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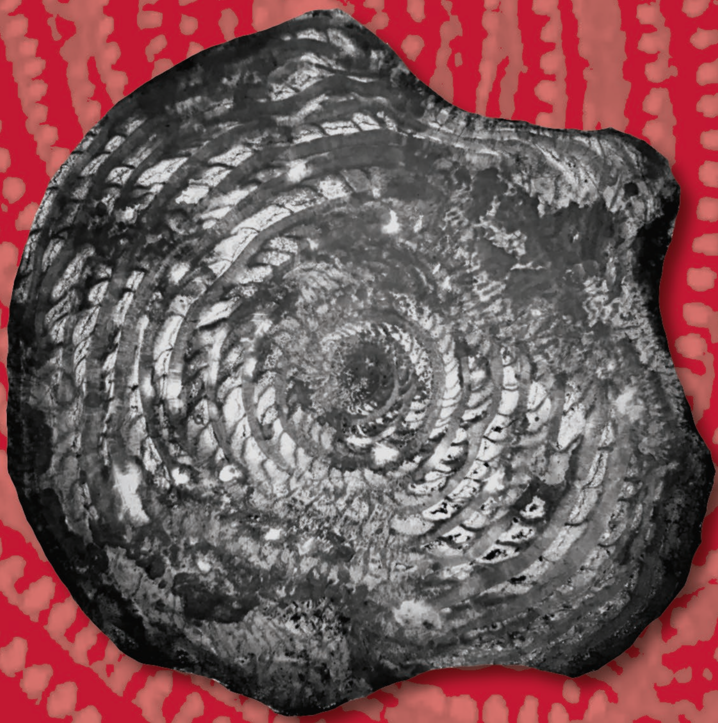
Ali DEVECILER



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Biostratigraphic revision and systematic discussion of *Granorotalia sublobata* Benedetti, Di Carlo & Pignatti, 2011

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ABSTRACT
Granorotalia sublobata Benedetti, Di Carlo & Pignatti, 2011 is studied in detail regarding the biostratigraphic range and systematic paleontology. Its biostratigraphic range extends from Cuisian to early Lutetian with the associated fauna in Memlik area, Central Anatolia and some former studies from Spain, Italy, Slovakia and Israel. In addition, the boundary between early and middle Lutetian (SBZ 13/14) is determined by reinterpreting data formerly obtained from Gölbayırı section. Also the close resemblance to *Neorotalia alicantina* Colom, 1954 in early Lutetian is discussed regarding the specific and generic characteristics.

KEY WORDS
Turkey,
Eocene,
Granorotalia,
biostratigraphy.

RÉSUMÉ
Révision biostratigraphique et discussion systématique de Granorotalia sublobata *Benedetti, Di Carlo & Pignatti, 2011.*
L'extension biostratigraphique et la paléontologie systématique de *Granorotalia sublobata* Benedetti, Di Carlo & Pignatti, 2011 sont étudiées en détail. Sa distribution biostratigraphique s'étend du Cuisien au Lutétien inférieur, comme en témoignent la faune associée dans la région de Memlik, en Anatolie centrale, et quelques études antérieures d'Espagne, d'Italie, de Slovaquie et d'Israël. De plus, la limite entre le Lutétien inférieur et moyen (SBZ 13/14) est déterminée en réinterprétant les données précédemment obtenues sur la section Gölbayırı. La ressemblance étroite avec *Neorotalia alicantina* Colom, 1954 du début du Lutétien est également discutée sous l'angle de ses caractéristiques spécifiques et génériques.

MOTS CLÉS
Turquie,
Éocène,
Granorotalia,
biostratigraphie.

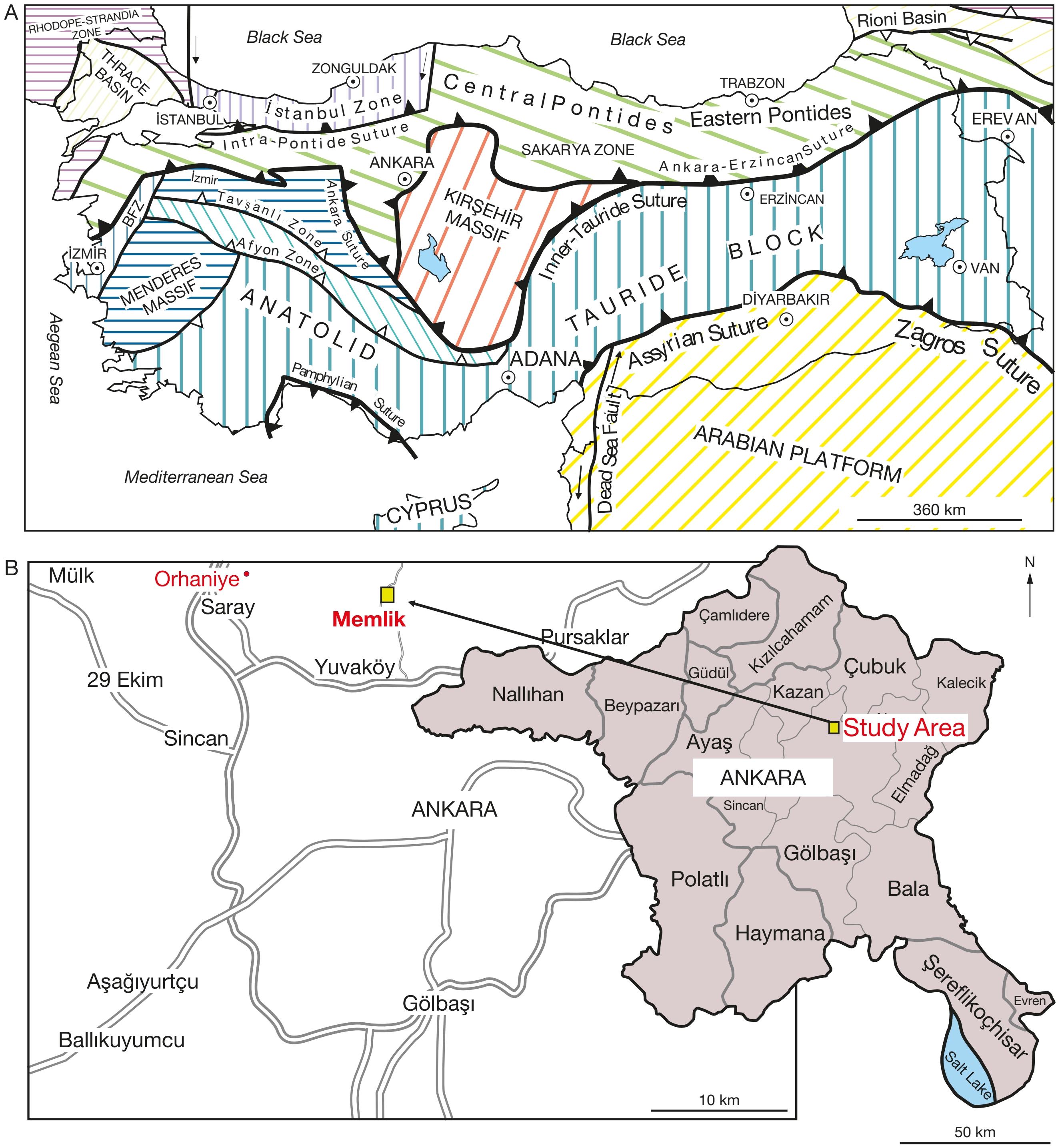

FIG. 1. — The tectonic map of Turkey (**A**, modified from Okay & Tüysüz 1999) and location map of the investigation area, Ankara-Türkiye (**B**).

INTRODUCTION

Granorotalia sublobata Benedetti, Di Carlo & Pignatti, 2011 has been accepted as a foraminifer, characteristic for the lower Eocene marine deposits of Tethys region so far. Benedetti *et al.* (2011) has introduced this small rotaliid from Cuisian marine deposits of Sicily (Italy), then it has been identified in the Çayraz limestone (Turkey) by Sirel & Deveciler (2017) at the same stratigraphic position. However, the close resemblance to *Neorotalia alicantina* Colom, 1954 of Lutetian by its outer characteristics, created a suspicion if it also exists in the middle Eocene or not. In this context, the shallow marine limestone at Memlik area (North of Ankara, Turkey) in Orhaniye basin were taken into account for good examples of the mentioned taxon.

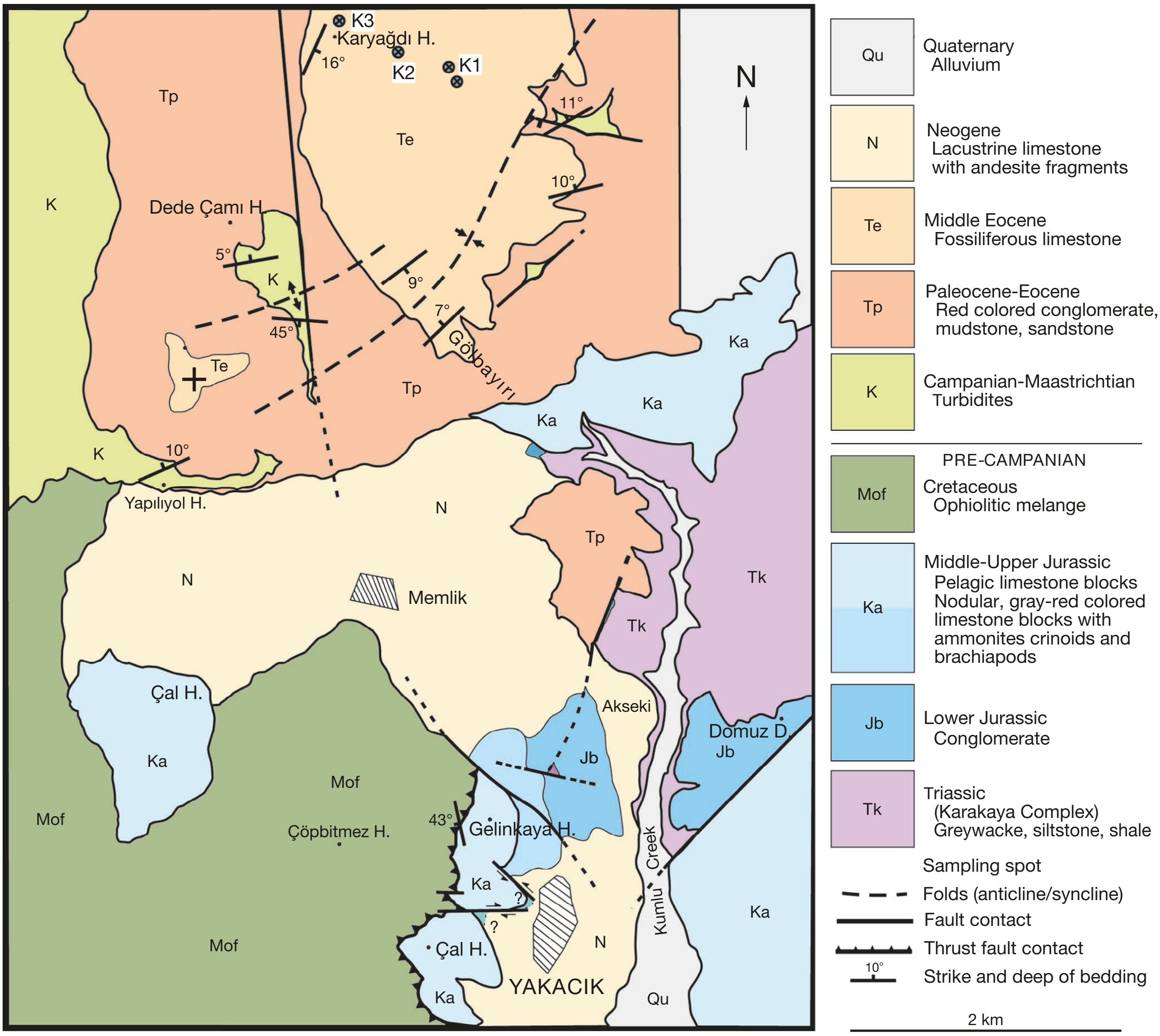

Fig. 2. — Geological map around Memlik area (it was drawn during the Ankara University Department of Geological Engineering geological mapping field trips). Map: Ali Deveciler and others.

