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 multidisciplinary approach (e.g., integrating LF distribution with magnetostratigraphy, chronostratigraphy, plankton and nannoplankton biostratigraphy) 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 reworked in turbiditic layers (e.g., Benedetti 2010, 2017; Benedetti & D’Amico 2012; Benedetti & Pignatti 2009, 2013; Cotton et al. 2017).
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.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Geographic coordinates</th>
<th>Faunal assemblage</th>
<th>Biozone</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC343</td>
<td>42° 29' 29.5&quot; N</td>
<td>Elazigina lenticula, Cuvillierina cf. sireli, Glomalveolina spp., Discocyclina sp. (fragments)</td>
<td>SBZ3</td>
</tr>
<tr>
<td>AC352</td>
<td>42° 29' 32.5&quot; N</td>
<td>Elazigina cf. subsphaerica, Elazigina spp.</td>
<td>SBZ4?</td>
</tr>
<tr>
<td>AM9</td>
<td>42° 35' 43.2&quot; N</td>
<td>Slovenites decastroi, Granorotalia sublobata, Ornatorotalia granum, Rotalia aff. trochidiformis, Nummulites cf. pratti, Alveolina spp., Discocyclina spp.</td>
<td>SBZ11</td>
</tr>
<tr>
<td>AM46</td>
<td>42° 35' 43.2&quot; N</td>
<td>Cuvillierina cf. sireli, Elazigina dieni, Miscelanea sp.</td>
<td>SBZ2</td>
</tr>
<tr>
<td>AM50</td>
<td>42° 35' 43.2&quot; N</td>
<td>Cuvillierina vallensis, Granorotalia sublobata, Ornatorotalia granum, Rotalia aff. trochidiformis, Nummulites cf. pratti, Nummulites irregularis, Discocyclina spp.</td>
<td>SBZ11</td>
</tr>
<tr>
<td>AM52</td>
<td>42° 35' 43.2&quot; N</td>
<td>Granorotalia sublobata, Ornatorotalia granum, Rotalia aff. trochidiformis, Slovenites decastroi, Nummulites cf. pratti, Orbitoclypeus munieri munieri, Alveolina spp., Assilina spp., Discocyclina spp.</td>
<td>SBZ11</td>
</tr>
</tbody>
</table>

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 Mioene 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 had 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): AC345 (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” E-42° 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 analysed 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. Biometric 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 Loeblisch & 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 Asterigerinoida 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 & Deveciler, 2017
Fig. 3A

aff. 2017 Asterigerina cayrazensis Sirel & Devecieler, 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. partishi, N. cf. pratti, N. ex. gr. distans, Grammatulina subhobuta, Ornatorotalia pinosa, 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 & Devecieler (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 & Devecieler (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. cayrazensis 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 Piveteau, 1952
Subfamily Miscellaneinae Kacharava in Rauzer-Chernousova & Furzenko, 1959
Genus Miscellanea Pfender, 1935
Type species: Nummulites micella d’Archiac & Haim, 1854
Fig. 3 - A) *Asterigerina* aff. *cayrazensis* Sirel & Delecive, 2017, AP272c; B-F) *Miscellanoa* sp. AM46 SBZ2; G-J) *Slovenites deaustri* 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.
**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 Miscellaneites 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.

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**Superfamily Rotaliacea Ehrenberg, 1839**

*Family Rotaliidae Ehrenberg, 1839*

*Subfamily Redmondininae Hottinger, 2014*

*Genus Slovenites Hottinger, 2014*

*Type species: Slovenites pembaphis* Hottinger, 2014

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

<table>
<thead>
<tr>
<th>Form (A/B)</th>
<th>Equatorial diameter (mm)</th>
<th>Axial diameter (mm) [Thickness]</th>
<th>Eq./ax diameter ratio</th>
<th>Proloculus diameter (mm)</th>
<th>No. of chambers in the last whorl</th>
<th>No. of chambers in penultimate whorl</th>
<th>No. of whorls</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>M. miscella</em> A</td>
<td>1.5 - 3.4</td>
<td>2.8</td>
<td>0.9 - 1.4</td>
<td>1</td>
<td>1.4 - 2.9</td>
<td>2.4</td>
<td>0.2 - 0.4</td>
</tr>
<tr>
<td>B</td>
<td>3 - 10.1</td>
<td>5</td>
<td>1.1 - 1.4</td>
<td>1.2</td>
<td>3 - 3.4</td>
<td>3.6</td>
<td>0.02</td>
</tr>
</tbody>
</table>

