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NEW EARLY RUPELIAN ENDEMIC PORCELLANEOUS LARGER FORAMINIFERA FROM THE PREBETIC RANGE, WESTERNMOST TETHYS. DISCUSSION ON *PRAERHAPYDIONINA*

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ABSTRACT

***Peneroplis peramplus* n. sp. and *Spirolinella emmae* n. gen., n. sp. are described from the early Rupelian of the Ibi section in the Prebetic Range (southeastern Iberia). The former is a *Peneroplis* species of evolute annular growth with a large bilocular megalospheric embryo. *Spirolinella* n. gen. is similar to *Spirolina*, from which it differs by a complex aperture. *Spirolinella* is also similar to *Praerhapydionina*, but it completely lacks radial partitions. It also differs in the wall texture, homogeneous in *Spirolinella* and with a pseudokeriotheca-like texture in *Praerhapydionina*. This newly observed character in *Praerhapydionina* will help to identify the genus and verify its presumed cosmopolitan distribution. The two new species show the same stratigraphical range, corresponding to the Shallow Benthic Zone SBZ 21, early Rupelian, and are considered endemic to the carbonate platform that developed during the Paleogene in the southeastern margin of the Iberian plate, at the westernmost Tethys.**

INTRODUCTION

The Prebetic domain, in the Betic Cordillera (eastern part of the Iberian Peninsula and the Balearic Islands, Figs. 1A, 1B) has a rich geological record of neritic facies of Paleogene age, which includes the Eocene/Oligocene boundary. The marine upper Priabonian, Rupelian, and Chattian are well represented by shallow-water platform carbonates rich in porcellaneous larger foraminifera. This contrasts with most areas of the western Tethys, where the marine Paleogene is usually recorded by relatively deep facies, with hyaline larger foraminifera (nummulitids, orthophragminids, lepidocyclinids) or with planktonic foraminifera.

The study of a stratigraphical section in Ibi (Alacant province, southeastern Iberian Peninsula; Figs. 1B, 1C) revealed a rich Oligocene assemblage of porcellaneous larger foraminifera, including species of *Austrotrillina*, *Coscinospira*, *Peneroplis*, *Praerhapydionina*, *Penarchaias*, *Praebullalveolina*, and *Borelis*, together with scarce hyaline larger foraminifera, such as nummulitids, lepidocyclinids, and amphisteginids.

Associated to these species two previously undescribed forms occur. The first is *Peneroplis peramplus* n. sp., an evolute species of *Peneroplis* with annular growth characterized by very large megalospheric initial chambers. The second, *Spirolinella emmae* n. gen., n. sp., has a test similar to that of *Spirolina* but with a complex apertural structure These two new taxa have not been reported from other Rupelian assemblages and are interpreted as endemic forms in the Prebetic domain.

Oligocene porcellaneous larger foraminifera from the Prebetic of Alacant are scarcely reported in previous works. From Moratalla (Murcia province, 120 km SW of Ibi) Hottinger (1963) reported the presence of *Austrotrillina howchini*, *Praerhapydionina delicata*, *Spirolina austriaca*, *S. cylindracea*, *Dentritina* cf. *rangi* [=*Sivasina egribucakensis*], *Peneroplis damesini*, *P.* cf. *elegans*, *P.* cf. *laevigatus*, *P.* cf. *farsensis*, *P.* cf. *evolutus*?, *P.* aff. *honestus*, and *P. glynnjonesi* [=*Penarchaias glynnjonesi*]. He interpreted an Oligocene age from the similarity with porcellaneous foraminifera reported by Henson (1950) from the Middle East, and from the presence of "*Globigerina ciperoensis*" [=*Ciperoella ciperoensis*]. This planktonic foraminifer indicates the middle Chattian (Wade et al., 2018). Azéma et al. (1969) reported foraminiferal assemblages from the Horna and Monteagudo mountains (Alacant) at the level of genera. They practically only determined some *Nummulites* species, without description or figures. Among the porcellaneous larger foraminifera, they reported the presence of *Borelis pygmaea*, *Austrotrillina* sp., *Dendritina* sp., and *Peneroplis* sp. on Horna Mountain. Geel (2000) studied the Ibi section and identified larger foraminifera at the level of group or genus (miliolids, alveolinids, *Praerhapydionina*, *Austrotrillina*, rotaliids, *Lepidocyclina*, and '*Operculina*'), that he interpreted as lower and middle Oligocene. Bover-Arnal et al. (2017) and Ferràndez-Cañadell & Bover-Arnal (2017) studied different Oligocene sections in the NE of Alacant province. From one of them (Rebaldí section), they reported *Austrotrillina asmariensis*, *Peneroplis thomasi*, *Praebullalveolina* aff. *oligocenica*, and *Schlumbergerina alveoliniformis*. The associated hyaline foraminifera (including *Miogypsinoides complanatus*, *Heterostegina assilinoides*, *Spiroclypeus blanckenhorni*, *Cycloclypeus mediterraneus*, *Neorotalia viennoti*, *N. lithothamnica*, *Risananeiza pustulosa*, and *Amphistegina bohdanowiczi*) indicate a late Chattian age (SBZ 23). Falces-Delgado & Giannetti (2023) studied the bivalve *Kuphus* in two Oligocene sections of the Argueña Range (northwest of Alacant province). They reported the presence of *Austrotrillina* "closer to *A. striata* than to *A. brunni*"), *Peneroplis* sp., *Praebullalveolina* sp., and rare *Praerhapydionina delicata* and *Borelis inflata*, which they interpreted as Chattian in age (SBZ 22B–23). Recently, Bassi et al. (2021) studied *Austrotrillina* from the Ibi section, which they assigned to *A. striata*. They give an age of latemost Rupelian for their material, based on Geel (2000).

GEOLOGICAL SETTING

The studied samples come from the Ibi section, along the Molins ravine (Barranc dels Molins), north from Ibi (Alacant province), in the southeast of the Iberian Peninsula (Figs. 1, 2). It belongs to the External Prebetic Domain, which comprises a mixed carbonate-siliciclastic succession of Triassic to Miocene age deposited in the South Iberian passive continental margin of the Tethys (García-Hernández et al., 1980; Vera, 2000; Höntzsch et al., 2013). The External Prebetic Domain is located in the

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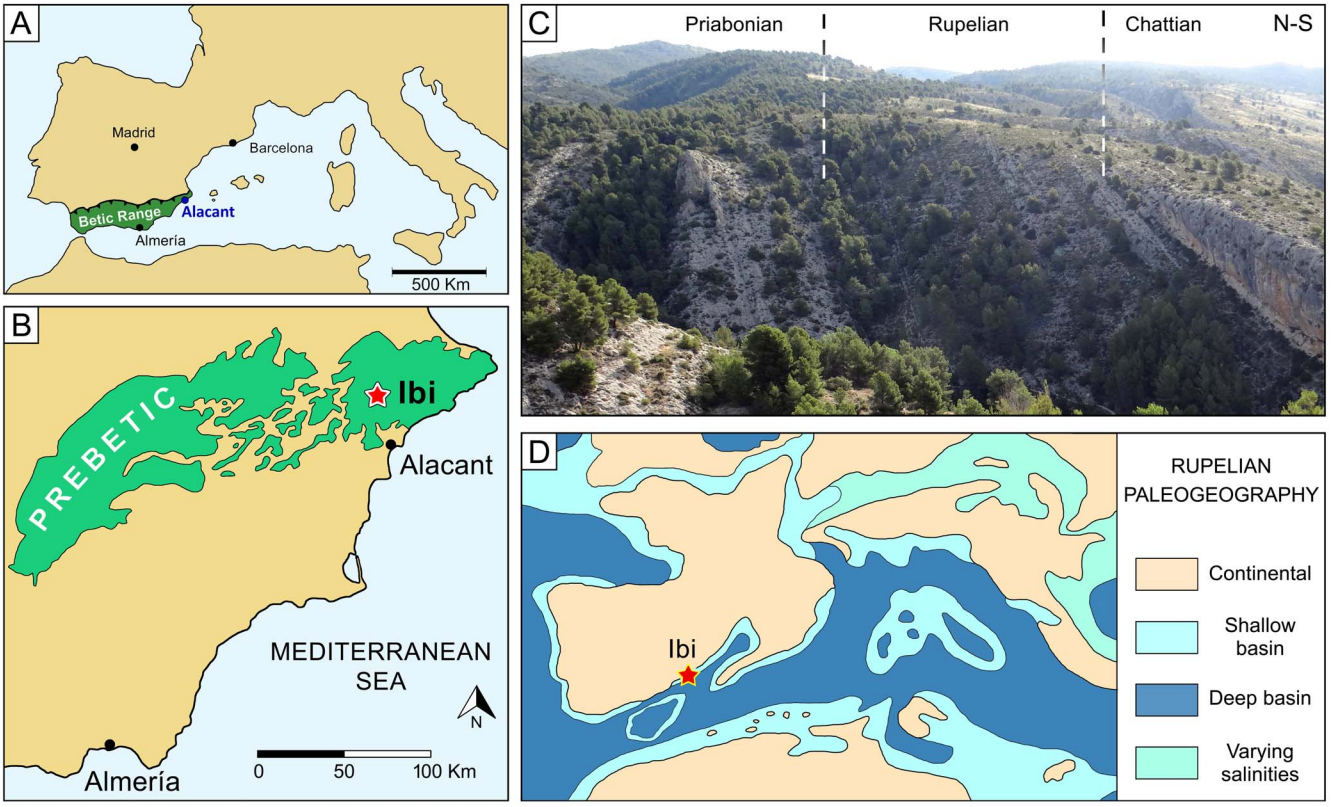

FIGURE 1. Geological setting. **A** Location of the Betic Range in southern Iberia. **B** Location of the section studied in the Prebetic zone of the Betic Range (from Vera, 2004). **C** View of the Molins ravine from the west hillside. **D** Paleogeographic map of the western Tethys during the Rupelian showing the location of the section studied (from Dercourt et al., 2000, and Meulenkamp & Sissingh, 2003).

northern part of the Prebetic zone, in a proximal relative position with respect to the southeastern Iberian margin, and corresponds to platform carbonates, periodically interrupted by detritic inputs (Fig. 1D). The Internal Prebetic consists of hemipelagic deposits including turbidites (Martín-Chivelet & Chacón, 2007; Höntzsch et al., 2013). The deposition of upper Eocene–Oligocene deposits in the Prebetic Domain was influenced by the Alpine tectonic activity, then later by the Betic orogeny and also by the opening of the Gulf of Valencia during the late Oligocene-Miocene (Azéma, 1977; Roca & Desegaulx, 1992; Geel, 1995; Geel et al., 1998).

