Lower Jurassic foraminiferal biostratigraphy of Podpeč Limestone (External Dinarides, Slovenia)

Spodnjejurske foraminifere podpeškega apnenca (Zunanji Dinaridi, Slovenija)

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Ključne besede: taksonomija, biostratigrafija, foraminifere, Dinarska karbonatna platforma, sinemurij, pliensbachij, lithiotidni apnenec

Abstract

The “Podpeč limestone” outcropping south of Ljubljana (Central Slovenia), deposited at the northern edge of the Dinaric Carbonate Platform, comprises mostly dark grey and black thick bedded oolitic limestone, and is renowned for several horizons of lithiotid bivalves. Foraminifera, especially Orbitopsella spp., are rather frequent, but no detailed distribution of foraminiferal taxa was given. Furthermore, documentation of foraminiferal species is scarce, with few photographs. In order to give a comprehensive picture of foraminiferal assemblage of the “Podpeč limestone” and its distribution, three sections were measured in detail and sampled. The foraminiferal assemblage consists of 17 species, described in detail. On the basis of foraminifera, the investigated part of the “Podpeč limestone” belongs to the Lituosepta recoarensis and Orbitopsella praecursor biozones of early Late Sinemurian and Early Pliensbachian age, respectively.

Introduction

Following the devastating effects of the alleged biocalcification crisis at the Triassic-Jurassic boundary in the Neotethys area (e.g., Hautmann et al., 2008; Črne et al., 2011), the Early Jurassic saw a gradual reestablishment of shallow water benthic communities, in which agglutinated large benthic foraminifera played a prominent role (Septfontaine, 1988; Bassoullet, 1997; Mancinelli et al., 2005; BouDagher-Fadel & Bosence, 2007; Velč, 2007; BouDagher-Fadel, 2008). Transition from poorly diversified Hettangian fauna with small involutinids and pfenderinids to Sinemurian Siphovalvulina- and Textularia-dominated assemblages, and further from simple into internally complicated lituolids of the Pliensbachian is well recorded (BouDagher-Fadel, 2008), and provides a useful tool in biostratigraphic studies throughout the present-Mediterranean area (e.g., Septfontaine, 1984, 1988; Bassoullet, 1997; Mancinelli et al., 2005; BouDagher-Fadel & Bosence, 2007).

Biostatigraphic division of Jurassic shallow water carbonates of the central Dinaric Carbonate Platform has been given by Radić (1966) and recently by Velč (2007). The key to a detailed subdivision of Lower Jurassic strata elsewhere in the Karst Dinarides is thus at hand.

The aim of this paper is to give a systematic account of foraminifera in the lithiotid bivalves-rich “Podpeč limestone”, an informal Pliensbachian stratigraphic unit of central Slovenia, and to present their distribution in three
detailed sedimentological sections from the Mt.
Krim area: the classical locality of the Podpeč
quarry, supplemented by data from Zalopate and
Grad sections (Fig. 1).

Previous research

The stratigraphic succession of the Krim
Mountain area was more extensively described
by PLENIČAR (1970), BUSER (1974), and recently
by MILER and PAVŠIČ (2008). As an informal
lithostratigraphic unit, the Plenianian
“Podpeč limestone”, characterized by lithiotid
bivalves, attracted the most attention due to its
architectural value (RAMOŠ, 1961, 2000) and
due to the local abundance of fossil brachiopods
and molluscs, most notable lithiotid bivalves
(BUSER, 1965; BUSER & DEBELJAK, 1996; DEBELJAK
& BUSER, 1997; RAMOŠ, 2000; MILER & PAVŠIČ,
2008). Coral patches can also occur locally
(TURNŠEK, 1997; TURNŠEK & KOŠIR, 2000; MILER &
PAVŠIČ, 2008).

Shallow-water carbonates with lithiotid
bivalves can be followed over the area of Slovenia in
an over 100 km long belt (BUSER & DEBELJAK, 1996).
Locally, DOZET and STROHMENGER (2000) introduced
a Lower Jurassic Podbukovje Formation, or
Predole Beds with five members (DOZET, 2009).
The correlation of the “Podpeč limestone” with
these units is unclear, due to the lack of definitions
and biostratigraphic studies of the lower and
upper boundaries of the “Podpeč limestone”.
Furthermore, no type sections for the Podbukovje/
Predole Formations and their members were
selected either, and a more detailed description
and definitions of lithostratigraphic boundaries
are missing as well. The “Podpeč limestone” may
thus correspond to one, two or all of the three
successive middle members of the Podbukovje/
Predole Formations, i.e. Orbitopsella limestone,
Lithiotis limestone and Oolitic limestone sensu
DOZET (2009).

Foraminifera were first recognized in the
“Podpeč limestone” by RAMOŠ (1961) and BUSER
(1965, 1974). Scattered reports on other species of
foraminifera from the “Podpeč limestone” or from
equivalent units are also given by ŠRIBAR (1966),
STROHMENGER and DOZET (1991), DOZET (1992,
1996), DOZET and STROHMENGER (2000), TURNŠEK
et al. (2003), MILER and PAVŠIČ (2008), and DOZET
(2009).

According to DOZET (2009), “Orbitopsella
limestone” contains Orbitopsella praecursor,
Lituosepta recoarensis Cati, Planisepa compressa,
Involutina farinacciae, Haurania deserta,
Agerina martana, Glomospira sp., Aeolisaccus
dunningtoni, Amijiella amiji (mentioned in

Fig. 1. Geological map of the Mt. Krim area with the position of the measured sections. Redrawn and modified after BUSER et al.
(1967) and BUSER (1968).

figure, not in the text), *Paleomayncina termieri*, *Pseudocyyclammina liassica* (names are spelled as written in Dozet, 2009). In the “Lithiots limestone”, the following taxa were determined (Dozet, 2009): *A. amiji*, *P. liassica*, *P. termieri* (mentioned only in figure). In addition, from the middle Early Jurassic *Orbitopella praecursor* subzone of the Early Jurassic *Paleoedasycladus mediterraneus* cenozoone, Dozet (1996) mentions *O. praecursor*, *Orbitopella* cf. *dubari*, *Mayncina termieri*, *Haurania amiji*, *H. deserta*, *L. recoarensis*, *Vidaltina martana*, *Neoangulodiscus leischneri*, *Involutina turris* and *Permodiscus sinuosus* (all names as in original).

All these reports lack a detailed sedimentological section and the details of foraminiferal distribution.

**Methods of study**

In order to investigate foraminifera from the “Podpeč limestone”, three sedimentological sections were measured bed-by-bed in the wider Mt. Krim area (Fig. 1). Samples were collected from 55 beds, and 62 thin sections made, in which foraminifera were determined. Foraminiferal systematics follows BouDagher-Fadel (2008). Terminology follows Höttinger (2006) and Basí et al. (2006). The positions of thin sections and the distribution of foraminifera are given in Figures 2–4.

**Geological setting**

Geological mapping of the Mt. Krim area was performed by Lipold (1858), Kramer (1905), Vettiers (1933), Buser et al. (1967), Buser (1968), and Miler and Pavšič (2008). The area structurally belongs to the External Dinarides (Placer, 1999, 2008). The Lower Jurassic succession consists of shallow-water carbonates, deposited at the northern margin of the Dinaric Carbonate Platform, facing the Slovenian Basin to the present north (Buser, 1989, 1996). At the time, the opening of the Piemont-Liguria Ocean on the far west caused a gradual deepening of the Slovenian Basin (Rozic, 2009), and a partial disintegration of the Dinaric Carbonate Platform margin (Miler & Pavšič, 2008). The latter, however, remained relatively stable until the end of the Cretaceous (Buser, 1989, 1996). The Lower Jurassic succession comprises: Hettangian and Sinemurian (?) coarse-grained dolomite, micritic and subordinately fine-grained oolitic limestone, locally dolomitic breccia (Buser, 1989; Miler & Pavšič, 2008; Ogorelec, 2009). Pliensbachian oolitic limestone and lithiotid limestone (“Podpeč limestone”; Plenica, 1970, 1998; Buser, 1974; Miler & Pavšič, 2008), and Toarcian thin bedded micritic limestone (A. Košir, pers. com., see also Dozet, 2009). The age of these units is determined on the basis of superposition, or fossils determined from individual levels within the stratigraphic units (Miler & Pavšič, 2008).