| *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 - 25 | 23 | 6 |

| *M. primitivus* A | 0.9 - 1.1 | 1 | 0.5 - 0.6 | 0.6 | 1.7 - 2.3 | 2 | 0.03 - 0.1 | 0.08 | 13 - 15 | 14 | 10 | 2.5 |

| *M. minutus* A | 0.9 - 1.1 | 1 | 0.6 - 0.7 | 0.7 | 2.1 | 2 | 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 | 1.13 - 1.62 | 1.21 | 1.07 - 1.05 | 0.94 | 1.34 - 1.62 | 1.5 | 0.06 - 0.12 | 0.1 | > 23 | 18 - 21 | 19 | 3.5 |

| Miscellanea sp. this work | 0.67 - 1.07 | 0.78 | 0.84 - 0.73 | 0.60 | 1.10 - 1.52 | 1.36 | 0.05 - 0.09 | 0.07 | 14 | 11 | 2.5 - 3 |

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**Miscellanea** sp.

Figs 3.B-3.F
**Slovenites decastroi** Hottinger, 2014  

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 *Orbito-clypeus munieri munieri*, *Discocyclina ex. gr. arcuata*, *Nummulites cf. partusbi*, *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 the test is 1.7-2.2 (mean: 1.9; n=4), the thickness varies between 0.67 and 0.97 mm (mean: 0.81 mm, n=4). The proloculus of megalo-sphere 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 *Cavillnerina vallen-sis*, *Nummulites irregularis*, *N. cf. pratti*, *N. cf. partusbi*, *N. ex. gr. distans*, *Nummulites irregularis*, *Ornatorotalia spinosa*, *O. granum*, *Granorotalia sublobata*, *Orbitoclypeus munieri* and *Asterigerina aff. sargiensis*.

**Description.** Trochospirally arranged test with a totally smooth dorsal side, consisting of about 3 whorls and with the typical columnellar structure in the umbilical region. The folia are distinct and not fused, and the ventral region is covered by prominent cylindrical papilae. 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 subphareirica* 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 subphareirica* Sirel) and it is possibly an effect of the diagenesis emphasised by the contrast of the photos.

*Plumokathina* was informally described as *no-men nudum* in Peybernes et al. (2000) and is was not formally described until the monography by Hottinger (2014). Since *P. dienii* and *E. subphareirica* 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 denii* (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’ Peybernès et al., p. 44, fig. 6/5, nomen nudum.
2014 Plumokathina dienii Hottinger, p. 110; figs. 3.5, 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 leriina* 2014 *Cuvillierina* occurs in association with *ticula* 2008 *Rotaliidae indet* 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.

**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 spherical proloculus measures about 0.15 mm (0.13-0.16 mm, n=4). The umbilical chamber of the last whorls usually incomplete in axial section (e.g., Fig. 5.1).

**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, 1972)
Figs 5.L-N; fig. 6.A

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:** Late Thanetian to early Ilerdian (SBZ 4-5; Sirel, 2012), although Hottinger (2014) restricted the range to the SBZ4. In our material *E. cf. subsphaerica* 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).

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

**Material:** Many random sectioned specimens from the samples AM50, AM52 and AM9.
**Stratigraphic range:** In our samples *O. granum* occurs in association with *Cuvillierina valdeni*, *Nummulites irregularis*, *N. cf. pratii*, *N. cf. partichi*, *N. ex. gr. distans*, *Grunorotalia sublobata*, *Ornatorotalia spinosa*, *Rotalia aff. trochidiformis*, *Slovenites decastri*, 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.
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, 10c-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 Rotalioida 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.

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 bi-convex; 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 & Deveciler 2017).

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

Granorotalia sublobata
Benedetti, Di Carlo & Pignatti, 2011

2011 Granorotalia sublobata - Benedetti, Di Carlo & Pignatti, p. 715; figs. 11a-e, 12a-h, 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 & Deveciler, 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

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)


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 1949; 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. trochidiiformis*, 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 miscellaneous and a new ornatortalid are reported from the SBZ 2 in assemblage with *Cuvillierina* cf. *sireli* and *Elazigiana dentic*. An unkeeled asterigerinid and *Rotalia aff. trochidiiformis* 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 sections 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 successions 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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**References**


Benedetti A. & Bruguglio A. (2012) - *Risananeiza crassaparies* n. sp. from the Late Chattian of Porto Badisco (southern