GEOLOGICAL SETTING

The Orhaniye basin is located at the collision suture of three continents called Eurasia, Gondwana and Sakarya, respectively (Şengör & Yılmaz 1981; Okay & Tüysüz 1999; Fig. 1A). This collision, which began in the Late Cretaceous, has formed the Orhaniye forearc basin as the northern margin of Haymana-Polatlı basin in Central Anatolia (Koçyiğit 1991). The stratigraphic units in the Orhaniye basin can be divided into two parts such as the basement made up of crystalline complexes, olistostromes and ophiolitic melanges of pre-Campanian, and the sedimentary deposits of Late Cretaceous-Tertiary period (Kazancı & Gökten 1986; Gökten *et al.* 1988; Koçyiğit 1991; Okay *et al.* 2019).

Memlik area is located eastern part of Orhaniye basin situated at the North of Ankara (Fig. 1B). Triassic greywacke, Jurassic conglomerate successions, nodular red-grey limestone, pelagic limestone and the ophiolite represent the oldest outcrops in the study area. The Campanian-Maastrichtian marine turbidites are the first sedimentary units filling the basin (Sağurlar & Toker 1990; Koçyiğit 1991; Okay *et al.* 2019) (Fig. 2). Mostly reddish terrestrial mudstone and conglomerate of Late Paleocene-early Middle Eocene (Lich *et al.* 2017; Métais *et al.* 2017; Okay *et al.* 2019) cover the Cretaceous units. Middle Eocene very shallow/shallow water marine argillaceous limestones represent the youngest Paleogene outcrops in the area (Gökten *et al.* 1988; Acar 1995; Sirel & Acar 2008; Deveciler 2014; Sirel & Deveciler 2018). Neogene carbonates containing andesite, chert and remnant of the basement rock pebbles cover the preceding successions (Fig. 2). The boundaries between the lithostratigraphic units has partly been affected by various faults caused by the collision tectonics (Figs 2; 3).

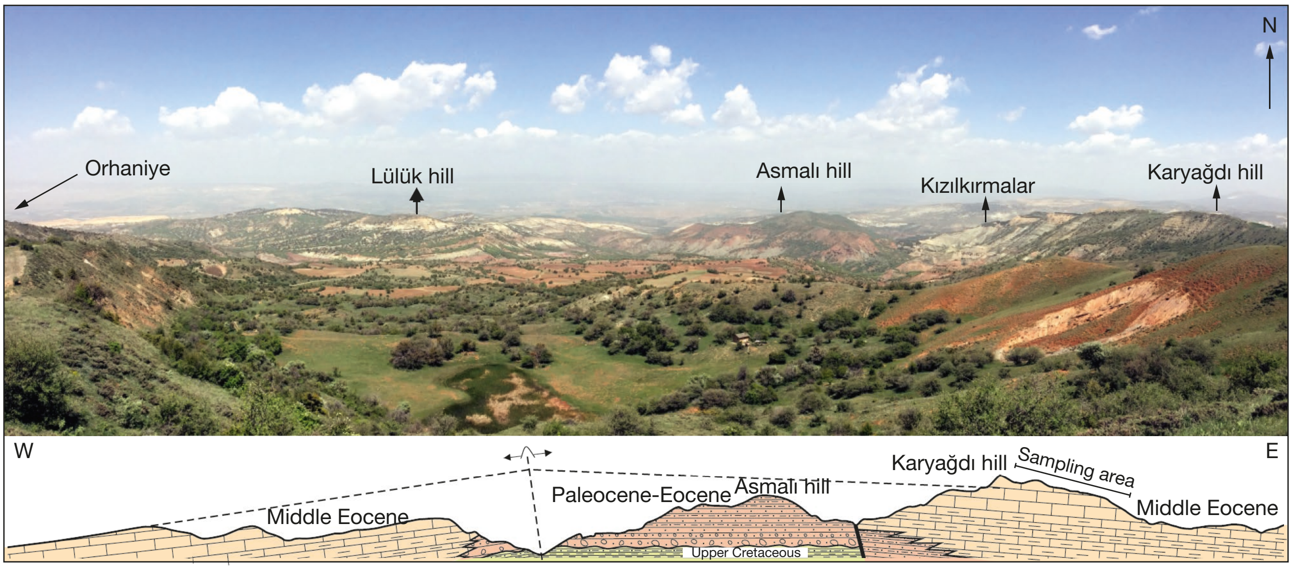

FIG. 3. — The cross-section from Dedeçamı hill to North of the investigation area, showing the boundary relations between Cretaceous and Paleogene units (not to scale). Photo: Ali Deveciler.

The larger foraminifera of Gölbayırı section near Memlik vicinity were previously studied by Deveciler (2014) (Fig. 2). The limestones were attributed to Bartonian stage depending on *Alveolina callosa* Hottinger, 1960, *A. fragilis* Hottinger, 1960, *A. fusiformis* Sowerby, 1850, *A. kieli* Sirel & Acar, 2008, *A. nuttalli* (Davies, 1940), *A. stercusmuris* Mayer-Eymar, 1886 and *Nummulites malatyaensis* Sirel, 2003 respectively. Regarding to the similar foraminiferal content, Erdoğdu *et al.* (2021) was reported the same unit from Karyağdı hill in late Lutetian-Bartonian. The equivalent deposits in Orhaniye village were studied by Acar (1995), Sirel & Acar (2008) and Harmandalı (2014) as well. The association here composed by *Alveolina tenuis* Hottinger, 1960, *A.* cf. *stipes* Hottinger, 1960, *A. callosa*, *A. kieli*, *A. orhaniyensis* Acar, 1995, *A.* aff. *violae* Checchia-Rispoli, 1905, *A. stercusmuris* and *A. nuttalli* indicates an early-middle Eocene period.

MATERIAL AND METHODS

This study was carried out from argillaceous limestone samples of Karyağdı Hill, North of Memlik Village (Northern Ankara; Turkey) (Fig. 1B). From bottom to top, limestone color turns into yellow-white from light grey due to the detritic content increase and the bottom has a weak fossilization for having an intense clay deposition (Fig. 3). Three spot samples labeled 20/K1 (40°05'52.4"N, 32°45'26.5"E), 20/K2 (40°05'57.9"N, 32°45'08.6"E) and 20/K3 (40°06'05.8"N, 32°44'50.0"E) were collected from the slope, which had good examples of *Granorotalia sublobata* with co-existing species of middle Eocene. The paleontological descriptions were based on 82 oriented hard rock thin sections and free samples obtained from the study field. The thin sections and free samples were studied and photographed by stereo and compound binocular microscopes. All the thin sections and free samples described and figured herein are preserved in the MTA, Department of Geological Researches, Ankara, Türkiye.

SYSTEMATIC PALEONTOLOGY

The suprageneric classification adopts Benedetti (2015) and Holzmann & Pawloski (2017). The morphological descriptions are based on Colom (1954), Loeblich & Tappan (1987), Hottinger (2006, 2014), Benedetti *et al.* (2011), and Sirel & Deveciler (2017). The shallow benthic zones (SBZ) follow Serra-Kiel *et al.* (1998).

Order ROTALIIDA Delage & Hérouard, 1896
Superfamily ROTALIOIDEA Ehrenberg, 1839
Family CALCARINIDAE d'Orbigny, 1826
Subfamily ORNATOROTALIINAE Benedetti, 2015

Genus *Granorotalia* Benedetti, Di Carlo & Pignatti, 2011

Granorotalia Benedetti, Di Carlo & Pignatti, 2011: 710. — Benedetti, Di Carlo & Pignatti *in* Sirel & Deveciler 2017: 70.

Neorotalia Bermúdez *in* Hottinger, 2014: 154.

TYPE SPECIES. — *Granorotalia sublobata* Benedetti, Di Carlo & Pignatti, 2011 by monotypy.

DESCRIPTION

Test is asymmetric biconvex, much swollen and ornamented on ventral side (Figs 4K, M; 6C, D; 7C, E; Benedetti *et al.* 2011: figs $14b_2$, e_2, g). Test surface is covered by coarse beads and small papillas on both dorsal and ventral side (Figs 4I-M; 6B-D; 7C-E; Benedetti *et al.* 2011: figs 14a-g). Small pseudospines may appear at the periphery (Figs 6C, E, J, K; 7D, F, G, J, L; Benedetti *et al.* 2011: fig. 11a, figs 13d-e). Chambers are arranged involute low trochospiral and may become evolute at the last whorl on the dorsal side (Figs 4I, L; 6B, E, M; 7F, J, L, N; Benedetti *et al.*