**Description of measured sections**

The Zalopate section (see position on Fig. 1) is located at approximate coordinates 45°56′09″ latitude and 14°27′21″ longitude, a few meters above the road. The section starts with micritic limestone, which may be banded (straight dark and white, 5 mm thick lamina). Black fine-grained oolite soon appears and then represents the dominant lithology. Accumulations of bivalves, brachiopods, intraclasts and oncoids are locally present at the base of oolite. Irregular reddish bedding planes are interpreted as short-time emersion levels (see Martinuš et al., 2012). Grading, parallel lamination, occasional scour structures and ripples are present.

The Podpeč 1 section (45°58′22″ lat., 14°25′16″ long.; Fig. 3 right) spans the “classical” locality with lithiotid bivalves (see Buser & Debeljak, 1996) at the eastern side of the now abandoned quarry (Fig. 1). The Podpeč 2 section (Fig. 3 right) starts with the outcrop in a private garden some meters further towards the east and overlaps with the Podpeč 1 section. The dominant lithology is medium- to very thick bedded gray oolite. Various amounts of mm- to cm-sized intraclasts and oncoids are locally present, as well as fragmented or complete fossil bivalves, gastropods and terebratulid brachiopods, sometimes forming floatstone or rudstone textures. At least nine lithiotid horizons were counted. Lithiotid shells are embedded in limestone or red claystone matrix and form coquinas, sometimes in lens-like bodies, which laterally thin-out. Though not in life position, shells are probably preserved in situ as testified by the presence of unseparated and unbroken valves. Wackestone and black mudstone are subordinate and bedding thin- to medium-thick. Irregular bedding planes and red clayey surfaces are frequent. They were interpreted as emersion levels (Buser & Debeljak, 1996). Parallel lamination and grading are common. Cross-lamination was found in an outcrop located outside the quarry.

The Grad section (45°55′46″ lat., 14°30′14″ long.) is the shortest of the measured sections (Fig. 4). Thick to very thick bedded oolite predominates. Lithiotid bivalves are present in two oolite levels, but are not in life position. Concentrations of broken mollusc shells are common.

**Systematic palaeontology**

Order Foraminifera J. J. Lee, 1990

Suborder Textulariina Delage & Hérouard, 1896

Superfamily Verneulinacea Cushman, 1911

Family Verneulinidae Cushman, 1911

Subfamily Verneulinoidinae Suleymanov, 1973

Genus Duotaxis Kristan, 1957

(type species: *Duotaxis metula* Kristan, 1957)
Fig. 2. Zalopate section with distribution of foraminifera.
Sl. 2. Profil Zalopate z razporeditvijo foraminifer.
Fig. 3. Podpeč sections with distribution of foraminifera.
Sl. 3. Profila Podpeč z razporeditvijo foraminifer.


**Duotaxis metula** Kristan, 1957
(Pl. 1, figs. 1-2; Pl. 2, fig. 5)

*1957* *Duotaxis metula* nov. gen. nov. spec. – Kristan, p. 295, Pl. 27, figs. 5a–d, 6.
1996 *Duotaxis metula* Kristan, 1957 – Fugagnoli, p. 388, Pl. 1, figs. 1–5; Fig. 2a–h.

**Material:** Thin sections 322, 325, 326, 328, 329, 330, 333, 337, 412, 415, 418, 424a, 424b, 429a, 517, 526, 533, 535, 535b, 536.

**Description:** The test is 0.27–0.51 mm high, and 0.29–0.54 mm wide, with the ratio between height and width 0.86–1.00. A simple proloculus is followed by chambers in a trochospiral arrangement. Most specimens have 4 or 5 trochospiral coils, but the largest bears 8 coils. No endoskeletal elements are present. The test wall is simple, agglutinated.

**Geographic distribution and stratigraphic range:** The type specimen of *D. metula* was described from Rhaetian of Northern Calcareous Alps (Kristan, 1957). Early Jurassic examples are cited from Southern Alps (Fugagnoli, 1996, 1998; Fugagnoli & Loriga Broglio, 1998), Sinemurian of Gibraltar (BouDagher-Fadel et al., 2001), Pliensbachian of Middle Atlas, Morocco (Bassoulet et al., 1999). According to Velic (2007), this species lasts until the end of Pliensbachian in the Karst Dinarides of Croatia.

Superfamily Biokovinoidea Gušić, 1977
Family Biokovinidae Gušić, 1977
Genus *Bosniella* Gušić, 1977
(type species: *Bosniella oenensis* Gušić, 1977)

*Bosniella oenensis* Gušić, 1977
(Pl. 1, figs. 3–9)

*1977* *Bosniella oenensis* n. gen., n. sp. – Gušić, p. 13, Pl. 11, figs. 1–2; Pl. 12, figs. 1–4; Pl. 13.
1998 *Bosniella oenensis* Gušić, 1977 – Fugagnoli, p. 173–175, Pl. 19, figs. 1–9; Pl. 20, figs. 1–2.
1998 *Bosniella oenensis* Gušić, 1977 – Fugagnoli & Loriga Broglio, p. 63, Figs. 10.1–5. 2007 *Bosniella oenensis* Gušić 1977 – BouDagher-Fadel & Bosence, p. 8, Pl. 5, figs. 4, 6; Pl. 7, figs. 3–4; Pl. 8, fig. 6.

**Material:** Thin sections 7329, 420, 424b, 510, 513, 515, 517, 524, 525, 526, 529, 534, 535, 535b. One specimen is possibly of microspheric generation, 49 specimens of megalospheric generation.

**Description:** Most of the material is identified as tests of megalospheric generation. The majority of specimens has only planispirally coiled part of the test. In a few cases the planispiral part is followed by uniserial part in a trochospiral arrangement. Most specimens have 4 or 5 trochospiral coils, but the largest bears 8 coils. No endoskeletal elements are present. The test wall is simple, agglutinated.

Geographic distribution and stratigraphic range: The type specimen of *D. metula* was described from Rhaetian of Northern Calcareous Alps (Kristan, 1957). Early Jurassic examples are cited from Southern Alps (Fugagnoli, 1996, 1998; Fugagnoli & Loriga Broglio, 1998), Sinemurian of Gibraltar (BouDagher-Fadel et al., 2001), Pliensbachian of Middle Atlas, Morocco (Bassoulet et al., 1999). According to Velic (2007), this species lasts until the end of Pliensbachian in the Karst Dinarides of Croatia.
0.06-0.08 mm thick. In the axial section the coiled part of the test appears umbilical or with parallel, slightly compressed sides, 0.42 mm wide. The periphery of the test is widely rounded. The degree of chamber overlap is not distinctly visible.

**Remarks:** According to Gušić (1977), the planispiral part of the *Bosniella oenensis* comprises 2-3 (megalospheric) or 3-4 (microspheric test) coils. Megalospheric tests with 1-1.5 coils, however, were described also by Fugagnoli (1998).

The wall was originally described as having bifurcating alveoles (Gušić, 1977). It was later mostly described as keriothecal (Bassoullet, 1994; Fugagnoli, 1998; Tasli, 2001; Schlagintweit & Velić, 2011). The original distinction from *Mesoendothyra* Dain was based on the different wall texture (simple microgranular in *Mesoendothyra* vs. complex in *Bosniella*). However, Septfontaine (1988) considered *Bosniella* a junior synonym of *Mesoendothyra*. Because *M. croatica* differs from *B. oenensis*, Bassoullet (1994) later considered *Bosniella* a valid Jurassic genus, comprising *B. oenensis*, *B. fontainei* and *B. croatica*. Fugagnoli (1998) also considered both genera distinct, but due to the lack of revision of the type material of *Mesoendothyra*. Tasli (2001) acknowledged both possibilities by considering *Bosniella* a junior synonym of *Mesoendothyra* or, alternatively, placing *M. croatica* into the valid genus *Bosniella*. I prefer the latter option, due to the presence of specimens referred to *Mesoendothyra* sp., which probably has a simple microgranular wall.

*Bosniella fontainei* Bassoullet from Middle Jurassic of Thailand has slightly smaller megalospheric tests, larger microspheric tests, less globular chambers and strongly inclined septa (Bassoullet, 1994). It is safe to add that *B. fontainei* has more numerous chambers (9-10 or 10-11) in the last whorl of megalospheric and microspheric tests, respectively.