The section of Ibi was previously studied by Geel (2000) who differentiated a lower and a middle Oligocene, based on foraminifera assemblages identified at the level of genus or group. He recognized four Oligocene sedimentary cycles, interpreted from different sections in the region, and placed the Oligocene deposits in the Ibi section in a backreef context. From the foraminiferal assemblages, also at level of group or genus, Höntzsch et al. (2013) elaborated a depositional model of the Prebetic Paleogene platform related to climate changes and tectonic influence.

The part of the section of Ibi studied here (base: 38°38′13″N, 0°34′43″W) shows a continuous series of shallow-water limestones ranging from the upper Eocene (Priabonian) to the upper Chattian (Figs. 1, 2). No formal lithostratigraphic unit has been defined for the succession analyzed. The uppermost part of the section corresponds to middle Miocene (Langhian?) marls unconformably overlying an erosive surface on the upper Chattian limestones. This paper focuses on the early Rupelian (Shallow Benthic Zone 21) part of the section and on the formal description of the two new larger foraminiferal taxa that were recognized in the samples studied.

MATERIAL AND METHODS

The section was studied and sampled in a field campaign in 2018. Thin sections of the samples were produced in the Laboratory of Paleontology and the Laboratory of Petrology of the Faculty of Earth Sciences of the University of Barcelona. The thin sections were photographed using a digital camera Zeiss AxioCam MRc 5 mounted on a petrographic Axioplan 2 Zeiss microscope. Thin sections with the types of the new taxa are stored in the Museum of Natural Sciences of Barcelona (Museu d'Història Natural de Barcelona), under the catalog numbers MGB 94151 (sample MN-6), MGB 94152 (sample MN-18), MGB 94153 (sample Ibi-120), and MGB 94154 (sample 126); the suffixes "LPx.y" correspond to the number of the thin section and the specimen. The rest of the samples and thin sections are housed in the Faculty of Earth Sciences of the University of Barcelona. A list of the species cited in the text is provided in the Appendix.

BIOSTRATIGRAPHY

In the Ibi section (Fig. 2) the Eocene/Oligocene boundary (SBZ 20/21) is recognized by the last occurrence (LO) of Eocene taxa, with the LO of *Orbitolites* in sample Ibi-116 (Hottinger et al., 1964; Serra-Kiel et al., 1998; Sirel, 2003; Less et al., 2011; Serra-Kiel et al., 2016; Sirel et al., 2020;

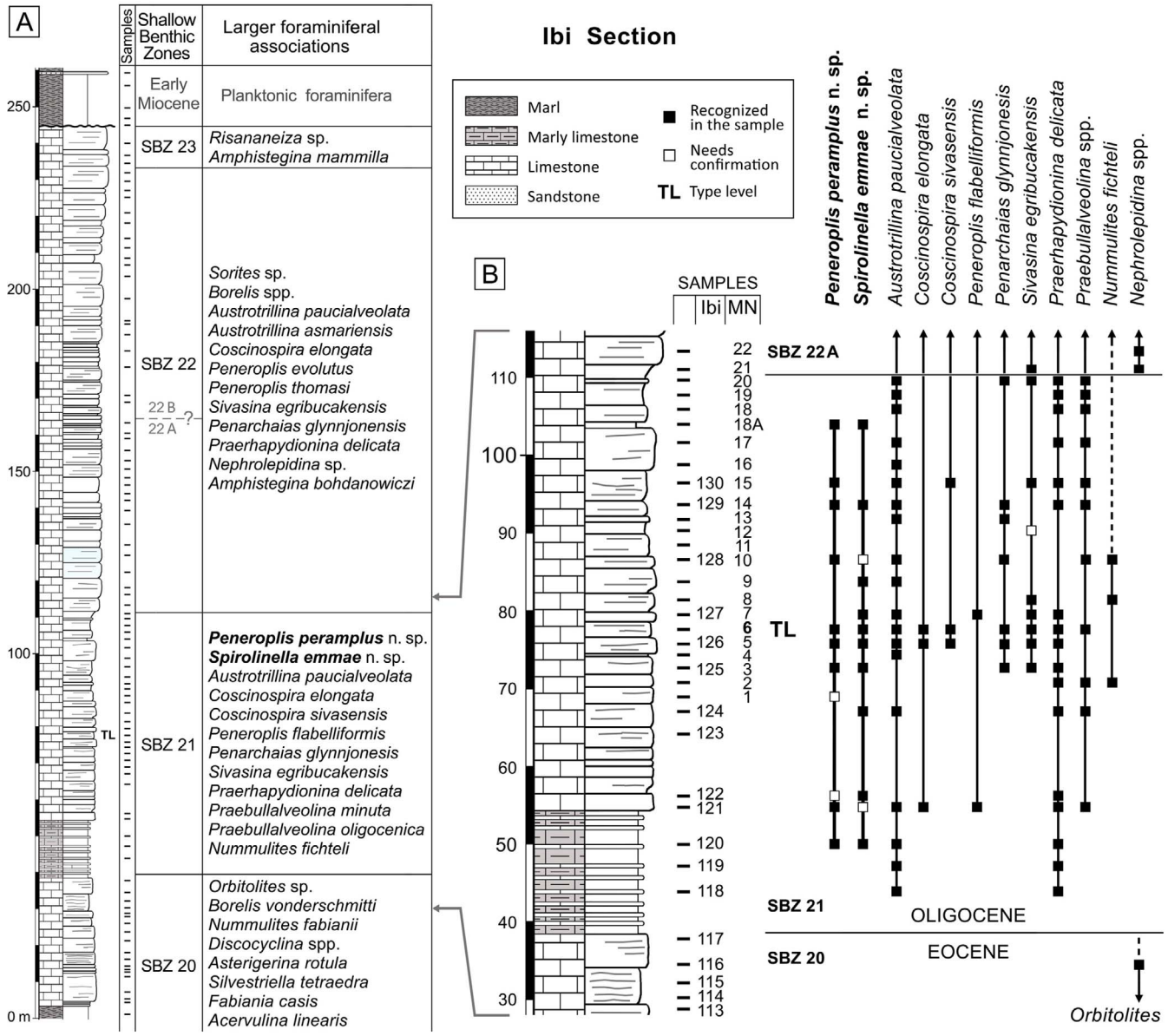

FIGURE 2. Stratigraphy and biostratigraphy of the section of Ibi. **A** Complete section with the main larger foraminifera assemblages and the recognized Shallow Benthic biozones. **B** Biostratigraphic distribution of the new taxa and main biostratigraphical markers.

Zakrevskaya, 2023). At the boundary (between samples Ibi-117 and Ibi-118, Fig. 2), there is a change in the foraminiferal association, with an assemblage dominated by hyaline larger foraminifera with *Borelis vonderschmitti*, *Nummulites fabianii*, *Discocyclina* spp., *Fabiania cassis*, *Acervulina linearis*, *Asterigerina rotula*, *Chapmanina gassinensis*, and *Silvestriella tetraedra*, being replaced by an assemblage dominated by porcellaneous foraminifera with *Austrotrillina paucialveolata*, *Praebullalveolina oligocenica*, *P. minuta*, *Sivasina egribucakensis*, *Penarchaias glynnjonesi*, *Coscinospira elongata*, *C. sivasensis*, *Praerhapydionina delicata*, and *Nummulites fichteli* (Fig. 3). The latter assemblage includes the new taxa *Spirolinella emmae* and *Peneroplis peramplus*. Its age is early Rupelian, Shallow Benthic Zone 21, as indicated by the presence of four species (*Coscinospira elongate*, *C. sivasensis*, *Praebullalveolina oligocenica*, and *P. minuta*) exclusive to this zone (Sirel, 2013, 2015; Serra-Kiel et al., 2016). This part of the sequence can be correlated with the sedimentary cycles O1 and O2 of Geel (1995, 2000), which he considers "pre-*Nephrolepidina*" and places (based on data from other correlated sections) in the biozones of planktonic foraminifers P18 and 19 of Berggren (1972), early Rupelian (Wade et al., 2018).

The early/late Rupelian boundary (SBZ 21/22A) is characterized by the first occurrence (FO) of lepidocyclinids (in sample MN-22; Fig. 2; Cahuzac & Poignant, 1997, 1998). Together with the first lepidocyclinids (*Nephrolepidina* spp.), the late Rupelian (SBZ 22A) is characterized by the association of *Austrotrillina paucialveolata*, *A. asmariensis*, *Borelis inflata*, *Peneroplis flabelliformis*, *P. thomasi*, *Sivasina egribucakensis*, *Sorites* sp., *Penarchaias glynnjonesi*, *Praerhapydionina delicata*, and *Amphistegina bohdanowiczi*. The Rupelian/Chattian boundary (SBZ 22A/22B) is not clear, as miogypsinids are

