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PALEOCENE TO LOWER EOCENE LARGER FORAMINIFERAL ASSEMBLAGES FROM CENTRAL ITALY: NEW REMARKS ON BIOSTRATIGRAPHY

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Abstract. We present the micropaleontological record on ongoing research on Paleogene larger foraminifers from Central Italy collected in the field work for the realization of the geological sheet 348 "Antrodoco" of the Geological Map of Italy 1:50.000 scale. The work provides an examination of the biostratigraphic potential of selected taxa with emphasis on rotaliids. *Ornatorotalia* is documented for the first time from the Paleocene. Possible new species of *Miscellanea*, *Ornatorotalia*, and *Rotalia* are figured and described in open nomenclature.

Introduction

Larger foraminifers are benthic foraminifers with large and internally complex test, generally reaching more than 2 mm in the microspheric generations, belonging to different taxonomic categories. Although characterised by considerable structural, functional, biological and ecological complexity, they represent good markers in having a limited temporal range of distribution in both specific and generic rank, and wide colonization in shallow-water environments.

The biostratigraphic potential of larger foraminifers was evident for paleontologists since the mid-nineteenth century, whereas their use for (paleo)environmental and (paleo)bathymetric interpretations was improved only since the second half of the twentieth century (e.g., Hottinger 1974). The shallow benthic biochronozones (SBZ) are routinely employed in studies on Paleocene-Eocene (Serra-Kiel et al. 1998), and Oligocene-Miocene (Cahuzac & Poignant 1997) larger foraminiferal assemblages. Unfortunately the SB zonations suffer their "oppelian" nature which needs to be revised favoring a multidiscipliary approach (e.g., integrating LF distribution with magnetostratigraphy, chronostratigraphy, plankton and nannoplankton biostratigtraphy) and the use of selected taxa of larger foraminifers (Papazzoni et al. 2017; Pignatti & Papazzoni 2017).

Research activities, carried out under the Geological Survey of Italy (ISPRA - Istituto Superiore per la Protezione e la Ricerca Ambientale), brought to collect a large amount of data about an area of the Central Italy. In the investigated area, Triassic to Miocene successions crop out; they are linked to various sedimentary environments, and are related to different geodynamic contexts.

The aim of the present contribution is to describe larger foraminiferal assemblages from the Paleocene and lower Eocene of central Italy, with special emphasis on the still poorly-known group of "rotaliids", whose systematics and biostratigraphic potential were recently summarized in the monograph by Hottinger (2014). Larger foraminifers are pivotal to identify and characterize shallow-water environments (e.g., Pignatti 1995; Tomassetti et al. 2016), but they are also a powerful instrument to investigate the biostratigraphy of deep-water settings in absence of other markers when they occur resedimented in turbiditic layers (e.g., Benedetti 2010, 2017; Benedetti & D'Amico 2012; Benedetti & Pignatti 2009, 2013; Cotton et al. 2017).

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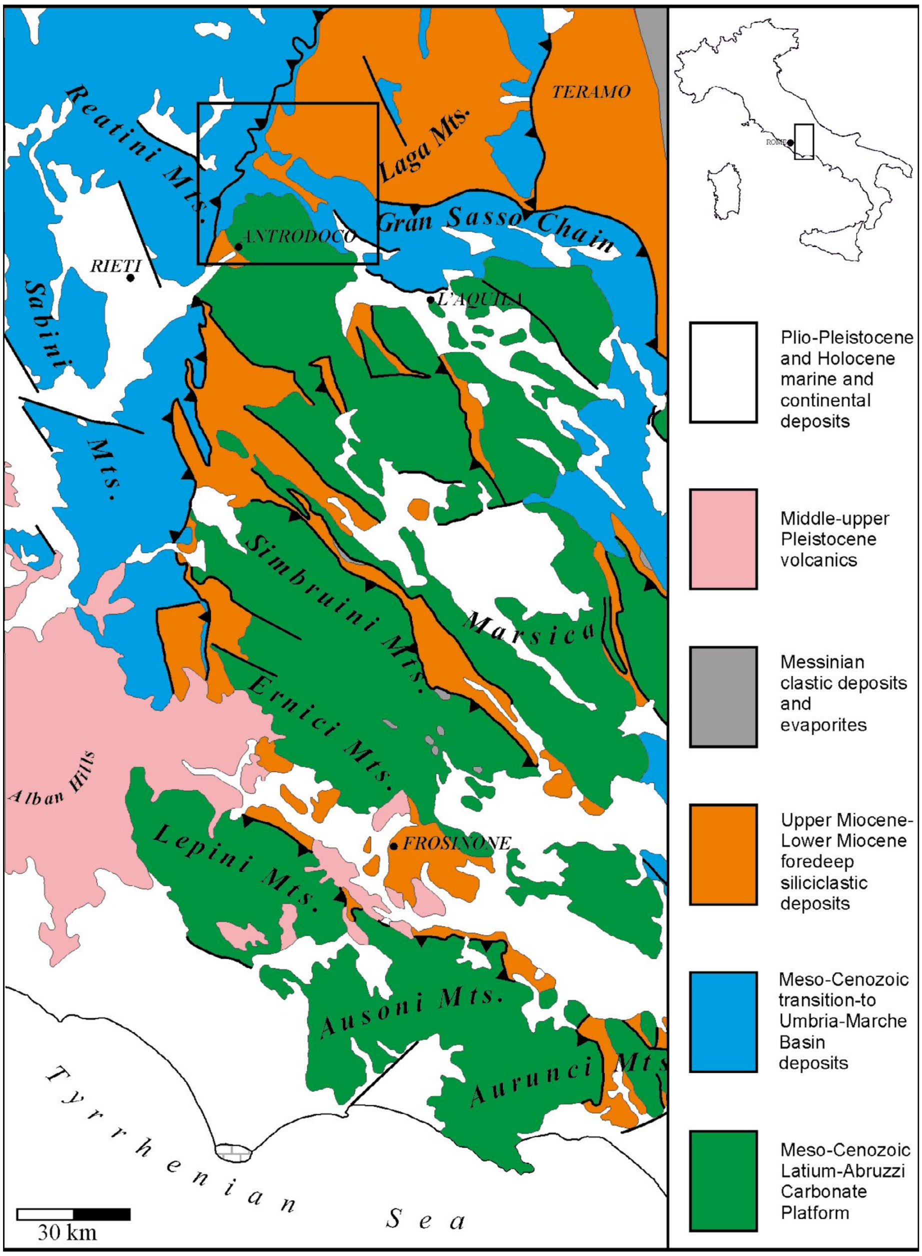

Fig. 1 - Schematic regional geological map with location of the studied area (modified and semplified after Parotto & Praturlon 2004).

Geological setting

The investigated material was collected by the geologists of the Geological Survey of Italy (ISPRA) in the latest years during the field-work for the geological mapping for the Sheet 348 "Antrodoco" of the Geological Map of Italy 1:50.000 scale (Figs 1-2). The study area pertains to the northern and central Apennines, where different pre-orogenic, mainly carbonate, successions are exposed, spanning from the Late Triassic to the late Miocene. These successions testify carbonate platform, platform-to-basin transition, and basin environments, pertaining to two main Mesozoic and Cenozoic contiguous paleogeographic domains: the Latium-Abruzzi Platform and the Umbria-Marche Basin (Fig. 1; Parotto & Praturlon 1975; Capotorti et al. 1991, 1995; Berti et al. 2012).

Carbonate platform and basinal pelagic deposits are the end-members of the Mesozoic successions of the investigated area; moreover, great amount of resedimented shallow-water material characterizes coeval deep-water sediments. These detrital facies are widely distributed in the whole "Antrodoco" sheet. In particular, the studied samples belong to the Paleogene beds of the "scaglia detritica" formation (SCZ), an informal "Scaglia"-type formation which spans from the Cenomanian to the Lutetian (e.g., Centamore et al. 2006) and is characterized by the occurrence of resedimented material, as compared to the typical "Scaglia" sediments composed exclusively by tests of planktonic organisms. Vertical and lateral variations of the facies and the thickness of the stratigraphic units document the environmental changes and synsedimentary tectonics during the evolution of the northern-central Apennines in the Mesozoic and Cenozoic (Capotorti 1993; Dela Pierre 1994; Centamore et al. 2002; Parotto & Praturlon 2004).

In the studied area, the pre-orogenic stratigraphic successions related to these domains are capped by Messinian siliciclastic syn-orogenic deposits, or directly by the more recent continental Quaternary deposits. Pliocene deposits were not observed in the sampling area during the field-work. The orogenetic Apenninic tectonics, thrusts, inverse faults, including positive inversion of previous extensional palaeostructures (Pierantoni et al. 2005; Calamita et al. 2012), and younger normal faults hamper the observation and reconstruction of the original relationships between pre-orogenic deposits.