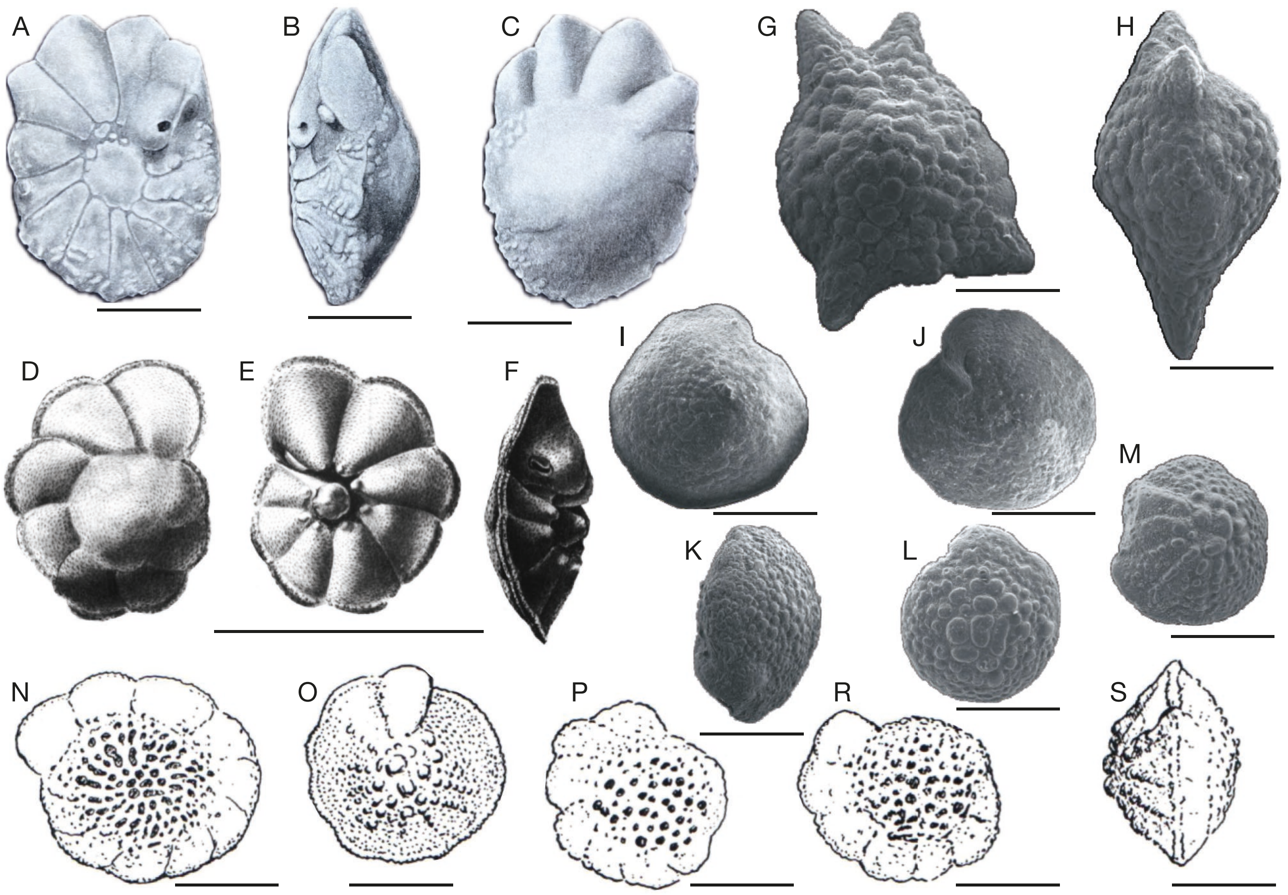

Fig. 4. — Type figures of: **A**-**C**, *Neorotalia mexicana* (Nuttall, 1928), lectotype in Loeblich & Tappan (1964); **D**-**F**, *Pararotalia inermis* (Terquem, 1882), hypotype in Loeblich & Tappan (1957); **G**-**H**, *Ornatorotalia spinosa* Benedetti, Pignatti & Di Carlo, 2011, holotype in Benedetti *et al.* (2011); **I**-**M**, *Granorotalia sublobata* Benedetti, Pignatti & Di Carlo, 2011; **I**-**K**, holotype; **L, M**, paratype in Benedetti *et al.* (2011); **N**-**S**, *Neorotalia alicantina* Colom, 1954, syntypes in Colom (1954). Scale bar: 0.5 mm.

2011: figs 11a, c, $14b_1$, e_1). Sutures on the last whorl are slightly depressed and generate interlocular space leading to a simple intraseptal canal (Figs 6A, H; 7A, G, I, O; Benedetti *et al.* 2011: figs 11b, d-e). Solid pillars are pierced by vertical canals (funnels) (Figs 6E-G, I-N; 7B, F, H, J-N; Benedetti *et al.* 2011: figs 11a, c, 13a-f). Tooth plate covers the base of the chamber lumen, also it produces spiral canal (Figs 6H; 7I). Wall calcareous, perforate and lamellar in pillars, aperture interiomarginal. Connection between chambers is provided by single intercameral foramina (Fig. 6H).

Discussion

Granorotalia is a simple rotaliid with asymmetric biconvex test, granulated surface on both dorsal and ventral side, small pseudospines emerging from the periphery. It was first described by Benedetti *et. al.* (2011) with *Ornatorotalia* (type species: *O. spinosa* Benedetti, Di Carlo & Pignatti, 2011 [Benedetti *et al.* 2011: 705]; Fig. 4G, H) from Cuisian deposits of Monte Bosco formation. Both are common in some generic charateristics, yet *Ornatorotalia* has spines with spinal canals (only see in *O. spinosa*), well developed radial and bifurcate intraseptal canals connected to the marginal openings (canal orifices) (Benedetti *et al.* 2011: figs 4.g-h, 7.a_{1-2}-d; Sirel & Deveciler 2017: 69-70, figs 5A, C, pl. 2, figs 4-7, 9, 11, pl. 3, figs 1, 5). Also it differs from *Neorotalia* Bermúdez, 1952 (type species: *Rotalia mexicana* Nuttall, 1928, synonym of ?*Rotalia burdigalesis* d'Orbigny, 1852 in Hayward *et al.* 2022; Fig. 4A-C) and *Pararotalia* Le Calvez, 1949 species (type species: *Pararotalia inermis* (Terquem, 1882) *in* Le Calvez [1949: 32]; Fig. 4D-F) by having granules (papillas and beads) on both dorsal and ventral sides.

Hayward *et al.* (2024) have transferred *Granorotalia* and *Ornatorotalia* to Pararotaliinae subfamily under Calcarinidae family. Calcarinidae mostly represents well-developed canaliculated spine bearing taxa with elaborated canal system (Loeblich & Tappan 1987; Holzmann & Pawlowski 2017). *Granorotalia* and *Ornatorotalia* can be related to Calcarinidae for having pustulated surface, true spine with canals or hallow pseudospines, pillars pierced by funnels, spiral and interseptal canals, but they are different from the members of Pararotalinae due to their generic elements. Therefore, Ornatorotaliinae subfamily has been adopted for low trochospiral coiling with coarse pustules, and the other mentioned characteristics.

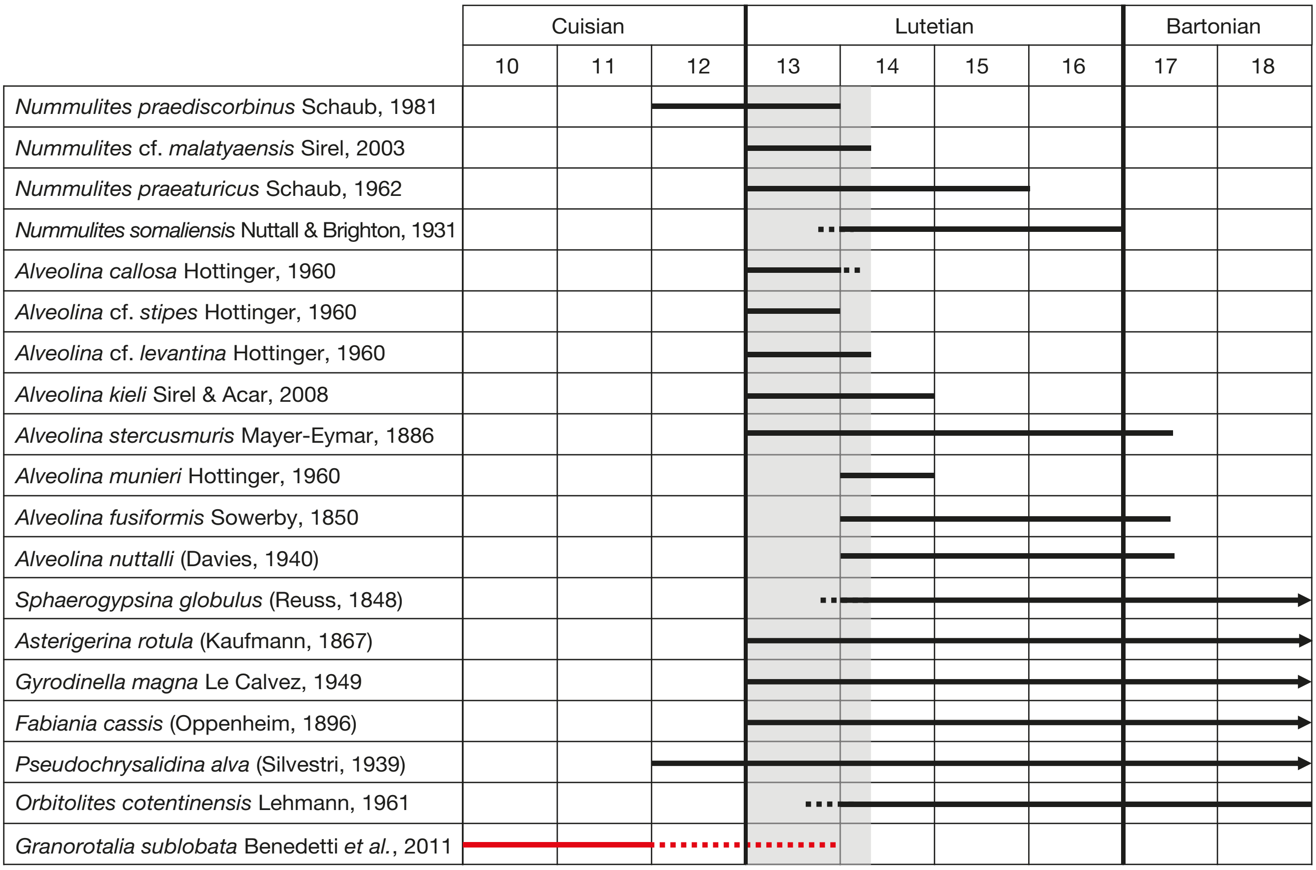

Fig. 5. — General biostratigraphic distribution of the studied species in Karyağdı Hill and Gölbayırı section from Memlik Village. The **grey area** represents the stratigraphic position of the studied samples according to the assemblage biozone. **Dotted lines** show the suggested distribution of the species in the studied area.

Granorotalia sublobata
Benedetti, Di Carlo & Pignatti, 2011
(Figs 4I-S; 6A-N; 7A-O; 9G[1]; 10L; 11C)

Granorotalia sublobata Benedetti, Di Carlo & Pignatti, 2011: 715, figs 11a-e, 12a-b, 13a-f, 14a-h. — Benedetti *et al.* 2018: 86, figs 7.H-7.K, 8.A-8.C. — Sirel & Deveciler 2017: 70, pl. 2, fig. 15, pl. 3, figs 10-17.

Pararotalia viennoti – Reiss & Merling 1958: pl. 3, fig. 5.

Rotalia sp. 8 – Samuel *et al.* 1972: pl. XLVII, figs 1-4.

