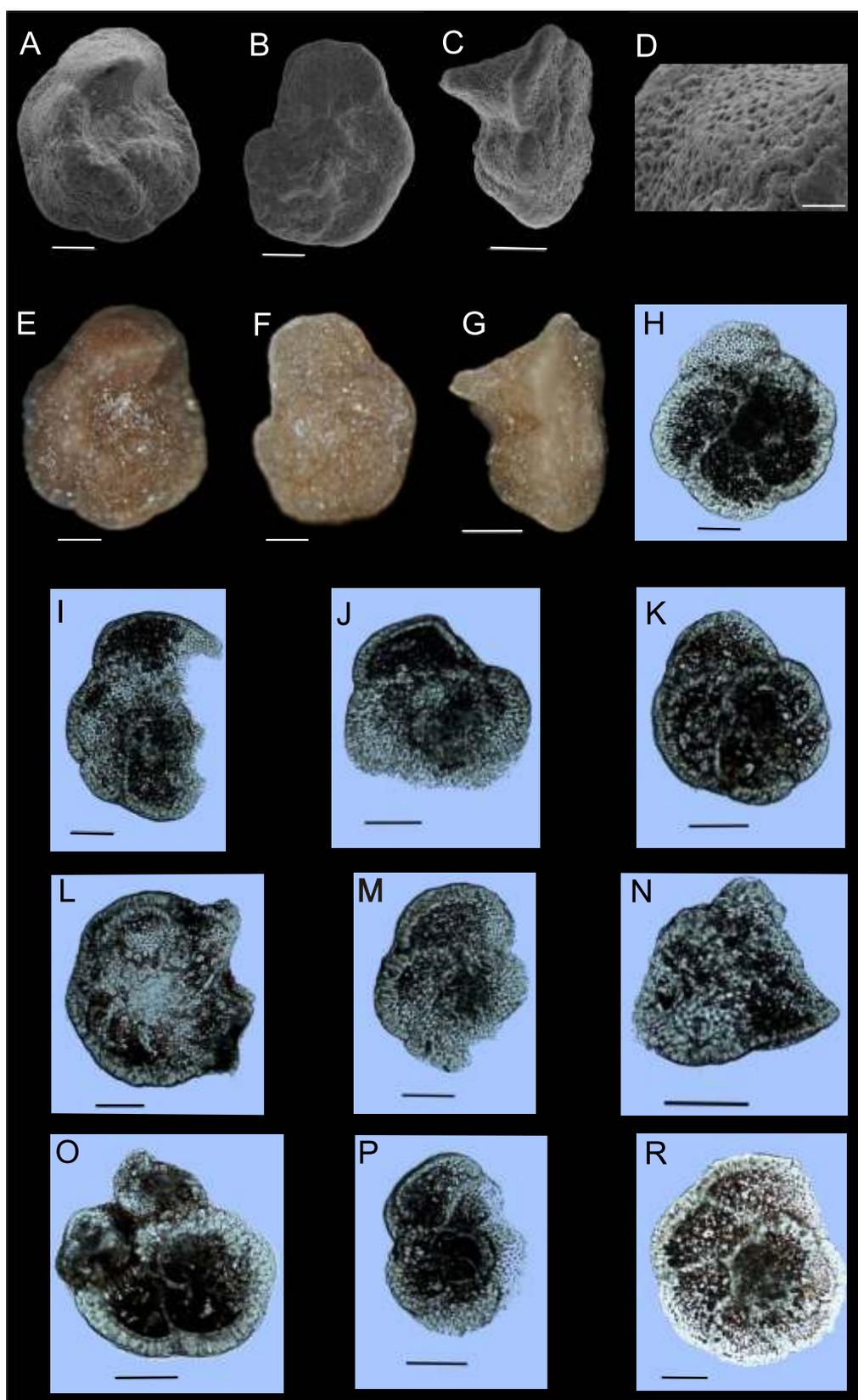


Fig. 11. *Morozovella cf. caucasica* (Glaessner)

A–C – SEM images of isolated specimens; D – detail of surface of test A (scale bar = 25 μm);
 E–G – stereomicroscope photos of isolated specimens; H–R – transmitted light photos
 of experimental thin-sections of *M. cf. caucasica*; scale bars = 100 μm

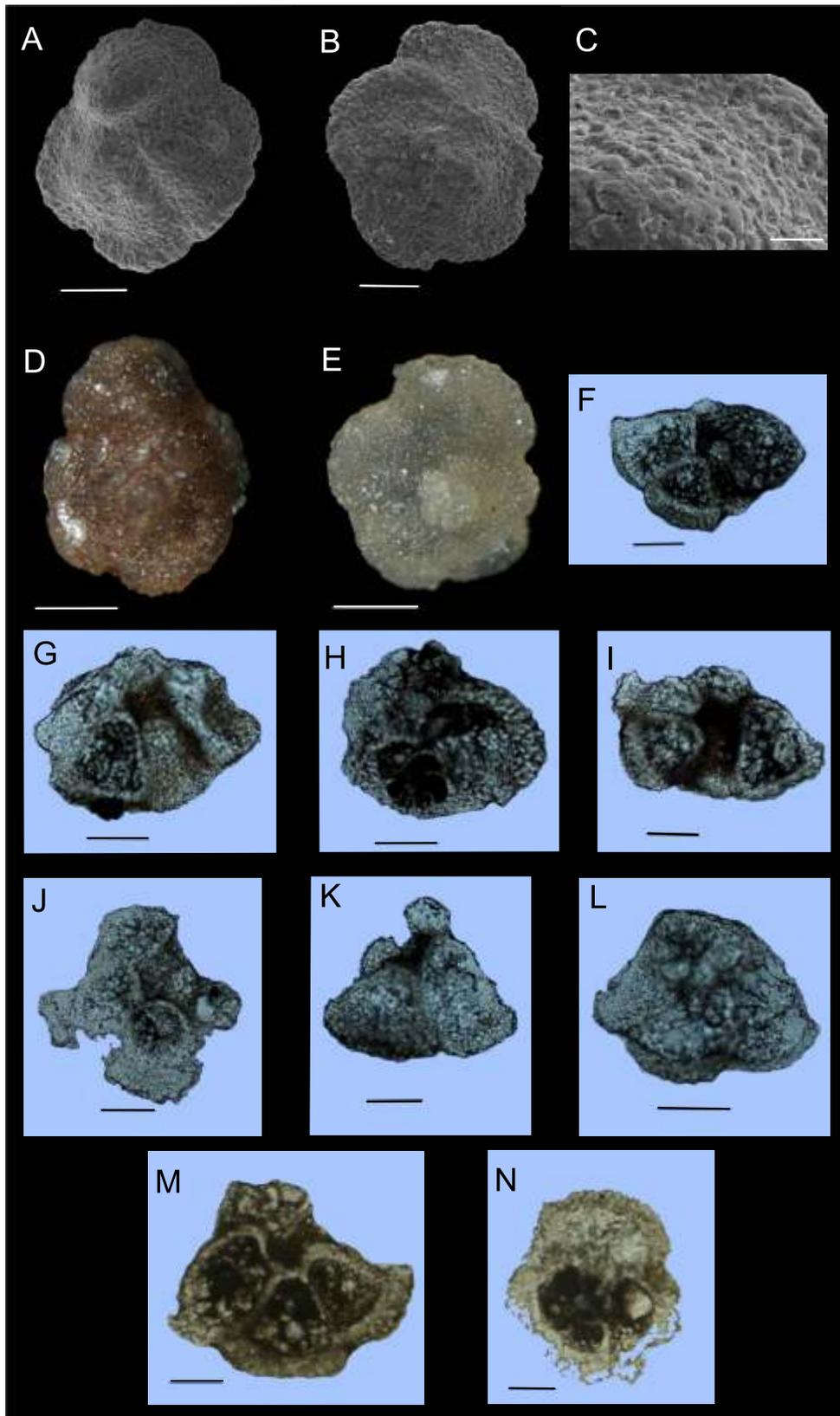


Fig. 12. *Morozovella gracilis* (Bolli)

