

Periloculina (?) *decastroi* n. sp., a new foraminifer from the Eocene (uppermost Ypresian - lowermost Lutetian) Trentinara Formation (southern Apennines, Italy)

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KEY WORDS - *Periloculina* (?) *decastroi* n. sp., *Trentinara Formation*, *southern Apennines*, *Spirolina Facies*, *Eocene*, *Ypresian*, *Lutetian*.

ABSTRACT - A new species, *Periloculina* (?) *decastroi* is described from a restricted shallow water facies (*Trentinara Formation*) of the southern Apennines, Tyrrhenian side. It was collected from a succession located near Lauria (Potenza, Basilicata, southern Italy). The megalospheric form shows an early quinqueloculine stage followed by a triloculine one, later tending to become biloculine. No monoloculine stage was observed. The microspheric form is very rare. Thickening of the endoskeletal basal layer gives rise to rough ribs, that usually reach the chamber roof. The aperture is simple and provided with a tooth; a multiple one (trematophorate aperture?) may occur sometimes in the ultimate adult chambers. The new species was found in the upper part of the *Trentinara Formation* (uppermost Ypresian-lowermost Lutetian).

RIASSUNTO - [*Periloculina* (?) *decastroi* n. sp., un nuovo foraminifero dell'Eocene (Ypresiano terminale-Luteziano basale) della Formazione di Trentinara (Appennino meridionale, Italia)] - I depositi carbonatici paleogenici di mare basso a circolazione ristretta dell'area tetidea sono caratterizzati da una peculiare facies a foraminiferi porcellanacei (Facies a *Spirolina*), rappresentata nell'Italia meridionale dai calcari della Formazione di Trentinara (Ypresiano-Luteziano inferiore). Lo studio di numerose successioni stratigrafiche di questa facies ha portato al riconoscimento di numerosi Rotaliidi, Epistomariidi, Discorbidi, Alveolinidi, foraminiferi conici agglutinanti (Valvulinidi, Chrysalidinidi, Orbitolinidi), Peneroplidi e Fabulariidi. Viene qui illustrata una nuova specie attribuita dubitativamente al genere *Periloculina*, proveniente da una serie stratigrafica campionata nei pressi di Lauria (Potenza, Basilicata). *Periloculina* (?) *decastroi* n. sp. mostra, nella forma macrosferica, un avvolgimento dello stadio iniziale quinqueloculino, seguito da giri triloculini e successivamente biloculini. Non è mai stato osservato nell'adulto lo stadio monoloculino finale caratteristico del genere. Gli ispessimenti dello strato basale originano coste irregolari che raggiungono il tetto della camera; esse compaiono già nello stadio triloculino. L'apertura è generalmente unica, provvista di dente, ma nelle ultime logge di alcuni esemplari di maggiori dimensioni sembra essere multipla; dubbia è la presenza del trematoforo. *Periloculina* (?) *decastroi* n. sp. è presente nella parte alta della Formazione di Trentinara, in sedimenti riferibili all'Eocene inferiore-medio (Ypresiano terminale - Luteziano basale).

INTRODUCTION

In the Tethyan area, Paleogene shallow-water limestones, referring to a restricted circulation shelf environment, are characterized by a peculiar porcelaneous foraminiferal association ("*Spirolina* Facies" Auctt., "Faciès à imperforés" *sensu* Fleury, 1997) belonging to the *Trentinara Formation* (Selli, 1962), referred to Lower Eocene-Lowermost Middle Eocene (Vecchio, 2003). The *Trentinara Formation* occurs along the Tyrrhenian side of the southern Apennines, from south of the Sele River (Campania region) to the Pollino Massif (northern Calabria). It attains variable thickness from a few meters (e.g. Alburni Mts., Barattolo & Vecchio, 2001a) up to 125 meters (e.g. Capaccio Vecchio, Sartoni & Crescenti, 1962). The strata usually consist of wackestone-packstone, light brownish to dark grey, in beds 20-40 cm thick, alternating with green clays, containing in

places calcareous nodules. This formation disconformably overlies Mesozoic (Senonian) shelf carbonates and is overlain in disconformity by the Lower Miocene deposits of the *Roccadaspide Formation* (Barattolo & Parente, 1991). In the southernmost outcrops, the latter formation is substituted by the *Cerchiara Formation*. The macroforaminifer structural analysis from several stratigraphic successions of the *Trentinara Formation* (Vecchio, 2003) revealed the presence of many taxa, among which rotaliids, epistomariids, discorbids, alveolinids, conical-imperforate foraminifera (valvulinids, chrysalidinids, orbitolinids), peneroplids and fabulariids. The present paper describes a new species of the fabulariid genus, dubiously ascribed to *Periloculina*; the new taxon, first recorded by Sartoni & Crescenti (1962) as *Periloculina raincourtii* Schlumberger, occurs in the upper part of the *Trentinara Formation*.

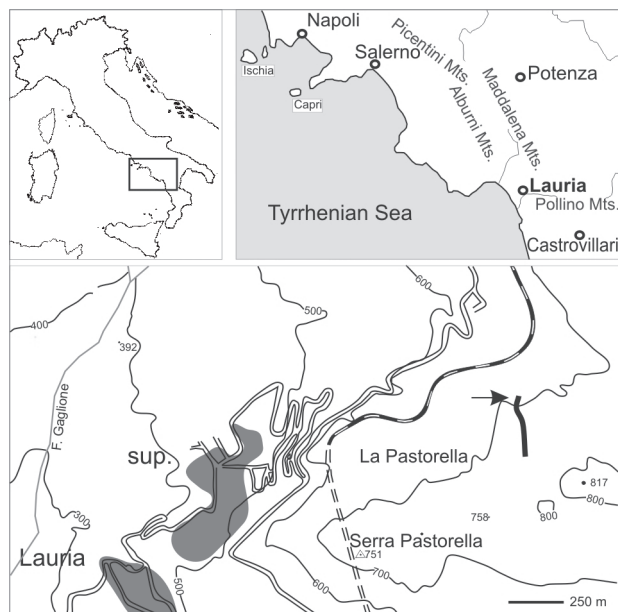


Fig. 2 - Stratigraphic section of Serra Pastorella (Basilicata) showing the position of *Periloculina* (?) *decastroi* n. sp.; A, B, C, and D: stratigraphic intervals. SBZ: Shallow Benthic Zones (Serra-Kiel et al., 1998).

Given the presence of *Alveolina stipes* Hottinger (1960) in the *Alveolina* assemblage, interval D could be referred to the Lower Lutetian (*Alveolina stipes* zone, SBZ 13); consequently, the sediments immediately below, containing the new species *Periloculina (?) decastroi*, could be referred to the uppermost Ypresian-lowermost Lutetian. Intervals A, B, and C may be ascribed to the Ypresian.

MATERIAL AND METHODS

The studied material is represented by dark brown packstone-grainstone coming from the bed marked in the field with the number 14; ninety-seven thin sections, labelled with the collection number BA 1703 (BA 1703.1 - BA 1703.97) were obtained.