Neorotalia alicantina – Hottinger 2014: pl. 8.1, figs 1-12, 16-27.

Description

Test is much convex on ventral side than the dorsal side (Figs 6D; 7C). Diameter is between 0.65-1.146 mm and the axial thickness is 0.43-0.7 mm. The ratio of (d/t-diameter/thickness) ranges from 1.51 to 1.63. Small spheric proloculus (0.0147-0.0265 mm in diameter) is followed by subrectangular chambers arranging in three (in a 0.65 mm diameter) and four (in a 1.04 mm diameter) regular coiled whorls (Figs 6A; 7A, G, O). There are 12-13 chambers at the last whorl of grown specimens (Figs 6A; 7A; Benedetti *et al.* 2011: figs 11b, d-e). Both dorsal and ventral sides filled with pillars (Figs 6E-H, I-N; 7B, F-O). It has intraseptal, spiral and vertical canals (funnels) (Figs 6A, E-N; 7A-B, F-O).

Remarks

One specimen in Reiss & Merling (1958: pl. 3, fig. 5) resembles to *G. sublobata* rather than *Pararotalia viennoti* (Greig) owing to the mentioned generic characteristics above. *Pararotalia* supposed to have smooth dorsal and ventral surface with a solid and undivided umbilical plug unlike the specimens in Reiss & Merling (1958).

Four specimens from Ovčiarsko village (Žilina/Slovakia) in (Samuel *et al.* 1972; Fig. 6K-N) defined as *Rotalia* sp. 8, are identical to *G. sublobata* for their pseudospine, pillars and funnels.

Neorotalia alicantina Colom, 1954 in Hottinger (2014) are not close to *Neorotalia* possessing different generic characteristics (also see in Benedetti *et al.* [2018: 86]). However, they are very close to *G. sublobata* related to the similar lateral, equatorial and axial features.

Additionally, one isolated specimen in Benedetti (2015: text-fig. 1, figs 1-3) was left out from the synonym because of the well-developed spines seeing in *Ornatorotalia spinosa* (Fig. 4G-H). The axial sections of *G. sublobata* in Samuel *et al.* (1972: pl. XLVII, fig. 1), Benedetti *et al.* (2011: fig. 11a, 13e), Sirel & Deveciler (2017: pl. 3, fig. 13), and Benedetti *et al.* (2018: fig. 8A) were illustrated short spine-like (pseudospine) structures rather than a canaliculate true spine.

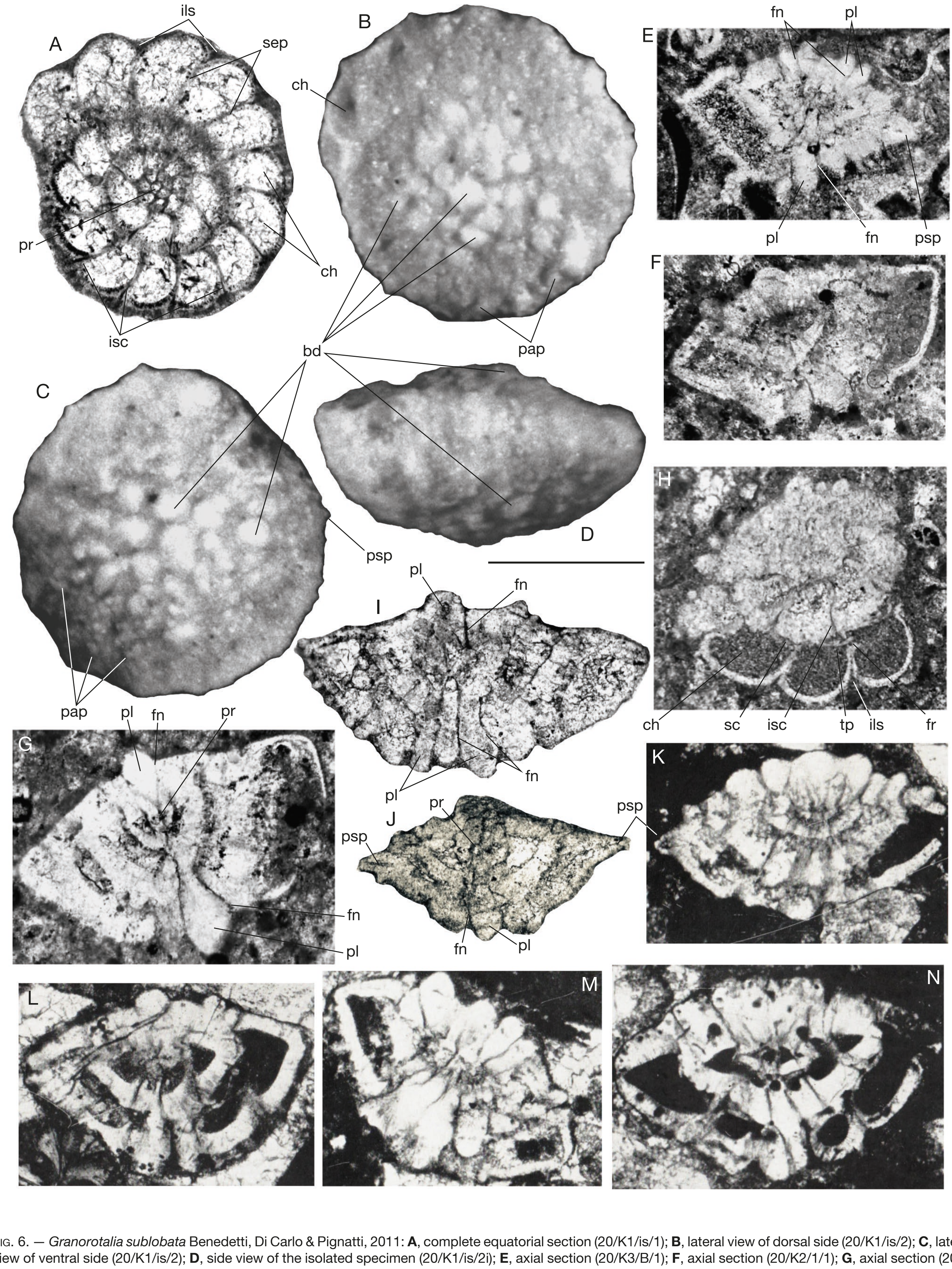

Fig. 6. — *Granorotalia sublobata* Benedetti, Di Carlo & Pignatti, 2011: **A**, complete equatorial section (20/K1/is/1); **B**, lateral view of dorsal side (20/K1/is/2); **C**, later view of ventral side (20/K1/is/2); **D**, side view of the isolated specimen (20/K1/is/2i); **E**, axial section (20/K3/B/1); **F**, axial section (20/K2/1/1); **G**, axial section (20/K2/2/1); **H**, transversal section showing tooth plate, interseptal canal-interlocular space and aperture (20/K3/4/1); **I**, axial section (20/K1/is/4); **J**, complete axial section (20/K1/is/12). The figures belong to the lower Lutetian limestone of Karyağdı Hill, NE Memlik Village, North of Ankara. **K**-**N** were taken from (Samuel *et al.* 1972), representing lower Lutetian limestone of West Carpatian, Slovakia. Abbreviations: **bd**, bead; **ch**, chamber; **fn**, funnel; **fr**, foramen; **ils**, interlocular space; **isc**, intraseptal canal; **pap**, papilla; **pl**, pillar; **pr**, proloculus; **psp**, pseudospine; **sc**, spiral canal; **sep**, septum; **tp**, tooth plate. Scale bar: 0.5 mm.