*Bosniella croatica* Gušić is smaller (mostly 0.5-0.6 mm in diameter), is more globular, with shorter, wider and involute chambers (cf. Bassoullet, 1994).

*Bosniella bassoulleti* Schlagintweit & Velić from Late Aalenian to Early Bajocian (?) is of the same size as *B. oenensis*. It has, however, 11-14 chambers in the last whorl (compared to 7-9 in *B. oenensis*), thinner septa (0.04-0.08 mm, compared to 0.12-0.13 mm for *B. oenensis*), and a well developed uniserial part with chambers retaining constant size or becoming only slightly wider, whereas these progressively increase in *B. oenensis* (Schlagintweit & Velić, 2011).

**Geographic distribution and stratigraphic range:** Sinemurian–Pliensbachian of Karst Dinarides, Bosnia (Gušić, 1977); Sinemurian – Early Pliensbachian of Betic Cordillera, Spain, and Sinemurian – Pliensbachian of High Atlas, Morocco (Boudagher-Fadel & Bosence, 2007); Sinemurian–Pliensbachian of Southern Alps, northern Italy (Fugagnoli, 1998; Fugagnoli & Loriga Brogli, 1998). Late Sinemurian – Pliensbachian according to Bassoullet (1997).

Genus *Lituolipora* Gušić & Velić, 1978
(type species: *Lituolipora polymorpha* Gušić & Velić, 1978)

*Lituolipora termieri* (Hottinger, 1967)
(Pl. 1, figs. 10-12)

* 1967 *Mayncina termieri* n. sp. – Hottinger, p. 31, Pl. 3, figs. 4-10; Fig. 14.
* 1978 *Lituolipora polymorpha* n. gen., n. sp. – Gušić & Velić, p. 74, Pl. 1, figs. 1-4; Pl. 2, figs. 1-5; Pl. 3, figs. 1-3; Pl. 4, figs. 1-6; Pl. 5, figs. 1-5; Pl. 6, figs. 1-6, pars 7; Pl. 7, figs. 1-4; Pl. 8, figs. 1-6; Pl. 9, figs. 1-11; Pl. 10, figs. 3, 4, 6.
* 1986 “*Mayncina*” termieri – Septfontaine, Pl. 2, fig. 1.
* 1999 *Paleomayncina termieri* (Hottinger) – Bassoullet et al., p. 222, Pl. 4, figs. 1-3.
* 2003 *Paleomayncina termieri* (Hottinger, 1967) – Azeredo et al., Pl. 10, fig. 8.

**Material:** Thin sections 533, 536. Three specimens; one certainly belonging to microspheric generation.

**Description:** Specimens likely belong to a microspheric generation. The initial, irregularly coiled part consists of few chambers. It is followed by a planispiral part, approximately in two coils. The last whorl has 9-11 chambers, separated by obliquely set septa of thickness approximately equal to the wall. The total diameter of the coiled part is 0.40-0.54 mm. The uncoiled part of the test is short, not well developed, with only 1-2 free chambers. They are 0.04-0.05 mm high (lumen) and 0.12-0.26 mm wide, of boxwork shape. The aperture is at first a single opening, later becoming multiple (see Pl. 1, fig. 10). The outer test wall is coarsely alveolar, 0.04-0.08 mm thick.

**Remarks:** *Lituolipora termieri* was described from the Lower Jurassic of Morocco as *Mayncina termieri* with a simple finely agglutinated wall (Hottinger, 1967). Gušić and Velić (1978) later introduced a new genus and species, *Lituolipora polymorpha*, from the Lower Jurassic of Croatia. The new genus was established on the basis of coarsely perforated wall. Gušić and Velić (1978) were aware of the close similarity with *M. termieri*, but they came to a conclusion that the wall of *M. termieri* is not diagnostically altered. Septfontaine (1988) later decided for the contrary,
and introduced a new genus *Paleomayncina* with the type species *M. termieri*. KABAL and TASLI (2003) proposed to retain *Lituitolpora* as a valid genus name for the sake of priority over *Paleomayncina*, and recognized *L. polymorpha* to be a junior synonym of *L. termieri*. Their opinion is followed in this paper. KABAL and TASLI (2003) further documented the variability of the species and recognized three morphotypes, two corresponding to different ontogenetic stages of the megalospheric generation and one to microospheric tests (KABAL & TASLI, 2003). SEPTFONTAINE (1988) and KABAL and TASLI (2003) describe the wall as coarse keriothecal with polygonal canaliculi, though GUŠIC and VELIČ (1978) argued for the inappropriate use of the term keriothecal. The open perforations in GUŠIC and VELIČ (1978) specimens were interpreted as result of test abrasion (SEPTFONTAINE, 1988).

The specimen in AZERÊDO et al. (2003) is considered doubtful, as only uniserial part is shown, though with a cribrate (or multiple?) aperture and flat chambers.

**Geographic distribution and stratigraphic range:** Sinemurian-Pliensbachian of southern Tibet, China (CAI et al., 2005); Late Sinemurian – Pliensbachian of Southern Alps, northern Italy (FUGAGNOLI, 1998; FUGAGNOLI & LORICA BROGLO, 1998); Late Sinemurian – Pliensbachian of Karst Dinarides, Croatia (GUŠIC & VELIČ, 1978, VELIČ, 2007); Pliensbachian of Atlas, Morocco (HOTTINGER, 1967; SEPTFONTAINE, 1986; BASSOUL et al., 1999); Late Sinemurian – Toarcian of Central Taurides, Turkey (KABAL & TASLI, 2003). Latest Sinemurian – Pliensbachian according to BASSOULLET (1997).

Superfamily Pfenderinoidea Smouth & Sugden, 1962

Family Pfenderinidae Smouth & Sugden, 1962

Subfamily Pseudopfenderininae Septfontaine, 1988


*Pseudopfenderina butterlini* (Brun, 1962) (Pl. 1, figs. 13-14)

1962 *Pfenderina butterlini* – BRUN, p. 188, Pl. 1, figs. 3–9; Pl. 2, fig. 3.

1967 *Pseudopfenderina butterlini* (Brun) 1962 – HOTTINGER, p. 87, Pl. 19, figs. 7–22; Fig. 44.


2007 *Pseudopfenderina* cf. *butterlini* (Brun 1962) – BOUDAGHER-FADEL & BOSENCE, p. 3, Pl. 7, fig. 2 [non Pl. 10, fig. 6].

**Material:** Thin sections 333, 418, 533, 533b. Specimens are in basal sections (perpendicular to the coiling axis, one in slightly oblique section.

**Description:** The test is free, roughly elliptical in outline. Test wall is dark, agglutinated and undifferentiated, simple. The outline of the test is continuous, without obvious sutures. Septa are of the same thickness as the outer test wall, and appear perpendicular or slightly oblique to the outer test wall. They divide the interior of the test in 5-10 chambers per whorl. A single solid micritic mass of circular outline (columella) occupies the center of the test. Columella is bordered by large, resorbed foramina (cf. BASSI et al., 2006).

Test diameter ranges from 0.11 to 0.54, with larger tests having greater chamber number.

**Remarks:** According to literature descriptions (e.g., HOTTINGER, 1967) *Pseudopfenderina* has a high trochospiral form, which, however, cannot be visible in the observed material due to the lack of axial sections. The genus is distinguished from similar genera possessing axial columella in its lack of complicated wall structure (subepidermal reticular network in *Kurnubia* Henson; primitive hypodermal network in *Praekurnubia* Redmond) or in the absence of subcavemeral tunnel, which is present in *Pfenderina* Henson and *Paleopfenderina* Septfontaine (HOTTINGER, 1967; SEPTFONTAINE, 1988; LOEBLICH & TAPPAN, 1987). The columella of *Pseudopfenderina* consists of pillars and secondary (?) carbonate deposits, forming a solid structure (HOTTINGER, 1967). As pillars are sometimes not visible, some authors prefer determination as *Pseudopfenderina* cf. *butterlini* (e.g., FUGAGNOLI, 1998; BOUDAGHER-FADEL & BOSENCE, 2007). Part of the material in BOUDAGHER-FADEL and BOSENCE (2007) is attributed to *Duotaxis metula* Kristan in basal section, as no columella is visible and the umbilicus appears unfilled.