Terminology of sections

Munier-Chalmas & Schlumberger (1885) were the first to assess the terminology adopted for miliolid sections, defining the *construction axis* as that passing across both the last apertural pole and the proloculus; it is conventionally placed vertically and directed upward (NM axis in Munier-Chalmas & Schlumberger, 1885 = y axis). The *coiling axis* is placed horizontally (IH axis of Munier-Chalmas & Schlumberger, 1885 = x axis). The sections perpendicular and parallel to the

construction axis are named *transversal* and *longitudinal*, respectively, by the two authors. Drobne (1984) defined as *axial section*, *equatorial section*, and *equatorial plane*, respectively, those along the IH/AB, AB/NM, and IH/NM couples of axes.

The terminology adopted in the present paper is modified as follows (Fig. 3):

a) the NM axis is indicated here as *apertural axis* (Drobne, 1974);

b) in the biloculine forms, also a *plane of symmetry* is recognized, which corresponds to the *equatorial section*: it is orthogonal to the coiling axis and includes the apertural axis; therefore the AB axis of Munier-Chalmas & Schlumberger, 1885 (= z axis) is indicated here as *symmetry axis*;

c) because all the sections passing along the coiling axis are, in terms, axial sections, then that passing through the coiling and the symmetry axis and perpendicular to the apertural axis is indicated as the *horizontal axial section*; instead, that passing through the coiling and apertural axes, corresponding to the "equatorial plane" *sensu* Drobne (1984), is indicated as the *vertical axial section*. All sections cutting obliquely at least one of the three axes are named *oblique sections*. However, a part of them may be more precisely defined. Axial sections intermediate between the horizontal and the vertical axial sections are defined as *oblique axial sections*. Sections passing through the apertural axis

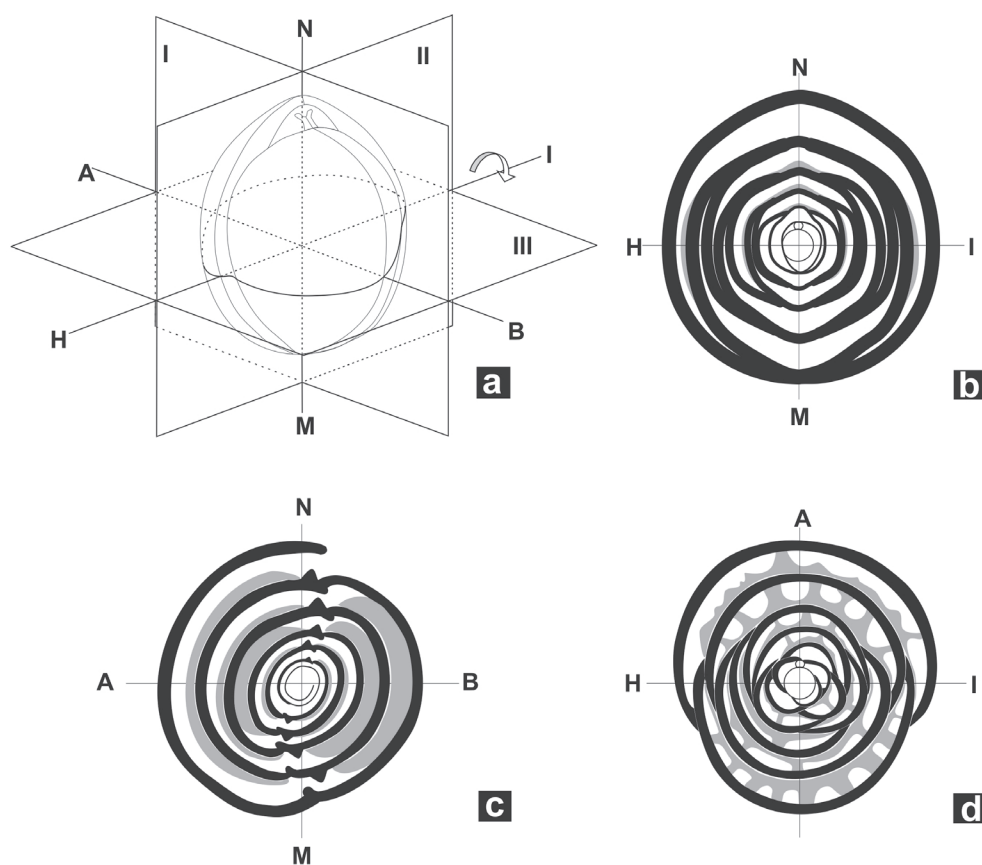


Fig. 3 - *Periloculina (?) decastroi* n. sp. Axes and planes of reference. a - NM: apertural axis along the apertural poles; IH: coiling axis; AB: symmetry axis. I: symmetry plane containing the equatorial section; II: vertical axial plane; III: horizontal axial plane; b - vertical axial section; c - equatorial section; d - horizontal axial section.