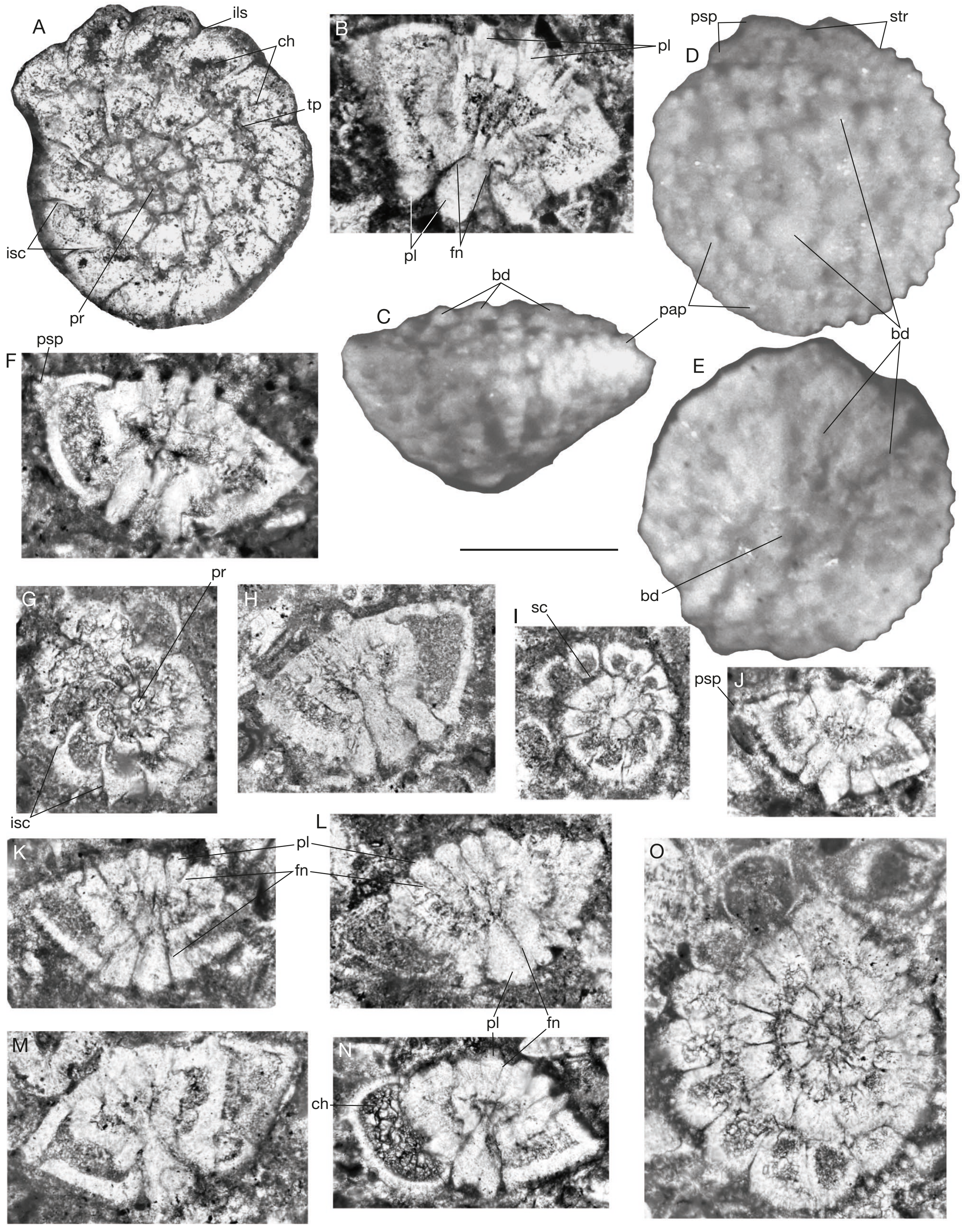

Fig. 7. — *Granorotalia sublobata* Benedetti, Di Carlo & Pignatti, 2011: **A**, complete equatorial section (20/K1/is/3); **B**, axial section (20/K3/A/1); **C**, side view of the isolated specimen (20/K1/iss/2); **D**, lateral view of dorsal side (20/K1/iss/2); **E**, lateral view of ventral side (20/K1/iss/2). The figures belong to the lower Lutetian limestone of Karyağdı Hill, NE Memlik Village, North of Ankara. **F**, axial section (B.5/6-1); **G**, centered equatorial section (B.6-5a); **H**, axial section (B.1/2-5); **I**, section tangent to the equatorial plane (B.3/4-7); **J**, axial section (B4/1-2); **K**, axial section (Ç.8-9); **L**, axial section (B.6-6); **M**, axial section (B.6-3a; also see in Sirel & Deveciler [2017: pl. 3, fig. 12]); **N**, axial section (B.3/4-5; also see in Sirel & Deveciler [2017: pl. 2, fig. 15]); **O**, oblique equatorial section (B.5/1-2). The figures belong to the Cuisian limestone of Çayraz Section, North of Haymana, South of Ankara (associated fauna were described and figured in Sirel & Deveciler 2017). Abbreviations: **bd**, bead; **ch**, chamber; **fn**, funnel; **ils**, interlocular space; **isc**, intraseptal canal; **pap**, papilla; **pl**, pillar; **pr**, proloculus; **psp**, pseudospine; **str**, suture; **tp**, tooth plate. Scale bar: 0.5 mm.

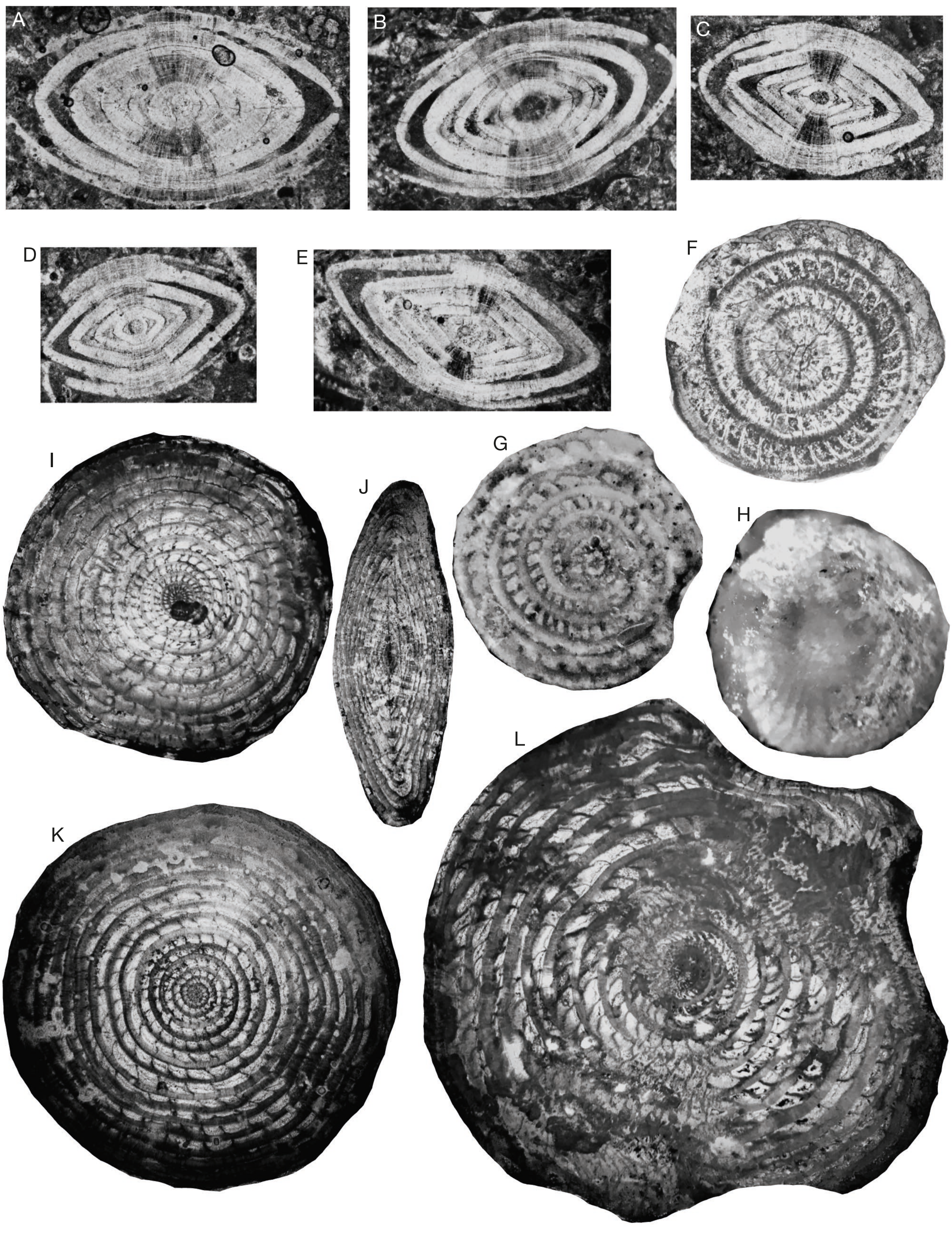

Fig. 8. — **A**, **B**, *Nummulites* cf. *malatyaensis* Sirel, 2003: **A**, axial section (20/K3/3/1); **B**, axial section (20/K3/B/9). **C**-**H**, *Nummulites praediscorbinus* Schaub, 1981: **C**, axial section (20/K1/7/1); **D**, axial section (20/K1/4/1); **E**, axial section (20/K3/1/1); **F**, complete equatorial section (20/K1/N/15); **G**, equatorial section (20/K1/N/16); **H**, lateral view showing radial septal filaments on the surface (20/K1/N/15). **I**-**K**, *Nummulites praeaturicus* Schaub, 1962: **I**, equatorial section (20/K1/N/11); **J**, axial section (20/K1/N/5); **K**, complete equatorial section (20/K1/N/3). **L**, *Nummulites somaliensis* Nuttall & Brighton, 1931, equatorial section (20/K1/N/24). All figures from lower Lutetian limestone of Karyağdı Hill, NE Memlik Village, North of Ankara. Scale bar: A-H, 1 mm; I-L, 4 mm.

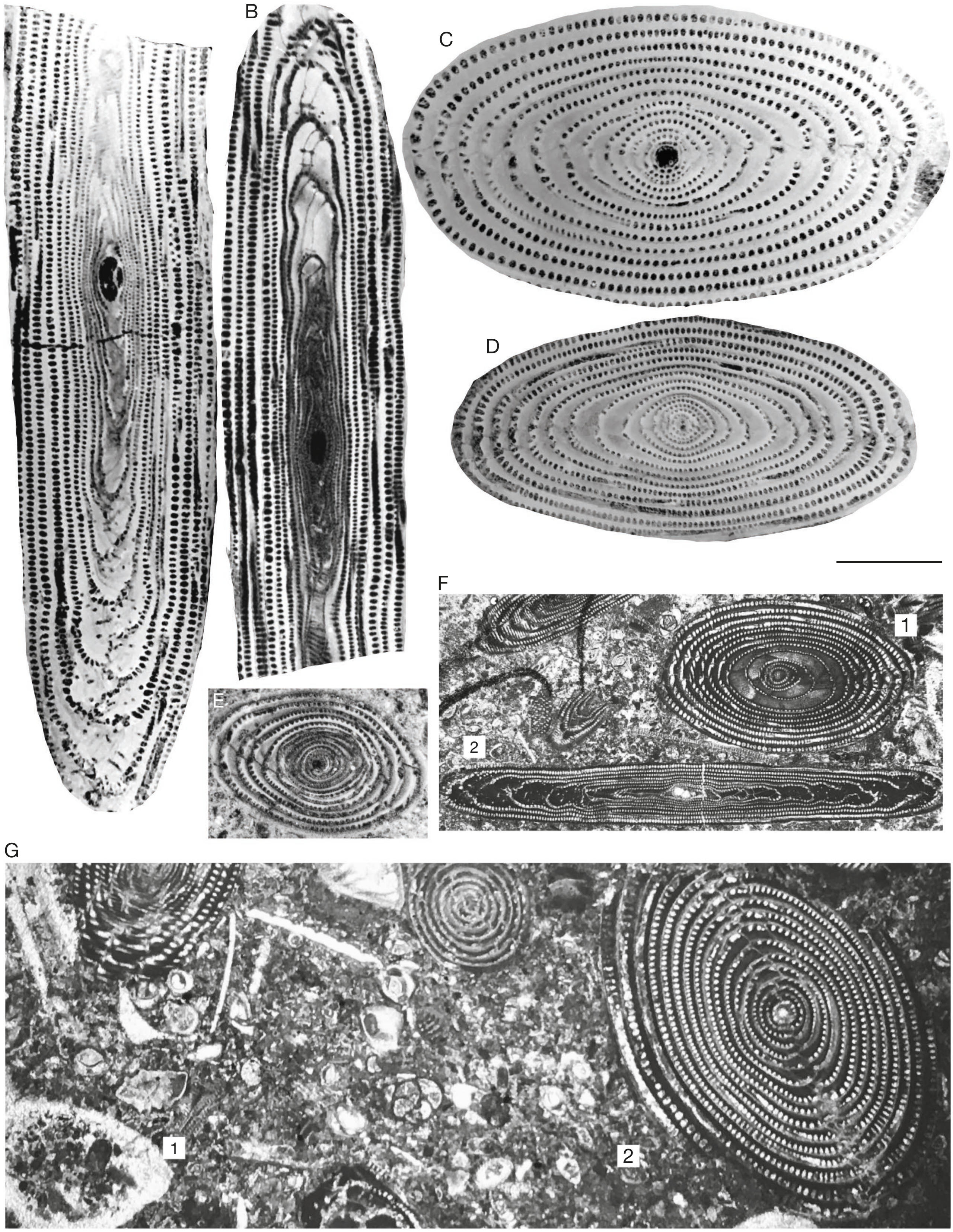

FIG. 9. — **A**, **B**, *Alveolina* cf. *stipes* Hottinger, 1960: **A**, axial section (20/K1/Al/9); **B**, axial section (20/K1/5/1). **C**, **D**, *Alveolina stercusmuris* Mayer-Eymar, 1886: **C**, axial section (20/K1/Al/6); **D**, axial section (20/K1/Al/7). **E**, *Alveolina kieli* Sirel & Acar, 2008, almost axial section (20/K2/3/2). **F**, *Alveolina nuttalli* (Davies, 1940) (**1**) with *Alveolina munieri* Hottinger, 1960 (**2**), mostly axial sections of the species (M/4/28/1-2). **G**, Floatstone (according to Dunham 1962) with *Alveolina kieli*, *Granorotalia sublobata* Benedetti, Di Carlo & Pignatti, 2011, *Alveolina* sp., globotextularid type, miliolids and various fossil fragments, axial section of *Granorotalia sublobata* (**1**), axial section of *Alveolina kieli* (**2**), chyrisalidinid type, and various fossil fragments (20/K2/1/1). **A**-**E**, **G**, from lower Lutetian limestone of Karyağdı Hill; **F**, collected by Deveciler (2014) from Gölbayırı section NE Memlik Village, North of Ankara. Scale bar: A-E, G, 1 mm; F, 2 mm.