HOTTINGER (1967) distinguished two-times smaller specimens with fewer chambers per whorl (5-7 compared to 7-9 of *P. butterlini*) as an unnamed new species. His opinion was later followed by FUGAGNOLI (1998), who counted 5-6 chambers per coil in material from the Southern Alps. However, HOTTINGER’s (1967) figures show 8-9 chambers per coil, and the size difference is here argued to derive from the different position of sections according to test’s height (even though the test has fairly parallel sides in the later stage of growth). Larger equatorial sections have more chambers than smaller ones.

**Geographic distribution and stratigraphic range:** Sinemurian – Pliensbachian of High Atlas, Morocco; Sibillini Mountains, central Italy; Dorsales Range, Tunisia; Iberian Basin, Spain (BOUDAGHER-FADEL & BOSENCE, 2007); Late Sinemurian of Southern Alps, northern Italy (FUGAGNOLI, 1998); Late Sinemurian of Algarve Basin, South Portugal (AZERÊDO et al., 2003); Sinemurian – Early Pliensbachian of
Tripolitza platform, Greece (Zambetakis–Lekkas et al., 1996). Latest Sinemurian to Early Pliensbachian according to Bassoulet (1997).

Genus *Siphovalvulina* Septfontaine, 1988
(type species: *Siphovalvulina variabilis* Septfontaine, 1988)

*Siphovalvulina gibraltarensis* BouDagher-Fadel, Rose, Bosence & Lord, 2001

(Pl. 1, figs. 15-16)


p.p. 1998 *Siphovalvulina variabilis* Septfontaine – Fugagnoli & Loriga Broglio, p. 60, Fig. 9.2.

2001 *Siphovalvulina gibraltarensis* sp. nov. – BouDagher-Fadel et al., p. 605, Pl. 1, figs. 6-11.

2007 *Siphovalvulina gibraltarensis* BouDagher-Fadel, Rose, Bosence & Lord, 2001 – BouDagher-Fadel & Bosence, p. 9, Pl. 2, figs. 1-2; Pl. 4, fig. 2; Pl. 6, figs. 3-5; Pl. 9, fig. 6; Pl. 11, figs. 1, 5.

**Material:** Thin sections 321, 322, 332, 335, 337, 424b, 429b, 533, 534, 535.

**Description:** Test is trochospiral, with an apical angle 90–130°. The spire comprises up to 5 coils. The test is 0.18–0.44 mm high, 0.16–0.46 mm wide. The test wall is simple, microagglutinated. The umbilical opening is wide, continuing into a wide, twisted umbilical canal. Apertural faces of chambers are well rounded.

**Remarks:** The high apical angle is a distinctive mark of this species (see BouDagher-Fadel et al., 2001).

**Geographic distribution and stratigraphic range:** Sinemurian of Gibraltar; Sinemurian – Early Pliensbachian of Betic Cordillera, Spain; Sinemurian of Iberian Range, Spain; Sinemurian – Pliensbachian of High Atlas, Morocco; Sinemurian of Dorsales Range, Tunisia; Sinemurian – Pliensbachian of Sibillini Mountains, central Italy; Sinemurian – Pliensachian of Evvia, Greece (BouDagher-Fadel & Bosence, 2007); Early Jurassic of Southern Alps, northern Italy (Fugagnoli, 1998); Sinemurian – Toarcian of Karst Dinarides, Croatia (Velic, 2007).

*Siphovalvulina variabilis* Septfontaine, 1988
(Pl. 1, figs. 17-18; Pl. 2, figs. 1-2)

? *Siphovalvulina variabilis* Septfontaine, 1988
(Pl. 1, figs. 17-18; Pl. 2, figs. 1-2)

nom. nudum 1980 “*Siphovalvulina*” – Septfontaine, Pl. 2, fig. 10.

L 1988 *Siphovalvulina* n. gen. – Septfontaine, p. 244.


p.p. 1998 *Siphovalvulina variabilis* Septfontaine – Fugagnoli & Loriga Broglio, p. 60, Fig. 9.1.

2001 *Siphovalvulina colomi* sp. nov. – BouDagher-Fadel et al., p. 605, Pl. 1, figs. 1-4.

2003 *Siphovalvulina variabilis* Septfontaine, 1988 – Azerêdo et al., Pl. 10, fig. 7.

2003 *Siphovalvulina* sp. – Kabal & Tasli, Pl. 4, figs. 9-10.

p.p. 2007 *Siphovalvulina colomi* BouDagher-Fadel, Rose, Bosence & Lord 2001 – BouDagher-Fadel & Bosence, p. 8, Pl. 9, fig. 4; Pl. 10, fig. 1; Pl. 11, figs. 4-5.

**Material:** Thin sections 321, 322, 326, 329b, 333, 412, 418, 423, 428, 429a, 7335, 337, 513, 517, 523, 533, 535b, 536.

**Description:** The test is trochospiral, with an apical angle 45–75° and up to 6 coils. Three chambers are visible in basal section of the last coil. The total test height is 0.25–0.77 mm, the width 0.20–0.51 mm. The twisted umbilical canal is clearly visible, indented on the inner side of the chambers. The chamber lumen is rounded to reniform. The wall is simple, microagglutinated.

**Remarks:** The specimens ascribed here to *S. variabilis* differ from *S. gibraltarensis* in having a narrower apical angle. The holotype of *S. variabilis* was figured by Septfontaine (1980) and described in Septfontaine (1988) as having a very variable morphology. At the time, *Siphovalvulina* was considered a monospecific genus, ranging from Hettangian to the Cretaceous. BouDagher-Fadel et al. (2001) later described *Siphovalvulina colomi* from Lower Jurassic strata. The later author considered *S. colomi* and *S. gibraltarensis* the only Early Jurassic species of this genus. *Siphovalvulina colomi* in their opinion differs from *S. variabilis* in having a more compact test, less visible sutures and smoothly convex septa, which are not highly arched and oblique to the main axis. Some of the specimens figured by the same author (e.g. BouDagher-Fadel & Bosence, 2007, Pl. 9, fig. 4; Pl. 11, fig. 4), including the holotype of *S. colomi* (BouDagher-Fadel et al., 2001, Pl. 1, fig. 1) in my opinion fail to meet this criteria. I thus consider *S. colomi* a probable junior synonym of *S. variabilis*.

**Geographic distribution and stratigraphic range:**
Early Jurassic specimens derive from: Sinemurian of Gibraltar; Sinemurian – Early Pliensbachian of Betic Cordillera, Spain; Sinemurian of Dorsales Range, Tunisia; Sinemurian – Pliensbachian of Sibillini Mountains, central Italy; Sinemurian – Pliensachian of Evvia, Greece (BouDagher-Fadel & Bosence, 2007); Early Jurassic of Southern Alps, northern Italy (Fugagnoli, 1998); Late Sinemurian of Algarve, Portugal (Azerêdo et al., 2003); Pliensbachian – Toarcian of Central Taurides, Turkey (Kabal & Tasli, 2003).

*Septfontaine* (1988) considered *S. variabilis* as Hettangian to Early (also Late?) Cretaceous in age. According to Velic (2007), this species in the Karst Dinarides first appears at the end of the Hettangian.
? Siphovalvulina sp. A
(Pl. 2, fig. 4)

p.p. 2007 Siphovalvulina colomi BouDagher-Fadel, Rose, Bosence & Lord 2001 – BouDagher-Fadel & Bosence, p. 8, Pl. 6, fig. 6; Pl. 9, fig. 5.

Material: Thin sections 413, 536.

Description: A high trochospiral test with remiform to rounded trapezoidal chambers in 6 coils measures 0.68 mm in height and 0.36 mm in width. The apical angle is 45°. The siphonal canal is relatively narrow.

Remarks: These specimens differ from S. variabilis in more flattened chambers. More specimens, however, would be needed to confirm the difference. The specimens resemble part of the material figured by BouDagher-Fadel and Bosence (2007) as Siphovalvulina colomi.

Geographic distribution and stratigraphic range: Similar specimens have been figured from Sinemurian – Pliensbachian of Sibillini Mountains, Italy and from Sinemurian of Dorsales Range, Tunisia by BouDagher-Fadel and Bosence (2007).