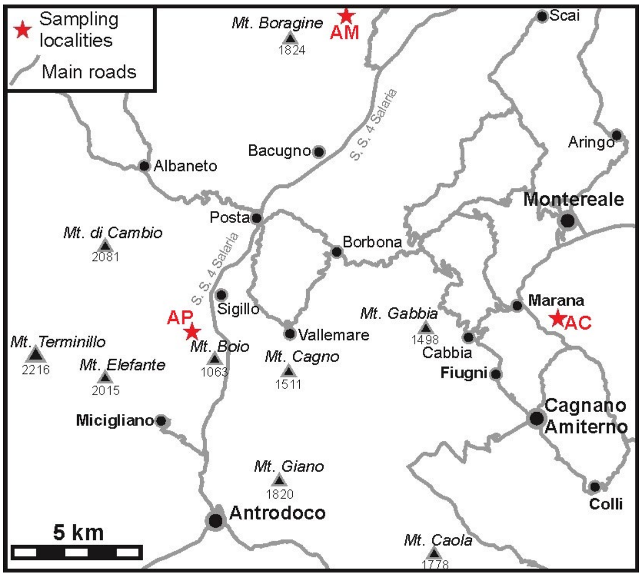

Fig. 2 - Location of the investigated samples in the studied area.

Sample	Geographic coordinates		Faunal assemblage	Biozone
	Latitude	Longitude		
AC343	42° 29' 29.5" N	13° 14' 59.3" E	*Elazigina lenticula, Cuvillierina* cf. *sireli, Glomalveolina* spp., *Discocyclina* sp. (fragments)	SBZ3
AC352	42° 29' 32.5" N	13° 13' 49" E	*Elazigina* cf. *subsphaerica, Elazigina* spp.	SBZ4?
AM9	42° 35' 43.2" N	13° 08' 11.9" E	*Slovenites decastroi, Granorotalia sublobata, Ornatorotalia granum, Rotalia* aff. *trochidiformis, Nummulites* cf. *partschi, Alveolina* spp., *Discocyclina* spp.	SBZ11
AM46	42° 35' 43.2" N	13° 08' 11.9" E	*Cuvillierina* cf. *sireli, Elazigina dienii, Miscellanea* sp.	SBZ2
AM50	42° 35' 43.2" N	13° 08' 11.9" E	*Cuvillierina vallensis, Granorotalia sublobata, Ornatorotalia granum, Ornatorotalia spinosa, Rotalia* aff. *trochidiformis, Nummulites* cf. *pratti, Nummulites irregularis, Discocyclina* spp.	SBZ11
AM52	42° 35' 43.2" N	13° 08' 11.9" E	*Granorotalia sublobata, Ornatorotalia granum, Rotalia* aff. *trochidiformis* , *Slovenites decastroi, Nummulites* cf. *partschi, Orbitoclypeus munieri munieri, Alveolina* spp., *Assilina* spp., *Discocyclina* spp.	SBZ11
AP272c	42° 28' 56.9" N	13° 04' 31.9" E	*Asterigerina* aff. *cayrazensis, Nummulites* cf. *partschi, N*. cf. *pratti, N*. ex. gr. *distans, Granorotalia sublobata, Ornatorotalia spinosa, Rotalia* aff. *Trochidiformis, Alveolina* spp., *Discocyclina* spp., *Asterocyclina* sp.	SBZ11

Tab. 1 - Schematic summary of the investigated samples with geological coordinates, larger foraminiferal assemblages and biozonal attribution.

Material and methods

The data here presented pertain to the stratigraphic analyses related to the compilation of the sheet "Antrodoco" that are still in progress; a complete Late Triassic to late Miocene stratigraphic scheme is under preparation, based on lithostratigraphy and integrated biostratigraphic analyses of algae, benthic foraminifers, benthic larger foraminifers, planktonic foraminifers, and calcareous nannofossils. However, because the geological units cropping in the area underwent different tectonic phases, sampling of continuous and thick stratigraphical sections is often impossible, and stratigraphy is reconstructed by correlating several outcrops.

This is the case for the Paleogene beds of the "scaglia detritica" formation (SCZ): the deposits are generally composed of gray/white grainstone-packstone, with intercalated light brown/gray and yellow, rarely pink wackestone. In the investigated area, they are mostly characterized by calcarenites rich in displaced larger foraminifers referred to the late Paleocene to? middle Eocene.

The tectonic deformation prevents the sampling of continuous stratigraphic successions, and meso- and microstructures pervasively affect finest wackestone beds, thus micro- and nannofossils are usually bad preserved and not useful for stratigraphic interpretations. This work focuses on some calcarenite levels cropping out in the area under investigations. The sampled lithofacies vary from bioclastic rudstone-floatstone to grainstone-packstone, generally unsorted, rich in larger foraminifers. Samples were collected in scattered outcrops in the area (Fig. 2), in order to describe larger foraminifers assemblages and to test the biostratigraphic potential of the larger foraminifers.

The studied samples are labelled and located as follows (see also Fig. 2 and Tab. 1): AC343 (13° 14' 59.3"E-42° 29' 29.5"N), AC352 (13° 13' 49"E-42° 29' 32.5"N), AM9, AM46, AM50, AM52 (13° 08' 11.9"-E42° 35' 43.2"N), AP272c (13° 04' 31.9"E-42° 28' 56.9"N).

It is noteworthy that the samples AC pertain to areas analised by Renz (1936) in his pioneering work about the stratigraphy and micropaleontology of the "Scaglia".

In the present work, a typological approach (e.g., Hottinger 2014) to taxonomic classification has been preferred respect to the biometric approach (e.g., Drooger 1993) because of the low number of individuals for each species and the assemblage composition (radial foraminifers, which require biometrical investigation, are very scarce and often in random sections). This kind of investigation allowed us to compare the single specimen with the type(s) representing the taxon and/or with previous illustrated figures published in the last decades. This implies the necessity to compare and evaluate critically a large amount of data.

The investigated foraminifers were photographed by a Nikon Coolpix 990 digital camera mounted on an optical microscope Olympus BX60. Biometrical data were measured by the vectorial software Canvas 14™. All samples are housed in the micropaleontological collection of the Italian Geological Survey (ISPRA).

Systematic paleontology

The suprageneric classification follows Loeblich & Tappan (1987, 1992) and, for Miscellaneidae and selected rotaliidae, Hottinger (2009, 2014). A detailed description is given for the genera and species with biostratigraphical relevance. Common well-known taxa, and long-ranging species are not considered in this work.

Order **Foraminiferida** Eichwald, 1830
Suborder **Rotaliina** Delage & Hérouard, 1896
Superfamily Asterigerinoidea d'Orbigny, 1839
Family Asterigerinidae d'Orbigny, 1839
Subfamily Asterigerininae d'Orbigny, 1839
Genus *Asterigerina* d'Orbigny, 1839
Type species: *Asterigerina carinata* d'Orbigny, 1839

Asterigerina aff. *cayrazensis* Sirel & Devecíler, 2017
Fig. 3.A

aff. 2017 *Asterigerina cayrazensis* Sirel & Devecíler, p. 68, pl. 1, figs 1-16.

Material: One specimen from the sample AP272c.

Stratigraphic range: *Asterigerina* aff. *cayrazensis* was found in association with *Nummulites* cf. *partschi*, *N.* cf. *pratti, N.* ex. gr. *distans*, *Granorotalia sublobata*, *Ornatorotalia spinosa*, and *Rotalia* aff. *trochidiformis,* suggesting a middle Cuisian age (SBZ11 of Serra-Kiel et al. 1998).

Description. The ventral side is much more convex than the dorsal which, in our specimen not exactly in axial section, seems completely flat. The diameter of the test measures 0.80 mm, and the thickness is 0.67 mm. The periphery is acute but without a real keel.

Remarks. Sirel & Devecíler (2017) recently described the new species *Asterigerina cayrazensis* from the late Ypresian (middle-late Cuisian) of Turkey. Our single specimen resembles those figured by Sirel & Devecíler (2017) by the huge umbilical plug and the conspicuous lamination, differing in the less pointed periphery. The middle to late Eocene species *Asterigerina rotula* (Kaufmann) resembles our specimen in the similar inequally convex test with a huge ventral side, but it also differs from *A.* aff. *cayarazensis* in having a more acute periphery. The unique individual found in the investigated material prevents the recognition of most of taxonomic characters needed for a differential diagnosis, such as number of whorls, number of chambers and stellate supplementary chamberlets and more accurate biometrical measures, thus it is left in open nomenclature.