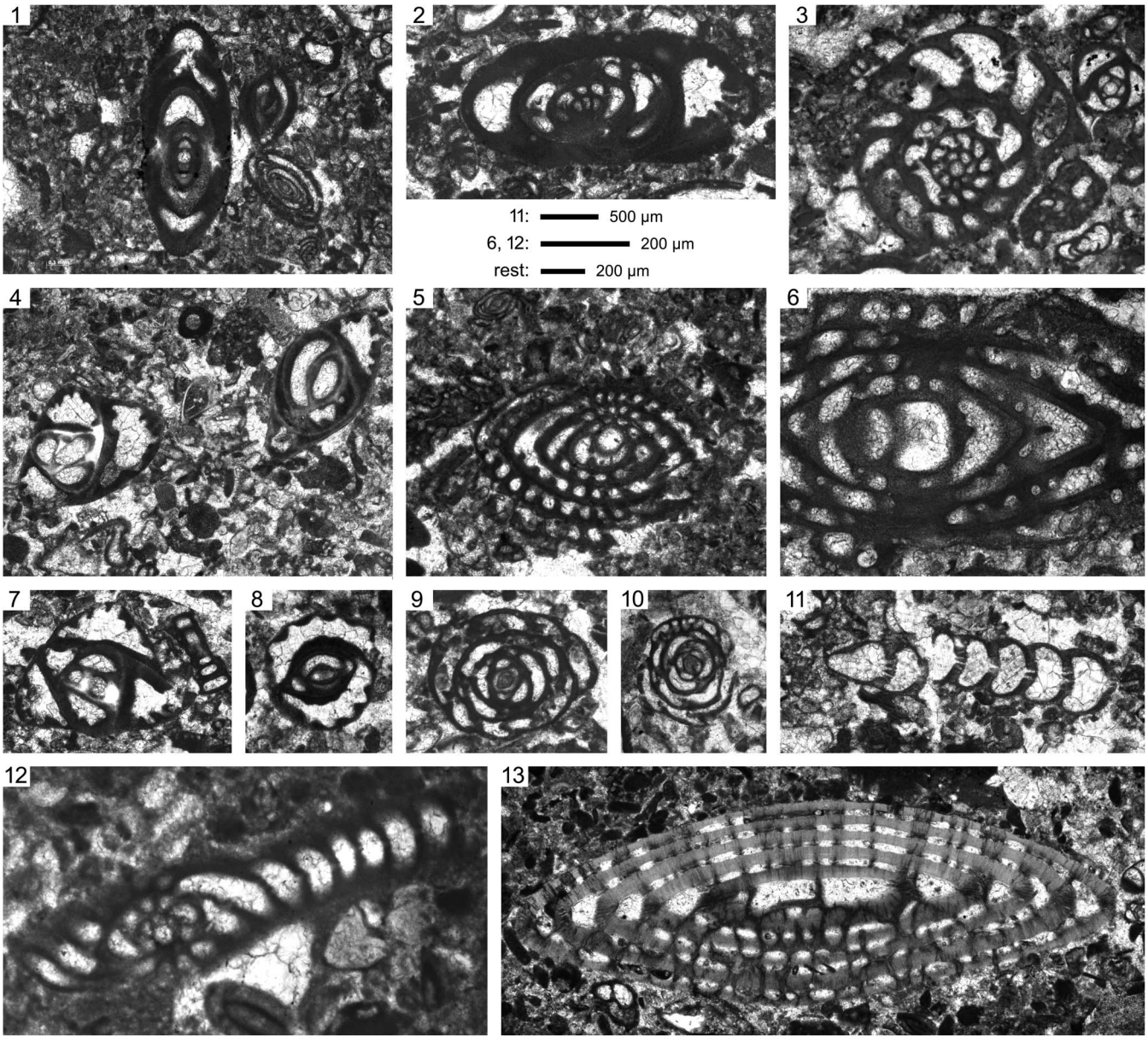

FIGURE 3. Larger foraminifera associated with *Peneroplis peramplus* n. sp. and *Spirolinella emmae* n. gen., n. sp. **1–2** *Sivasina egribucakensis*; **1** axial section, **2** subaxial-oblique section, MGB 94151 LP1 (MN-6). **3** *Coscinospira sivasensis,* Ibi-126. **4** *Austrotrillina paucialveolata*, Ibi-MN-13. **5–6** *Penarchaias glynnjonesi*; 5: subaxial-oblique section, MGB 94151 LP1 (MN-6); 6: subaxial section, note the apertures, MGB 94151 LP2 (MN-6). **7, 8** *Austrotrillina paucialveolata*; 7: MGB 94151 LP2 (MN-6), 8: Ibi-129. **9** *Praebullalveolina oligocenica*, MGB 94151 LP2 (MN-6). **10** *Praebullalveolina minuta*, Ibi-129. **11** *Coscinospira elongata*, subaxial section, MGB 94151 LP2 (MN-6). **12** *Peneroplis flabelliformis*, Ibi-127. **13** *Nummulites fichteli*, Ibi-MN-8.

completely absent throughout the section. The early/late Chattian boundary (SBZ 22B/23) is recognized by the FO of *Risananeiza* sp. and *Amphistegina mammilla* (Benedetti & Briguglio, 2012; Ferràndez-Cañadell & Bover-Arnal, 2017).

The biostratigraphy is, to some extent, obscured by the microfacies. The Eocene/Oligocene boundary coincides with a replacement of an assemblage dominated by hyaline larger foraminifera by another one dominated by porcellaneous ones. Similarly, not so marked changes in facies are found in the boundaries SBZ 21/22A (early/late Rupelian) and 22B/23 (early/late Chattian). The complete absence of miogypsinids throughout the section and the scarcity of nummulitids together with the difficulty in identifying species (or even genera) in thin section adds further difficulty in the biostratigraphic interpretation, especially in the recognition of the Rupelian/Chattian boundary (SBZ 22A/22B), currently recognized by the FO of *Miogypsinoides* (Less et al., 2018). Following Hottinger (2007) and Yazdi-Moghadam et al. (2018), this boundary is tentatively placed at the LO of *Praerhapydionina delicata*, although the presence of *P. delicata* in the Chattian cannot be completely ruled out (e.g., Henson, 1950; Esu et al., 1995). Some taxa are relevant for biostratigraphy in the section, such as *Orbitolites* (LO in sample Ibi-116) and *Nephrolepidina* sp. (FO in sample MN-21), which mark the Priabonian/early Rupelian and the early/late Rupelian respectively. The range of *Peneroplis peramplus* n. sp. and *Spirolinella emmae* n. sp. is restricted to the early Rupelian, SBZ 21.

SYSTEMATICS

The high-rank classification follows Pawlowski et al. (2013), the low-rank classification Loeblich & Tappan (1987), Hayward et al. (2021), and other works cited throughout the text.

Phylum FORAMINIFERA d'Orbigny, 1826

Class TUBOTHALAMEA Pawlowski et al., 2013

Order MILIOLIDA Delage & Hérouard, 1896

Superfamily SORITOIDEA Ehrenberg, 1839

Family PENEROPLIDAE Schultze, 1854

Genus *Peneroplis* De Montfort, 1808

Type species: *Nautilus planatus* Fichtel & Moll, 1798

Peneroplis peramplus n. sp.
Figs. 4.1–4.21, 5.1–5.14

Etymology. From the Latin *peramplus* (very large).

Type material. Holotype MGB 94151 LP3.1 (Fig. 4.11) and paratypes MGB 94151 LP1.1 (Fig. 4.7, 5.8), MGB 94151 LP1.2 (Fig. 4.12), MGB 94151 LP1.3 (Fig. 4.17), MGB 94151 LP1.4 (Fig. 4.19), MGB 94151 LP1.6 (Fig. 5.11), MGB 94151 LP2.1 (Fig. 4.13), MGB 94151 LP2.2 (Fig. 4.14), MGB 94151 LP2.3 (Figs. 5.2, 5.10), MGB 94151 LP2.4 (Figs. 5.7, 5.13), and MGB 94151 LP3.2 (Fig. 5.9). The holotype is a megalospheric form in equatorial section, showing a bilocular embryo with a protoconch and a deuteroconch, followed by 4 progressively larger and encircling chambers and 7 annular chambers. Diameter of the test: 1.4 mm, diameter of the protoconch: 218 μm, diameter of the deuteroconch: 267 μm.

Type locality. Ibi section, north of Ibi town. Base of the section: 38°38′13″N, 0°34′43″W.

Type horizon. Sample MN-6, early Rupelian, Shallow Benthic Zone 21 (Fig. 2).

Diagnosis. A *Peneroplis* species with completely evolute chambers, annular growth, and a large bilocular megalospheric embryonic apparatus with a protoconch diameter of around 240 μm; test diameter of about 1.5 mm in megalospheric forms and up to 10 mm in microspheric forms.

Megalospheric form. The test is discoidal, about 1.5 mm in diameter (maximum diameter: 2.4 mm), with a swollen central part due to the large size of the initial chambers. The initial chambers consist of a bilocular embryo, with a subcircular protoconch and a deuteroconch of crescent shape in equatorial section; both chambers usually flattened in axial direction. The protoconch measures about 240 μm in equatorial diameter (mean: 226.06, range: 192–288, N: 17), and the deuteroconch is up to 380–400 μm in width (mean: 282.4, range: 190–409, N: 11). These values were taken on random sections of thin sections, so the values are biased, especially the lower values, which likely correspond to non-centered or oblique sections. The post-embryonic chambers are elongate and narrow. The annular growth starts at the 3rd–4th post-embryonic chamber, with up to 20 annular chambers. Apertures are multiple, circular, arranged in a median row in the apertural face. Peripheral chambers may have a secondary row, with apertures of the two rows in alternate arrangement.

Microspheric form. In most samples with megalospheric forms of *P. peramplus*, a very large form of evolute annular peneroplid, up to about 10 mm in diameter was observed. This large form is interpreted as the microspheric form of the new species. The megalospheric form of *P. peramplus* reaches 2.4 mm in test diameter, with a large bilocular embryo up to 400 μm in diameter. An embryo of this size is indicative of a proportionally large microspheric form. No other peneroplid in any of the samples studied shows an embryo of similar dimensions. The microspheric test is discoidal, with a biconcave morphology due to the increase in size of the chambers through ontogeny. It has a median row of rounded stolons (previous apertures) in the first chambers. With the increase in chamber size, supplementary rows of apertures are added to the central one, with at least three irregular rows of apertures in peripheral chambers. Some of the apertures of the supplementary rows merge with those of the central row forming elongate or figure eight-shaped apertures (Fig. 5.9). The initial chambers were not observed.

Remarks. A net of cavities was observed in the lateral walls of some specimens, all of them microspheric forms (Figs. 5.7, 5.9, 5–10 bottom, 5.12–5.14); sometimes only locally or only in one of the lateral walls (e.g., upper part in Fig. 5.9). The small cavities, roughly 20 μm in both width and height, show a polygonal network in tangential section (Fig. 5.14) and are interpreted as an incipient exoskeletal structure.

Comparison. Peneroplis peramplus is the only Paleogene species of *Peneroplis* with a bilocular embryonic apparatus. The protoconch of *P. peramplus* n. sp. is larger than the proloculus of any known species of *Peneroplis* of Eocene or Oligocene age. The reported diameter of the megalospheric proloculus is of 50–80 μm in *P. flabelliformis* (Sirel & Özgen-Erdem in Sirel et al., 2013; Serra-Kiel et al., 2016); 65–80 μm in *Peneroplis* cf. *elegans* (Hottinger, 1963; Serra-Kiel et al., 2016); 50–100 μm in *P.* cf. *laevigatus* (Hottinger, 1963; Serra-Kiel et al., 2016); 120 μm in *P. evolutus* (Serra-Kiel et al. 2016; proloculus size not mentioned in the original description by Henson, 1950); 120 μm in *Peneroplis* cf. *evolutus* (Serra-Kiel et al., 2016); 110 μm in the involute *P. thomasi* (Henson, 1950), and 110 μm in the Eocene *P. dusenburyi* (Henson, 1950). It differs also by the presence of a true deuteroconch forming a bilocular embryo. *Peneroplis peramplus* has a completely evolute growth, found only in *P. evolutus*. The rest of species are involute in the initial (spiral) stage. In *P. farsensis*, the proloculus reaches 190 μm in diameter (Henson, 1950), but this species has an involute or semi-involute growth and its stratigraphical range is Lower-Middle Miocene (Henson, 1950). None of the seven species of Chattian *Peneroplis* reported by Hottinger (1963) from Moratalla (120 km SW from Ibi) is comparable to *P. peramplus*; their proloculi are simple (not bilocular) and very small (<90 μm).