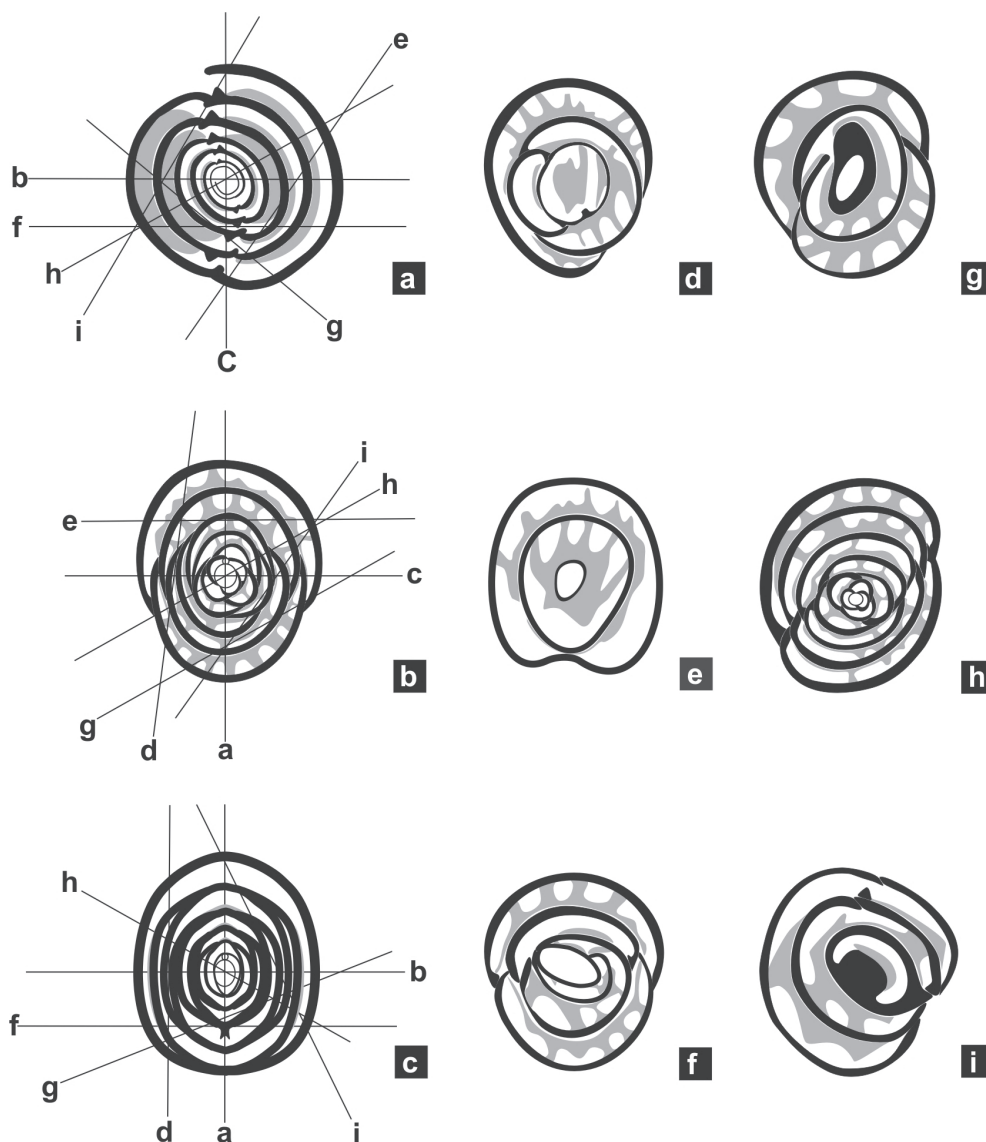


Fig. 4 - Main types of section in *Periloculina* (?) *decastroi*. a - equatorial section; b - horizontal axial section; c - vertical axial section; d - tangential oblique section parallel to the apertural axis; e - tangential section parallel to the coiling axis; f - horizontal section; g - oblique section; h - oblique section cutting the proloculus; i - oblique section.

and intermediate between the equatorial section and the vertical axial section are defined as *oblique vertical sections*. Those passing through the symmetry axis (AB) and intermediate between the equatorial section

and the horizontal axial section are here indicated as *oblique symmetrical sections*. The term *vertical section* is restricted to the sections parallel to the apertural axis, while the term *horizontal section* is applied to sections

EXPLANATION OF PLATE 1

Periloculina (?) *decastroi* n. sp.; fig. 13, holotype; figs. 1-12, 14-21 paratypes; uppermost Ypresian-lowermost Lutetian, Serra Pastorella (Lauria), Trentinara Formation, x 30.

figs. 1-13 - Horizontal axial sections.

1 - Small specimens showing throughout a miliolid arrangement of chambers. Note the early quinqueloculine stage; BA 1703.90. 2 - Note the longitudinal ribs in the quinqueloculine stage; BA 1703.57. 3 - BA 1703.1. 4 - BA 1703.7. 5 - BA 1703.8. 6 - Microspheric form. Note the fine structure of all the elements and the small test-size (incomplete specimen?); BA 1703.42. 7 - BA 1703.59. 8 - BA 1703.93. 9 - BA 1703.40. 10 - BA 1703.44. 11 - BA 1703.6. 12 - BA 1703.6. 13 - BA 1703.58.

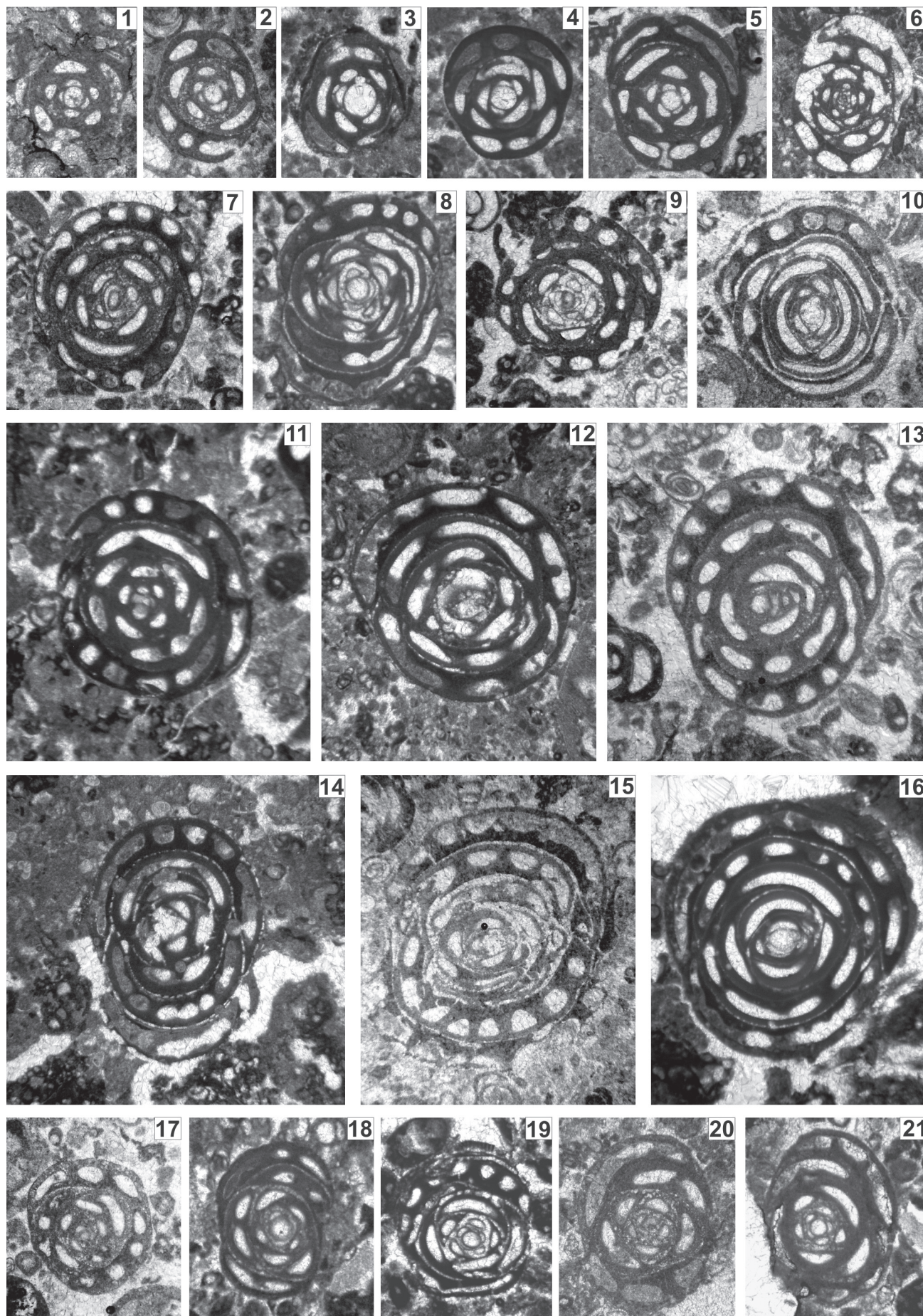
fig. 14 - Oblique axial section; BA 1703.9.

figs. 15-16 - Horizontal axial sections.

15 - Note the coiling poles slightly depressed; BA 1703.29. 16 - BA 1703.11.

figs. 17-21 - Oblique sections cutting the proloculus.