A, B – SEM images of isolated specimens; **C** – detail of surface of test A (scale bar = 25 μm); **D, E** – stereomicroscope photos of isolated specimens; **F–L** – transmitted light photos of experimental thin-sections of *M. gracilis*; **M, N** – stereomicroscope photos of experimental thin-sections of *M. gracilis*; scale bars = 100 μm

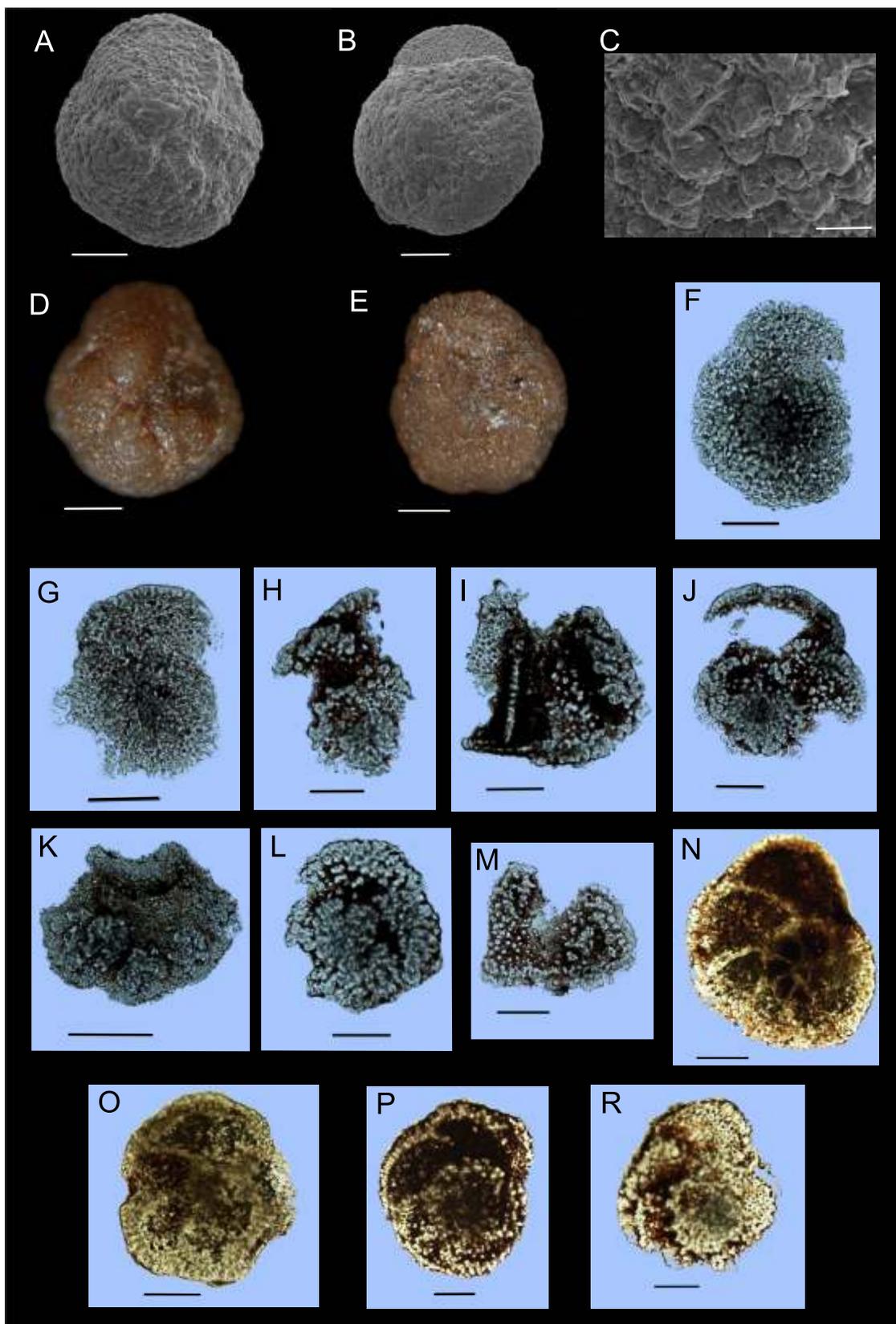


Fig. 13. *Morozovella lensiformis* (Subbotina)

A, B – SEM images of isolated specimens; **C** – detail of surface of test A (scale bar = 25 μm);
D, E – stereomicroscope photos of isolated specimens; **F–R** – transmitted light photos of experimental thin-sections of *M. lensiformis*; scale bars = 100 μm

Stratigraphic range. – Middle Early Eocene (E4–E6 zones; Berggren and Pearson, 2005; Pearson et al., 2006); in the POC, reported from the Early Eocene (Olszewska et al., 1996).

Remarks. – In spite of diagenetic obliteration the characteristic muricate surface texture is visible both on isolated specimens (Fig. 13C) and in some sections (Fig. 13F, G). In Figure 13F and G transverse dorsal cuttings similar to those of *M. aragonensis* can be recognized. Figure 13N and P shows transverse dorsal cuttings, and Figure 13O depicts a section transversal to coil axis through the central part of a test.

Morozovella marginodentata (Subbotina, 1953)
(Fig. 14)

Globorotalia marginodentata n. sp. – Subbotina (1953): 212, 213, pl. 17, fig. 14–16; pl. 18, figs. 1–3.

Morozovella marginodentata (Subbotina) – Olszewska et al. (1996): 120, pl. 37, figs. 1, 2.

Stratigraphic range. – Latest Paleocene–Early Eocene (P5–E5 zones; Berggren and Pearson, 2005; Pearson et al., 2006); in the POC – oldest Early Eocene (Olszewska et al., 1996).

Remarks. – The species with a very characteristic thick and broad peripheral muricocarina. Due to moderately convex spiral side, most of the cuts are oblique. The sections in Figure 14E, G and M display peripheral carina (keel). Figure 14H shows transverse umbilical cut. Species identification can be based on the section in Figure 14H.

Morozovella subbotinae (Morozova, 1939)
(Fig. 15)

Globorotalia subbotinae n. sp. – Morozova (1939): 80, pl. 2, fig. 16, 17 (fide Ellis et Messina, Cat. of Foram.).

Morozovella subbotinae (Morozova) – Olszewska et al. (1996): 120, 121, pl. 37, figs. 11, 12.

Stratigraphic range. – Latest Paleocene–Early Eocene (P5–E5 zones; Berggren and Pearson, 2005; Pearson et al., 2006); in the POC – Early Eocene excluding its youngest part (Olszewska et al., 1996).

Remarks. – Most of the experimental sections do not display diagnostic features of this species, however, the section in Figure 15O can be used for species identification. Wall surface texture is well-visible on isolated specimens (Fig. 15D, G).

Muricoglobigerina senni (Beckmann, 1954)
(Fig. 16)

Sphaeroidinella senni n. sp. – Beckmann (1954): 394, pl. 26, fig. 2 (fide Ellis et Messina, Cat. of Foram.).

Muricoglobigerina senni (Beckmann) – Olszewska et al. (1996): 122, pl. 42, figs. 13, 14.

Stratigraphic range. – Late Early–Middle Eocene (E6–E13; Berggren and Pearson, 2005; Pearson et al., 2006); in the POC – late Middle Eocene (Olszewska et al., 1996).

Remarks. – Recently, this species has been placed in the genera *Muricoglobigerina* (Olszewska et al., 1996), *Subbotina* (Pearson et al., 2006) and *Globigerinatheka* (BouDagher-Fadel, 2012). In this paper, we accept its genetic designation to *Muricoglobigerina*. In the adult stage, its wall is covered by a thick calcite crust, which is shown in Figure 16D, E. The sections in Figure 16F and K display a “sacculifer type” of test surface (Pearson et al., 2006). Species identification can be based on the sections in Figure 16F, M and O, showing the characteristic compact and globular morphology of its test.

Subbotina corpulenta (Subbotina, 1953)
(Fig. 17)

Globigerina corpulenta n. sp. – Subbotina (1953): 76, pl. 9, fig. 5.

Subbotina corpulenta (Subbotina) – Olsson et al. (2006): 129, 130, 133, pl. 6.7, figs. 1–14.