Superfamily Nonionoidea Schultze, 1854
Family Miscellaneidae Sigal in Pivetau, 1952
Subfamily Miscellaneinae Kacharava in Rauzer-Chernoussova & Furzenko, 1959
Genus *Miscellanea* Pfender, 1935
Type species: *Nummulites miscella* d'Archiac & Haime, 1854

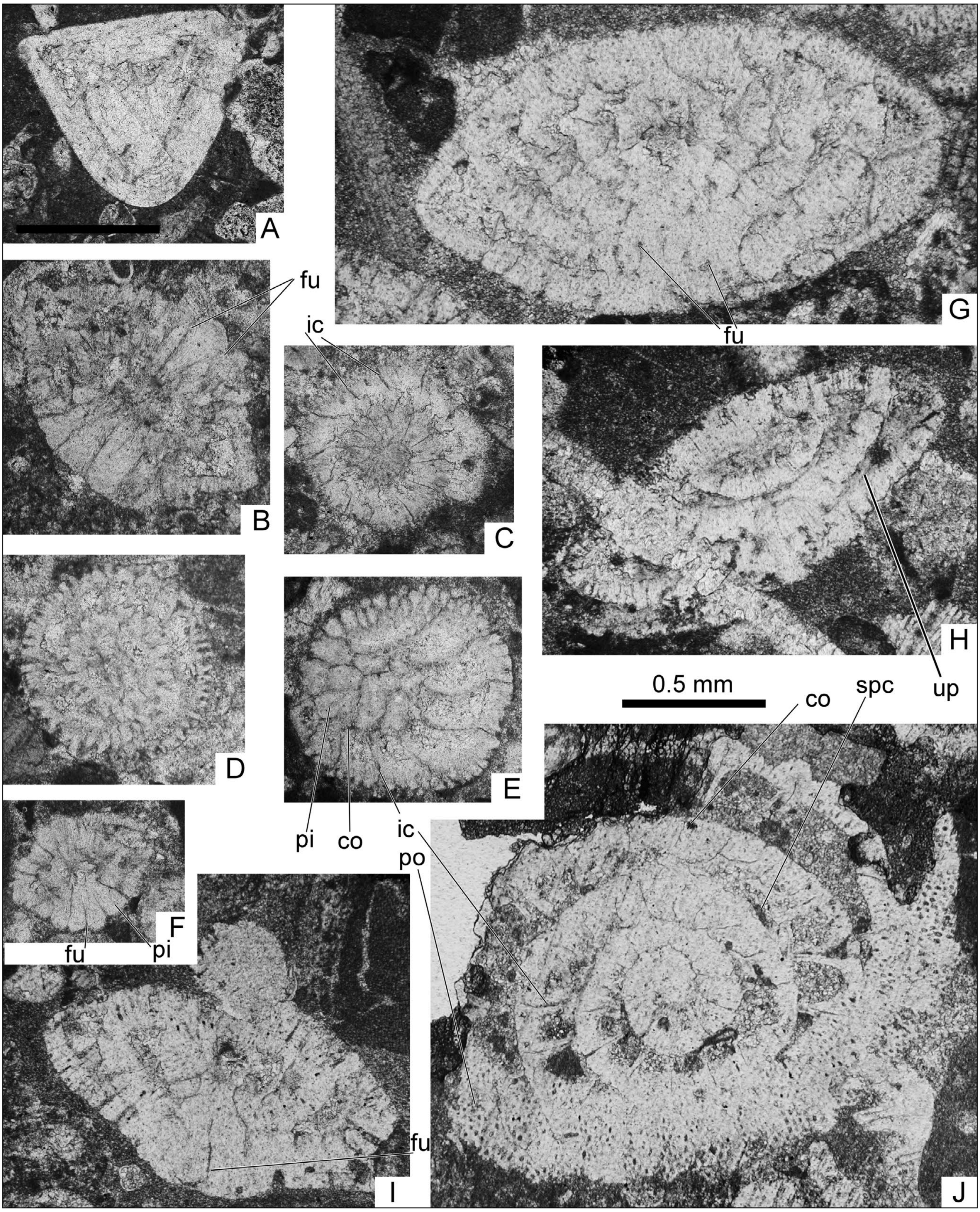

Fig. 3 - A) *Asterigerina* aff. *cayrazensis* Sirel & Deleciver, 2017, AP272c; B-F) *Miscellanea* sp. AM46 SBZ2; G-J) *Slovenites decastroi* Hottinger, 2014. G-I. AM52. J. AM9. Scale bar = 0.5 mm. co: canal orifice; fu: funnel; ic: intraseptal canal; pi: pillar; po: pores; spc: spiral canal; up: umbilical plate.

	Form (A/B)	Equatorial diameter (mm)		Axial diameter (mm) [Thickness]		Eq./ax diameter ratio		Proloculus diameter (mm)		No. of chambers in the last whorl		No. of chambers in penultimate whorl		No. of whorls
		min - Max	M	min - Max	M	min - Max	M	min - Max	M	min - Max	M	min - Max	M	
M. miscella	A	1.5 - 3.4	2.8	0.9 - 1.4	1	1.4 - 2.9	2.4	0.2 - 0.4	0.27	22 - 31	26	12 - 22	16	2.5 - 3
	B	3 - 10.1	5	1.1 - 1.4	1.2	3 - 4	3.6	0.02		26 - 40	31	20 - 32	25	6 - 7
M. juliettae	A	0.7 - 1.9		0.4 - 1.0		1-5 - 2.2		0.12 - 0.25		10 - 20		10 - 16		2 - 2.5
	B	1.5 - 3.0		0.8 - 1.4		1.6 - 2.3		-		19 - 27		13 - 20		4 - 5
M. yvettae	A	1.3 - 2.1	1.7	0.8 - 1.1	0.9	1.8 - 2.2	2	0.15 - 0.27	0.21	18 - 25	20	12 -18	14	2.5 - 3
	B	1.9 - 3.2	2.8	1.0 - 1.6	1.3	1.7 - 2-1	2	0.02		23 - 26	25	22 2- 25	23	6
M. primitivus	A	0.9 - 1.1	1	0.5 - 0.6	0.6	1.7 - 2.3	2	0.05 - 0.1	0.08	13 -1 5	14	10		2.5
	-	-		-		-		-		-		-		-
M. minutus	A	0.9 - 1.1	1	0.6 - 0.7	0.7	2.1		0.05 - 0.1	0.06	13 - 15	14	10		2.5
	-	-		-		-		-		-		-		-
M. iranicus	A	0.97 - 1.69	1.39	0.86 - 1.08	0.94	1.47 - 1.91	1.7	0.09 - 0.23	0.14	20 - 24	22	17		3
	-	-		-		-		-		-		-		-
M. agriensis	A	1.57 - 1.9	1.73	1.21		1.3		0.28 - 0.33	0.31	21		18		3 - 3.5
	B	3.28 - 3.8	3.53	-		-		-		> 25		21		5.5
M. globularis	A	0.5 - 0.92	0.73	0.52 - 0.87	0.69	0.97 - 1.18	1.07	0.03 - 0.05	0.04	14		13		2
	-	-		-		-		-		-		-		-
Miscellanea n. sp. Di Carlo et al. 2010	A	1.15 - 1.62	1.25	0.77 - 1-05	0.94	1.34 - 1.62	1.5	0.06 - 0.12	0.1	> 23		18 - 21	19	3.5
	B	1.78		1.11		-		-		33		22 - 25	24	4
Miscellanea sp. this work	A	0.67 - 1.07	0.78	0.44 - 0.73	0.60	1.10 - 1.52	1.36	0.05 - 0.09	0.07	14		11		2.5 - 3
	-	-		-		-		-		-		-		-

Tab. 2 - Biometrical values of *Miscellanea* species after Hottinger (2009), Di Carlo et al. (2010) and Leppig & Langer (2015).

Miscellanea **sp.**
Figs 3.B-3.F

Material: Six specimens in random sections from sample AM46.

Stratigraphic range: *Miscellanea* sp. occurs with *Cuvillierina* cf. *sireli* and *Elazigina dienii* suggesting a Selandian age (SBZ 2 of Serra-Kiel et al. 1998).

Description. Wall hyaline, biconvex test planispirally coiled. Both sides are strongly ornamented by numerous pillars concentrated in the central part of the test. The diameter ranges from 0.67 mm to 1.07 mm (mean: 0.78 mm, n=5) and the thickness varies between 0.44 mm and 0.73 mm (mean: 0.60 mm, n=3) with a ratio diameter/thickness of 1.36 (1.10-1.52, n=3). The small spherical megalosphere measures 68.8 µm (52.3-90.2 µm, n=3) in diameter and is followed by subrectangular chambers arranged in 2.5 to 4 whorls (mean: 3.3, n=4). 14 chambers occur in the last whorl (Table 2). The chambers seem to communicate through a single intercameral foramen.

No microspheric specimen has been found in our material.