Peneroplis armoricus ("*Archiacina armorica*" in the literature) is an evolute peneroplid with annular growth, abundant in Rupelian (Stampian) beds (Calcaire à *Archiacina* of Rennes Basin, NW France), and reported also from the Basin of Paris (Alimen & Lucas, 1946), Majorca (Colom, 1957, 1974), and Romania (Bombita, 1980). According to Bauer et al. (2016), the age of the *Archiacina* Limestones of Rennes Basin is early Rupelian, SBZ 21, which is in agreement with the basal Oligocene age of the '*Archiacina* beds' in Romania (Bombita, 1980). Originally described as *Cyclolina armorica* (d'Archiach in Tournouer, 1868, p. 376–377), it was renamed as *Archiacina armorica* by Munier-Chalmas (in Vasseur, 1878, p. 1049,

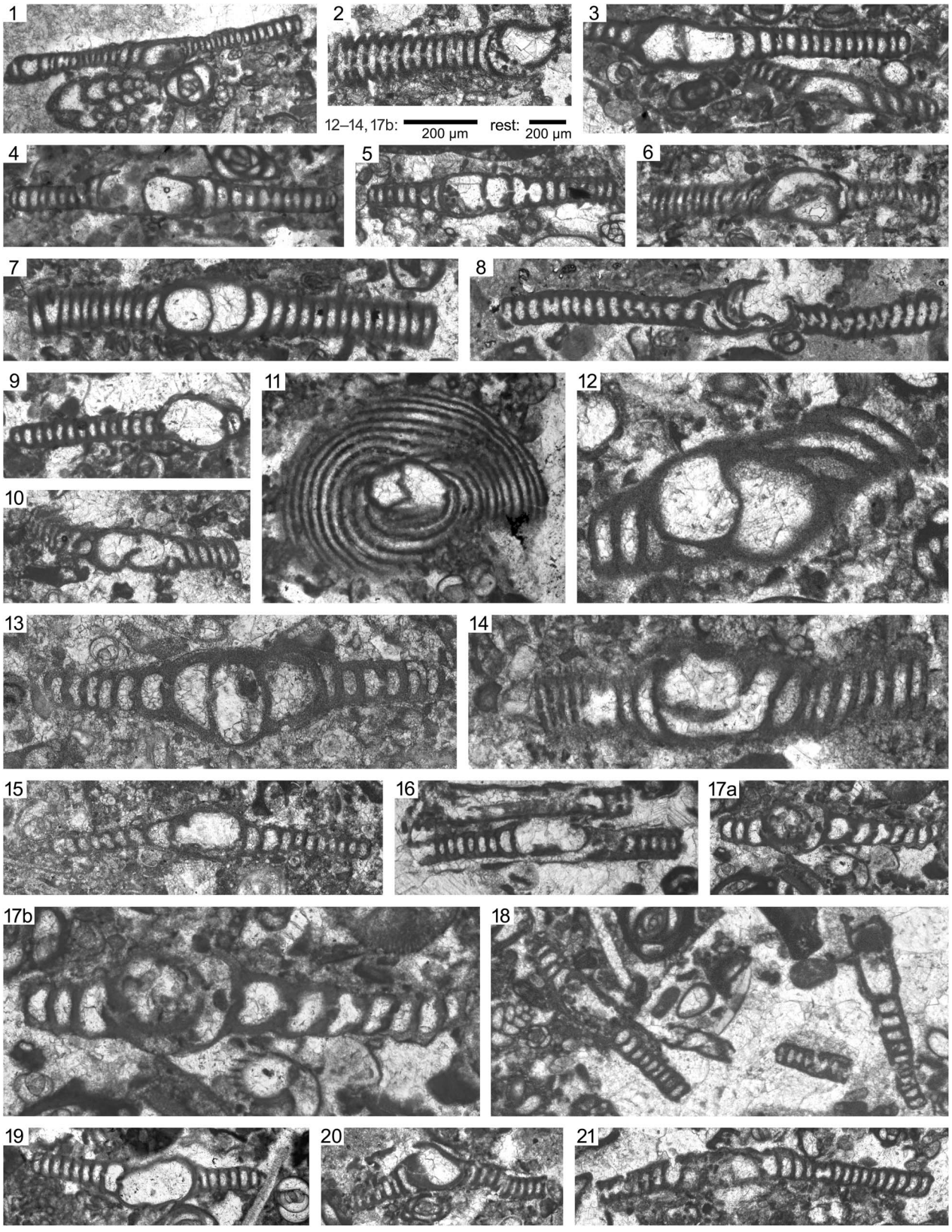

FIGURE 4. *Peneroplis peramplus* n. sp., megalospheric form. **1** Axial, slightly oblique section, MGB 94151 LP1 (MN-6). **2** Equatorial-oblique section, paratype MGB 94151 LP3.3 (MN-6). **3** Two specimens in axial (above) and equatorial-oblique (below), MGB 94151 LP1 (MN-6). **4** Axial section, MGB 94151 LP3 (MN-6). **5** Axial section, MGB 94151 LP1 (MN-6). **6** Equatorial-oblique section, Ibi-130. **7** Axial section, paratype MGB 94151 LP1.1 (MN-6). **8** Axial-oblique section, Ibi-126. **9** Axial section MGB 94151 LP3 (MN-6). **10** Equatorial-oblique section, MGB 94151 LP2 (MN-6). **11** Equatorial section, holotype MGB 94151 LP3.1 (MN-6). **12** Subequatorial section, paratype MGB 94151 LP1.2 (MN-6). **13** Axial section, paratype MGB 94151

footnote 1) and now considered a species of *Peneroplis* by most authors (Henson, 1948, 1950; Colom, 1957, 1974; Poignant, 1981). The microspheric test of *P. armoricus* can attain 6–10 mm in test diameter (Alimen & Lucas, 1946; Colom, 1957), with a proloculus of 16 μm. The megalospheric form, 1–3 mm in diameter, has a small megalospheric proloculus, about 30 μm in diameter in the Paris Basin specimens (Alimen & Lucas, 1946). Bombita reported proloculus diameter of 40–60 μm in what he interpreted as microspheric forms but are probably megalospheric forms, for which he did not provide measurements. The small size of these proloculus values clearly differentiates *P. armoricus* from *P. peramplus*. There are no references to the presence of *P. armoricus* in the Oligocene of the Iberian Peninsula, and it is absent in the Ibi section and nearby Oligocene sequences.

Known stratigraphic range. In the samples studied (Fig. 2), *P. peramplus* n. sp. occurs associated with *Austrotrillina paucialveolata*, *Coscinospira elongata*, *C. sivasensis*, *Sivasina egribucakensis*, *P. peramplus*, *Penarchaias glynnjonesi*, *Praerhapydionina delicata*, *Praebullalveolina oligocenica*, *P. minuta*, and *Nummulites fichteli.* The assemblage characterizes the lower Rupelian, SBZ 21.

Genus *Spirolinella* n. gen.

Type species: *Spirolinella emmae* n. sp.

Diagnosis. Test elongate, early chambers planispirally arranged, later uncoiling and rectilinear, with short barrel-like chambers; interior simple and undivided; wall porcellaneous, lateral walls thickened at the base; surface smooth; aperture terminal, simple in the first chambers, becoming progressively complex and multiple, with several apertures arranged in stellar pattern with developed protruding elongated capsular lips in radial arrangement.

Stratigraphic and geographic range. Early Rupelian (SBZ 21) of the westernmost Tethys (Prebetic Range, eastern Iberia).

Remarks. Spirolinella is similar to *Spirolina* in test shape, type of growth, and wall structure. It differs by a slender test and thinner walls, and by its particular complex aperture. *Spirolina* spp. have been reported from the Oligocene of the Paris Basin (*S. cylindracea*, Le Calvez, 1970); Majorca (*S.* cf. *cylindracea*, Colom Casasnovas, 1935); Malta (*S. semilituus*, Brandano et al., 2009); Turkey (Malatya, *Spirolina* sp., Kayğili, 2016); Somalia (*S. pedum*, Silvestri, 1937); and Iran (*S.* cf. *cylindracea*, Yazdi-Moghadam, 2011; Amirshahkarami, 2013). All these forms show the characteristic aperture of *Spirolina*, described either as simple, rounded or petaloid, or as a single aperture with radial extensions towards the center (e.g., Le Calvez, 1970; Kayğili, 2016; i.e., without the protruding lips that characterize *Spirolinella*).

Spirolinella emmae n. sp.

Figs. 6.1–6.16, 7.1, 7.4, 8.3, 8.5–8.7

Etymology. Dedicated to the author's wife, Emma.

Type material. Holotype MGB 94152 LP2.1 (Figs. 6.1, 7.1) and paratypes MGB 94151 LP1.5 (Fig. 6.5), MGB 94153 LPb.1 (Fig. 6.15), MGB 94153 LPb.2 (Figs. 6.7, 7.4), MGB 94153 LPb.3 (Fig. 6.9), MGB 94154 LP1.1 (Figs. 6.13), and MGB 94154 LP(3)2.1 (Figs. 6.14). The holotype is a megalospheric form in near-equatorial section, 0.55 mm long and 0.3 mm wide, showing a spherical proloculus of 70 μm in diameter, followed by 9 planispiral chambers and 3 uniserial rectilinear chambers.

Type horizon. Sample MN-6, early Rupelian, Shallow Benthic Zone 21 (Fig. 2).

Type locality. Ibi section, north of Ibi town (province of Alacant, Spain). Coordinates of the base of the section: 38°38′13″N, 0°34′43″W (Figs. 1, 2).

Diagnosis. A *Spirolinella* species with a megalospheric proloculus of 60–70 μm in diameter and 9–11 planispiral chambers.