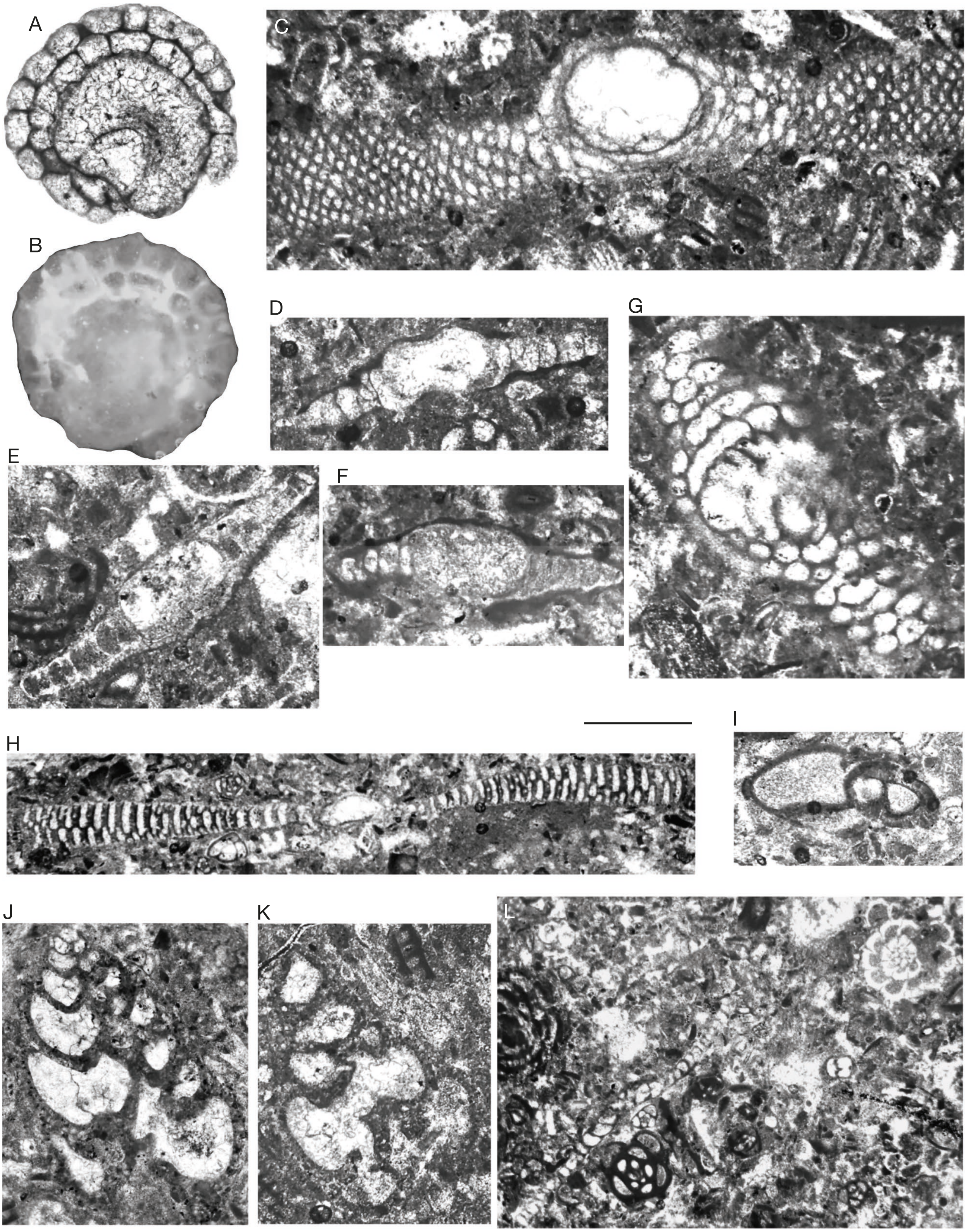

Fig. 10. — *Orbitolites cotentinensis* Lehmann, 1961: equatorial section showing embryonic stage with protoconch and deuteroconch and subrectangular chamberlets (**A**) and the lateral view of the same specimen (**B**) (20/K1/is/14); **C**, transversal section showing the embryonic stage (20/K3/3/1); **D**, axial section (20/K2/4/2); **E**, axial section (20/K1/7/5); **F**, axial section (20/K2/4/5); **G**, transversal section showing embryonic stage (20/K1/A/4); **H**, axial section (20/K1/4/2). Stomatorbinid type: **I**, axial section (20/K1/4/4). **J**, **K**, *Pseudochrysalidina alva* (Silvestri, 1939): **J**, longitudinal section (20/K1/A/3); **K**, longitudinal section (20/K1/4/3). **L**, Floatstone (according to Dunham 1962) with Middle Eocene benthic foraminifera, *Granorotalia sublobata* Benedetti, Di Carlo & Pignatti, 2011 with *Orbitolites* sp., miliolid and alveolinid fragments (20/K3/1/1a). All figures from lower Lutetian limestone of Karyağdı Hill, NE Memlik Village, North of Ankara. Scale bar: A-G, I-K, 0.5 mm; H, L, 1 mm.

Stratigraphic distribution

G. sublobata was created first in Cuisian limestone deposits in Monte Bosco formation, Sicily-Italy and it was identified in the same stratigraphic position from Haymana-Turkey (Benedetti *el al.* 2011; Sirel & Deveciler 2017). However, it was previously figured under different names in Middle Eocene of Nitzana, Israel (Reiss & Merling 1958) and West Carpatian from Slovakia (Samuel *et al.* 1972). Although 27 figures in pl. 8.1 in (Hottinger 2014) are identical to *G. sublobata*, the stratigraphic position and locality of the samples were left unclear.

In this study, *G. sublobata* has been found in early Lutetian (SBZ 13) together with *Nummulites* cf. *malatyaensis* (Fig. 8A, B), *N. praediscorbinus* Schaub, 1981 (Fig. 8C-H), *N. praeaturicus* Schaub, 1962 (Fig. 8I-K), *Nummulites somaliensis* Nuttall & Brighton, 1931 (Fig. 8L), *Alveolina* cf. *stipes* (Fig. 9A, B), *A. stercusmuris* (Fig. 9C, D), *A. kieli* (Fig. 9E, F1, G2), *A.* cf. *levantina* Hottinger, 1960 (Fig. 11A, B), *Orbitolites cotentinensis* Lehmann, 1961 (Fig. 10A-H), *Pseudochrysalidina alva* (Silvestri, 1939) (Fig. 10J, K), *Asterigerina rotula* (Kaufmann, 1867) (Fig. 11C-E), *Sphaerogypsina globulus* (Reuss, 1848) (Fig. 11F), *Gyroidinella magna* Le Calvez, 1949 (Fig. 11G-I) and *Fabiania cassis* (Oppenheim, 1896) (Fig. 11J).

BIOSTRATIGRAPHIC AND PALEONTOLOGIC IMPLICATIONS

Serra-Kiel *et al.* (1998) were first to establish shallow benthic zones (SBZ) for Tethyan Paleocene and Eocene. Serra-Kiel *et al.* (2016) and Silva-Casal *et al.* (2021) have recently rearranged the ranges of some taxa between SBZ 10 and 20 by the help of magneto stratigraphy and nannofossil correlations providing from Pyrenean Basin (Spain), Dhofar (Oman) and Socotra Island (Yemen). Also Rodríguez-Pintó *et al.* (2022) have recalibrated Ypresian-Lutetian boundary by elevating SBZ 12 to bottom of the early Lutetian. The reference distribution of the foraminiferal species for SBZ 13 and SBZ 14 (Fig. 5) has been compiled from the foregoing studies and Schaub (1981), Sirel (2003, 2015), Sirel & Acar (2008), Deveciler (2010, 2014), Sirel & Deveciler (2018), Hadi *et al.* (2020, 2024).

A. stercusmuris, *A. rotula*, *G. magna* and *F. cassis* was accepted as a typical association for Bartonian by Sirel (2003, 2015) and Sirel & Acar (2008). However, this fauna was offered for an early to late Eocene range after Silva-Casal *et al.* (2021). Therefore, the biostratigraphic position of the studied samples was determined as middle Eocene (SBZ 13) by the last appearance of *N. praediscorbinus*, and the first appearance of *A. munieri* Hottinger, 1960, *A. fusiformis*, *A. nuttalli* (Fig. 5). On the other hand, Deveciler (2014) identified the same limestones as Bartonian by describing *A. fragilis*, *A. fusiformis* and *N. malatyaensis* from Gölbayırı.

Hottinger (1960) was created four elongated fusiform species *A. stipes, A. tenuis* from lower Lutetian, *A. munieri* from middle Lutetian and *A. fragilis* from Bartonian respectively. Three samples illustrated in Deveciler (2014: pl. I, fig. 3, pl. 2, figs 2, 5) clearly resemble to *A. munieri* of SBZ 14 rather than *A. fragilis* for their index of elongation, slightly elongated spherical proloculus and whorls count in the same diameter. Also the results in Silva-Casal *et al.* (2021) support the presence of *A. fusiformis* in the middle Lutetian (SBZ 14). *A. nuttalli* appears in the lower boundary of middle Lutetian (SBZ14) at Gölbayırı section together with *A. munieri* and *A. fusiformis. A. nuttalli* was defined in Bartonian with *N. perforatus* by Deveciler (2010) before, and it was found in lower Lutetian outcrops of Suçınak section (Dinar, Turkey) by Bozkurt *et al.* (2023) recently. The presence of *A. callosa* (Deveciler 2014: pl. 3, figs 1-4) with the forgoing SBZ 14 association in Gölbayırı section is also noteworthy, because it was identified only in SBZ 13 from a stratigraphic section near Orhaniye village (Acar 1995; Sirel & Acar 2008). Moreover, *N. malatyaensis* in Deveciler (2014) was left open since it doesn't completely match with the original figures and the type description in (Sirel 2003). As a consequence, the samples illustrated in (Deveciler 2014) was evaluated as belonging to lower middle Lutetian (SBZ 14).