17 - BA 1703.25. 18 - BA 1703.93. 19 - BA 1703.86. 20 - BA 1703.82. 21 - BA 1703.93.



parallel to the coiling axis. The main types of sections are drawn in Fig. 4, where the specimens follow the standard enlargements adopted by Drobne (1984, 1985).

SYSTEMATIC PALAEONTOLOGY

Order FORAMINIFERIDA Eichwald, 1830

Suborder MILIOLINA Delage and Hérouard, 1896

Superfamily MILIOLACEA Ehrenberg, 1839

Family FABULARIIDAE Ehrenberg, 1839, emended by Drobne, 1984

Genus *Periloculina* Munier-Chalmas & Schlumberger, 1885

Type species: *Periloculina zitteli* Munier-Chalmas & Schlumberger, 1885

Periloculina (?) *decastroi* n. sp.
(Pls. 1-4)

1962 *Periloculina raincourti* Schlumberger - SARTONI & CRESCENTI, Tav. 52, Figs. 1-2.

Origin of the name - The new species is dedicated to Prof. Piero De Castro, Department of Earth Sciences, University of Naples Federico II, for his contributions to micropaleontology of the Meso-Cenozoic carbonate platform facies.

Holotype - Megalospheric specimen in axial section illustrated in Pl. 1, fig. 13. Thin section BA.1703.15.

Paratypes - Specimens of the sample BA.1703 and relative thin sections (BA.1703.1 - BA.1703.97) illustrated in Pls. 1-4.

Depository - Department of Earth Sciences, University of Naples Federico II (Barattolo collection).

Type locality - Serra Pastorella, about 1.5 km east of Lauria (Basilicata, southern Italy) at 680 m a.s.l. (see Fig. 1). Kilometric coordinates: Long. = 572.80 km; Lat. = 4433.88 km (datum WGS84, Projection NUTM33).

Type level - Uppermost Ypresian - lowermost Lutetian (Lower-Middle Eocene).

Type material - Brown to dark grey packstone-grainstone containing *Periloculina* (?) *decastroi* n. sp., *Peneroplis dusemburyi*, *Spirolina* spp., *Cincoriola* sp., *Epistomaria* sp., rotaliids, agglutinated conical foraminifera, miliolids, textulariids, nubeculariids and *Thaumatoporella* sp.

Diagnosis - Globular to ovate calcareous imperforate porcelaneous test, of medium size. The megalospheric form shows an early quinqueloculine stage followed by a triloculine one, later tending to become biloculine. The endoskeleton consists of a basal thickening of the wall (basal layer) appearing at least in the triloculine stage forming longitudinal ribs, which normally touch the chamber roof. The chamber lumen is therefore subdivided. Single aperture with a tooth; in the final chambers of the largest specimens a multiple aperture (trematophore?) possibly occurs. The very rare microspheric forms are characterized by a thinner wall as well as finer ribs.

Description - Megalospheric form: Test calcareous imperforate, porcelaneous, of medium size, globular to ovoid in shape. The spherical proloculus, 120-190 µm in diameter, is provided with a flexostyle extending for a quarter of a whorl. Initial quinqueloculine stage formed by 7-8 chambers, followed by triloculine stage with about 6 chambers and later by the biloculine stage with 2-4 chambers, where the subsequent chamber covers the preceding one, for half a coil. In some specimens, the triloculine stage is the last to be observed, while no biloculine stage is ever reached (Pl. 1, figs. 1-3). The number of chambers per whorl seems slightly less than two (1.9). None of the specimens in the adult stage shows clear evidence of chambers embracing previous ones (monoloculine stage, *sensu* Drobne, 1984). Their presence, however cannot be excluded with certainty; consequently, the new species is referred doubtfully to *Periloculina*. The axial diameter measures 0.7-1.4 mm. The coiling poles are sometimes slightly depressed and form two umbilici (Pl. 1, figs. 8, 14-15) that can be seen also in the oblique sections (Pl. 2, fig. 8; Pl. 3, fig. 20). The endoskeleton consists of thickening of the basal layer that normally

EXPLANATION OF PLATE 2

Periloculina (?) *decastroi* n. sp., paratypes, uppermost Ypresian-lowermost Lutetian, Serra Pastorella (Lauria), Trentinara Formation, x 30.

figs. 1-13 - Oblique sections cutting the proloculus.

1 - BA 1703.47. 2 - BA 1703.25. 3 - BA 1703.5. 4 - BA 1703.66. 5 - BA 1703.40. 6 - BA 1703.49. 7 - BA 1703.10. 8 - BA 1703.59. 9 - BA 1703.36. 10 - BA 1703.15. 11 - BA 1703.57. 12 - BA 1703.73. 13 - BA 1703.47.

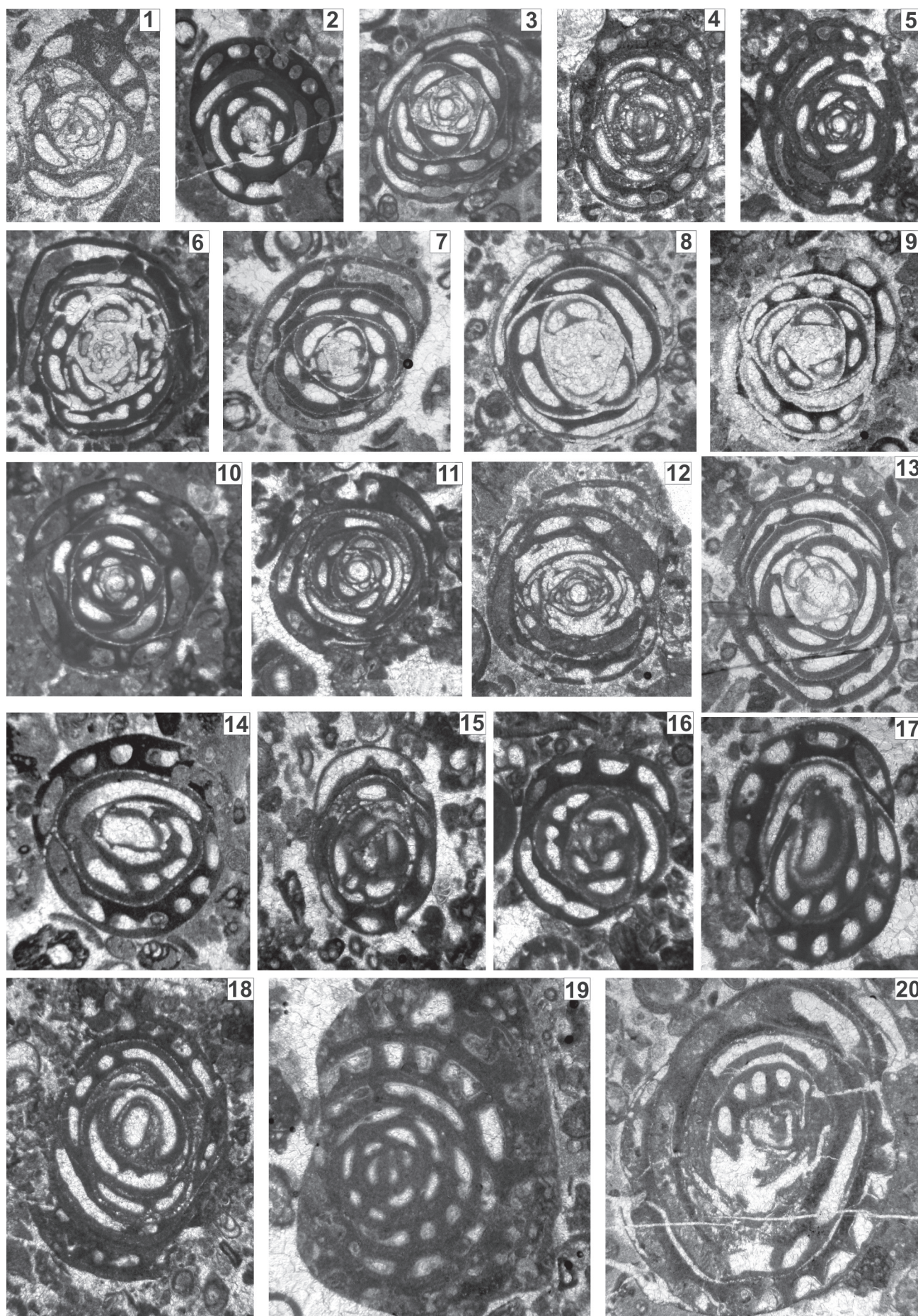
figs. 14, 16 - Horizontal section.