Stratigraphic range. – Middle Eocene–Early Oligocene (E7–O1 zones; Berggren and Pearson, 2005; Pearson et al., 2006); in the POC – Late Eocene (Olszewska et al., 1996).

Remarks. – The species is characterized by a lobulate test, usually with 4 globular chambers in ultimate whorl, and by the frequent presence of bulla-like chamber covering umbilical area. Due to a more or less spherical test, thin-sections randomly cut single chambers that are not diagnostic for taxonomic assignments. In Figure 17G, the section displays a characteristic cancelate (honeycomb-like) surface texture.

Subbotina eocaena (Gümbel, 1868)
(Fig. 18)

Globigerina eocaena n. sp. – Gümbel (1868): 662, pl. 2, fig. 109a, b (fide Ellis et Messina, Cat. of Foram.).

Subbotina eocaena (Gümbel) – Olsson et al. (2006): 134, 137, 138, pl. 6.9, figs. 1–16.

Stratigraphic range. – Early Eocene–earliest Oligocene (?E6–O1 zones; Berggren and Pearson, 2005; Pearson et al., 2006); in the POC – latest Early–Late Eocene (Olszewska et al., 1996).

Remarks. – Randomly oriented sections are usually transversal to the whorl axis. In Figure 18H and I, “rubber/sacculifer”-type wall texture (Pearson et al., 2006) of the surface is visible. In Figure 18L and M, the sections display a general shape of a test. Species identification can be based on the sections in Figure 18G, L, M.

Subbotina hagni (Gohrbandt, 1967)
(Fig. 19)

Globigerina hagni n. sp. – Gohrbandt (1967): 325, pl. 1, fig. 1–3.

Subbotina hagni (Gohrbandt) – Olsson et al. (2006): 142, 145, pl. 6.11, figs. 1–17.

Stratigraphic range. – Middle–Late Eocene (E7–E16 zones; Berggren and Pearson, 2005; Pearson et al., 2006); in the POC – Middle–Late Eocene (Olszewska et al., 1996).

Remarks. – *S. hagni* is similar to *S. eocaena*, and its sections display some similarities. However, they are mainly transversal, usually cutting only some of the chambers. Its sections reveal “sacculifer” – type wall texture.

Subbotina linaperta (Finlay, 1939)
(Fig. 20)

Globigerina linaperta n. sp. – Finlay (1939): 126, pl. 13, fig. 56 (fide Ellis et Messina, Cat. of Foram.).

Subbotina linaperta (Finlay) – Olsson et al. (2006): 149, 150, 153, 154, pl. 6.14, figs. 1–16.

Stratigraphic range. – Late Early–Late Eocene (E5–E16 zones; Berggren and Pearson, 2005; Pearson et al., 2006); in the POC – Paleocene–Eocene (Olszewska et al., 1996).

Remarks. – Its thin-sections (Fig. 20F–O) display “sacculifer”-type wall texture (Pearson et al., 2006). Most of the cross-sections reveal characteristic features of this species. The sections display various directions of cuttings, both axial (Fig. 20J) and transversal (Fig. 20O), and they show a general

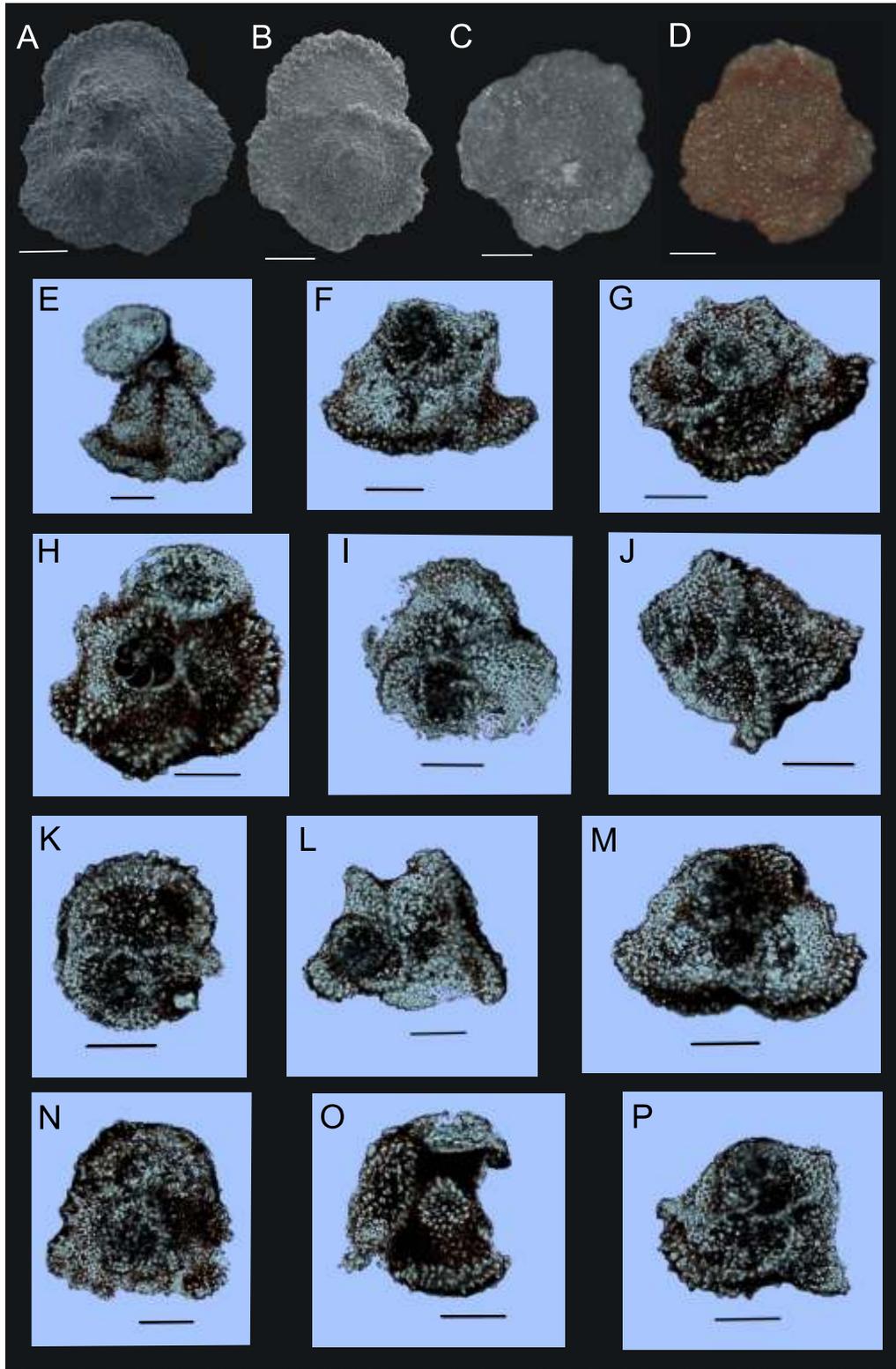


Fig. 14. *Morozovella marginodentata* (Subbotina)

A, B – SEM images of isolated specimens; **C, D** – stereomicroscope photos of isolated specimens; **E–P** – transmitted light photos of experimental thin-sections of *M. marginodentata*; scale bars = 100 μm