Differential diagnosis. The biometrical comparison with other known miscellaneids is proposed in table 2. In particular comparing our specimens with the coeval taxa *Miscellanites globularis* and *Miscellanea* n. sp. of Di Carlo et al. (2010), the new miscellaneid differs from *M. globularis* in having a lenticular (not circular) shape of the test, a larger proloculus, a greater number of whorls and in lacking multiple apertures. *Miscellanea* sp. resembles *Miscellanea* n. sp. of Di Carlo et al. (2010), differing from the latter by the smaller size, the lower numbers of chamberlets in the ultimate and penultimate whorls and in the fewer number of whorls. Unfortunately, the type of material, i.e., the randomly oriented sections, the low number of specimens and the difficulty to obtain new samples, is not actually sufficient to erect a new species, and we hope that further studies on coeval material will help in the definition of a new taxon here left in open nomenclature.

Superfamily Rotaliacea Ehrenberg, 1839
Family Rotaliidae Ehrenberg, 1839
Subfamily Redmondininae Hottinger, 2014
Genus *Slovenites* Hottinger, 2014
Type species: *Slovenites pembaphis* Hottinger, 2014

Slovenites decastroi Hottinger, 2014
Figs 3.G-3.J

2003 Rotaliidae n. gen. 1. Vecchio, p. 58; pl. 7-9.
2014 *Slovenites decastroi* Hottinger, p. 49; pl. 4.6, figs. 3-10; pl. 4.7, figs. 1-12.
2016 *Slovenites decastroi* - Tomassetti et al., fig. 3.20-21.

Material: Five specimens from the samples AM52 and AM9.

Stratigraphic range: Hottinger (2014), in its tentative range chart (Hottinger 2014, fig. 1.3, p. 10), referred the species to SBZ 11-12, although in the text he added that *S. decastroi* occurs at several levels of the Monte Gargano Peninsula and of the Adriatic platform with alveolinids from SBZ 11-13 (Hottinger 2014, p. 47). Vecchio (2003) described specimens referring to *S. decastroi* in open nomenclature from the Ypresian to lower Lutetian of Southern Appennine. Tomassetti et al. (2016) figured *S. decastroi* from the lower Lutetian of Monte Porchio (Central Italy).

In our samples *S. decastroi* occurs in association with *Orbitoclypeus munieri munieri*, *Discocyclina* ex. gr. *archiaci*, *Nummulites* cf. *partschi*, *Nummulites* cf. *pratti*, *Ornatorotalia granum*, *Granorotalia sublobata, Ornatorotalia spinosa*, and *Rotalia* aff. *trochidiformis* suggesting a middle Cuisian age (SBZ11).

Description. Biconvex test composed by chambers trochospirally arranged in about five whorls. The dorsal side is convex and evolute, whereas the ventral side is convex to slightly flattened and involute. The umbilical region is filled by thick foliar walls that are fused to a solid mass. In axial section the ratio between diameter and thickness of the test is 1.7-2.2 (mean: 1.9; n=4), the diameter ranges from 1.2 to 2.0 mm (mean: 1.9 mm, n= 5), the thickness varies between 0.67 and 0.97 mm (mean: 0.81 mm, n= 4). The proloculus of megalosphere reaches a diameter of 0.17 mm (0.10-0.17, mean: 0.13, n=4).

No generational dimorphism is documented.

Subfamily Rotaliinae Ehrenberg, 1839
Genus *Rotalia* Lamarck, 1804
Type species: *Rotalites trochidiformis* Lamarck, 1804

Rotalia aff. ***trochidiformis*** (Lamarck, 1804)
Figs 4.A-4.E

aff. 1804 *Rotalites trochidiformis* Lamarck, p. 183; lectotype illustrated by Davies (1932), pl. 3, fig. 4.
aff. 2014 *Rotalia trochidiformis* - Hottinger, p. 35, pl. 3.4, figs. 1-4.

Material: Thirteen specimens in random sections from the sample AM52, AM50 and AP272c.

Stratigraphic range: The herein investigated *Rotalia* occurs in middle Cuisian (SBZ11) beds in association with *Cuvillierina vallensis*, *Nummulites irregularis*, *N.* cf. *pratti, N.* cf. *partschi*, *N.* ex. gr. *distans*, *Slovenites decastroi*, *Ornatorotalia spinosa, O. granum*, *Granorotalia sublobata*, *Orbitoclypeus munieri* and *Asterigerina* aff. *cayrazensis*.

Description. Trochospirally arranged test with a totally smooth dorsal side, consisting of about 3 whorls and with the typical columellar structure in the umbilical region. The folia are distinct and not fused, and the ventral region is covered by prominent cylindrical papillae. The diameter ranges from 1.2 to 1.6 mm (mean: 1.3 mm, n=7) and the thickness from 0.89 to 1.2 mm (mean: 1.0 mm, n=5). The diameter/thickness ratio is about 1.5 (1.3-1.6) and the proloculus measures 0.11 mm (0.08-0,11 mm, n=4). There are 11-13 chambers in the last measurable whorl.

Remarks. *Rotalia* aff. *trochidiformis* differs from the typical Lutetian *R. trochidiformis* in having lower values of the diameter/thickness ratio, lower number of whorls and a larger proloculus. In addition, *R. trochidiformis* has a larger spiral canal and a different type of foliar fusion. *Rotalia* cf. *newboldi*, described by Hottinger (2014) from the Ilerdian, has a higher D/T values and a smaller proloculus diameter.

Subfamily Kathininae Hottinger, 2014
Genus *Elazigina* Sirel, 2012
Type species: *Kathina subsphaerica* Sirel, 1972

Remarks. Sirel (2012) described the new genus as characterised by radial canals (funnels) in the dorsal side. These family-rank important taxonomic characters are not visible in the material illustrated by Hottinger (2014) under the new genus *Plumokathina* (including *Kathina subsphaerica* Sirel) and it is possibly an effect of the diagenesis emphasised by the contrast of the photos.

Plumokathina was informally described as *nomen nudum* in Peybernes et al. (2000) and is was not formally described until the monography by Hottinger (2014). Since *P. dienii* and *E. subsphaerica* show the same taxonomical features recognised also by Hottinger (2014), according to the Principle of Priority (ICZN, article 23), *Plumokathina* can be considered invalid and a junior synonym of *Elazigina* (Serra-Kiel et al. 2016).

Elazigina dienii (Hottinger, 2014)
Figs 5.A-5.G

1999 *Plumokathina* sp. Accordi et al., p. 196, pl. 14, fig. 6.