14 - BA 1703.56. 16 - BA 1703.93.

fig. 15 - Oblique section cutting parallel to the coiling axis; BA 1703.54.

figs. 17-20 - Oblique sections.

17 - BA 1703.18. 18 - BA 1703.66. 19 - BA 1703.37. 20 - BA 1703.39.



protrudes towards the chamber roof to form parallel longitudinal ribs (Pl. 4, fig. 3). It appears at least in the triloculine stage, persists up to the last whorl and shows a constant thickness, both within the chamber and from one chamber to the other. These ribs are tapered outwards and touch the chamber roof; consequently the chamber lumen in axial section seems to be subdivided into a row of chamberlets. The chamberlet lumen is 0.13-0.33 mm wide (measured in the axial section in the middle part) and shows a fairly regular outline that has an elongated to laterally compressed semielliptical shape, whose flattened part corresponds to the roof chamber. The ribs are 0.06-0.13 mm thick (measured in the axial section in the middle part). Examples of a quinqueloculine stage where the basal layer protrudes towards the chamber roof have been recorded (Pl. 1, fig. 2). The basal layer of some specimens becomes more and more irregular in the last biloculine whorl, and sometimes it does not reach the chamber roof (Pl. 1, figs. 15-16). Several specimens in the equatorial (Pl. 3, fig. 5) and vertical sections (Pl. 3, fig. 9) show evidence of a single aperture with a tooth. While rare specimens (e.g. Pl. 4, fig. 9) in vertical axial sections exhibit the bifid shape of the tooth. The tooth persists at least until the penultimate whorl (see Pl. 3, fig. 9). A multiple aperture (a trematophore is not to be excluded) seems to occur in one specimen only, in horizontal oblique section (Pl. 4, fig. 7). The test is externally ornamented by fine longitudinal ribs (Pl. 4, figs. 10-11).

Microspheric form: Only one specimen has been actually recognized as a microspheric form (Pl. 1, fig. 6). It displays a thinner test as well as finer ribs with respect to megalospheric forms. The pluriloculine early stage is followed by a single biloculine whorl, with ribs touching the chamber roof. The microspheric adult stage is unknown.

Comparisons - The new taxon differs from other *Periloculina* species in the persistence of a single aperture with a tooth until the adult stage; the trematophorate aperture possibly occurs only in the last chamber of the adult stage. *Periloculina* (?) *decastroi* n. sp. also differs in having a well-developed

pluriloculine stage in the megalospheric form and in lacking the monoloculine one.

Periloculina (?) *decastroi* n. sp. differs from *Periloculina zitteli* Munier-Chalmas & Schlumberger, 1885 (Cretaceous, Turonian-Santonian) in its basal layer, which always reaches the chamber roof; the early stage is quinqueloculine in the former species and biloculine in the latter.

It also differs from *Periloculina slovenica* Drobne, 1974 (Paleocene, Thanetian, SBZ 3) in its considerably smaller size, as well as in the smaller proloculus and in its basal layer, which always reaches the chamber roof.

The new taxon shows a number of ribs per chamber higher than in the case of *Periloculina ovalis* Rahaghi, 1983 (= *P. persica* Rahaghi, 1983 and *P. minuta* Rahaghi, 1983, according to Drobne 1988, Lower Eocene, Ilerdian, SBZ 5-6), and ribs touch the chamber roof. Finally a quinqueloculine early stage occurs in *Periloculina* (?) *decastroi*, while a biloculine early stage is present in *P. ovalis*.

With respect to *Periloculina dalmatina* Drobne, 1985 (Lower Eocene, Cuisian, SBZ 10-11), it is considerably smaller and has ribs reaching the chamber roof.

Periloculina (?) *decastroi* n. sp. differs from *Periloculina raincourtii* Schlumberger, 1905 (Middle Eocene, Bartonian, SBZ 17) in its smaller proloculus and in its basal layer with uniform thickness, thus reaching the chamber roof and forming larger chamberlets.