The two alveolinid species found together with *G. sublobata* is discussed as follow. Two alveolinid samples in (Fig. 9A, B) are similar to *A. stipes* (Hottinger 1960: 163) with their axial diameter, index of elongation and tight coiling but have an ovoid proloculus just as *A. fragilis.* Bozkurt *et al.* (2023: fig. 8c-e) illustrated the same specimens in lower Lutetian from Dinar vicinity. The samples are left open herein since they don't have a typical spherical proloculus like *A.stipes*. Also two other incomplete axial sections in Figure 11A, B are defined as *A.* cf. *levantina* for having large proloculus and tight coiling.

The major issue encountered in this study regarding *Granorotalia* is to examine two identical species in Lutetian. *Granorotalia sublobata* is comperable with *Neorotalia alicantina* Colom (1954: pl. 6, figs 8-12; Fig. 4N-S) for similar asymmetric biconvex test with spiny periphery (Colom 1954: 165), equatorial and axial diameters, numerous small and coarse granules (beads and papillas) on both dorsal and ventral side and evolute planispiral coiling on the dorsal side of the last whorl. On the other hand, *N. alicantina* doesn't carry the generic characteristics of *Neorotalia* such as smooth dorsal and ornamented ventral side with one solid umbilical plug (Fig. 4A-C). This issue arises a question mark on the validity of *N. alicantina*.

There is an enigma over earlier defined rotaliids because of the inadequate internal material. They can only be divided into the groups by their external structures. In this context, *G. sublobata* and *N. alicantina* are similar regarding their test coiling, ventral, dorsal and peripheral characteristics. This similarity may even have led Serra-Kiel *et al.* (1998: 289) to illustrate the stratigraphic distribution of *N. alicantina* between SBZ10-13? However, due to the foregoing issue they can not be combined under one taxon for now. An emendation to *N. alicantina* depending on the type locality is needed to make a reasonable comparison for further studies.

Although the Cuisian specimens from Çayraz section in (Sirel & Deveciler 2017) are overly smaller in size than those of Samuel *et al.* (1972) and Benedetti *et al.* (2011) there are no significant differences in terms of the test shape, count of whorls and subrectangular chambers. The geographic distribution seems limited to western and central Tethys, however it may have spread over a wider area in the Eocene shallow marine strata.

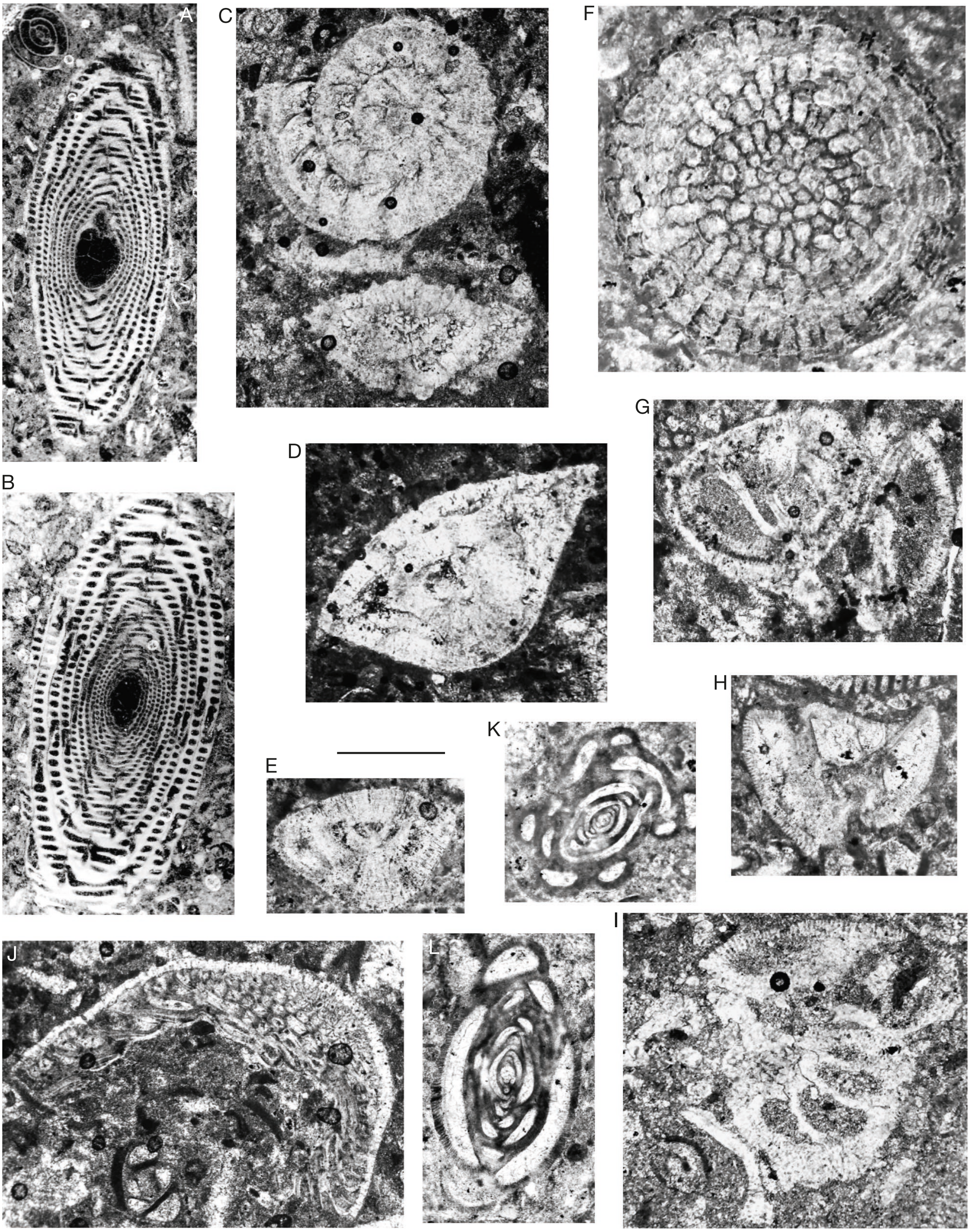

Fig. 11. — **A**, **B**, *Alveolina* cf. *levantina* Hottinger, 1960: **A**, almost axial section (20/K1/6/1); **B**, transversal section (20/K2/4/7). **C**-**E**, *Asterigerina rotula* (Kaufmann, 1867): **C**, equatorial section with stellate chambers around umbilicus, and axial section of *Granorotalia sublobata* Benedetti, Di Carlo & Pignatti, 2011 (20/K3/3/1a); **D**, axial section (20/K2/4/1); **E**, axial section (20/K1/1/2). **F**, *Sphaerogypsina globulus* (Reuss, 1848), transversal section showing globular test shape (20/K1/C/3). **G**-**I**, *Gyroidinella magna* (Le Calvez, 1949): **G**, transversal section (20/K3/1/2); **H**, nearly axial section (20/K3/A/6); **I**, transversal section (20/K2/2/3). **J**, *Fabiania cassis* (Oppenheim, 1896), axial section (20/K1/3/1). **K**, **L**, unidentified miliolids: **K**, centered longitudinal section (20/K1/A/2); **L**, centered longitudinal section (20/K1/A/5). All figures from lower Lutetian limestone of Karyağdı Hill, NE Memlik Village, North of Ankara. Scale bar: A, B, 1 mm; C-L, 0.5 mm.

CONCLUSION

Granorotalia sublobata is discussed regarding its biostratigraphy and the systematic paleontology. It was detected in Cuisian deposits from Italy and Turkey initially. For the first time, it was found in the early Lutetian (SBZ 13) limestones of Karyağdı Hill with the associated fauna such as *N.* cf. *malatyaensis*, *N. praediscorbinus*, *N. praeaturicus*, *N. somaliensis*, *A.* cf. *stipes*, *A. stercusmuris*, *A. kieli*, *A.* cf. *levantina*, *O. cotentinensis*, *P. alva*, *A. rotula*, *S. globulus*, *G. magna, F. cassis*. The upper boundary corresponds to lower middle Eocene (SBZ 14) with *A. munieri*, *A. fusiformis* and *A. nuttalli* from Gölbayırı section. On the other hand, *G. sublobata* and *Neorotalia alicantina* share common characteristics like asymmetric biconvex test, much swollen ventral side, spiny (pseudospine) periphery, their diameters and numerous granules (beads and papillas) all over the test surface. It is also clear that *N. alicantina* doesn't have a smooth dorsal side and a solid plug filled the umbilical cavity just as in *Neorotalia*. It is possible that these two species would be the synonyms of each other, but the inadequate description of *N. alicantina* prevents such a new combination. As the final consequence, *G. sublobata* has a range from Cuisian to early Lutetian around Mediterranean province, however it hardly needs a investigation regarding the taxonomic controversies with *N. alicantina.*

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REFERENCES

Acar Ş. 1995. — *Türkiye' nin değişik bölgelerinin Paleojen' inden bazı alveolin cinslerinin (Alveolina (Alveolina), Alveolina (Glomalveolina), Borelis ve Praebullalveolina) sistemaik tanımları ve stratigrafik dağılımları*. Unpublished Phd Thesis, Selçuk University, Konya, 166 p. (in Türkiye).

Benedetti A. 2015. — The new family Ornatorotaliidae (Rotaliacea, Foraminiferida). *Micropaleontology* 61 (2): 231-236. https://doi.org/10.47894/mpal.61.3.09

Benedetti A., Di Carlo M. & Pignatti J. 2011. — New late Ypresian (Cuisian) Rotaliids (foraminiferida) from central and southern Italy and their biostratigraphic potential. *Turkish Journal of Earth Sciences* 20: 701-719. https://doi.org/10.3906/yer-0910-47

Benedetti A., Mario M. & Pichezzi R. M. 2018. — Paleocene to lower Eocene larger foraminiferal assmblages from central Italy: new remarks on biotratigraphy. *Rivista Italiana di Paleontologia e Stragtigrafia* 124 (1): 73-90. https://doi.org/10.13130/2039-4942/9627

Bermudez P. J. 1952. — Estudio sistemático de kıs foraminiferos rotaliformes. *Boletin de Geologia, Venezeula* 2 (4): 1-230.

Bozkurt A., Görmüş M. & Türkmen-Bozkurt B. 2023. — Middle Eocene *Alveolina*-dominated bentic foraminiferal assemblages of the western flank of the Isparta Angle (SW Türkiye): Taxonomy, biostratigraphy, microfacies analysis, and paleoenvironmental implications. *Turkish Journal of Earth Sciences* 32 (7): 854-879. https://doi.org/10.55730/1300-0985.1879

Colom G. 1954. — Estudio de lan biozonas con foraminiferos del Terciario de Alicante. *Boletín del Instituto Geológico y Minero de España* 66: 101-279.