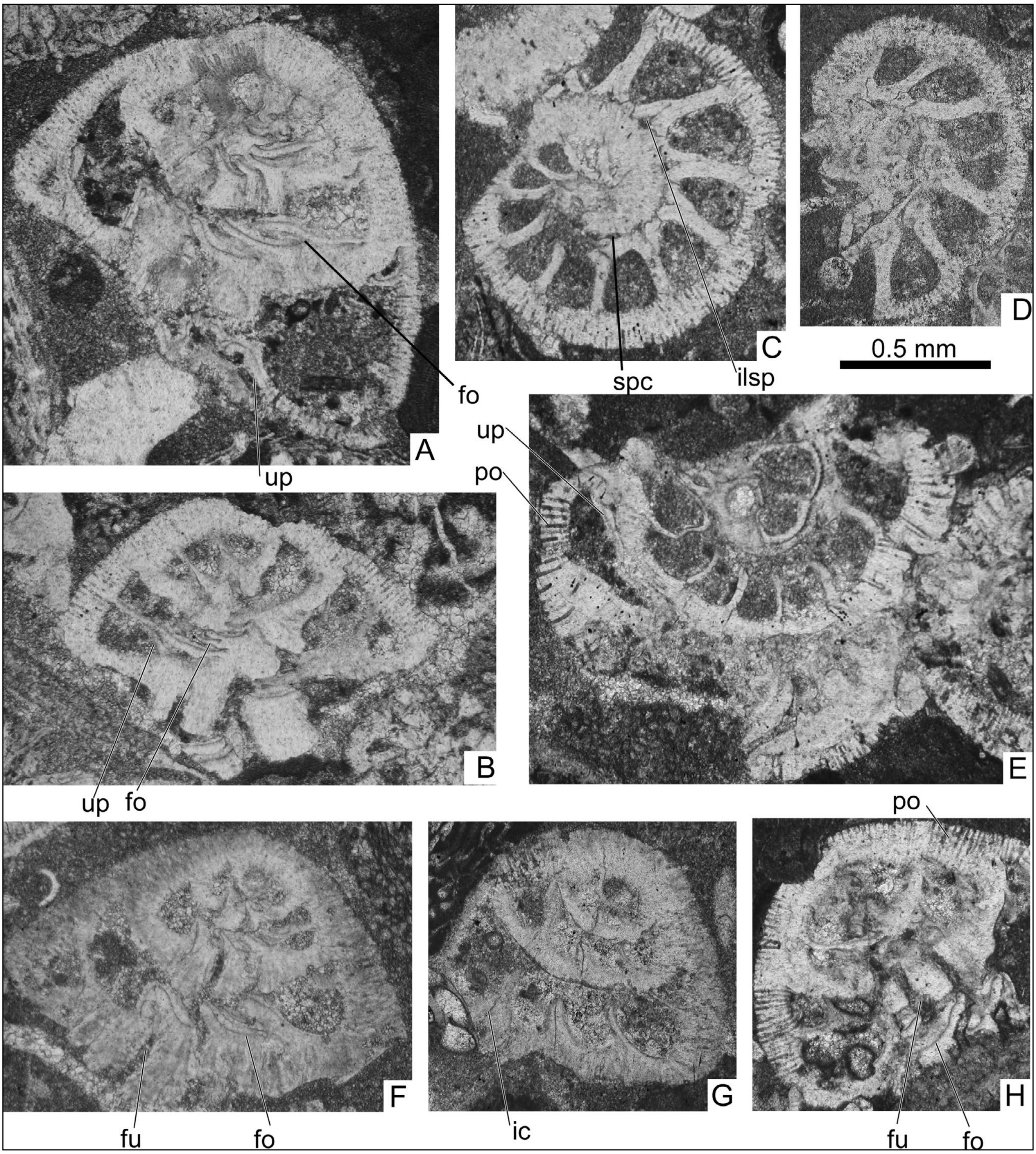

Fig. 4 - A-H) *Rotalia* aff. *trochidiformis* (Lamarck, 1804), A-E sample AM52; F-G AM52; H AP272c. Scale bar = 0.5 mm. fo: folium; fu:funnel; ic: intraseptal canal; ilsp: intraseptal interlocular space;po: pores; spc: spiral canal; up: umbilical plate.

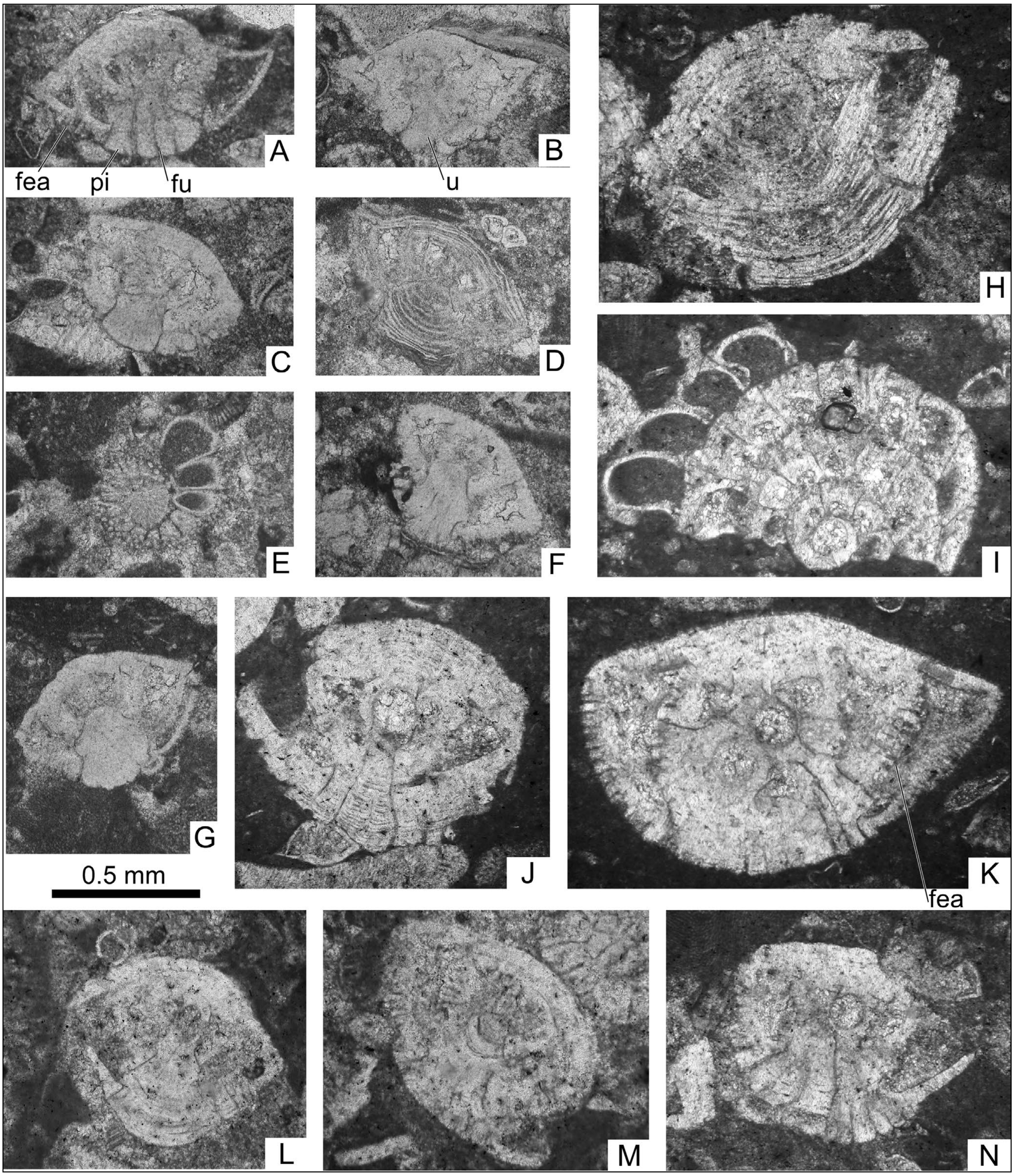

Fig. 5 - A-G) *Elazigina dienii* (Hottinger, 2014), sample AM46. SBZ2; H-K) *Elazigina lenticula* (Hottinger, 2014), sample AC343. SBZ3; L-N) *Elazigina* cf. *subsphaerica* (Sirel, 1972), sample AC352 - SBZ4. Scale bar = 0.5 mm. fea: feathering of the intraseptal interlocular space; fu: funnel; pi: pillar; u: umbilicus.

2000 *'Plumokathina dienii'* Peybernés et al., p. 44, fig. 6/5, nomen nudum.
2014 *Plumokathina dienii* Hottinger, p. 110; figs. 3.5J, 6.1A-N; pl. 6.8, figs. 1-21.

Material: Many specimens from the sample AM46.

Stratigraphic range: SBZ 2 according to Hottinger (2014). In our samples *E. dienii* occurs in association with *Miscellanea* sp., *Cuvillierina* cf. *sireli*, and *Ornatorotalia* sp.

Description. Biconvex lenticular test, the ventral side is usually more convex than the dorsal side. The periphery of the test has no keels, but it is very sharp and slightly upturned in dorsal direction.

The equatorial diameter of tests reaches 0.9 mm (min: 0.6 mm, mean: 0.7 mm). The ratio of equatorial to axial diameter of the shells varies from 1.4 to 2.1 (mean: 1.7), and there are about 12 chambers in the last whorl. The small proloculus measures 43 to 56 μm in diameter (mean: 48 μm).

Remarks. This species is easy to recognize in axial and subaxial thin sections by the acute periphery of the test which differs from that of *E. lenticula* by the shape upturned in dorsal direction. *Elazigina lenticula* is also larger and has more evident lamellar structure, whereas *E. subsphaerica* and *E.* cf. *subsphaerica* have rounded periphery and globular test.

Elazigina lenticula (Hottinger, 2014)

Figs 5.H-5.K

2008 Rotaliidae indet Pignatti et al., pl. 2, figs. 5-6.
2014 *Plumokathina lenticula* Hottinger, p. 110; pl. 6.9, figs. 1-6; pl. 6.10, figs. 1-12; pl. 6.11, figs. 1-31.

Material: Five specimens from the sample AC343.

Stratigraphic range. According to Hottinger (2014) *E. lenticula* spans from SBZ3 to SBZ6. In the here investigated sample it occurs in association with *Cuvillierina* cf. *sireli* in SBZ3.

Description. Lenticular biconvex test equally convex. The wall is hyaline and finely lamellar. The diameter of the test ranges from 1.0 to 1.4 mm (mean: 1.2, n=5) and the thickness varies from 0.8 to 0.9 (mean: 0.86, n=4) with a mean ratio D/T of 1.4 (1.2-1.5, n=4). The spherical proloculus measures about 0.15 mm (0.13-0.16 mm, n=4). The umbilical architecture is conform with the generic diagnosis.

Remarks. Our specimens are quite smaller and have a lower D/T ratio respect to the type material. This is probably due to the fact that our specimens are juveniles and incomplete tests with the last chambers of the last whorls usually incomplete in axial section (e.g., Fig. 5.J).