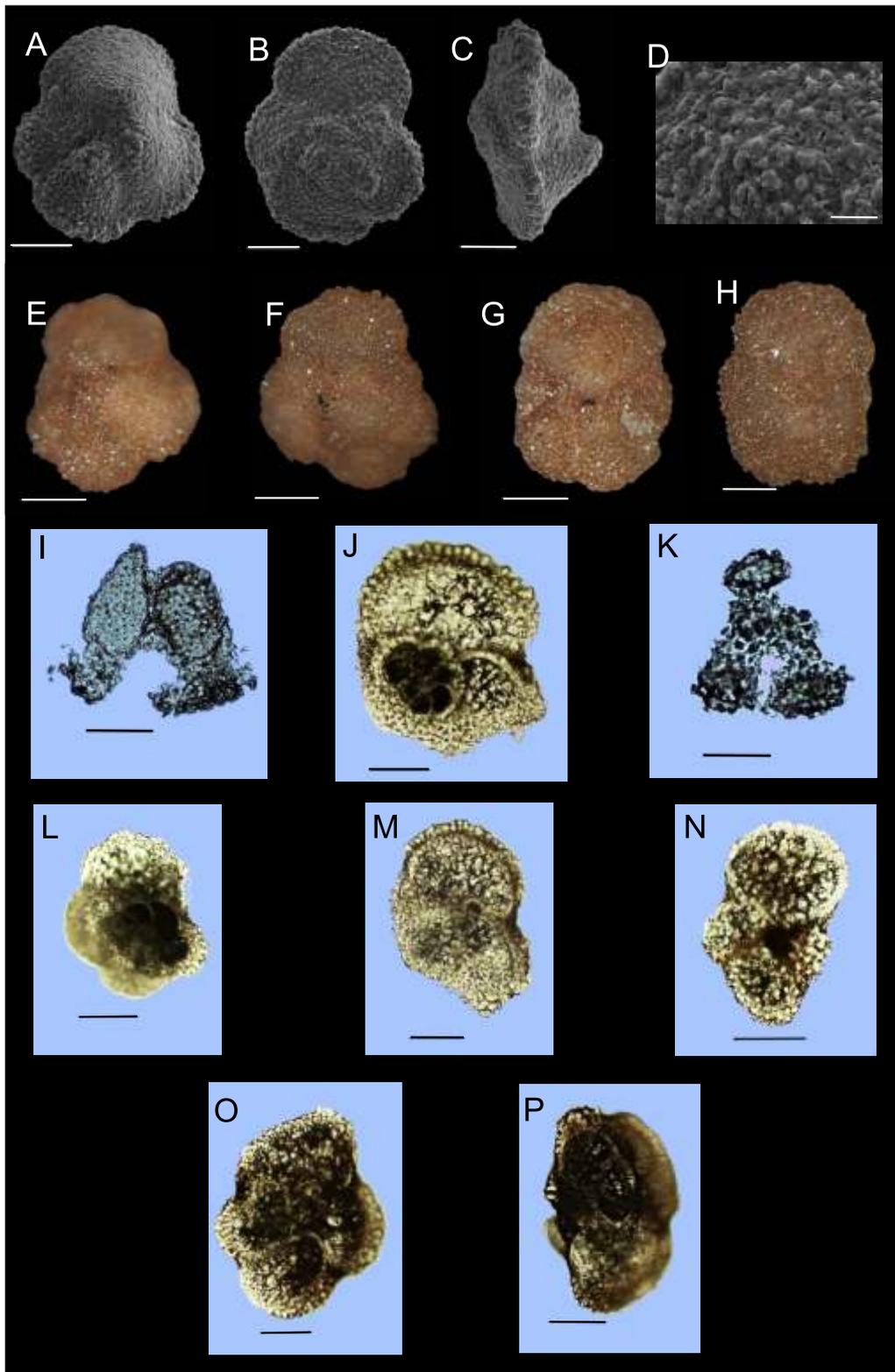


Fig. 15. *Morozovella subbotinae* (Morozova)

A–C – SEM images of isolated specimens; D – detail of surface of test A (scale bar = 25 μm); E–H – stereomicroscope photos of isolated specimens; I–P – transmitted light photos of experimental thin-sections of *M. subbotinae*; scale bars = 100 μm

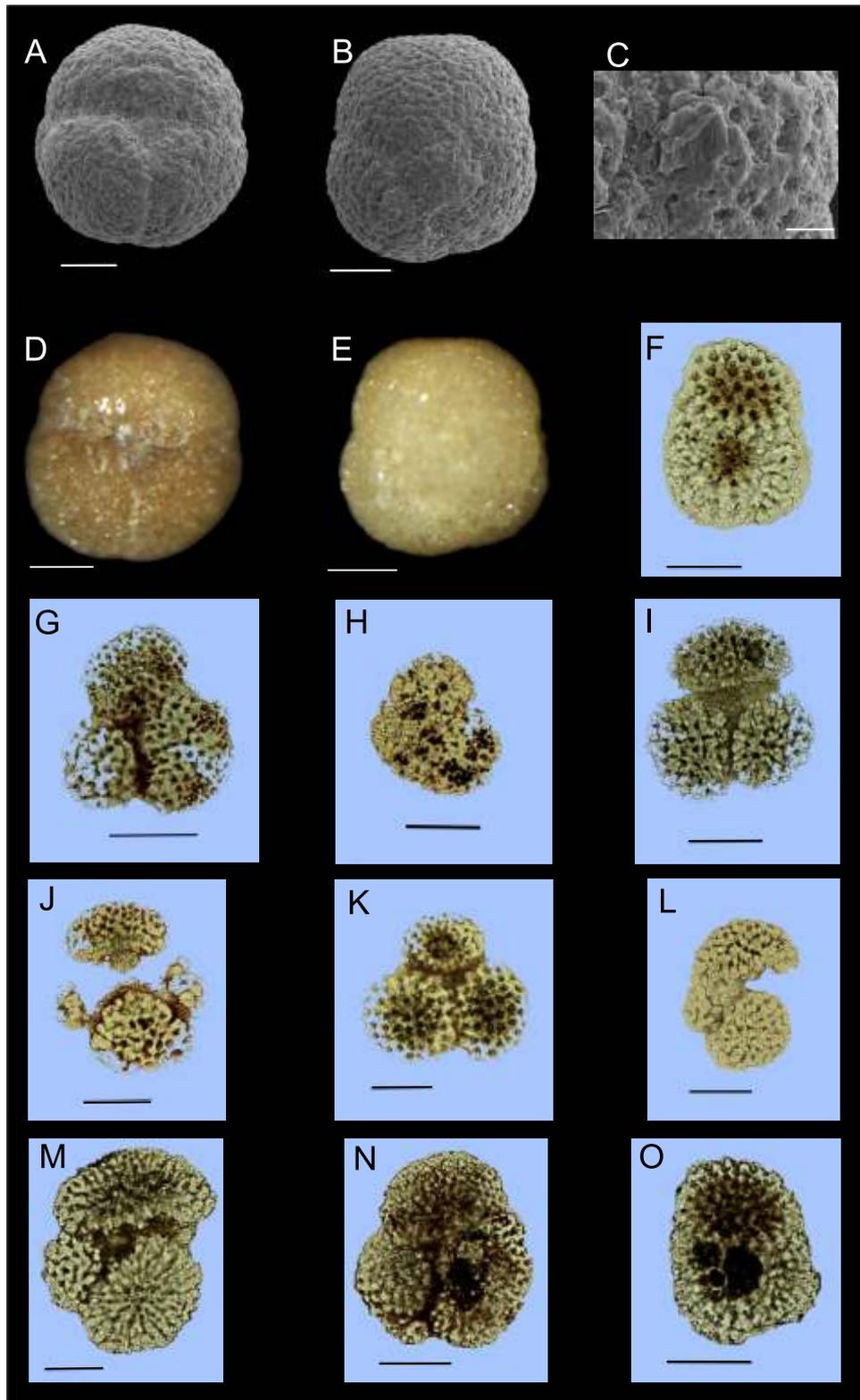


Fig. 16. *Muricoglobigerina senni* (Beckmann)

A, B – SEM images of isolated specimens; **C** – detail of surface of test B (scale bar = 25 μm);
D, E – stereomicroscope photos of isolated specimens; **F–O** – transmitted light photos
of experimental thin-sections of *M. senni*; scale bars = 100 μm