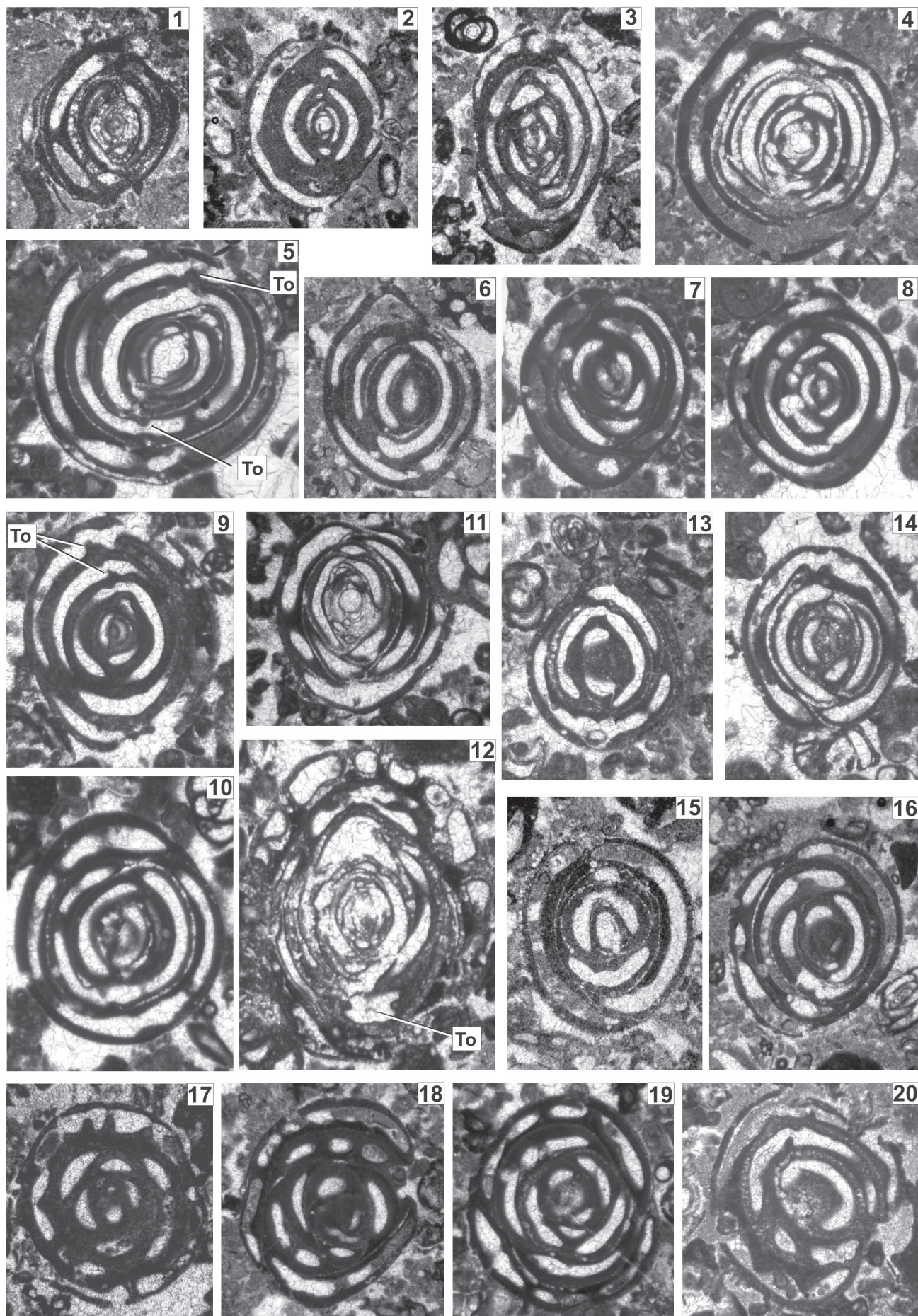
Periloculina drobnae Rahaghi, 1989, from the Campanian of Ilam Formation (Iran), shows a planispiral arrangement; therefore, it is not considered here.

Some horizontal axial section of *Periloculina* (?) *decastroi* n. sp. shows a certain degree of similarity with that of *Helenalveolina* Hottinger et al. (1989), but the new taxon differs from this Cretaceous alveolinid in showing a single aperture with a tooth until the adult stage, instead of a broad, elongate slit with notched margin, and a miliolid chamber arrangement (two chambers per whorl) instead of a steptospiral chamber arrangement with up to five chambers per whorl.

EXPLANATION OF PLATE 3

Periloculina (?) *decastroi* n. sp., paratypes, uppermost Ypresian-lowermost Lutetian, Serra Pastorella (Lauria), Trentinara Formation, x 30. To = tooth.

- figs. 1-5 - Equatorial to subequatorial sections.
 1 - BA 1703.85. 2 - Ovoidal specimen; BA 1703.36. 3 - Ovoidal specimen; BA 1703.45. 4 - BA 1703.25. 5 - BA 1703.1.
 figs. 6-10 - Vertical sections cutting more or less parallel to the symmetry axis.
 6 - Ovoidal specimen; BA 1703.30. 7 - Ovoidal specimen; BA 1703.11. 8 - Ovoidal specimen; BA 1703.13. 9 - Ovoidal specimen. Note the tooth that persists at least until the second-last whorl; BA 1703.60. 10 - BA 1703.7.
 figs. 11-12 - Vertical axial sections.
 11 - BA 1703.46. 12 - The thin structure can be interpreted as a bifid tooth; BA 1703.60.
 figs. 13-16 - Vertical sections nearly parallel to the coiling axis.
 13 - BA 1703.57; 14 - BA 1703.55; 15 - BA 1703.35; 16 - BA 1703.60.
 figs. 17-20 - Oblique sections.
 17 - Subspherical specimen; BA 1703.97. 18 - Subspherical specimen; BA 1703.26. 19 - Subspherical specimen; BA 1703.2. 20 - Note the coiling poles slightly depressed; BA 1703.74.



Stratigraphic position - *Periloculina* (?) *decastroi* n. sp. occurs in the upper part of the Trentinara Formation, at the top of the C interval (see Fig. 3). The following interval, D, contains a rich association of *Alveolina* species (Vecchio, 2003) characteristic of the Lower Lutetian (*Alveolina stipes* zone, SBZ 13). According to the associated fauna in the C and D intervals, the bed containing *Periloculina* (?) *decastroi* n. sp. can be attributed to the uppermost Ypresian-lowermost Lutetian. Considering the whole stratigraphic distribution of the various species of the genus *Periloculina* (Fig. 5), the range of the new species overlaps that of *Periloculina dalmatina* Drobne, 1985.

CONCLUSIONS

According to biozonation based on alveolinids (*Alveolina stipes* zone, SBZ 13, Lower Lutetian) which crop out immediately above, *Periloculina* (?) *decastroi* n. sp. occurs in the uppermost Ypresian-lowermost Lutetian sediments. The study of the present taxon allows us to enrich the still incomplete biostratigraphical scheme of the Eocene Trentinara Formation. From a structural point of view, *Periloculina* (?) *decastroi* n. sp. opens up some questions.

The fact that the endoskeletal ribs are regularly arranged and well developed, so that they usually divide the chamber lumen into chamberlets, appears to be an advanced evolutionary character, but it occurs in a species of relatively small size. Moreover, the ribs already appear in the early pluriloculine stage (Pl. 1, fig. 2). On the other hand, the quinqueloculine and triloculine early stages in the megalospheric form are characteristically present in the new species; this fact seems to be ancestral rather than innovative, as confirmed by the presence of a single aperture provided by a tooth in most of the chambers. *Periloculina* (?) *decastroi* n. sp. is a species occurring in a flourishing period for the genus, but containing a mixture of both primitive and innovative characters.