Elazigina* cf. *subsphaerica (Sirel, 1972)

Figs 5.L-N; fig. 6.A

cf. 1972 *Kathina subsphaerica* Sirel, p. 287, pl. 5, figs. 1-5.
1999 ?*Kathina subsphaerica* - Accordi et al., p. 200, pl. 16, figs. 1, 3.
2008 *'Plumokathina'* sp. Pignatti et al., p. 134, pl. 2, figs. 7-10; pl. 4, figs. 5-6.
2010 *'Plumokathina'* sp. Di Carlo et al., p. 67; pl. C, fig. 2.

Material: Five specimens from sample AC352.

Stratigraphic range: Late Thanetian to early Ilerdian (SBZ 4-5; Sirel, 2012), although Hottinger (2014) restricted the range to the SBZ4. In our material *E.* cf. *subspherica* occurs in a sample dominated by random sectioned *Elazigina* tests, *Polystrata alba*, rare textulariids and echinoids without significant markers and the sample was tentatively assigned to SBZ4 according to Hottinger (2014).

Description. lamellar biconvex and globular to oval test with rounded periphery. The ventral side is characterised by a large emispherical umbo composed by the umbilical pillars. The ratio D/T ranges from 1.2 to 1.3 (mean=1.25) and the spherical proloculus in the megalospheric generation measures about 0.09 mm. The diameter of the test varies from 0.74 to 0.86 mm (mean: 0.80, n=3) and the thickness measures 0.65 mm (0.64-0.66 mm, n=3).

One single microspheric specimen has been found (Fig. 6.A) measuring 1.85 mm in diameter and 1.55 in thickness (D/T=1.20).

Family Ornatorotaliidae Benedetti, 2015
Subfamily Ornatorotaliinae Benedetti, 2015
Genus *Ornatorotalia* Benedetti, Di Carlo & Pignatti, 2011

Type species: *Ornatorotalia spinosa* Benedetti, Di Carlo & Pignatti, 2011

Ornatorotalia granum Benedetti, Di Carlo & Pignatti, 2011

Figs 6.B-6.H

2011 *Ornatorotalia granum* Benedetti, Di Carlo & Pignatti, p. 710; figs. 8a-g, 9a-f, 10a-d.
2014 *Neorotalia alicantina* Colom - Hottinger, p. 154; pl. 8.1, fig. 15.
2017 *Ornatorotalia granum* - Sirel and Devecíler, p. 70, pl. 2, figs 9-14.

Material: Many random sectioned specimens from the samples AM50, AM52 and AM9.

Stratigraphic range: In our samples *O. granum* occurs in association with *Cuvillierina vallensis*, *Nummulites irregularis*, *N.* cf. *pratti, N.* cf. *partschi*, *N.* ex. gr. *distans*, *Granorotalia sublobata*, *Ornatorotalia spinosa, Rotalia* aff. *trochidiformis*, *Slovenites decastroi*, and *Orbitoclypeus munieri* confirming a middle Cuisian (SBZ11) age of the taxon.

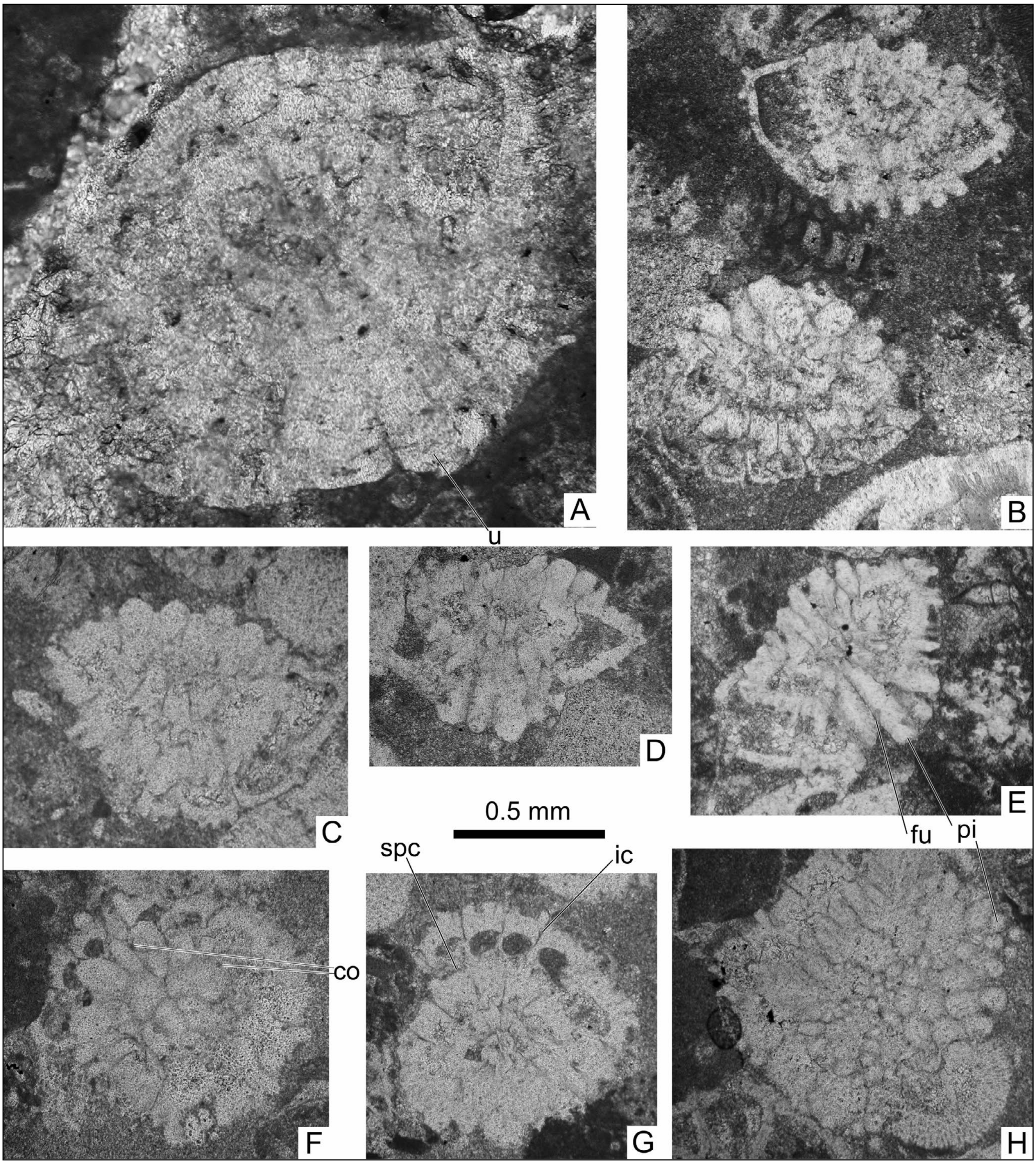

Fig. 6 - A) Microspheric specimen of *Elazigina* cf. *subsphaerica* (Sirel, 1972), sample AC352 - SBZ4; B-H) *Ornatorotalia granum* Benedetti, Di Carlo & Pignatti, 2011, sample AM52. Scale bar = 0.5 mm. co: canal orifice; fu: funnel; intraseptal canal; pi: pillar; spc: spiral canal system; u: umbilicus.