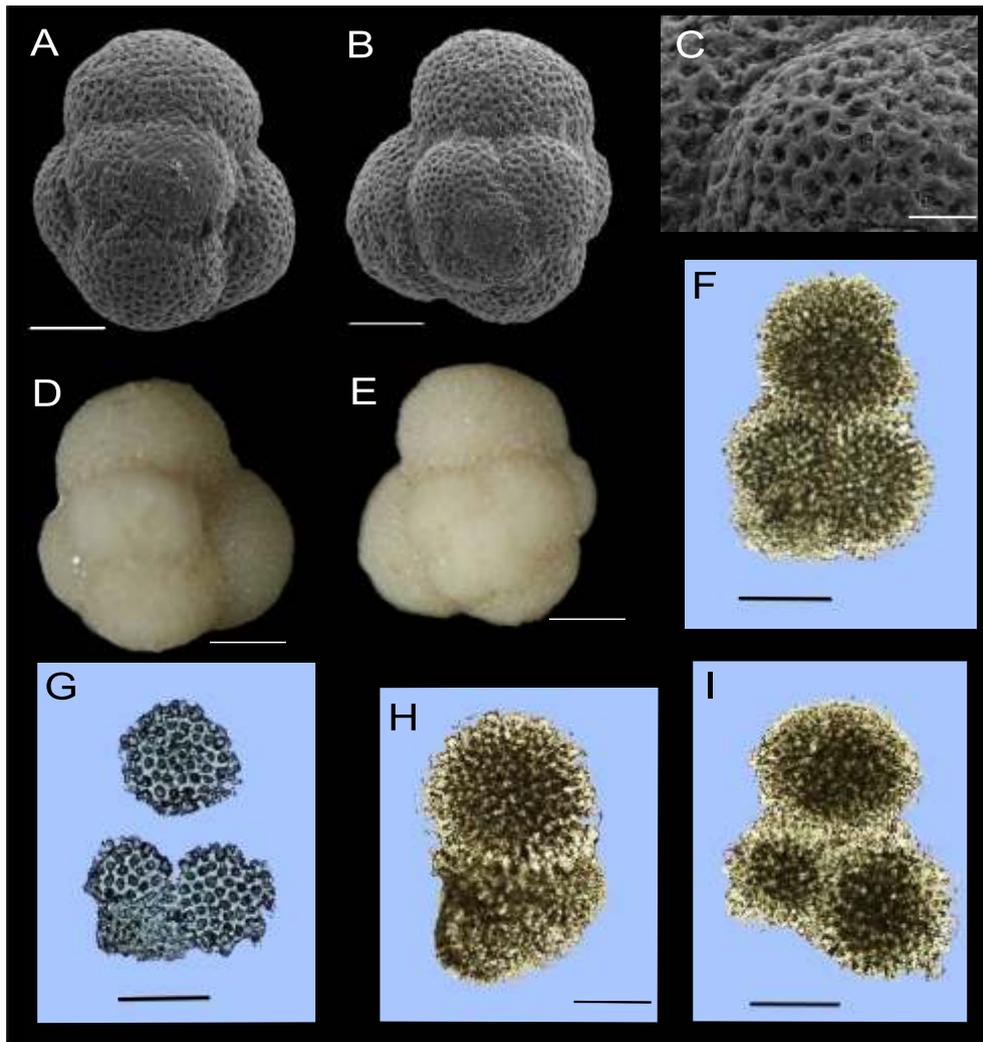


Fig. 17. *Subbotina corpulenta* (Subbotina)

A, B – SEM images of isolated specimens; D, E – stereomicroscope photos of isolated specimens; F–I – transmitted light photos of experimental thin-sections of *S. corpulenta*; scale bars = 100 μm

character of the species test. Species identification can be based on the sections in [Figure 20F, G](#).

Subbotina cf. roesnaesensis Olsson and Berggren, 2006
([Fig. 21](#))

Subbotina roesnaesensis n. sp. – Olsson et al. (2006): 157, pl. 6.16, fig. 1–15.

Stratigraphic range. – Latest Paleocene–early Middle Eocene (P5–E10 zones; [Berggren and Pearson, 2005](#); [Pearson et al., 2006](#)).

Remarks. – Lack of distinct wall texture in comparison with the other species of *Subbotina*. Cuttings are usually random with some inclination to be transversal.

In [Figure 21M](#) the section shows a distinct aperture. Experimental cuttings of this species display similarities to other species of *Subbotina*.

Subbotina triangularis (White, 1928)
([Fig. 22](#))

Globigerina triangularis n. sp. – White (1928): 195, pl. 28, fig. 1 (*vide* Ellis et Messina, Cat. of Foram.).

Subbotina triangularis (White) – Olsson et al. (1999): 30, 31, pl. 26, figs. 1–13.

Stratigraphic range. – Late Paleocene ([Olsson et al., 1999](#)).

Remarks. – In the thin-sections the wall texture shows some similarities to *S. roesnaesensis*. The cross-sections are randomly oriented without any preferential position of specimens, resulting from its overall morphology. Species identification can be based on the sections in [Figure 22E, G and K](#).

Parasubbotina inaequispira (Subbotina, 1953)
([Fig. 23](#))

Globigerina inaequispira n. sp. – Subbotina (1953): 69, pl. 6, fig. 1.
Parasubbotina inaequispira (Subbotina) – Olszewska et al. (1996): 141, 142, pl. 15, fig. 1.

Stratigraphic range. – Early Eocene–earliest Middle Eocene (E1–E8 zones; [Berggren and Pearson, 2005](#);

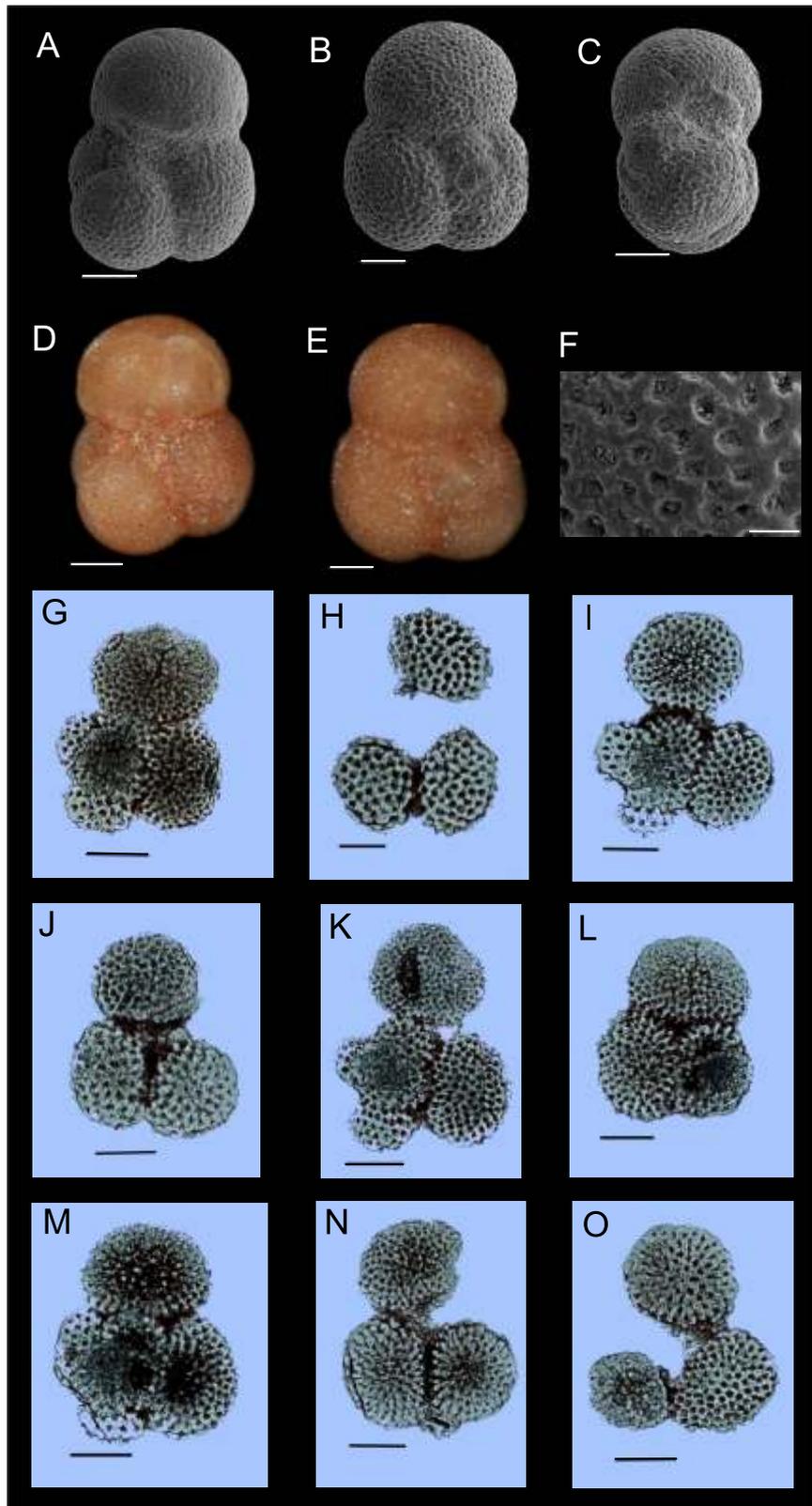


Fig. 18. *Subbotina eocaena* (Gümbel)