Description. Cylindrical test with a short initial planispiral biumbilicate growth that changes to rectilinear uniserial growth. Surface smooth, without ornamentation and with poorly marked sutures. Uniserial chambers of cylindrical shape with rounded margins; walls thickened at the base, smoothing the sutures between chambers. The aperture is terminal, simple, petaloid to stellar in shape; with small lips in the spiral chambers and becoming increasingly complex in the uniserial chambers, with distally protruding lips forming capsular or curved tubular cavities radially arranged with an aperture at the distal end (Figs. 6.1, 6.5, 6.8–6.16, 8.3, 8.5–8.7).

Dimorphism. Megalospheric forms have a subspherical proloculus of 60–70 μm in diameter (Figs. 6.1–6.5), with a small flexostyle (Figs. 6.4–6.5), followed by 9–11 planispiral chambers and up to 6–7 barrel-like chambers, 0.3–0.43 mm in diameter, in uniserial growth. No complete microspheric test was observed, but their presence is revealed by one specimen recording the process of asexual reproduction (schizogony; Fig. 6.4). Its test contains about 27 megalospheric proloculi, the diameter of which matches that of the megalospheric specimens in Figures 6.1–6.3 and 6.5. The initial growth of microspheric forms was not observed, but the microspheric test is clearly larger, with uniserial chambers reaching 0.6 mm in diameter (Figs. 6.4, 6.8).

Remarks. Praerhapydionina delicata, which occurs in the same samples, is similar in test shape and size to *Spirolinella*, and has a petaloid aperture with lips that may resemble those of *S. emmae* in some axial sections. *Praerhapydionina* differs from *Spirolinella* by the presence of radial partitions and by lacking the developed and protruding tubular lips present in *Spirolinella*. *Praerhapydionina delicata* specimens from the samples containing *Spirolinella* have a larger proloculus, about 100 μm in diameter (95–108 μm, N=2, Figs. 7.2, 7.3). The size of the proloculus was not given in the original description of the species (Henson, 1950). According to Hottinger (1963), the proloculus diameter of *P. delicata* from the Oligocene of Moratalla (Prebetic domain, 120 km SW from Ibi) ranges from 75 to 90 μm (mean=82.5, N=4), and measures 115 μm in the original material of Henson based on the unique specimen figured showing the proloculus (pl. 2, fig. 4 in Henson, 1950–not pl. 2 fig. 6 as stated by Hottinger, 1963). Our

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FIGURE 4. Continued. LP2.1 (MN-6). **14** Subequatorial section, paratype MGB 94151 LP2.2 (MN-6). **15** Axial, slightly oblique section, MGB 94151 LP1 (MN-6). **16** Axial section, Ibi-129. **17** Equatorial-oblique section (17a) and detail (17b), paratype MGB 94151 LP1.3 (MN-6). **18** Two specimens in axial section, MGB 94151 LP1 (MN-6). **19** Axial section, note the large size of the central chamber, probably the deuteroconch, paratype MGB 94151 LP1.4 (MN-6). **20** Oblique section, MGB 94154 LP(3)2 (Ibi-126). **21** Axial-oblique section, MGB 94151 LP1 (MN-6).

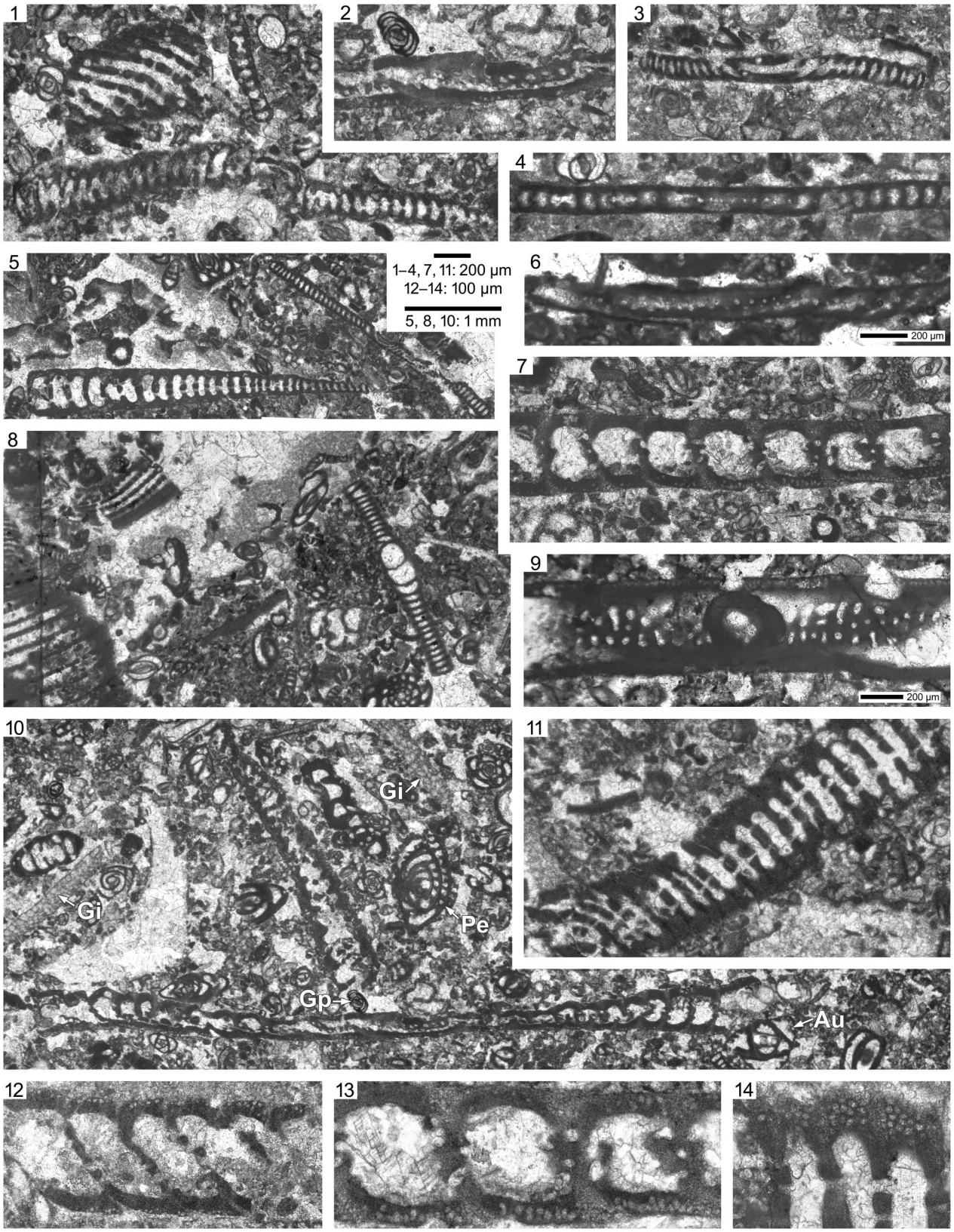

FIGURE 5. *Peneroplis peramplus* n. sp., microspheric and megalospheric specimens showing stolons and apertures. **1** Fragmentary equatorial section of a microspheric form showing stolons (top left) and axial, slightly oblique section of a megalospheric form (bottom), MGB 94151 LP1 (MN-6). **2** Equatorial-oblique section of a microspheric specimen (detail of the specimen in fig. 5.10 bottom) showing multiple stolon rows of different size, and *Glomospira* sp. (top left), MGB 94151 LP2.3 (MN-6). **3** Oblique section of a megalospheric form showing two rounded stolons, Ibi-126. **4** Subaxial section of a megalospheric form showing a median row of stolons, Ibi-127. **5** Axial section of half microspheric form (bottom) and axial, slightly oblique

specimens of *Praerhapydionina* fit these values of proloculus diameter, which differ from those of *Spirolinella emmae*.

Spirolinella and *Praerhapydionina* differ also in the structure of the wall: homogeneous in *Spirolinella* and with a pseudokeriothecal-like texture in *Praerhapydionina*, with a clear pattern of tubular cavities, 6–9 μm in diameter, normal to the test walls (Figs. 7.5–7.12, see Discussion).

Known stratigraphic range. In our samples (Fig. 2), *Spirolinella emmae* occurs associated with *Austrotrillina paucialveolata*, *Coscinospira elongata*, *C. sivasensis*, *Sivasina egribucakensis*, *Peneroplis flabelliformis*, *P. peramplus*, *Penarchaias glynnjonesi*, *Praerhapydionina delicata*, *Praebullalveolina oligocenica*, and *P. minuta.* The assemblage characterizes the lower Rupelian, SBZ 21 (Sirel, 2013, 2015; Serra-Kiel et al., 2016).

DISCUSSION

During the early Paleogene, a shallow carbonate platform developed in the southern Iberian continental margin and the adjacent Alboran microplate (Geel, 1995, 2000; Höntzsch et al., 2013; Fig. 1D). The Eocene/Oligocene transition is marked by a shallowing of the depositional facies in the Ibi-Onil zone, already noted by Geel (1995, 2000). The assemblages of benthic foraminifera change from being composed mainly by hyaline forms with some porcellaneous specimens in the Eocene to a wide predominance of porcellaneous ones in the lower Oligocene ("*Praerhapydionina* limestones and marls" of Geel, 1995). The Rupelian porcellaneous foraminifera have been studied in sequences from the Middle East: Turkey (Sirel et al., 2013, 2020; Kayğili, 2016), Oman (Serra-Kiel et al., 2016), Iran, and Iraq (Henson, 1950; Yazdi-Moghadam, 2011; Amirshahkarami, 2013; Karim & Hama, 2019). Shallow-water facies with porcellaneous larger foraminifera are rarely represented in the early Oligocene record of the western Tethys. An exception is the Prebetic in eastern Iberia, already reported by Geel (1995, 2000), Hottinger (1963), and Höntzsch et al. (2013). The section of Ibi records a continuous succession from the middle Eocene to the upper Chattian, with a relevant record of Oligocene shallow facies in the western Tethys. The assemblages of porcellaneous foraminifera recognized in the Ibi section include most of the species described from the Oligocene of the central Tethys, with species of *Austrotrillina*, *Coscinospira*, *Sivasina*, *Peneroplis*, *Penarchaias*, *Praebullalveolina*, and *Borelis*. In addition, the early Rupelian from Ibi includes two new forms, here described as *Peneroplis peramplus* n. sp. and *Spirolinella emmae* n. gen., n. sp., which are restricted to the Shallow Benthic Zone 21 (early Rupelian).