Superfamily Lituloidea de Blainville, 1827
Family Hauraniidae Septfontaine, 1988
Subfamily Amijiellinae Septfontaine, 1988
Genus Amijiella Loeblich & Tappan, 1985
(type species: Haurania amiji Henson, 1948)

Amijiella amiji (Henson, 1948)
(Pl. 2, figs. 6-10)

1948 Haurania amiji – Henson, p. 12, Pl. 15, figs. 5-10.
1966 Lituloïdes – Radoicic, Pl. 23, fig. 1 pars.
1967 Haurania amiji Henson 1948 – Hottinger, p. 52, Pl. 8, figs. 1-6, 20-21; Fig. 25.
1977 Haurania amiji Henson – Velić, Pl. 2, figs. 6-8.
1981 Haurania amiji Henson 1948 – Baloge, p. 130, Fig. 2, Pl. 1, figs. 1-7; Pl. 2, figs. 1-3, 5-7, 11-12.
1994 Amijiella amiji (Henson) – Chocchini et al., Pl. 1, fig. 2; Pl. 24, figs. 2-4.
1997 Amijiella amiji (Henson) – Banner et al., Pl. 1, fig. 8.
1998 Amijiella amiji (Henson), 1948 – Fugagnoli & Loriga Broglio, p. 53, Figs. 7.5, 6.
1999 Amijiella sp. – Bassoulet et al., p. 217, Pl. 4, fig. 4.
2000 Amijiella amiji (Henson) 1948 – Perelis Grossowicz et al., Pl. 1, fig. 2.
2003 Amijiella amiji (Henson) – Kabal & Tasli, Pl. 4, figs. 1-6.
2005 Amijiella amiji (Henson) – Cai et al., Pl. 4, figs. 1-7.
2007 Amijiella amiji (Henson 1948) – BouDagher-Fadel & Bosence, p. 7, Pl. 1, fig. 5; Pl. 3, fig. 5, Pl. 7, fig. 1; Pl. 8, fig. 1.
2008 Amijiella amiji (Henson) – Al-Saad, Pl. 2, fig. 1.

Material: Thin sections 322, 325, 330, 413, 417, 424b, 513, 523, 529, 535. Two specimens of megalospheric generation and ten microspheric tests, all in longitudinal sections. Two transverse sections.

Description: The test is elongated, with pronounced dimorphism, expressed in the development of the planispiral part, followed by chambers in uniserial rectilinear or curvilinear arrangement. The aperture is not clearly visible; it could be multiple or circular. In some specimens, a single central opening is observed. The uniserial part of the test is circular in cross-section. Thick radial beams of the exoskeleton are pronounced, reaching far towards the centre of chamber. The wall is of variable thickness (0.04-0.06 mm).

Type 1: The test is uniserial throughout, or perhaps with a very small coiled initial part, which is not discernible. The number of chambers in uniserial part ranges from 4 to 8. They are fairly constant in height (lumen around 0.04-0.06 mm) and width, resulting in a test with roughly parallel sides, 0.65-1.00 mm long and 0.32-0.39 mm wide.

Type 2: The initial part of the test is planispiral, 0.19-0.34 mm in diameter. The number of coils is not clearly visible (27). The coiled part is followed by 4 uniserial chambers in total length of 0.48 mm. Individual chambers are 0.05-0.06 mm high (lumen), maintaining approximately constant width.

Remarks: A reconstruction of A. amiji is given by Baloge (1981). Radial partially developed beams (incipient septula?) are clearly visible in sections perpendicular to the axis of growth. Rafters are also depicted. BouDagher-Fadel and Bosence (2007) interpreted aperture as multiple, later reduced to a single central opening. Loeblich and Tappan (1987) and Septfontaine (1988) write about crinoid aperture. Smaller (1.2 mm) specimens with planispiral initial part were originally interpreted as microspheric tests, and the specimens lacking planispiral part as megalospheric. Hottinger (1967), however, could not confirm this. Fugagnoli (1998) on the basis of the literature survey allowed for a possibility that both generations could possess a planispiral part.

Geographic distribution and stratigraphic range: Middle Liassic of Dinarides, Montenegro (Radoicic, 1966); Middle Liassic of Central Apennines, central Italy (Chocchini et al., 1994); latest Hettangian to end of Pliensbachian of Dinarides, Croatia (Velić, 1977); Sinemurian – Early Pliensbachian of Betic Cordillera, Spain; Sinemurian – Pliensbachian of High Atlas, Morocco (BouDagher-Fadel & Bosence, 2007); Late Sinemurian – Pliensbachian of Southern Alps, northern Italy (Fugagnoli, 1998; Fugagnoli & Loriga Broglio, 1998); Late Sinemurian of Poitou, France (Baloge, 1981); Pliensbachian of Middle Atlas, Morocco (Bassoulet et al., 1999); Middle Liassic and Toarcian of southern Tibet, China (Cai et
Family Mesoendothyridae Voloshinova, 1958
Subfamily Mesoendothyridinae Voloshinova, 1958
?Genus Mesoendothyra Dain, by Bykova et al., 1958
(type species: Mesoendothyra izumijana Dain, in Bykova et al., 1958)

Mesoendothyra? sp. A
(Pl. 2, figs. 11-13)

1998 Mesoendothyra sp. – Fugagnoli, p. 155, Pl. 23, figs. 4-5.
2000 “Mesoendothyra” sp. – Perelis Grossowicz et al., Pl. 1, fig. 7.
2007 Mesoendothyra sp. – Vellic, Pl. 2, figs. 1-4.

Material: Thin sections 515, 517, 519, 526, 534, 535b, 536.

Description: The test is mostly circular in equatorial section; planispiral coils are rarely followed by the uniserial part of the test. The outer test wall is microagglutinated. A keirothecal structure is suggested, but not clearly visible. The wall is 0.02-0.03 mm thick. Septa are approximately of the same thickness, situated slightly oblique. The aperture is simple basal, in the uncoiled part multiple.

Microspheric (?) test: The proloculus is not distinguishable. The planispiral part consists of (2?) 2.5-3 coils. Counting from the aperture backwards, the last coil comprises 7-10 chambers. The uniserial part is present in only one of the specimens, consisting of 4 chambers. Chambers are approximately as high as they are wide. The planispiral part of the test measures 0.22-0.43 mm in diameter. The total test length of the test with the uniserial part is 0.69 mm. The higher number of planispiral coils suggests these tests belong to the microsphaeric generation.

Megalsospheric test: The proloculus is circular, 0.03-0.04 mm in diameter. It is followed by 1.5-2.5 planispiral coils, with 9 chambers in total (6 are counted in the last whorl). The entire spiral part is 0.26-0.39 mm in diameter.

Remarks: The shape of the test and the test size correspond to Mesoendothyra sp. described by Fugagnoli (1998), Perelis Grossowicz et al. (2000), and Vellic (2007). The wall was determined by Fugagnoli (1998) as simple, without exoskeletal structure. If this is the case, then it is appropriate to place this species into genus Mesoendothyra (although the stratigraphic gap between this and later species of this genus is not considered). However, the simple structure may be the product of diagenetic alteration of keirothecal wall, and the species should be assigned into genus Bosniella. The specimens presented here do not offer reliable evidence for this. The uniserial part in some specimens figured by Vellic (2007) bears much flatter chambers.

Geographic distribution and stratigraphic range: Early Jurassic of Southern Alps, northern Italy (Fugagnoli, 1998); Sinemurian – Pliensbachian of Karst Dinarides of Croatia (Vellic, 2007); Toarcian–Early Bajocian (undifferentiated) of Israel (Perelis Grossowicz et al., 2000).
crossing the chamber lumen. The wall appears undifferentiated, microagglutinated. The aperture is multiple in the uncoiled part, not visible in the planispiral one.