A–C – SEM images of isolated specimens; **D, E** – stereomicroscope photos of isolated specimens; **F** – detail of surface of test B (scale bar = 25 μm); **G–O** – transmitted light photos of experimental thin-sections of *S. eocaena*; scale bars = 100 μm

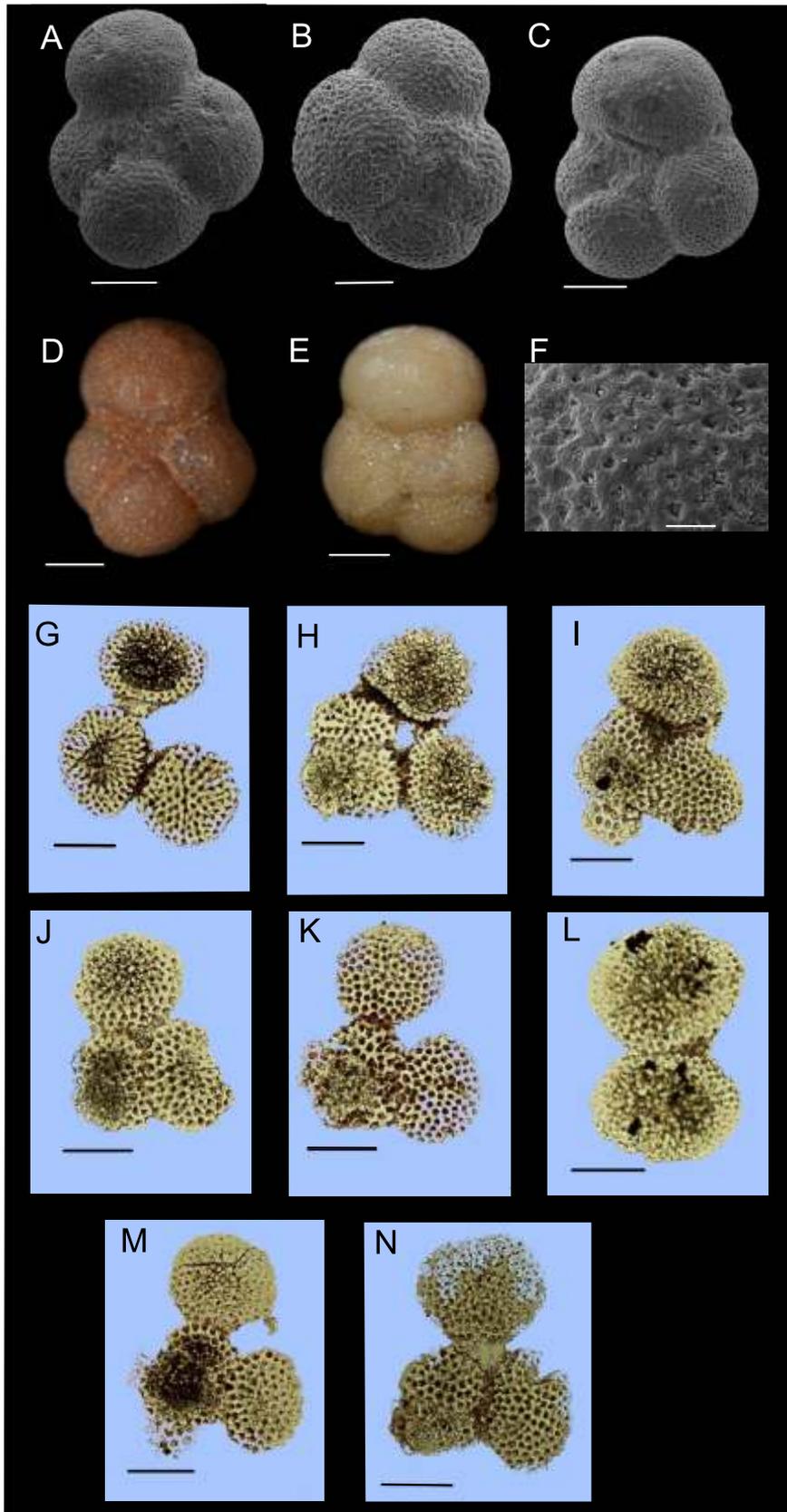


Fig. 19. *Subbotina hagni* (Gohrbandt)

A–C – SEM images of isolated specimens; D, E – stereomicroscope photos of isolated specimens; F – detail of surface of test B (scale bar = 25 μm); G–N – transmitted light photos of experimental thin-sections of *S. hagni*; scale bars = 100 μm

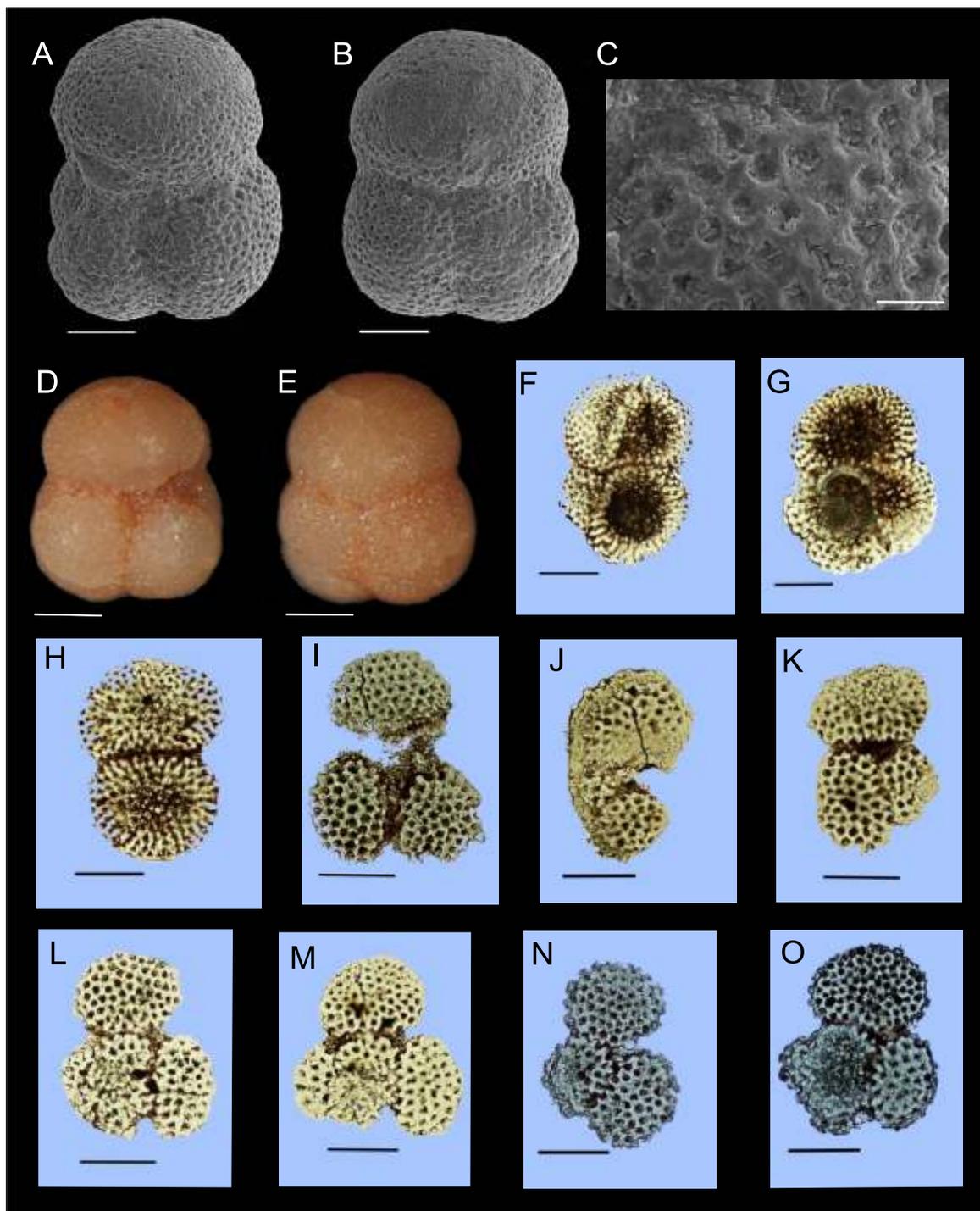


Fig. 20. *Subbotina linaperta* (Finlay)