The new species *Peneroplis peramplus* differs from all other Paleogene species of its genus by its large proloculus, followed by an equally large second chamber. These two initial chambers indicate a true bilocular megalospheric embryo (Fig. 4), absent in the rest of known Paleogene species of *Peneroplis*. Its age is clearly restricted to the early Rupelian (SBZ 21) in the Ibi section. A revision of the literature revealed that *P. peramplus* is absent in other lower Oligocene sequences rich in porcellaneous forms, such as those in Oman and Yemen (Dhofar and Socotra: Serra-Kiel et al., 2016); Turkey (Sivas Basin, central Turkey: Sirel et al., 2013; Malatya, eastern Turkey: Kayğili, 2016; Gedik, 2015); Iran and Iraq (e.g., Henson, 1950; Adams & Bougeois, 1967; Radoičić, 1981; Kharajiany, 2008; Amirshahkarami & Taheri, 2010; Karim & Hama, 2019). The species is thus considered endemic to the Prebetic Domain in southeastern Iberia.

Spirolinella is most similar to *Spirolina*, from which differs basically by its complex aperture (Figs. 6.8–6.16, 8.3, 8.5–8.7). *Spirolina* has been reported from different Paleogene rocks: the upper Ypresian (Cuisian) of Croatia (Sokač et al., 2012); the Lutetian and Bartonian of the Paris Basin (d'Orbigny, 1926 in Vénec-Peyré, 2005; Le Calvez, 1952, 1970); the Bartonian-Priabonian of eastern Turkey (Dinçer & Avsar, 2012) and Greece (Fleury, 1997; Barattolo et al., 2007); the Oligocene of the Paris Basin (Le Calvez, 1970), Turkey (Kayğili, 2016; Kayğili & Aksoy, 2018), Somalia (Silvestri, 1937), and Iran (Amirshahkarami, 2013). Tronchetti & Grosheny (1993) defined a new species, *S. cretacea* from the Santonian of Provence (southeastern France). They revised previously reported Mesozoic species of *Spirolina* and concluded that all previous attributions of Jurassic and Cretaceous species to this genus are doubtful. Recently, Schlagintweit & Rashidi (2016) erected a new species, *Spirolina? farsiana* n. sp., from the upper Maastrichtian Tarbur Formation of Zagros Zone in southwestern Iran.

The disagreements in the definition of the genus *Spirolina* are mainly based on two characters: the ornamentation and the aperture, which are discussed in both fossil and recent forms. A striate ornamentation is considered as generic diagnostic character by some authors (e.g., Cushman, 1927; Loeblich & Tappan, 1987; Crapon de Caprona d'Ersu, 1983). Cushman (1927) distinguished fossil and recent *Spirolina* species based on the stronger ornamentation, with more prominent ribs in the former. Other authors include in the genus forms with a smooth surface (e.g., Tronchetti & Grosheny, 1993). According to Loeblich & Tappan (1964), *Spirolina* has a rounded terminal aperture "with numerous tooth-like projections extending into opening" (not visible in their figures), whereas dendritic apertures characterize the genus *Dendritina*. However, they later (Loeblich & Tappan, 1987) described the aperture of *Spirolina* as terminal and rounded. Other authors, such as Crapon de Caprona d'Ersu (1983), Crapon de Caprona d'Ersu & Benier (1985), and Tronchetti & Grosheny

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FIGURE 5. Continued. section of a megalospheric form (right), MGB 94151 LP1 (MN-6). **6** Tangential-oblique section of a megalospheric form showing two rows of stolons in alternate arrangement, MGB 94151 LP3 (MN-6). **7** Axial, slightly oblique section of a microspheric form showing septa with three rows of stolons in alternate arrangement, note the cavities in the lower lateral wall, paratype MGB 94151 LP2.4 (MN-6), see detail in 13. **8** Fragmentary equatorial sections of microspheric specimens (left) and axial section of a megalospheric form (same specimen as in fig. 4.7, paratype MGB 94151 LP1.1), note the pronounced dimorphism, MGB 94151 LP1. **9** Tangential section of a peripheral chamber of a microspheric form showing three rows of stolons. Note that the stolons are roughly axially superposed and that some stolons of the central row merge with those of marginal rows forming elongated to 8-shaped stolons; also note the cavities in the lateral walls; Paratype MGB 94151 LP3.2 (MN-6). **10** Two microspheric forms in axial (center-left) and peripheral-oblique section (bottom, paratype MGB 94151 LP2.3, see detail in 2). Note the association with gypsinids (Gi), *Penarchaias glynnjonesi* (Pe), *Austrotrillina paucialveolata* (Au) and *Glomospira* sp. (Gp), MGB 94151 LP2 (MN-6). **11** Equatorial-oblique section of a microspheric specimen showing the stolons, note the radial alignment and the small distal lip of stolons, paratype MGB 94151 LP1.6 (MN-6). **12–14** Subaxial sections of microspheric specimens showing the cavities in the lateral walls, MGB 94151 LP2 (MN-6) (13 is a detail of 7, paratype MGB 94151 LP2.4).

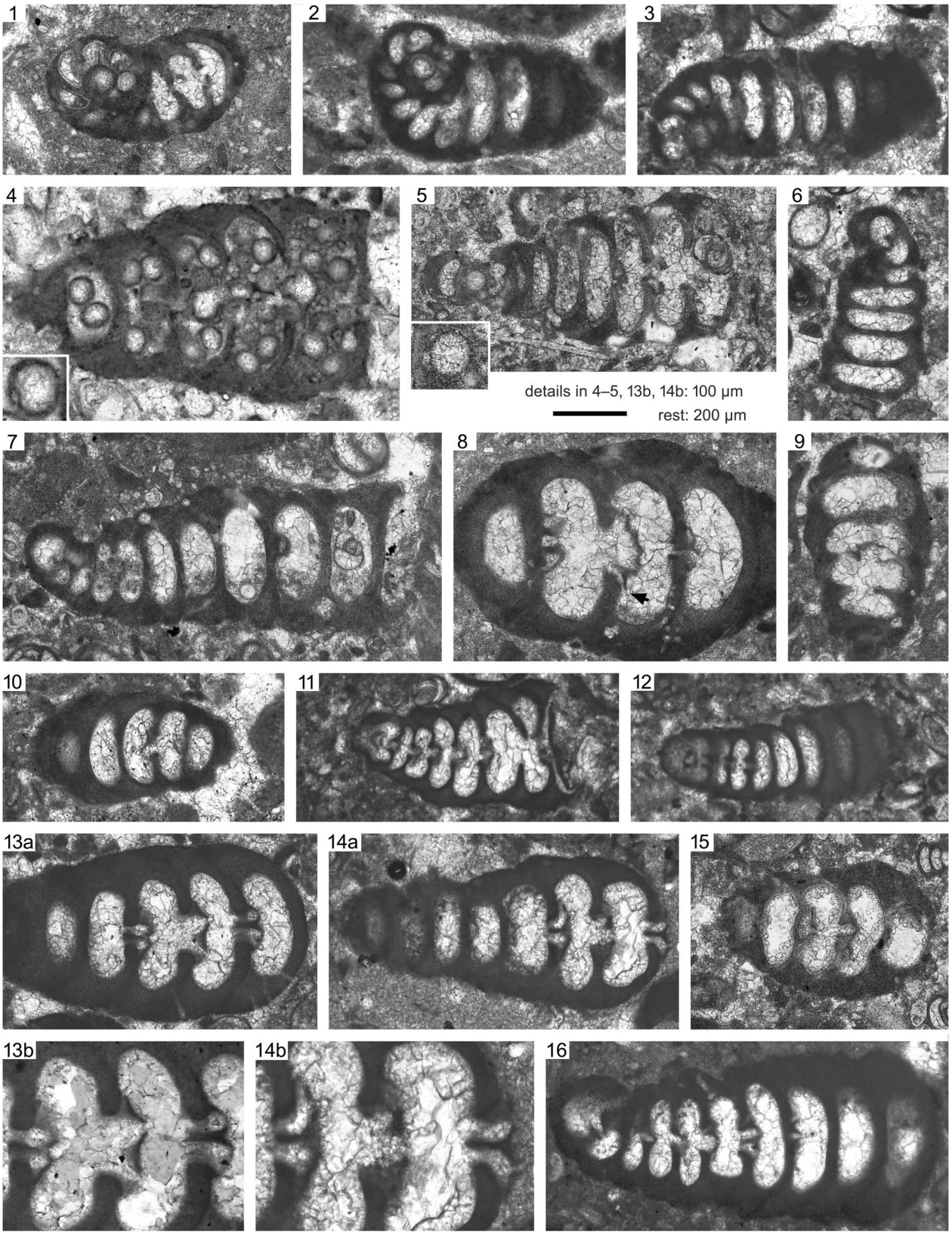

FIGURE 6. *Spirolinella emmae* n. gen., n. sp. **1** Megalospheric form, equatorial section, holotype MGB 94152 LP2.1 (MN-18). **2** Megalospheric form, equatorial section, Ibi-120. **3** Megalospheric form, subequatorial section, Ibi-126. **4** Longitudinal section of a microspheric form in asexual reproduction process and detail of one of the juveniles showing the flexostyle, Ibi-MN-5. **5** Megalospheric form, axial section and detail of the proloculus, note the biumbilical shape of the test and the flexostyle in the proloculus, paratype MGB 94151 LP1.5 (MN-6). **6** Megalospheric form, subaxial section, Ibi-126. **7** Megalospheric form, subaxial section, paratype MGB 94153 LPb.2 (Ibi-120). **8** Microspheric form, longitudinal-oblique section, note the apertural

(1993) included in their definition of the genus both forms with simple and dendritic openings.

The type of aperture with tooth-like projections was described in topotypes of the type species of *Spirolina*, *S. cylindracea* (Loeblich & Tappan, 1964), and in Eocene specimens as well (Le Calvez, 1952). These projections may be convex with a thickened margin (see, for example, pl. 15, fig. 5 in Le Calvez, 1970). This type of aperture, described in the type species, could be considered diagnostic for *Spirolina*, whereas dendritic and cribate apertures would characterize *Dendritina* and *Coscinospira*, respectively. However, this would leave open the problem to allocate the forms with simple rounded apertures. Besides, the difference between dendritic apertures and apertures with tooth-like projections is subtle, and it is difficult to distinguish in fossil specimens without well-preserved loose specimens.