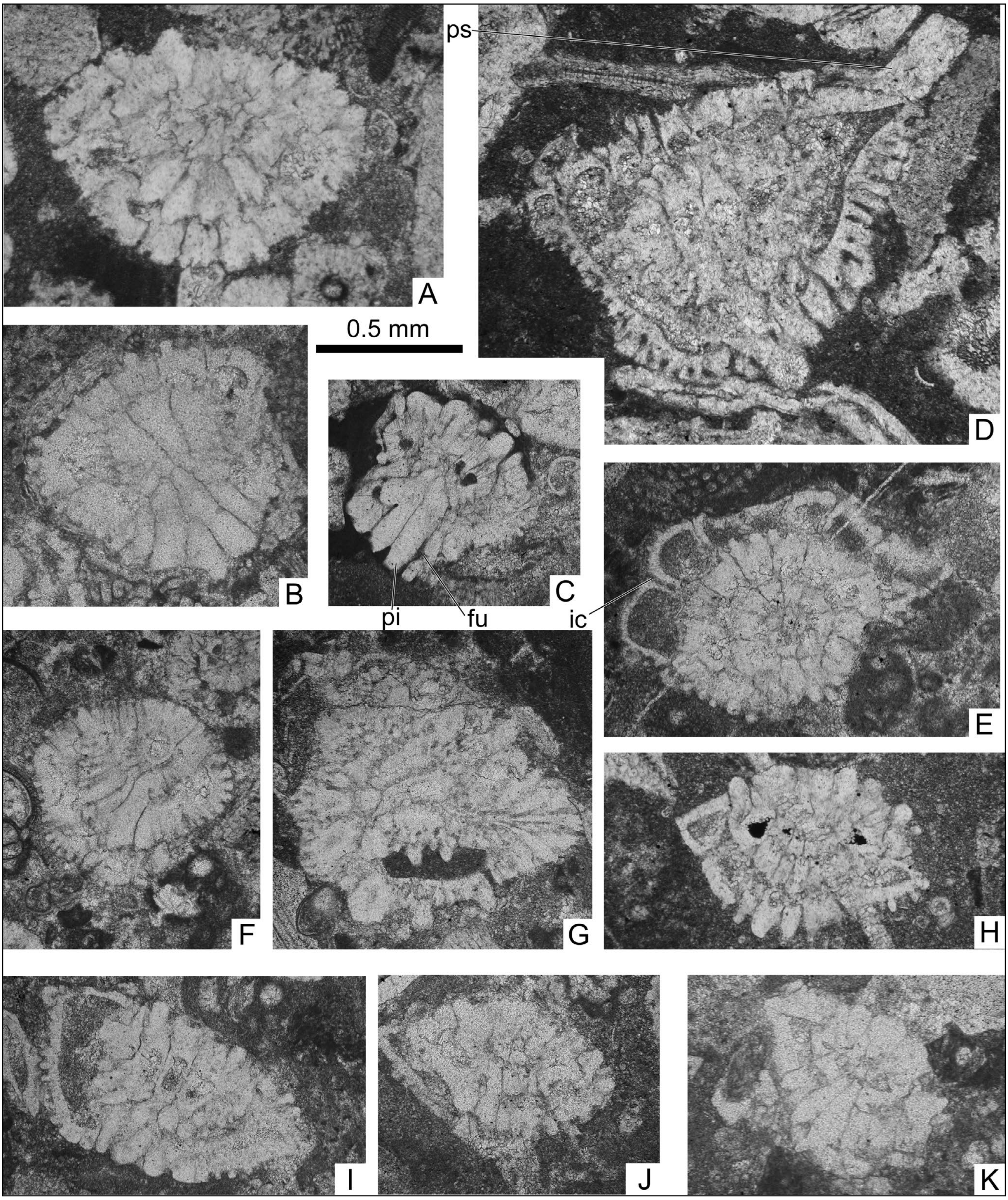

Fig. 7 - A-E) *Ornatorotalia spinosa* Benedetti, Di Carlo & Pignatti, 2011. A, E. AM52; B-C. AM50, D. AP272c; F-G) *Ornatorotalia* sp. AM46. SBZ 2; H-K) *Granorotalia sublobata* Benedetti, Di Carlo & Pignatti, 2011; H. AM50, I-K. AM52. Scale bar = 0.5 mm. fu: funnel; ic: intraseptal canal; pi: pillar; ps: pseudospine.

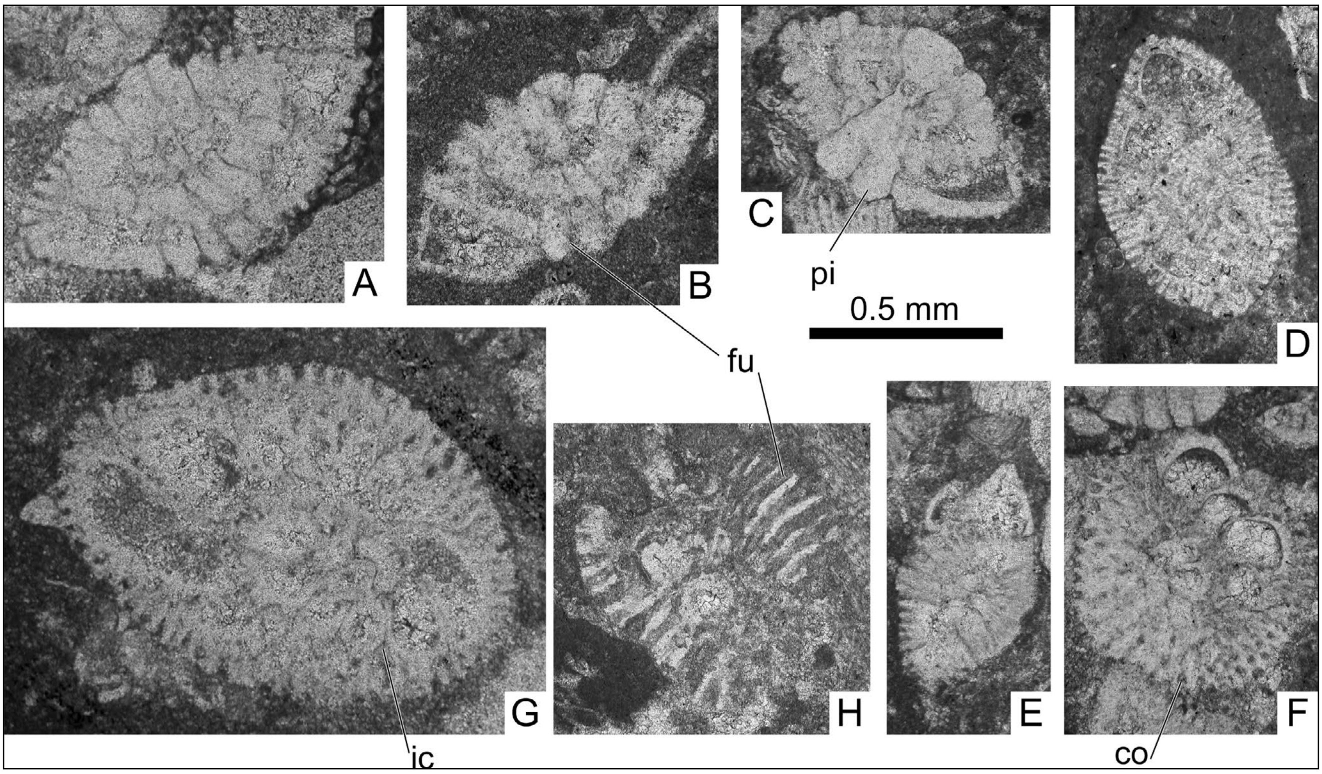

Fig. 8 - A-C) *Granorotalia sublobata* Benedetti, Di Carlo & Pignatti, 2011. A-B. AM52; C. AM50; D-F) *Cuvillierina* cf. *sireli* Inan, 1988. D. AC343 SBZ3; E-F. AM46, SBZ2; G-H) *Cuvillierina vallensis* Ruiz de Gaona 1949, AM50. Scale bar = 0.5 mm. co: canal orifice; fu: funnel; ic; intraseptal canal; pi: pillar.

Description. Biconvex involute trochospiral test. Both sides are covered by coarse piles, whereas the periphery is rounded to subangular without strong ornamentation. The diameter of the test varies from 0.82 to 1.03 mm (mean: 0.93, n=7) and the thickness measures 0.67 mm (0.60-0.69 mm, n=4). The ratio D/T ranges from 1.4 to 1.6 (mean=1.48, n=4), and the spherical proloculus in the megalospheric generation measures about 40 µm. *Ornatorotalia granum* was described by Benedetti et al. (2011) in great detail and its description is based on the modern terms employed by Hottinger (2006). Intraseptal canal systems are well developed for each chamber (pl. 4, fig. 7); the spiral system is not well preserved in the investigated material.

Remarks. The individual figured by Hottinger (2014; pl. 8.1, fig. 15) as *Neorotalia alicantina* is here actually considered a specimen of *O. granum* in having funnels in both ventral and dorsal sides, and numerous pustules covering almost the entire test.

Ornatorotalia spinosa

Benedetti, Di Carlo & Pignatti, 2011

Figs 7.A-7.E

2011 *Ornatorotalia spinosa* Benedetti, Di Carlo & Pignatti, p. 705; figs. 4a-h, 5a-l, 7a-j, 10e-f.

2015 *Ornatorotalia spinosa* - Benedetti, text-fig. 1, 4-6, text-fig. 2, 1-4.

2017 *Ornatorotalia spinosa* - Sirel & Deveciler, p. 69, pl. 2, figs 1-14; Pl. 3, figs 1-5; Pl. 5, figs 1-3.

Material: Many random sectioned specimens from the samples AM50, AM52 and AP272c.

Stratigraphic range: In the investigated material *Ornatorotalia spinosa* occurs in larger foraminiferal assemblages characterised by the presence of *Cuvillierina vallensis*, *Nummulites* cf. *partschi*, *N.* cf, *pratti*, *N.* ex gr. *distans*, *N. irregularis*, *Rotalia* aff. *trochidiformis, Granorotalia sublobata*, *Ornatorotalia granum*, *Slovenites decastroi*, and *Orbitoclypeus munieri* marking the middle Cuisian (SBZ11).