A, B – SEM images of isolated specimens; **C** – detail of surface of test A (scale bar = 25 μm);
D, E – stereomicroscope photos of isolated specimens; **F–O** – transmitted light photos
 of experimental thin-sections of *S. linaperta*; scale bars = 100 μm

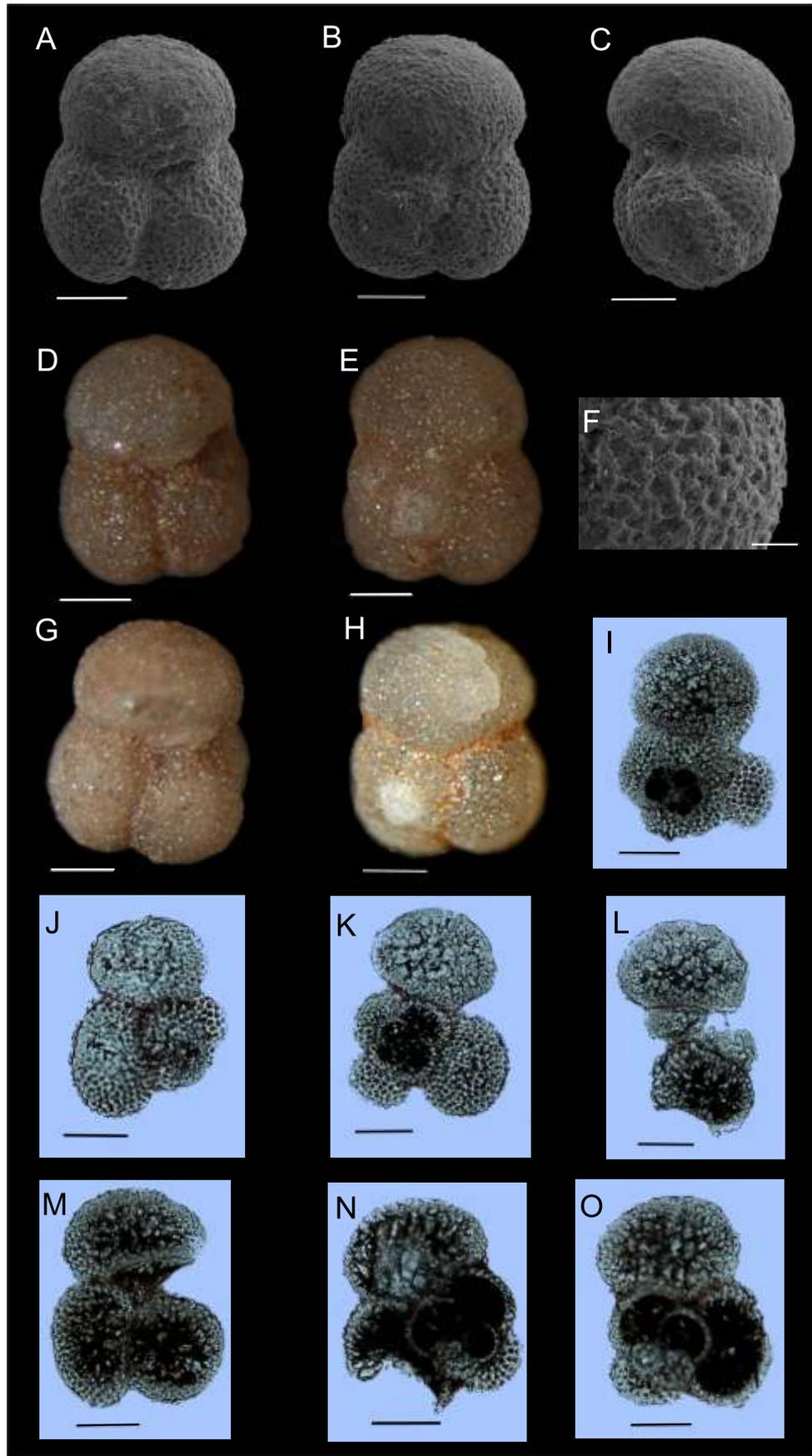


Fig. 21. *Subbotina cf. roesnaesensis* (Olsson and Berggren)

A–C – SEM images of isolated specimens; D–E, G, H – stereomicroscope photos of isolated specimens; F – detail of surface of test B (scale bar = 25 μm); I–O – transmitted light photos of experimental thin-sections of *S. cf. roesnaesensis*; scale bars = 100 μm

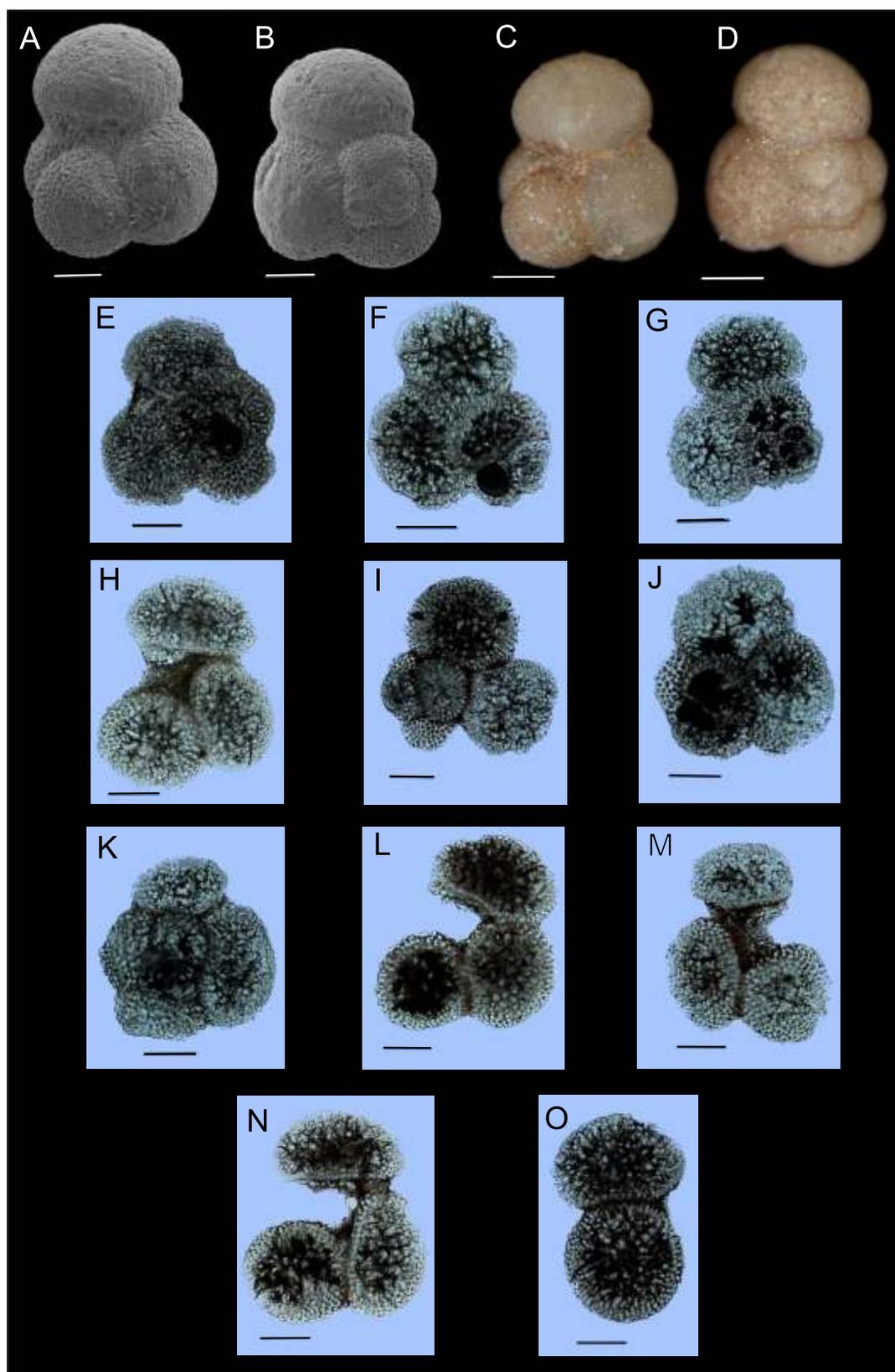


Fig. 22. *Subbotina triangularis* (White)