Despite these disagreements in the definition of *Spirolina* and the debatable attribution of Mesozoic, Paleogene, and recent species to this genus, the Rupelian specimens from Ibi clearly differ from all of them by their particular aperture, thus justifying the establishment of a new genus. The complex apertures in *Spirolinella*, with tubular cavities projecting radially from the central part of the septa and protruding from the septal face, are clearly different of those described in *Spirolina*, either as simple and rounded, dendritic, or "with numerous tooth-like projections extending into opening."

Spirolinella emmae seems also to be endemic, restricted also to the Prebetic Domain. A specimen reported from the Islet of Lampione (Pelagian Sea, Mediterranean) by Bismuth & Bonnefous (1981) as "*Spirolina* cf. *cylindracea*" seems to fit the diagnostic features of *Spirolinella*. The specimen is an axial section, with 9–10 spiral chambers and apertures with protruding lips (pl. 2, fig. 4 in Bismuth & Bonnefous, 1981, reproduced as *Spirolina cyclindracea* Lamarck in pl. 9, fig. 1 in Bonnefeus & Bismuth, 1982). Its age is interpreted as Priabonian based on the presence of *Nummulites fabianii*, *N. bouillei*, and *N. incrassatus* (determined by Blondeau), to which we add *Coskinolina perpera*, determined as "*Lituonella roberti*" (plate 2, fig. 9; pl. 3, figs. 1, 7 in Bismuth & Bonnefous, 1981). The fact that only a low-detail photograph of a single specimen is available prevents a conclusive assignment to *Spirolinella*. If confirmed, this might place the origin of the genus in the Priabonian of the northeastern offshore of Tunisia.

According to Fleury (1997), the Paleogene species of *Spirolina*, *Paraspirolina*, and *Praerhapydionina* (including "*P. huberi*", nowadays accepted as *Haymanella huberi* after Hottinger, 2007) would constitute a natural group, characterized by a spiral test with a uniserial evolute rectilinear final part and a single distal aperture, with or without radial partitions. *Haymanella huberi* has been recently interpreted as an agglutinated species and placed within the Lituolidae (Kaminski, 2004; Hayward et al., 2021). However, it has a true porcellaneous wall with agglutinated grains in the outer surface, similar to that in the hauerinid *Schlumbergerina* (see pl. 4, fig. 15, pl. 5, figs. 12-14, pl. 6, fig. 3 in Hottinger, 2007). This, together with a petaloid aperture and the presence of radial partitions support its inclusion in the Praerhapydioninae. *Spirolina*, *Spirolinella*, and *Praerhapydionina* have similar tests of spiral–uniserial growth and apparently similar petaloid apertures. Figure 8 shows the similarities and differences in the shape of the aperture in the three genera. Apertures can be simple (either rounded or petaloid) or dendritic-like in *Spirolina*; they are simple with a petaloid outline in *Praerhapydionina,* and petaloid to stellar with protruding capsular lips radially arranged in *Spirolinella*.

Praerhapydionina differs from *Spirolina* and *Spirolinella* by the presence of exoskeletal radial partitions. In axial section, the aperture of *Praerhapydionina* may have thin protruding "lips" than resemble those in *Spirolinella* (Fig. 7.5). They are actually thin radial walls that correspond to the end of the main radial partitions, which extend towards the aperture between the petaloid lobules (Fig. 8.4). As stated above, the two genera further differ in the structure of the wall, homogeneous in *Spirolinella* and with a pseudokeriothecal-like wall texture in *Praerhapydionina* (Figs. 7.5–7.12). The pseudokeriotheca is defined as a wall texture consisting of uniform, parallel, radial elements covered by some kind of tectum (Hottinger, 2006). It is present in several genera of Mesozoic and Paleogene agglutinated foraminifera (including several genera of Pfenderinidae, Coskinolinidae, Orbitolinidae, and Chrysalinidae; e.g., Serra-Kiel et al., 2016). Here we report the first observation of a similar structure in a porcellaneous genus, *Praerhapydionina*.

As pointed out by Hottinger (2007), *Praerhapydionina* has been reported from many places, from Cuba to Indonesia, based on random sections in cemented rock, not distinctive enough to permit the identification of different species. Added to this is the poor knowledge of the type species, *P. cubana* (Fleury, 1997). The particular texture of the wall in *Praerhapydionina* will be a useful criterion for identifying the genus, even from non-centered sections. Pseudokeriothecal-like wall can be seen in some photographs of Tethyan *P. delicata* in the literature (e.g., specimens from Greece in pl. 1, figs. 7, 19, 23, 24 in Fleury, 1997; specimens in samples of Adams, 1965, from Indonesia, figured in Lunt, 2014). The presence of pseudokeriothecal-like wall in the type species, the American *P. cubana* (van Wessem, 1943) could not be verified. Nevertheless, pseudokeriothecal-like walls can be seen in figured specimens assigned to *P. delicata* from the Oligocene of Jamaica (pl. 6.8, figs. 4–6 in BouDagher-Fadel, 2008) and the Bahamas (text-fig. 8 and pl. 1, fig. 1 in Fischer et al., 2016). When confirmed in the type species, this particular wall structure should be included in the diagnosis of the genus. It will be a useful character to verify the assignment to *Praerhapydionina* of specimens described from non-centered sections and would confirm the striking wide geographical distribution of the genus.

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FIGURE 6. Continued. covering structure and the lateral aperture (arrow), Ibi-127. **9** Longitudinal section of the uniserial chambers, paratype MGB 94153 LPb.3 (Ibi-120). **10** Longitudinal-oblique section of the uniserial chambers, Ibi-120. **11** Subaxial section, note the simple apertures in the initial spiral chambers, Ibi-126. **12** Subaxial-oblique section, note the simple apertures in the initial spiral chambers, Ibi-124. **13** Longitudinal section (13a) and detail (13b) of the uniserial chambers showing the apertures, paratype MGB 94154 LP1.1 (Ibi-126). **14** Subaxial-oblique section (14a) and detail (14b) showing the apertures in the distal uniserial chambers, paratype MGB 94154 LP(3)2.1 (Ibi-126). **15** Subaxial section showing the apertures in uniserial chambers, paratype MGB 94153 LPb.1 (Ibi-120). **16** Subaxial section, note the increasing complexity of the apertures, Ibi-127.

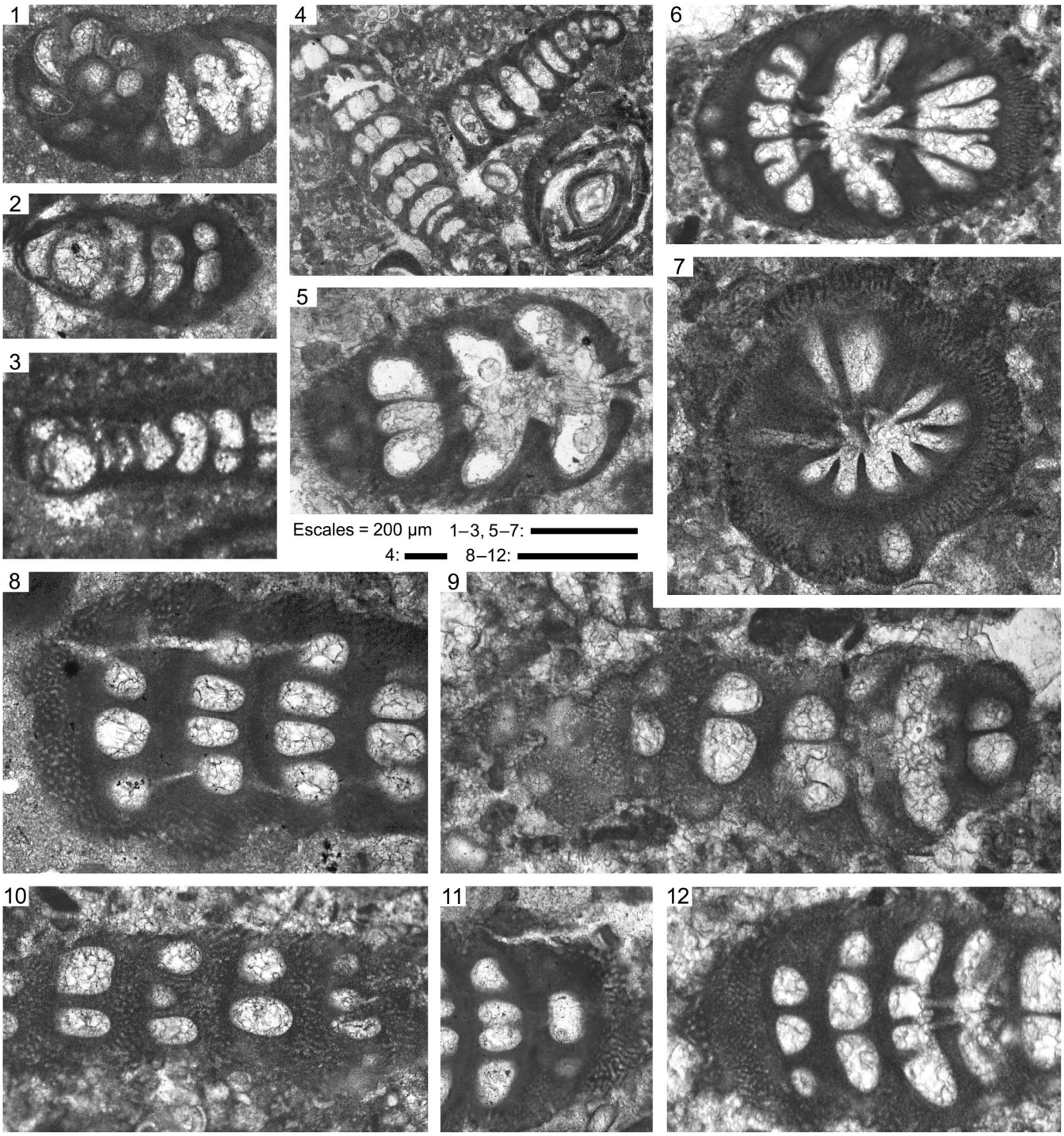

FIGURE 7. *Spirolinella emmae* n. sp., comparison with *Praerhapydionina delicata*. **1–3** Proloculus and initial chambers in *S. emmae* (1) and *P. delicata* (2, 3). Note the larger size of the proloculus and the shorter spiral stage in *P. delicata*; 1: holotype MGB 94152 LP2.1 (MN-18). 2: Ibi-121. 3: Ibi-119. **4** Longitudinal-oblique sections of *P. delicata* (left) and *S. emmae* (right, paratype MGB 94153 LPb.2), note the similarities and the absence of radial partitions in *Spirolinella*, Ibi-120. **5** Longitudinal-oblique section of *P. delicata*, note the microstructure of the wall and the radial partitions, and the similarities and differences in the apertures with those in *Spirolinella*; sample SA-60 (at meter 163.5 of the section of Ibi, SBZ 22). **6–12** Different sections of *P. delicata* showing the microstructure of the wall. 6: Oblique transversal section, Ibi-118. 7: Transversal section, Ibi-119. 8: Subaxial section, Ibi-126. 9: Subaxial-tangential section, MGB 94151 LP2 (MN-6). 10: Subaxial-tangential section, Ibi-MN-1. 11: Subaxial-oblique section, MGB 94151 LP2 (MN-6). 12: Subaxial-oblique section, MGB 94151 LP3 (MN-6).