Deveciler A. 2010. — The first appearance of the Bartonian benthic foraminifera at the Çayraz section (north of Haymana, south Ankara, Central Turkey). *Bulletin for Earth Sciences (Yerbilimleri)* 31 (3): 141-168.

Deveciler A. 2014. — Description of larger bentic foraminifera species from the Bartonian of Yakacık-Memlik region. *Bulletin for Earth Sciences (Yerbilimleri)* 35 (2): 137-150.

Dunham R. J. 1962. — Classification of Carbonate Rocks According to Depositional Texture, *in* Ham W. E. (ed.), *Classification of Carbonate Rocks*. American Association of Petroleum Geologist: 108-121.

Erdoğdu E., Kılıç N. & Deveciler A. 2021. — Benthic foraminiferal biostratigraphy of middle Eocene Orhaniye formation at the North of Memlik village (Central Anatolia, Turkey), *in* Parlak O., Sayit K., Mesci L. B., Akilli H. & Akyildiz M. (eds), *73. Geological Congress of Turkey, the Proceedings and Abstracts Book (Posters)*. Online, Ankara: 929-930.

Gökten E., Kazanci N. & Acar Ş. 1988. — Ankara kuzeybatısında (Bağlum-Kazan arası) geç Kretase-Pliyosen serilerinin stratigrafisi ve tektoniği. *MTA Dergisi* 108: 69-81.

Hadi M., Consorti L. & Vahidinia M. 2020. — Upper Ypresian to lower Lutetian (SBZ 10 to 13) *Alveolina* stratigraphic horizons from the Hormak section, Zahedan District, Sistan Suture Zone, Eastern Iran. *Micropaleontology* 66 (4): 317-337. https://doi.org/10.47894/mpal.66.4.04

Hadi M., Consorti L., Bahrami A., Parandavar M. & Khorramdel S. 2024. — Stratigraphy of the *Alveolina elliptica* group from the middle Eocene of Iran: Calibration with calcareous nannofossils biozones and description of *Alveolina ozcani* n. sp. *Journal of Paleogeography* 13 (1): 54-79. https://doi.org/10.1016/j.jop.2023.11.002

Harmandali K. 2014. — *Paleontology of the Paleongene Alveolinids in the Orhaniye (Nw Ankara) region*. Unpublished Master Thesis, Ankara University (Graduate School of Natural and Applied Science Department of Geological Engineering), Ankara, 34 p. (in Türkiye).

Hayward B. W., Le Coze F., Vachard D. & Gross O. 2022. — World foraminifera database, *Neorotalia* Bermúdez, 1952. https://www.marinespecies.org/Foraminifera/aphia.php?p=taxdetails&id=112239 [last access May 30, 2022].

Hayward B. W., Le Coze F., Vachard D. & Gross O. 2024. — World foraminifera database. Ornatorotaliidae Benedetti, 2015 †. https://www.marinespecies.org/foraminifera/aphia.php?p=taxdetails&id=1591916 [last access May 05, 2024].

Holzmann M. & Pawlowski J. 2017. — An updated classification of rotaliid foraminifera based on ribosomal DNA phylogeny. *Marine Micropaleontology* 132: 18-34. https://doi.org/10.1016/j.marmicro.2017.04.002

Hottinger L. 1960. — *Recherches sur les Alvéolines du Paléocène et de l'Éocène.* Mémoires suisses de Paléontologie, Basel, 243 p.

Hottinger L. 2006. — *Illustrated Glossary of Terms Used in Foraminiferal Research*. Notebooks on Geology, 126 p. (Carnets de Géologie; 2006/2). https://doi.org/10.4267/2042/5832

Hottinger L. 2014. — *Paleogene Larger Rotaliid Foraminifera from the Western and Central Neotethys.* Springer International Publishing, Swizerland, 196 p. https://doi.org/10.1007/978-3-319-02853-8

Kazanci N. & Gökten E. 1986. — Deformational stages of the upper Cretaceous-Tertiary rocks in the area around Orhaniye and Memlik village-northwest Ankara. *Communications Faculty of Science University of Ankara* C (4): 129-138.

Koçyiğit A. 1991. — An example of an accretionary forearc basin from northern central Anatolia and its implications for the history of subduction of Neo-Tethys in Turkey. *Geological Society of America Bulletin* 103: 22-36. https://doi.org/10.1130/0016-7606(1991)103%3C0022:aeoaaf%3E2.3.co;2

Le Calvez Y. 1949. — *Révision des foraminifères lutétiens du Bassin de Paris II, Rotaliidae et familles affines*. Mémoires du Service de la Carte géologique détaillée de la France, 54 p.

Lich A., Coster P., Ocakoğlu F., Campbell C., Méthais G., Mulch A., Taylor M., Kappelman J. & Beard K. C. 2017. — Tectono-stratigraphy of the Orhaniye basin, Turkey: implications for collision chronology and Paleogene biogeography of central Anatolia. *Journal of Asian Earth Sciences* 143 (2017): 45-58. https://doi.org/10.1016/j.jseaes.2017.03.033

Loeblich A. R. & Tappan H. 1957. — Morphology and taxonomy of the foraminiferal genus *Pararotalia* Le Calvez, 1949. *Smithsonian Miscellaneous Collection* 135 (2): 1-24. http://hdl.handle.net/10088/22949

Loeblich A. R. & Tappan H. 1964. — Sarcodina chiefly "Thecamoebians" and Foraminiferida, *in* Moore R. C. (ed.), *Treatise on Invertebrate Paleontology*. Geological Society of America and University of Kansas Press, Lawrence, Pt. C.: Protista: 1-900.

Loeblich A.R. & Tappan H. 1987. — *Foraminiferal Genera and their Classification*. Van Nostrand Reinhold Company, New York, 910 p., 847 pls. https://doi.org/10.1007/978-1-4899-5760-3

Métais G., Erdal O., Erturaç K. & Beard K. C. 2017. — Tarsal morphology of the pleuraspidotheriid mamal *Hilalia* from the middle Eocene of Turkey. *Acta Palaeontologica Polonica* 62 (1): 173-179. https://doi.org/10.4202/app.00314.2016

Okay A. & Tüysüz O. 1999. — Tethyan sutures of northern Turkey, *in* Durand B., Jolivet L., Horvath E. & Seranne M. (eds), The Mediterranean Basins: Tertiary Extension within the Alpine Orogen. *Geological Society, Special Publications* 156: 475-515. https://doi.org/10.1144/gsl.sp.1999.156.01.22

Okay A., Altiner D. & Kylander-Clark A. R. C. 2019. — Major late Cretaceous mass flows in central Turkey recording the disruption of the Mesozoic continental margin. *Tectonics* 38: 960-989. https://doi.org/10.1029/2018tc005076

Reiss Z. & Merling P. 1958. — Structure of some Rotaliidea. *State of Israel Ministry of Development Geological Survey Bulletin* 21: 1-29.

Rodríguez-Pintó A., Serra-Kiel J., Bernaola G., Barnolas A., Pueyo E. L., Tosquella J., Arbués P. & Scholger R. 2022. — The early/middle Eocene transition at the Ésera valley (South-Central Pyrenees): Implications in Shallow Benthic Zones (SBZ). *Geologica Acta* 20 (6): 1-25. https://doi.org/10.1344/GeologicaActa2022.20.6

Sağurlar E. K. & Toker V. 1990. — Orhaniye (Kb Ankara) yöresinin nannoplanktonlarla Kretase biyostratigrafisi. *Türkiye Jeoloji Bülteni* 33: 57-78.

Samuel O., Borza K. & Köhler E. 1972. — *Microfauna and lithostratgiraphy of the Paleogene and adjacent Crateceous of the middle Váh Valley (West Carpatian)*. Geologický ústav Dionýza Štúra, Bratislava, 246 p.

Schaub H. 1981. — Nummulites et assilines de la Tethys paléogène : taxonomie, phylogénèse et biostratigraphie. *Abhandlungen der schweizerischen paläontologischen Gesellschaft*, 104: 1-236, 105: 1-48 pls, 106: 49-97 pls (*Mémoires de la Société paléontologique Suisse)*.

Serra-Kiel J., Hottinger L., Caus E., Drobne K., Ferrandez C., Jauhri A. K., Less G., Pavlovec, R., Pignatti, J., Samso, J. M., Schaub H., Sirel E., Strougo A., Tambareau Y., Tosquella J. & Zakrevskaya E. 1998. — Larger foraminiferal biostratigraphy of the Tethyan Paleocene and Eocene. *Bulletin de la Société géologique France* 169: 281-299.

Serra-Kiel J., Gallardo-Garcia A., Razin, Ph., Robinet J., Roger J., Grelaud C., Leroy S. & Robin C. 2016. — Middle Eocene-Early Miocene larger foraminifera from Dhofar (Oman) and Socotra Island (Yemen). *Arabian Journal of Geosciences* 9 (5): 1-95. https://doi.org/10.1007/s12517-015-2243-3

Silva-Casal R., Serra-Kiel J., Rodríguez-Pintó A., Pueyo E. L., Aurell M. & Payros A. 2021. — Systematics of Lutetian larger foraminifera and magneto-biostratigraphy from the South Pyrenean Basin (Sierras Exteriores, Spain). *Geologica Acta* 19 (7): 1-64. https://doi.org/10.1344/geologicaacta2021.19.7

Sirel E. 2003. — Foraminiferal description and biostratigraphy of the Bartonian, Priabonian and Oligocene shallow-water sediments of the southern and eastern Turkey. *Revue de Paléobiologie* 22 (1): 269-339.

Sirel E. 2015. — *Reference Sections and Key Localities of the Paleogene Stage and Discussion C-T, P-E and E-O Boundaries by the Very Shallow-Shallow Water Foraminifera in Turkey.* Ankara Üniversitesi Yayınları, 461, 171 p.

Sirel E. & Acar Ş. 2008. — *Description and biostratigraphy of the Thanetian-Bartonian glomalveolinids and alveolinids of Turkey*. Uctea the Chamber of Geological Engineers Publication, 103, 265 p.

Sirel E. & Deveciler A. 2017. — A new late Ypresian species of *Asterigerina* and the first records of *Ornatorotalia* and *Granorotalia* from the Thanetian and upper Ypresian of Turkey. *Rivista Italina di Paleontologia e Stratigrafia* 123 (1): 65-78. https://doi.org/10.13130/2039-4942/8038

Sirel E. & Deveciler A. 2018. — *Description and some Revision of Ranikothalia Caudri, Nummulites Lamarck and Assilina d'Orbigny Species from Thanetian-Early Chattian of Turkey*. Ankara Üniversitesi Yayınları, Ankara, 598, 182 p.

Şengör A. M. C. & Yilmaz Y. 1981. — Tethyan evolutionF of Turkey: A plate tectonic approach. *Tectonophysics* 75: 181-241. https://doi.org/10.1016/0040-1951(81)90275-4

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