Remarks: The specimens figured herein correspond best to *Lituosepta recoarensis*, originally described by Catì (1959) from the Lower Jurassic of Southern Alps. Hottinger (1967) later figured some of Catì's (1959) specimens, adding some new specimens from High Atlas of Morocco, as well as a wealth of specimens, which he attributed to a new species, *Lituosepta compressa*. According to Hottinger (1967), the new species differs from *L. recoarensis* in having smaller test, a more pronounced flattening, a better developed pillars in the endoskeleton, a tighter coiling and a smaller proloculus in megalospheric forms (0.06-0.08 mm compared to 0.08-0.10 for *L. recoarensis*). In his opinion, transverse sections of *L. recoarensis* in Catì (1959) possibly belong to *Haurania*. Both species of *Lituosepta* should thus be laterally compressed. In contrary to Hottinger, Septfontaine (1984) believed Catì was right about *L. recoarensis* having circular cross section, and he subsequently established a new genus, *Planisepa*, to comprise flattened ex *L. compressa* (Septfontaine, 1988). Furthermore, Septfontaine (1984) regarded specimens designated by Hottinger (1967) as *L. recoarensis* as belonging to *P. compressa*. Fugagnoli (1990) and Fugagnoli and Loriga Broglio (1998) later accepted Hottinger's (1967) interpretation, disregarding validity of genus *Planisepa*. Loeblich and Tappan (1987) considered *Lituosepta* as a junior synonym of *Labyrinthina Weynschenk*. According to Septfontaine (1988), the initial coiled stage is more pronounced in the latter (3 coils compared to 1.5 coil in *Lituosepta*), whereas BouDagher-Fadel (2008) mentions also a fan-shaped flabelliform test and a canalicular wall in *Lituosepta*.

In my opinion, the distinction between the two species is not well established. The size difference proves to be irrelevant (see specimens in Fugagnoli, 1998, and BouDagher-Fadel & BoSence, 2007). In fact, the only useful quantitative parameter seems to be the size of the proloculus, but the latter overlap at 0.08 mm. Based on the material figured by Catì (1959) and Hottinger (1967), the difference may be in the tightness of coiling, i.e. the planispiral part of the megalospheric form opens after 1.5 coils in *L. recoarensis* and after 2 in *L. compressa*, and in the number of endoskeletal pillars, which are better developed (more numerous) in the latter species. It is also true, that Catì's microsphaeric specimen does not show a pronoucnely fan-shaped uncoiled part. Thus, I agree with Septfontaine's opinion and regard Hottinger's specimens as belonging to *L. compressa* only. However, as the type material of *L. recoarensis* needs to be re-examined, I refrain from species designation. Regarding the genus name, I agree with Fugagnoli (1998) and Fugagnoli and Loriga Broglio (1998) that the degree of flattening is not a generic criterion. The name *Planisepa* is thus regarded as a junior synonym of *Lituosepta*, especially since there is no equivocal proof of the *L. recoarensis* cross section.

One of the specimens, figured by Chiocchini et al. (1994), does not show endoskeletal pillars. Its determination is thus considered doubtful.

*Lituosepta* differs from *Orbitopsella* Munier-Chalmas in having a simple megalospheric proloculus, and from *Haurania* Henson in a simple exoskeleton and in a laterally flattened test (Hottinger, 1967; Loeblich & Tappan, 1987).

Geographic distribution and stratigraphic range: Bassoulet (1997) regards *L. recoarensis* and *L. compressa* as stratigraphically very useful species, as the former is of Sinemurian and the latter of Pliensbachian age. However, due to taxonomic uncertainties regarding the distinction of both species, a careful re-examination of material is needed. The specimens from the synonymy list were collected in: middle Early Jurassic of Apennines, central Italy (Catì, 1959; Sartoni & Crescenzì, 1962; Chiocchini et al., 1994); Late Sinemurian of Central Taurides, Turkey (Kabal & Taslı, 2003); Late Sinemurian of Aglarve Basin, Portugal (Azeredo et al., 2003); Late Sinemurian – Early Pliensbachian of Karst Dinardies (Velic, 2007); Pliensbachian of Israel (Perelis Grossowicz et al., 2000); Sinemurian – Early Pliensbachian of Betic Cordillera, Spain; Sinemurian – Pliensbachian of High Atlas, Morocco; Sinemurian – Pliensbachian of Evvia, Greece (BouDagher-Fadel & BoSence, 2007); and Pliensbachian of Southern Alps, northern Italy (Fugagnoli, 1998).

*Lituosepta* sp. var. B

(Pl. 2, fig. 18)

Cf. 1967 *Lituosepta compressa* n. sp. – Hottinger, p. 36-38, Pl. 4, figs. 1-13; Figs. 17-18.


Description: A relatively small coiled (planispiral?) part of the test, 0.43 mm in diameter, is not clearly visible, so the number of coils (possibly 2) is poorly defined. In the outer part, however, more than 12 chambers can be counted, prior to the following uniserial part. In the latter, chambers, while retaining a constant height of 0.05 mm, become increasingly wider, producing a flaring test of total length of 2.07 mm. The uniserial part consists of 26 chambers. Septa and the outer test wall are 0.03 mm thick. Chamber lumen is crossed by numerous pillars. The wall is presumably simple in structure, microagglutinated. The aperture is multiple in the last part of the coiled and in the uniserial part at least.

Remarks: Tests of distinct fan shaped planispiral part are here described separately from the rest of the *Lituosepta* material, as they
better correspond to Hottinger’s (1967) specimens, which he regarded as belonging to *L. recoarensis*, but which, according to Septfontaine (1984), belong to *L. compressa* instead. Rađočić (1966; Pl. 144, fig. 2; Pl. 145, fig. 1) shows microspheric tests of supposedly *L. recoarensis* from middle Lower Jurassic of Karst Dinarides (Žumberak, Croatia), which have fewer chambers than specimens figured herein.

Genus *Orbitopsella* Munier-Chalmas, 1902
(type species: *Orbitolites praecursor* Gümbel, 1872)

*Orbitopsella primaeva* Henson, 1948
(Pl. 2, fig. 18; Pl. 3, figs. 1-5)

1948 *Coskinolinopsis primaevus* Henson –
Henson, p. 27, Pl. 10, figs. 4-5.

1967 *Orbitopsella primaeva* (Henson) –
Hottinger, p. 46, Pl. 4, figs. 17-18; Figs. 23k-s.

1998 *Orbitopsella primaeva* (Henson) –
Fugagnoli, p. 147, Pl. 1, figs. 1-9; Pl. 2, figs. 1-10.

1998 *Orbitopsella primaeva* (Henson) –
Fugagnoli & Loriga Broglio, p. 50, Figs. 6.1-5.

2000 *Orbitopsella primaeva* (Henson) –
Perelis Grossowicz et al., Pl. 1, figs. 8, 9, 10.

2003 *Orbitopsella primaeva* (Henson) –
Kabal & Tasli, Pl. 3, figs. 1-3.

2007 *Orbitopsella primaeva* (Henson) –
Boudagher-Fadel & Bosence, p. 6, Pl. 1, figs. 1, 2, 4; Pl. 2, fig. 4.

1972 *Haurania deserta* Henson, 1948 –
Boudagher-Fadel & Bosence, Pl. 8, figs. 2-5.

2007 *Orbitopsella primaeva* (Henson) –
Velic, Pl. 2, figs. 9-11; Pl. 3, figs. 1-4.

**Material:** Thin sections ?329b, 413, 418, 421, 424a, 424b, 513, 532, 533, 534, 535b.

**Description:** Dimorphism is strongly pronounced.

**Megaspheric test:** In equatorial view the test appears fan shaped, semicircular, whereas in axial view the test is strongly elongated with parallel sides. Protoconch is complex, though the wall separating the protoconch from the deuteroloculus is usually not preserved. The size of the protoconch (lumen) is 0.18-0.31 mm. A short planispiral part follows with up to 12 chambers, and in the last stage of growth numerous uniserially arranged strongly arched chambers. These maintain constant height while gradually becoming wider. The total diameter of the test amounts to 2.14-2.35 mm.

The outer wall and the septa are 0.03 mm thick. A notable difference among specimens is in the size of agglutinated grains: while some specimens have uniformly thick wall, in others incorporated grain size exceeds the basic wall thickness by as much as 6.4-times. The exoskeleton is simple, with poorly visible beams. The endoskeleton consists of widely spaced and few pillars. Four to five stolon planes are visible.

**Microspheric test:** The test is in »axial« section flat, with parallel sides, or with a gradually higher periphery, becoming biconcave. The total test diameter is 2.50-6.22 mm. The protoconch and the initial spiral part were not observed. The exoskeletal and endoskeletal features are as described above.