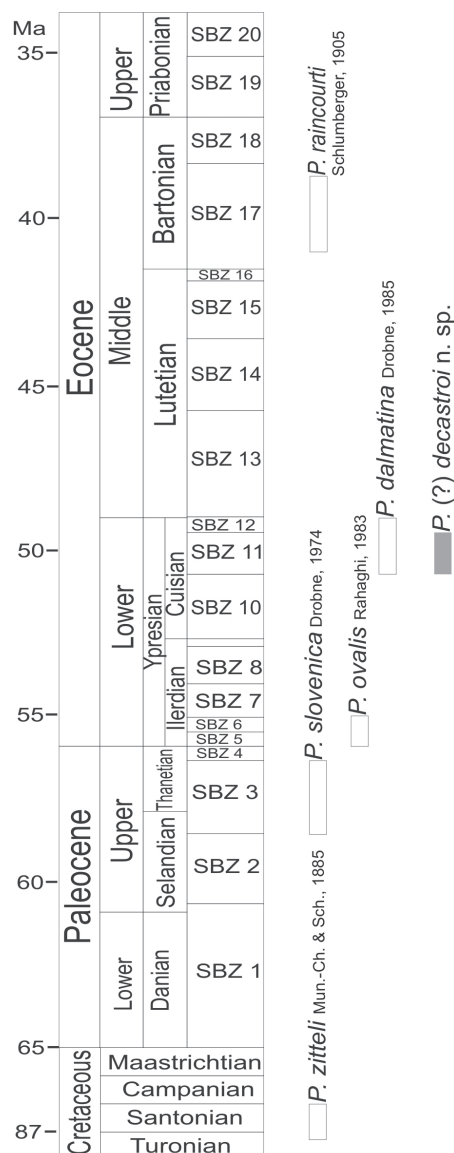
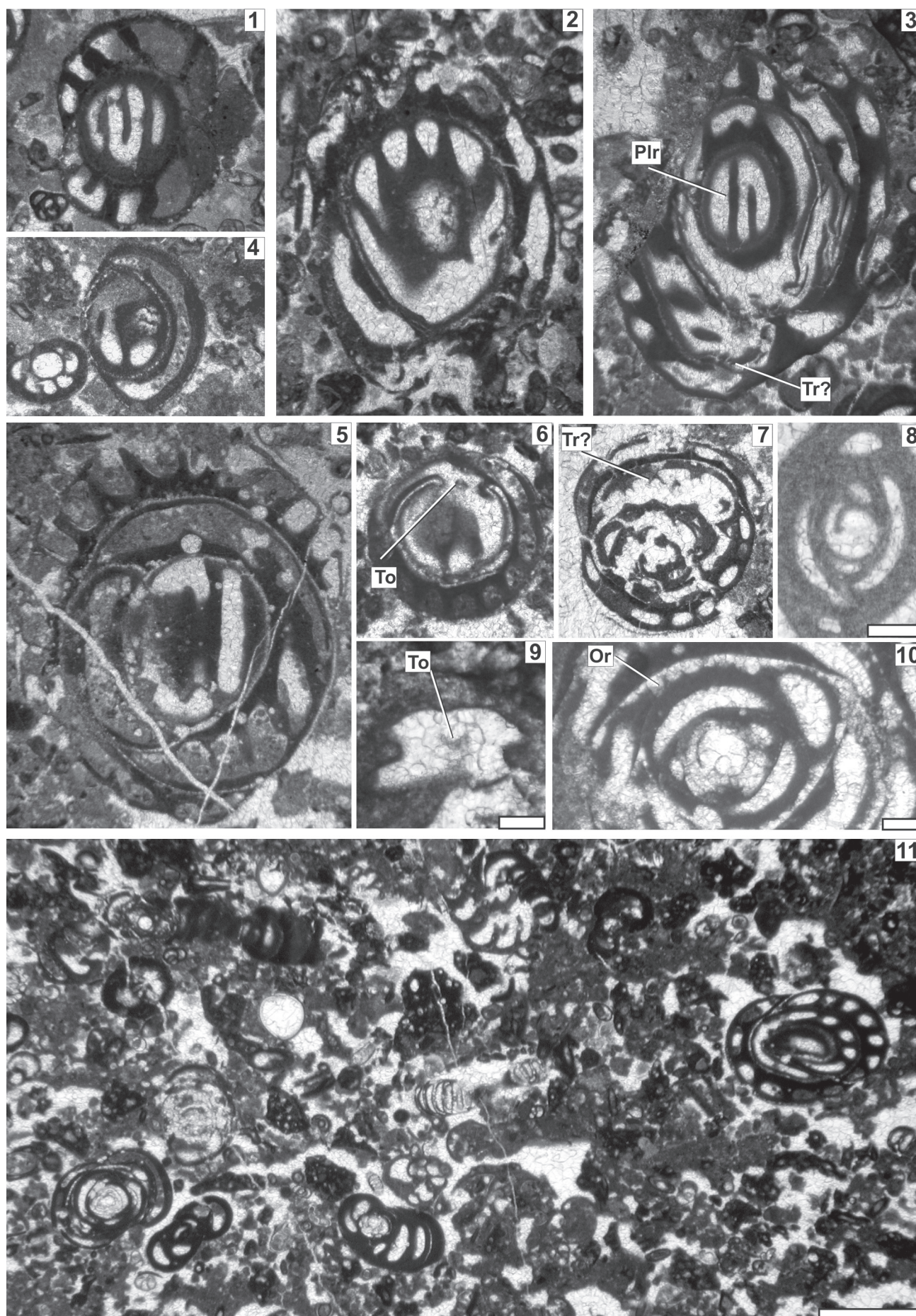


Fig. 5 - Stratigraphical distribution of *Periloculina* species (see Drobne et al., 2002). SBZ: Shallow Benthic Zones after Serra-Kiel et al. (1998). Chronostratigraphic correlation after Aubry et al. (2002); Pujalte et al. (2003); Dupuis (2004).

EXPLANATION OF PLATE 4

figs. 1-10 - *Periloculina* (?) *decastroi* n. sp., paratypes, uppermost Ypresian - lowermost Lutetian, Serra Pastorella (Lauria), Trentinara Formation, x 30 except figs. 8-10, where scale bar = 0.1 mm. Plr = parallel longitudinal ribs; Tr = trematophore; To = tooth; Or = ornamentation.

- figs. 1-3 - Tangential sections parallel to the coiling and apertural axes. Note the parallel longitudinal ribs growing up from the basal layer.
1 - BA 1703.2. 2 - BA 1703.2. 3 - BA 1703.57.
- figs. 4-5 - Tangential oblique sections parallel to the apertural axis.
4 - BA 1703.28. 5 - BA 1703.10.
- fig. 6 - Horizontal section showing the aperture partially closed by a tooth; BA 1703.75.
- fig. 7 - Horizontal oblique section probably cutting the aperture. The several bifid elements are interpreted as multiple opening sections (trematophorate structure?); BA 1703.44.
- fig. 8 - Detail of Pl. 3, fig. 2, showing the megalosphere provided by a flexostyle; BA 1703.36.
- fig. 9 - Detail of Pl. 3, fig. 12, showing probably the bifid tooth; BA 1703.60.
- fig. 10 - Detail of Pl. 3, fig. 4, showing the ornamentation constituted by longitudinal fine ribs; BA 1703.25.
- fig. 11 - Microfacies containing *Periloculina* (?) *decastroi* n. sp., *Spirolina* sp., conical agglutinated foraminifera; uppermost Ypresian-lowermost Lutetian, Serra Pastorella (Lauria), Trentinara Formation; BA 1703.86. Scale bar = 1 mm.