Description. *Ornatorotalia spinosa* was described by Benedetti et al. (2011) and Benedetti (2015) as a trochospirally coiled biconvex to planoconvex test, characterised by strong ornamentations in both the sides of the test and along the periphery. The diameter of complete megalospheric specimens ranges from 0.9 to 1.1 mm and the thickness measures about 0.7 mm. The spherical proloculus reaches a diameter of about 77 µm in the investigated specimens. The piles are more developed in the ventral side, whereas the microspheric generation shows robust spines along the periphery (pl. 5, fig. 4).

Remarks. The species belonging to the family Ornatorotaliidae are referred to the superfamily Rotalioidea in this work, although according to Hottinger (2014) the taxa with dorsally open canals and without folia should be reassigned to other superfamily. We retain that a systematic revision at superfamily rank will require future investigations and it is not the aim of this paper.

Ornatorotalia sp.

Figs 7.F-7.G

cf. 1998 Unidentified rotalinid genus 5 Sirel, p. 99; pl. 61, figs. 1-6, pl. 68, figs. 21-23.
cf. 2017 *Ornatorotalia* sp. Sirel & Devecíler, p. 70, Pl. 3, figs 6-9.

Material: Two specimens from the sample AM46.

Stratigraphic range: *Ornatorotalia* sp. occurs in assemblage with *Elazigina dienii*, *Cuvillierina* cf. *sireli*, *Miscellanea* sp. assigned to the SBZ2.

Description. Trochospiral coiling, test biconvex; the ventral side is more convex than the dorsal side. Vertical canals (funnels) occur in both ventral and dorsal side of the test. The maximum diameter is approximately 0.7 mm and the spherical proloculus measures 88 µm.

A large and short spine is visible in the larger (?microspheric) specimen (Fig. 7.7) as for the diagnosis of the genus (Benedetti et al. 2011; Benedetti 2015).

Remarks. Although the material is not sufficient to a complete description of a new species, this finding is very important being the second record of the genus *Ornatorotalia* from the Paleocene, after the description of spiny specimens of *Ornatorotalia* from the Thanetian of Harabekayış section (Sirel & Devecíler 2017).

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

Type species: *Granorotalia sublobata* Benedetti, Di Carlo & Pignatti, 2011

Granorotalia sublobata Benedetti, Di Carlo & Pignatti, 2011

Figs 7.H-7.K; 8.A-8.C

2011 *Granorotalia sublobata* Benedetti, Di Carlo & Pignatti, p. 715; figs. 11a-e, 12a-b, 13a-f, 14a-h.
2014 *Neorotalia alicantina* Colom - Hottinger, p. 154, pl. 8.1; figs. 24-27, not 1-23.
2015 *Granorotalia sublobata* - Benedetti, text-fig. 1.1-3.
2017 *Granorotalia sublobata* - Sirel & Devecíler, p. 70, Pl. 2, fig. 15; Pl. 3, figs 10-17.

Material: Many random sectioned specimens from the samples AM9, AM50, AM52 and AP272c.

Stratigraphic range: See *Ornatorotalia granum* and *O. spinosa*; middle Cuisian, SBZ11.

Description. Lenticular biconvex test, characterised by piles developed on both ventral and dorsal sides. The periphery is usually acute and poorly ornamented. The diameter, ranging from 0.8 to 1.0 mm (mean: 0.9, n=6), is about twice the thickness (0.43-0.55 mm, mean: 0.49, n=6; D/T: 1.7-2.0, mean: 1.9, n=6), and the small proloculus measures about 44 µm. *Granorotalia sublobata* was described by Benedetti et al. (2011) in great detail, and Benedetti (2015) demonstrated the occurrence of spines in the microspheric generation.

Remarks. Hottinger (2014) figured some specimens with dorsal and ventral funnels and acute periphery, under the name *Neorotalia alicantina*. We consider they fully belonging to *G. sublobata.* As stated by Benedetti and Briguglio (2012) and Benedetti (2015), *Neorotalia* differs from Ornatorotaliids in lacking dorsal canals, and its internal structure is well-described in Hottinger et al. (1991).

Family Cuvillierinidae Loeblich &Tappan, 1964
Subfamily Cuvillierininae Loeblich & Tappan, 1964
Genus *Cuvillierina* Debourle, 1955

Type species: *Laffitteina vallensis* Ruiz de Gaona, 1948

Cuvillierina cf. ***sireli*** Inan, 1988

Figs 8.D-8.F

cf. 1988 *Cuvillierina sireli* Inan, pl. 1, figs. 1-9; pl. 2, figs. 1-8.

Material: Few specimens in subaxial section and transverse sections from sample AM46 and AC343.

Stratigraphic range: Sirel (2012) restricted the range of *C. sireli* to the late Selandian (SBZ 2), but it was reported from the Selandian to the lower Thanetian SBZ3 (e.g., Ćosović et al. 2006). In our samples *C.* cf. *sireli* occur in association with *E. dienii*, *Miscellanea* sp. and *Ornatorotalia* sp. in the sample AM46 (SBZ 2) and with *Elazigina lenticula* in the sample AC343 (SBZ 3). The distribution range proposed by Hottinger (2014, p. 11, fig. 1.3) is wrong resulting Ilerdian, probably due to a problem in the preparation of the scheme.

Description. Test lenticular, planispiral involute with thin pillars occurring on both the side of the test. Vertical canals occur both in dorsal and ventral sides. The diameter ranges from 0.7 to 0.8 mm and the thickness from 0.4 to 0.5 mm. The diameter of the megalosphere is about 0.07 mm.

Remarks. This species has been recently reassigned to the genus *Cuvillierina* by Hottinger (2014) because of the absence of the taxonomic characters described by Sirel (1998) for *Pseudocuvillierina,* i.e., the lack of septal and umbilical flaps. *Cuvillierina sireli* differs from *C. vallensis* for its smaller size and in a more regular spiral growth increase.

Cuvillierina vallensis (Ruiz de Gaona, 1949)

Figs 8.G-8.H

1949 *Laffitteina vallensis* Ruiz de Gaona, 77-91.
1980 *Cuvillierina vallensis* - Müller-Merz, p. 34; pl. 7, fig. 5, pl. 8, figs. 1-2.
1987 *Cuvillierina vallensis* - Loeblich & Tappan, p. 656; pl. 752, figs. 5-9.
2011 *Cuvillierina vallensis* - Benedetti et al., fig. 2, i-k; fig. 3, c-d.
2015 *Cuvillierina vallensis* - Benedetti, text-fig. 3, figs. 1-6.

Material: Three specimens from the samples AM50.

Stratigraphic range: Lower to middle Cuisian (Pignatti 1995; Serra-Kiel et al. 1998). Hottinger (2014) extended the range to the late Cuisian (SBZ12). In the sample AM50 *Cuvillierina vallensis* occurs in association with *Nummulites* cf. *pratti*, *N. irregularis*, *Granorotalia sublobata*, *Ornatorotalia granum*, *O. spinosa*, and *Rotalia* aff. *trochidiformis*, marking the middle Cuisian (SBZ11).

Description. Lenticular hyaline test with more or less pointed periphery. The type of coiling is planispiral with a slight asymmetry. The chambers increase rapidly in size during the growth. Pillars and funnels occur from the inner to the outer part of the test in axial sections. The measured diameter of the test reaches 1.3 mm and the thickness 0.6 mm. The proloculus size is about 0.14 mm. The external surface appears reticulate.

Conclusions

The present work provides evidence on larger foraminiferal assemblages of the Paleocene and lower Eocene of Central Italy. Six taxa are here described in open nomenclature in absence of a sufficient number of specimens to perform complete description and differential diagnosis of the supposed new taxa. In particular, a new miscellaneid and a new ornatorotaliid are reported from the SBZ 2 in assemblage with *Cuvillierina* cf. *sireli* and *Elazigina dienii*. An unkeeled asterigerinid and *Rotalia* aff. *trochidiformis* are described in Cuisian assemblages and the species *Ornatorotalia spinosa*, *O. granum* and *Granorotalia sublobata* confirmed their importance as stratigraphic markers of SBZ 11. The latter forms could be pivotal in the biostratigraphic interpretation of larger foraminiferal assemblages in thin section of rocks, when centered axial or equatorial sections of currently used taxa, such as nummulitids, alveolinids and orbitoidiforms, are lacking.

In the biostratigraphic reconstruction of the Cenozoic succession cropping out in the Antrodoco area, larger foraminifers demonstrate their powerful potential also when the geologic complexity, and the bad preservation of planktonic organisms prevent the use of other biozonal schemes.

The monograph on rotaliids by Hottinger (2014) contributed to increase the knowledge on a group that requires an accurate study of the microstructure and gave a new impulse to the investigation of these as yet poorly-known forms. Rotaliids may represent a powerful tool for recognizing the SBZ allowing in future detailed correlation and helping in redefining the SBZ boundaries of the Tethyan Paleogene. However, we still lack continuous sedimentary sections to collect adequate material (phylogenetically related) for assessing the time span of each species and for defining the best zonal markers.

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