**Remarks:** Despite the large number of specimens attributed to *Orbitopsella* only a few were determined to the species level. The criteria used in distinguishing *O. primaeva* from *O. praecursor* (Gümbel) and *O. dubari* Hottinger are: protoconch size and the test size (both smaller in *O. primaeva*) in megalospheric tests, and fewer stolon planes and much microspheric smaller test for *O. primaeva* (see Hottinger, 1967). The number of spiral chambers could not be observed due to insuitable orientation of specimens. Compared to specimens in Hottinger (1967), the megalospheric specimens from the Krim area belong to A1 generation. The difference in coarseness of the wall is considered a phenotypic character (Fugagnoli, 1998).

**Geographic distribution and stratigraphic range:** Sinemurian – Early Pliensbachian of Betic Cordillera, Spain (Boudagher-Fadel & Bosence, 2007); Late Sinemurian – Early Pliensbachian of Southern Alps, northern Italy (Fugagnoli, 1998; Fugagnoli & Loriga Broglio, 1998); Late Sinemurian – Early Pliensbachian of Karst Dinarides, Croatia (Velić, 2007); Pliensbachian of High Atlas, Morocco (Hottinger, 1967); Early Pliensbachian of Israel (Perelis Grossowicz et al., 2000); Early Pliensbachian of Central Taurides, Turkey (Kabal & Tasli, 2003). Latest Sinemurian and Early Pliensbachian according to Bassoullet (1997).

*Orbitopsella praecursor* (Gümbel, 1872)
(Pl. 3, figs. 6-8)

1962 *Orbitopsella praecursor* (Gümbel) –
Sartoni & Crescenti, p. 274, Pl. 47, fig. 1.

1966 *Orbitopsella praecursor* (Gümbel) –
Rađočić, Pl. 20, figs. 1-2; Pl. 72, figs. 1-2.

1967 *Orbitopsella praecursor* (Gümbel) –
Hottinger, p. 40, Pl. 5, figs. 1-12; Fig. 20.

1977 *Orbitopsella praecursor* (Gümbel) –
Velic, Pl. 1, figs. 1-5.

1987 *Orbitopsella praecursor* (Gümbel) –
Ulciograi et al., Figs. 5-7.

1994 *Orbitopsella praecursor* Gümbel –
Chiocchini et al., Pl. 2, figs. 12-13; Pl. 27, fig. 10.

1998 *Orbitopsella praecursor* (Gümbel), 1872 –
Fugagnoli & Loriga Broglio, p. 52, Figs. 6.6-9.

1998 *Orbitopsella praecursor* (Gümbel, 1872) –

1999 *Orbitopsella praecursor* (Gümbel), 1872 –
Bassoullet et al., p. 224, Pl. 1, figs. 1-8.

2003 *Orbitopsella praecursor* (Gümbel) –
Kabal & Tasli, Pl. 3, figs. 4-11.

2005 *Orbitopsella praecursor* (Gümbel) –
Cai et al., Pl. 3, figs. 17-25.
2007 Orbitopsella praecursor (Günbel 1872) – 
Boudagher-Fadel & BoScience, p. 7, Pl. 3, fig. 3.
2007 Orbitopsella praecursor (Günbel) – Velic, 
Pl. 3, figs. 5-6; Pl. 4, figs. 1-4.

Material: Thin sections 427, 528, 529, 532, 535b.

Description: Few specimens are in appropriate 
section to allow for the recognition of this species. 
The endoskeletal pillars are few and widely 
spaced. The wall structure is not visible. The 
wall thickness is around 0.04 mm. The protoconch 
of megalospheric forms measures 0.44 mm in 
diameter and the total test diameter is 1.46-1.75 
mm. The initial part of the test is often wider 
than the rest of the test. The microspheric form 
measures 10.71 mm in diameter. The initial spiral 
part consists of 14 chambers.

Remarks: According to Hottinger (1967), 
Fugagnoli (1998) and Bassoulet et al. (1999), 
O. circumvolata probably represents a junior 
synonym of O. praecursor. Hottinger (1967) 
retained it as a special morphotype.

Geographic distribution and stratigraphic 
age: Middle Early Jurassic of Apennines, central 
Italy (Sartoni & Crescenti, 1962; Chiocchini 
et al., 1994); middle Early Jurassic of southern 
Tibet, China (Cai et al., 2005); Sinemurian – 
Early Pliensbachian of Betic Cordillera, Spain; 
Sinemurian – Pliensbachian of High Atlas, 
Morocco (Boudagher-Fadel & BoScience, 2007); 
Late Sinemurian – Pliensbachian of Southern 
Alps, northern Italy (Ulbrigrai et al., 1987; 
Fugagnoli, 1998; Fugagnoli & Loriga Biocchio, 
1998); Pliensbachian of Middle Atlas, Morocco 
(Bassoulet et al., 1999); Early Pliensbachian of 
Central Taurides, Turkey (Kabal & Tasli, 2003); 
Early to Middle Pliensbachian of Karst Dinarides, 
Croatia (Velic, 2007). Middle part of Pliensbachian 
according to Bassoulet (1997).

Suborder Loftusiina Kaminski & Mikheleivich, in 
Kaminski, 2004
Superfamily Loftusiacea Brady, 1884
Family Everticyclamminidae Septfontaine,
1988
Genus Everticyclammina Redmond, 1964
(type species: Everticyclammina hensoni 
Redmond, 1964)

Everticyclammina praevirguliana Fugagnoli, 2000 
(Pl. 3, figs. 9-15)

* 2000 Everticyclammina praevirguliana n. sp. – 
Fugagnoli, p. 127, Pl. 1, figs. 1-9; Pl. 2, figs. 
1-10; Pl. 3, figs. 1-8.
2001 Everticyclammina praevirguliana Fugagnoli, 
2000 – Boudagher-Fadel et al., p. 611, Pl. 2, 
fig. 12.
2007 Everticyclammina praevirguliana Fugagnoli 
3, fig. 6; Pl. 4, figs. 1, 5; Pl. 5, fig. 3; Pl. 9, figs. 
2-3.

Material: Thin sections 328, 329, 329B, 333, 
337, 413, 429B, 510, 513, 515, 517, 522, 524, 526, 
530, 533, 535, 535b. Specimens of megalo- 
and microspheric generation. One specimen in axial 
section, 10 specimens in equatorial section.

Description: Fairly large specimens have thick, 
finely agglutinated alveolar wall with widely 
spaced alveolae. Both generations (micro- and 
megalospheric) usually comprise well developed 
planispirally coiled initial part, followed by few 
uniserially arranged chambers. Chambers of the 
coiled part appear remiform, whereas chambers 
are triangular in shape in the uncoiled part of 
the test, tapering towards distal end. Aperture is 
a simple, large, centrally situated opening. Septa 
are of the same thickness (0.03 to 0.10 mm) as the 
outer test wall. The thickness of both, however, 
varies largely even in the same specimen.

Microspheric test: The coiled part of the test 
comprises 2-5 coils; the first is very small, with 
an indistinguishable number of chambers. The 
second coil consists of 3-4 chambers. The diameter 
of the coiled part is 0.16-0.41 mm. The rectilinear or 
curvilinear uniserial part, 0.5-0.87 mm long, consists 
of 2-5 chambers. The width of these in some sections 
appears equal to diameter of the initial coiled part. 
The maximum height of chambers (lumen, measured 
to the top of aperture, i.e. with septa thickness 
included) in the uncoiled part is 0.11-0.23 mm. A 
proloculus is too small to be measured.

Megalospheric test: The initial part measures 
0.26-0.48 mm in diameter and has 2 coils with 3 
(?) and 5-7 chambers, respectively. The uncoiled 
part, 0.35-0.75 mm long, consists of 3-4 chambers, 
which are up to 0.11-0.28 mm high and 0.17-0.42 
mm wide. A simple spheric proloculus measures 
0.03-0.11 mm in diameter. In axial section, 
the initial coiled part appears biconvex, with 
chambers of the last whorl by 1/2 wider than the 
first whorl. The periphery is rounded, yet with 
box-like outline.