A, B – SEM images of isolated specimens; **C, D** – stereomicroscope photos of isolated specimens; **E–O** – transmitted light photos of experimental thin-sections of *S. triangularis*; scale bars = 100 μ m

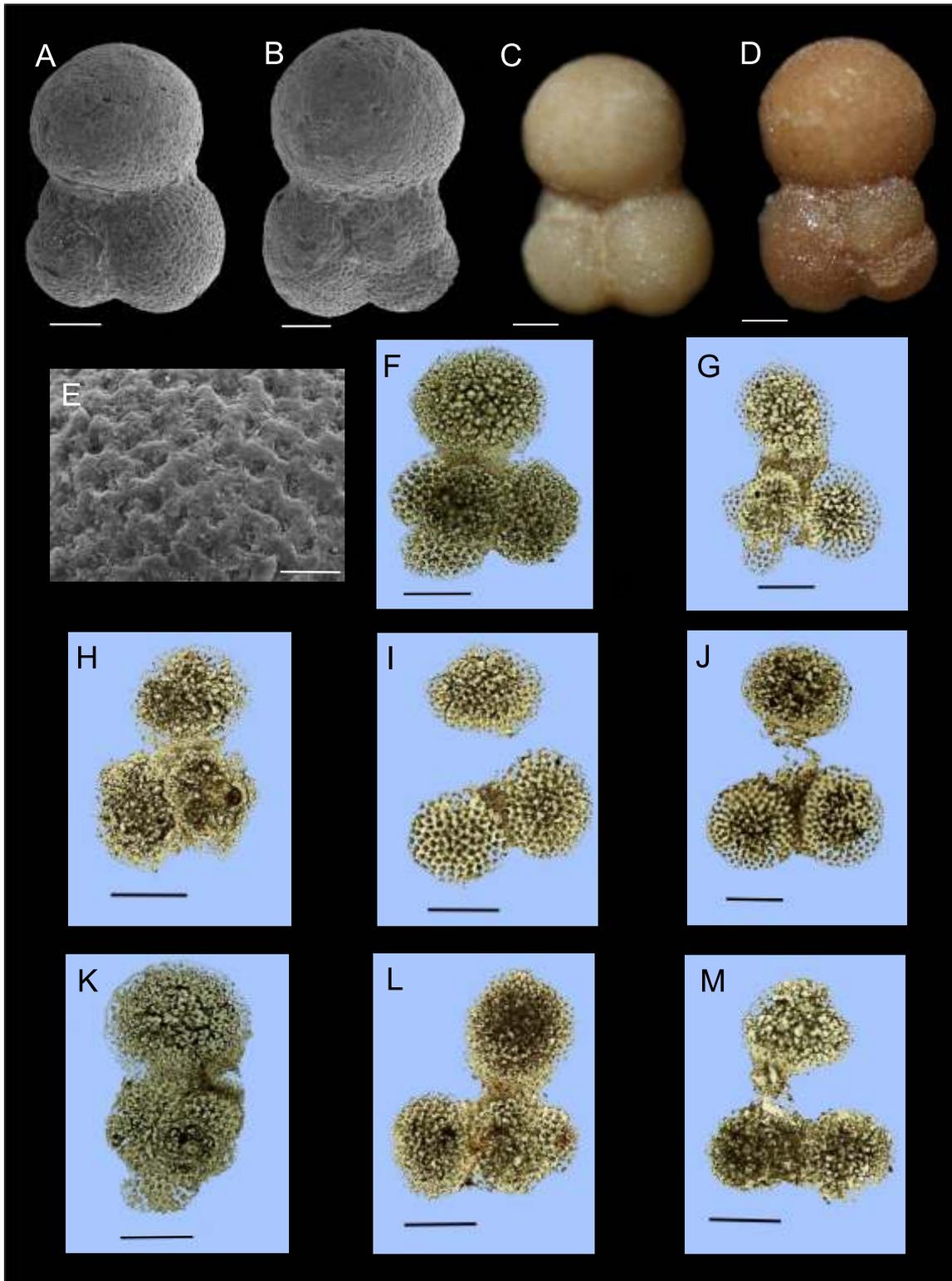


Fig. 23. *Parasubbotina inaequispira* (Subbotina)

A, B – SEM images of isolated specimens; **E** – detail of surface of test A (scale bar = 25 μm);
C, D – stereomicroscope photos of isolated specimens; **F–M** – transmitted light photos of experimental thin-sections of *P. inaequispira*; scale bars = 100 μm

Pearson et al., 2006); in the POC – youngest Late Paleocene–Early Eocene (Olszewska et al., 1996).

Remarks. – The wall texture shows some similarities to a “sacculifer”-type, commonly occurring in the genus *Subbotina*. The cuttings are random due to globular chambers and do not display the characteristic test morphology, however, showing some overall similarities to some species of *Subbotina* (Fig. 23F). Species identification can be based on the section in Figure 23F.

SUMMARY

The original method applied for thin-section on isolated specimens of planktic foraminifera, using epoxy resin (*Araldite 1000-Struers*), appeared to be sufficiently effective in the course of the first experiment of this kind.

The quality of experimental thin-sections in respect to diagnostic features of a particular species much depends on the general test morphology, resulting in the random but preferential position of specimens immersed and then hardened in epoxy resin.

Random cuttings of various taxa, exhibiting morphological resemblance, result in similar figures that show no morphological criteria necessary for the determination to a specific taxonomic level. In our material, this refers particularly to the group of *Subbotina*.

Based on the experimentally obtained cross-sections we can conclude that taxonomic identification, at least to the generic level, is possible.

Diagnostically best sections have been obtained for the biserial specimens of elongated, flattened “wedge-shape” tests of *Chiloguembelina*, which have a natural tendency to axial-sagittal orientation of plane cuts.

Oblique thin-sections of trochospiral tests with globigeriniform coiling, which are generally biconvex and lobulate (round-shaped group), such as *Subbotina* and *Parasubbotina*, usually cut a smaller number of chambers, but display globular shapes of chambers and cancelate surface texture. Transversal sections, more centrally situated, show a characteristic lobulate outline of their tests.

Trochospiral tests with a truncated cone shape and flattened dorsal side reveal natural tendency to get into position resulting in sections more or less transversal to the axis of coiling. Their truncated cone shape is usually preserved in oblique sections; however, sections of tests representing such morphology are of variable quality. Peripheral margins with distinct muricocarina, which is characteristic of majority of species within the *Morozovella* genus, are present in most of their sections. The outlines of tests of both types of acarinids, with angular and rounded chambers, are displayed in their transverse dorsal sections.

SEM images of identified species show considerable diagenetic obliterations that, in most cases, blur the primary and characteristic texture of test surfaces while in some thin-sections these textural features are better preserved (e.g., *Subbotina hagni*).

The sections from our experiment reveal that their diagnostic quality could have been higher if the specimens of particular species used in a single slide had been of similar sizes. In case of continuation of such experiment, mechanical grounding of slides should also be tested.

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