CONCLUSIONS

The Ibi stratigraphical section records a sequence of shallow-water carbonate platform facies that includes the Eocene/Oligocene transition. The early Oligocene is represented by shallow facies with larger porcellaneous foraminifera, which are rarely recorded in the western Tethys.

The early Rupelian foraminiferal assemblage from Ibi includes a new species of *Peneroplis*, *P. peramplus* n. sp., and

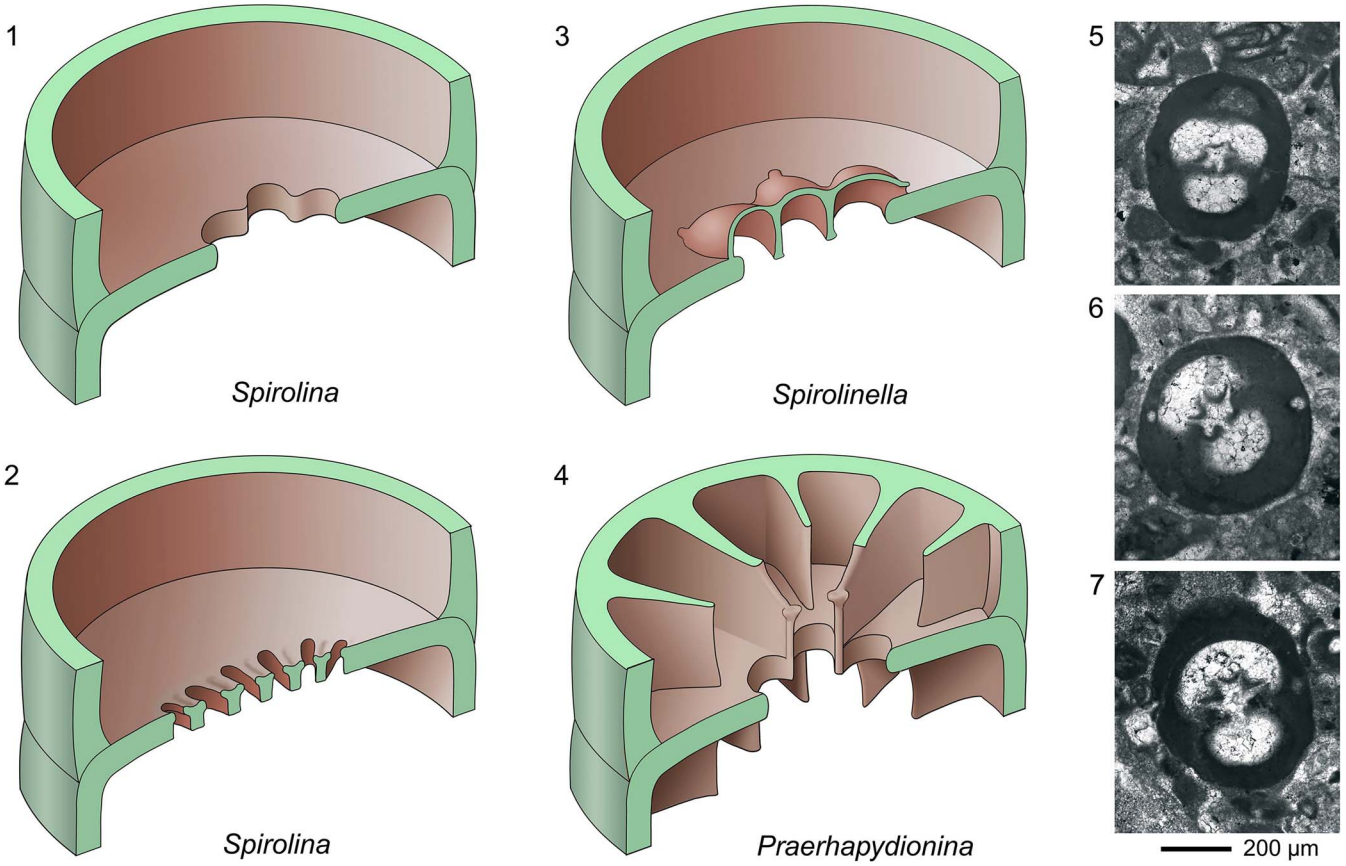

FIGURE 8. Models (schematic, not to scale) of the different types of apertures in S*pirolina*, *Spirolinella*, and *Praerhapydionina*. Test ornamentation (present only in some species of *Spirolina*) has been omitted. **1** *Spirolina* sp., simple aperture of petaloid shape, it can be also rounded. **2** *Spirolina* sp., dendritic-like aperture, described in Le Calvez (1952) and Loeblich & Tappan (1987) as "with numerous tooth-like projections extending into opening" (see pl. 15, fig. 5 in Le Calvez, 1970). **3** *Spirolinella emmae* n. gen., n. sp., the apertures are at the distal end of capsular lips radially arranged. **4** *Praerhapydionina delicata*, note the first order radial partitions extending towards the aperture. **5–7** Transversal sections of *Spirolina* showing the petaloid to stellar shape of the foramen with apertures radially arranged, Ibi-127.

a new genus, *Spirolinella emmae* n. gen., n. sp. These two new taxa are restricted to the Shallow Benthic Zone 21 (early Rupelian). They are absent in the known Oligocene assemblages from the Central Tethys and are thus interpreted as endemic to the Prebetic domain.

The new genus *Spirolinella* has a complex aperture, which resembles the petaloid aperture in *Praerhapydionina* and some species of *Spirolina*. In *Spirolinella* the petaloid aperture has developed protruding capsular or tubular lips radially arranged, absent in the other two genera. *Praerhapydionina* differs from *Spirolina* and *Spirolinella* by the presence or radial partitions, but also by a particular wall structure resembling the pseudokeriotheca of agglutinated forms. The presence of this character should be confirmed in the type species, *P. cubana*, although it is present in Oligocene specimens reported from the Bahamas and Jamaica. It will be a useful character to check the assignation to *Praerhapydionina* of specimens reported from Europe, North Africa, Middle East, Far East, and the Caribbean to confirm its wide geographical distribution.

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APPENDIX. TAXONOMIC REFERENCE LIST

Acervulina linearis Hanzawa, 1947
Amphistegina bohdanowiczi Bieda, 1936
Amphistegina mammilla (Fichtel & Moll, 1798)
Asterigerina rotula (Kaufmann, 1867)
Austrotrillina asmariensis Adams, 1968
Austrotrillina brunni Marie, 1955
Austrotrillina howchini (Schlumberger) 1893
Austrotrillina howchini
Austrotrillina paucialveolata Grimsdale, 1952
Austrotrillina striata Todd and Post 1954
Borelis pygmaea Hanzawa, 1930
Borelis inflata (Adams, 1965)
Borelis vonderschmitti (Schweighauser, 1951)
Chapmanina gassinensis (Silvestri, 1905)
Ciperoella ciperoensis (Bolli, 1954)
Coscinospira elongata Sirel & Özgen-Erdem in Sirel, Özgen-Erdem & Kangal, 2013
Coscinospira sivasensis Sirel and Özgen-Erdem in Sirel, Özgen-Erdem & Kangal, 2013
Coskinolina perpera Hottinger & Drobne, 1980
Cycloclypeus mediterraneus Matteucci & Schiavinotto, 1985
Dendritina rangi d'Orbigny in Fornasini, 1904
Fabianina cassis (Oppenheim, 1896)
Haymanella huberi (Henson, 1950)
Kuphus Guettard 1770
Lituonella roberti Schlumberger, 1905
Miogypsinoides complanatus (Schlumberger 1900)
Neorotalia lithothamnica (Uhlig 1886)
Neorotalia viennoti (Greig) 1935
Nummulites fabianii (Prever in Fabiani, 1905)
Nummulites fichteli Michelotti, 1841
Nummulites vascus Joly & Leymerie 1848
Penarchaias glynnjonesi (Henson, 1950)
Peneroplis damesini Henson 1950
Peneroplis dusenburyi Henson, 1950
Peneroplis elegans d'Orbigny, 1839
Peneroplis evolutus Henson, 1950
Peneroplis farsensis Henson, 1950
Peneroplis flabelliformis Sirel & Özgen-Erdem in Sirel, Özgen-Erdem & Kangal, 2013
Peneroplis honestus Todd et Post, 1954
Peneroplis laevigatus d'Orbigny in Fornasini, 1904
Peneroplis peramplus n. sp.
Peneroplis thomasi Henson, 1950
Praebullalveolina minuta Sirel & Özgen-Erdem in Sirel, Özgen-Erdem & Kangal, 2013
Praebullalveolina oligocenica Sirel & Özgen-Erdem in Sirel, Özgen-Erdem & Kangal, 2013
Praerhapydionina cubana van Wessem, 1943
Praerhapydionina delicata Henson, 1950
Risananeiza pustulosa Boukhary, Kuss and Abdelraouf, 2008.
Schlumbergerina alveoliniformis (Brady 1879)
Silvestriella tetraedra (Gümbel, 1870)
Sivasina egribucakensis Sirel & Özgen-Erdem in Sirel, Özgen-Erdem & Kangal, 2013
Spiroclypeus blanckenhorni Henson, 1937
Spirolina austriaca d'Orbigny, 1846
Spirolina cretacea Tronchetti & Grosheny, 1993
Spirolina cylindracea (Lamarck, 1804)
Spirolina farsiana Schlagintweit & Rashidi, 2016
Spirolina pedum d'Orbigny, 1850
Spirolina semilituus (Linnaeus, 1758)
Spirolinella n. gen.
Spirolinella emmae n. sp.

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