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REFERENCES

- Aubry M.P., Ouda K.H., Depuis C., Van Couvering J.A. & the Members of the Working Group on the Paleocene/Eocene Boundary (2002). Proposal: Global Standard Stratotype-section and Point (GSSP) at the Dababiya section (Egypt) for the Base of the Eocene Series. *In* International Union of Geological Sciences. International Commission on Stratigraphy, Subcommittee on Paleogene Stratigraphy, Internal Report: 57 pp.
- Barattolo F. (1978) - Su di una nuova dasycladacea (Alghe verdi) nel Paleocene dell'Appennino Meridionale. *Bollettino della Società dei Naturalisti in Napoli*, 87: 1-36.
- Barattolo F. & Parente M. (1991). Cenozoic. *In* Field trip guide-book, 5th International Symposium on Fossil Algae, Capri, 7-12 April, 1991: 39-44.
- Barattolo F. & Romano R. (2002). *Clypeina bucuri* n. sp. and *Clypeina lucana* n. sp. (green algae, Dasycladales) from the Uppermost Paleocene (?) - Lower Eocene of Trentinara Formation (Southern Italy). *In* Bucur I.I. & Filipescu S. (eds.), Research advances in calcareous algae and microbial carbonates. Proceedings of the 4th IFAA Regional Meeting Cluj-Napoca, August 29 -September 5, 2001. Cluj University Press: 41-69.
- Barattolo F. & Vecchio E. (2001a). Stop 3: Castelcivita. *In* Field trip guide book 5th meeting of the IGCP 393 IUGS- UNESCO "Shallow water benthic communities at the Middle-Upper Eocene boundary", Southern and North-Eastern Italy, Slovenia, Croatia, Hungary, 18-31 July, 2000. *Annali dell'Università di Ferrara*, 8 [2000]: 31-34.
- Barattolo F. & Vecchio E. (2001b). Stop 4: La Pastorella (Lauria). *In* Field trip guide book 5th meeting of the IGCP 393 IUGS- UNESCO "Shallow water benthic communities at the Middle-Upper Eocene boundary", Southern and North-Eastern Italy, Slovenia, Croatia, Hungary, 18-31 July, 2000. *Annali dell'Università di Ferrara*, 8 [2000]: 34-36.
- Delage Y. & Hérouard E. (1896). *Traité de Zoologie concrète, La cellule et les Protozoaires*. Schleicher Frères, 1: 584 pp.
- Depuis C. (2004). Dababia Quarries P-E GSSP. *In* Field trip guide Fifth International Conference on "Climate and Biota of the Early Paleogene: CBEP V", Luxor, Egypt, February 8-12, 2004: 1-4.
- Drobne K. (1974). Les grandes Miliolidés des couches paléocènes de la Yougoslavie du Nord-Ouest (*Idalina*, *Fabularia*, *Lacazina*, *Periloculina*). *Razprave 4 Razreda SAZU*, 17 (3): 127-184.
- Drobne K. (1984). *Periloculina slovenica*, B form, from Paleocene of Majevica Mt. (Yugoslavia) and the new Family Fabulariidae. *Razprave 4 Razreda SAZU*, 25 (1): 1-32.
- Drobne K. (1985). *Periloculina dalmatina*, a new trematophorid miliolid from the Cuisian of Yugoslavia. *Razprave 4 Razreda SAZU*, 26: 159-176.
- Drobne K. (1988). Elements structuraux et répartition stratigraphique des grands Miliolidés de la famille des Fabulariidae. *Revue de Paléobiologie*, Vol. Spéc. 2 (2) [Benthos '86]: 643-661.
- Drobne K., Čosović V. & Robinson E. (2002). Larger miliolids of the Late Cretaceous and Paleogene seen through space and time. *Geologija*, 45 (2): 359-366.
- Ehrenberg C.G. (1839). Über die Bildung der Kreidefelsen und des Kreidemergels durch unsichtbare Organismen. *Physikalische Abhandlungen der Königlich Akademie der Wissenschaften zu Berlin*: 59-147.
- Eichwald C.E. von (1830). *Zoologia Specialis*, Vilnae, D.E. Eichwaldus, 2: 323 pp.
- Fleury J.J. (1997). Eocene soritids with ribs and/or faint sub-epidermal partitions: the genera *Spirolina*, *Praerhapydionina* and *Paraspirolina* n. gen. in the middle to upper Eocene "faciès à imperforés" of Greece. *Revue de Micropaléontologie*, 40 (4): 297-311.
- Henson F.R.S. (1950). Middle Eastern Tertiary Peneroplidae (Foraminifera), with Remarks on the Phylogeny and Taxonomy of the Family. *Thèse*, Leiden. West Yorkshire Pr. Co., Wakefield, England, 70 pp.
- Hottinger L. (1960) - Recherches sur les Alvéolines du Paléocène et de l'Eocène. *Schweizerische Palaeontologische Abhandlungen*, 75/76: 1-243.
- Hottinger L., Drobne K. & Caus E. (1989). Late Cretaceous, larger, complex miliolids (Foraminifera) endemic in the Pyrenean faunal province. *Facies*, 21: 99-134.
- Munier-Chalmas E. & Schlumberger C. (1885). Note sur les Miliolidés trématophorés. *Bulletin de la Société géologique de France*, 3 (13): 273-323.
- Pujalte P., Orue-Etxebarria X., Schmitz B., Tosquella J., Baceta J.I., Payros A., Bernaola G., Caballero F. & Apellaniz E. (2003). Basal Ilerdian (earliest Eocene) turnover of larger foraminifera: Age constraints based on calcareous plankton and $\delta^{13}\text{C}$ isotopic profiles from new southern Pyrenean sections (Spain). *In* Wing S.L., Gingerich P.H., Schmitz B. & Thomas E. (eds.), Causes and consequences of Globally Warm Climates in the Early Paleogene. *Geological Society of America Special Paper*, 369: 205-221.
- Rahaghi A. (1983). Stratigraphy and faunal assemblage of Paleocene-Lower Eocene in Iran. *National Iranian Oil Company Geological Laboratories, Teheran*, 10: 33 pp.
- Rahaghi A. (1989). The new porcellaneous foraminiferal species from the upper part of Ilam Formation (Campanian) of Costal Fars area, SW Iran. *Rivista Española de Micropaleontologia*, 21 (3): 177-187.
- Sartoni S. & Crescenti U. (1962). Ricerche biostratigrafiche nel Mesozoico dell'Appennino meridionale. *Giornale di Geologia* (Serie 2), 29: 153-302.
- Schlumberger Ch. (1905). Les Miliolidés trématophorés. *Bulletin de la Société géologique de France* (série 4), 5 (2): 115-134.
- Selli R. (1962). Il Paleogene nel quadro della geologia dell'Italia meridionale. *Memorie della Società Geologica Italiana*, 3: 737-789.
- Serra-Kiel J., Hottinger L., Caus E., Drobne K., Ferrández C., Jauhri A.K., Less G., Pavlovic 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 de France*, 169 (2): 281-299.
- Terquem O. (1882). Les foraminifères de l'Éocène des environs de Paris. *Mémoires de la Société Géologique de France* (série 3), 2 (3): 193 pp.
- Vecchio E. (2003). La "Facies a *Spirolina*" nelle successioni carbonatiche del Paleocene-Eocene dell'Italia Meridionale: paleontologia, paleoecologia e biostratigrafia delle associazioni a foraminiferi bentonici. *Ph.D. Thesis*, Università degli Studi di Napoli "Federico II": 171 pp. (unpublished).

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