Remarks: According to Boudagher-Fadel et 
al. (2001) and Boudagher-Fadel and BoScience 
(2007), E. praevirguliana represents the only 
species of Everticyclammina from the Early 
Jurassic. Based on the original diagnosis of the 
species (Fugagnoli, 2000), it seems difficult to 
distinguish E. praevirguliana from other species 
of this genus. Fugagnoli (2000) mentions a 
smaller test size and a more uniform chamber 
growth in E. praevirguliana in comparison to 
Everticyclammina virgulina (Koechlin), the 
next species in phylogeny. The biumbilical axial 
section and the triangular, tapering chambers 
(compared to rounded chambers of E. virguliana) 
of the uniserial part of the test might provide a 
better distinguishing character, but the range of 
chamber shape from triangular to semi-circular is
present also in the original material of Fugagnoli (2000). The two species may thus be synonyms, but a further discussion is needed. Schlagintweit and Velč (2011) described specimens of the genus Everticyclammina from Aalenian of the Dinarides in Croatia as E. praevirguliana, extending the stratigraphic range of this species into younger strata. Due to the similarity between the two species, their species might also be determined as E. virguliana. Alternatively, the two species may have coexisted for some time.

**Geographic distribution and stratigraphic range:** Latest Hettangian to end of Toarcian of Karst Dinarides, Croatia (Velč, 2007); Sinemurian of Gibraltar (BouDagher-Fadel et al., 2001; BouDagher-Fadel & Bösend, 2007); Late Sinemurian–Pliensbachian of Southern Alps, northern Italy (Fugagnoli, 2000); Sinemurian – Pliensbachian of Betic Cordillera, Spain; Sinemurian of High Atlas, Morocco; Sinemurian – Pliensbachian of Dorsales Range, Tunisia; Sinemurian – Pliensbachian of Sibillini Mountains, central Italy; Sinemurian – Pliensbachian of Evvia, Greece (BouDagher-Fadel & Bösend, 2007).

Suborder Miliolina Delage & Hérouard, 1896

Superfamily Cornuspiracea Schultze, 1854

Family Cornuspiridae Schultze, 1854

Subfamily Meandrospirinae Saidova, 1981


**Meandrovoluta asiagoensis** Fugagnoli & Rettori, 2003 (Pl. 3, figs. 16-18)

1966 *Glomospira* sp. – Radocic, Pl. 92, fig. 2; Pl. 111, fig. 2; Pl. 124, fig. 2 paras; Pl. 125, figs. 1-2 paras.

1994 *Glomospira* sp. – Chiocchini et al., Pl. 2, figs. 19, 21; Pl. 27, fig. 7.

p.p. 1998 *Glomospira* sp. Rzehak, 1885 – Fugagnoli & Loriga Broglio, p. 66-68, Fig. 9.12 [non Figs. 9.10-9.11].

1999 *Meandrospiranella* sp. – Bassoullet et al., p. 228, Pl. 4, figs. 12-13.

1999 *Hoyenella* sp. – Bassoullet et al., p. 228, Pl. 4, figs. 14-17.

*2003 Meandrovoluta asiagoensis* Fugagnoli & Rettori gen. et sp. nov. – Fugagnoli et al., p. 45, Pl. 1, figs. 1-12; Pl. 2, figs. 1-16.

*2005 Glomispira tingriensis* sp. nov. – Cai et al., p. 45, Pl. 1, figs. 27-32.


**Description:** Specimens are morphologically very variable. A globular proloculus is followed by an undivided second chamber, which coils mostly in irregular fashion, or at some stage remaining close to one plane, producing roughly globular or disc-like tests. The test wall dark and dense, sometimes brownish in appearance. The size of the measured specimens (a few of the total number) is 0.17-0.36 mm. The lumen height in the outermost preserved deuterolocus is 0.03-0.05 mm. Up to 11 coils were counted on either side of the proloculus. The microspheric and megalospheric generations are currently not distinguished due to the lack of centered sections.

**Remarks:** *Meandrovoluta* is among the most common benthic foraminifera in Early Jurassic carbonates, often described as *Glomospira* sp. The distinction from the latter, however, is in its wall structure, which is porcelaneous in *Meandrovoluta* and finely agglutinated in *Glomospira* Rzehak (Fugagnoli et al., 2003). Its morphological variability, its presence in a variety of facies and assemblages, and a locally high abundance in low-diversity assemblages (personal observation in resemdments of Perblia Formation, depository of B. Rožič, University of Ljubljana) suggest it is an opportunistic species (see Dodd & Stanton, 1990, p. 288). A somewhat similar Triassic genus *Hoyenella* Rettori has an initial mioloid coiling and a regularly developed last planispiral stage (Rettori, 1994, 1995).

Finally, Cai et al. (2005) described three new species from the Middle Jurassic of Tibet: *Glomospira wolongensis*, *Glomospira tingriensis* and *Glomospirella minuscula*. The latter has a pronounced planispiral stage, and *G. wolongensis* appears smaller and with fewer coils, but *G. tingriensis* may prove to be a junior synonym of *M. asiagoensis*.

**Geographic distribution and stratigraphic range:** The specimens cited in the synonymy list belong to Sinemurian – Toarcian of Southern Alps, northern Italy (Fugagnoli, 1998; Fugagnoli et al., 2003); Sinemurian – Toarcian of Karst Dinarides, Croatia (Velč, 2007), and Bosnia (Radocic, 1966); Middle Early Jurassic of Apennines, central Italy (Chiocchini et al., 1994), Pliensbachian of Middle Atlas, Morocco (Bassoullet et al., 1999).

Suborder Involutinina Hohenegger & Piller, 1977

Superfamily Involutinoidea Bûtschi, 1880

Family Involutinidae Bûtschi, 1880

Subfamily Involutininae Bûtschi, 1880

Genus *Involutina* Terquem, 1862 (type species: *Nummulites liassicus* Jones, in Brodie, 1853)

*Involutina farinacciae* Brønnimann & Koehn-Zaninetti, 1969

(Pl. 4, figs. 1-3)

1969 *Involutina farinacciae*, n. sp. – Brønnimann & Koehn-Zaninetti, p. 76, Figs. 1c, 2a-g.

2011 *Involutina farinacciae* Brønnimann & Koehn-Zaninetti – Radocic & Jovanovic, Pl. 1, figs. 3-5; Pl. 2, figs. 1-4; Pl. 3, figs. 1-6; Pl. 4, figs. 1-6, 8-9.
**Material:** Thin sections 324, 517, 519, 522, 523, 526, 528, 530, 533, 534, 535, 535b.

**Description:** Tests are small, recrystallized into spar (originally aragonitic), mostly overgrown by ooid or micritic coatings. All specimens identified with confidence are in axial section. A planispiral coil is visible. Only lumen of a few last coils is visible; the total number of coils is probably around 5. The umbilical part is strongly thickened on both sides, being biconvex and bearing numerous papillae. The last 1-2 coils are evolute. The test diameter is 0.15-0.27 mm.

**Remarks:** Based on the original description, “Involutina farinacciae” differs from other species of this genus by its small size and the shape of the chamber lumen. However, Rigaud et al. (in press) say there is no reliable criterion to separate “I. farinacciae” from Involutina liassica (Jones), due to the large variability of the species.

**Geographic distribution and stratigraphic range:** The type material derives from early Early Jurassic of Monte Lacerone, Italy (Bönnimann & Köhn-Zaninetti, 1969). Radovic and Jovanovic (2011) add numerous localities in Inner Dinarides, Karst Dinarides, Budva Basin and from Avroman Range area in Iraq, advocating “I. farinacciae” as a marker of middle Early Jurassic. The Podpeč quarry is among the listed localities.

Family Trocholinidae Kristan-Tollmann, 1963, emend. Rigaud et al., 2013

? Subfamily Lamelliconinae Zaninetti et al., 1987, emend. Rigaud et al., 2013

? Genus Coronipora Kristan, 1958

(type species: Coronipora austriaca Kristan, 1957)

? Coronipora sp.

(Pl. 4, figs. 4?-5?, 6-17)

Cf. 1957 Semiinvoluta clari nov. gen. nov. spec. – Kristan, p. 276, Pl. 22, figs. 11a-c, 12-15, 16a-c, 17.

Cf. 1957 Coronella austriaca nov. gen. nov. spec. – Kristan, p. 281, Pl. 23, figs. 10a-c, 11-13.

Cf. 1966 Lasiodiscus (?) etruscus n. sp. – Pirini, p. 91, Pl. 1, figs. 1-3

Cf. 1966 Lasiodiscus (?) sp. – Pirini, p. 92, Pl. 1, figs. 4-9

?Cf. 1986 Semiinvoluta clari Kristan – Kristan-Tollmann, Fig. 1.6.

Cf. 1986 Coronipora austriaca (Kristan) – Kristan-Tollmann, Fig. 1.7-1.8.

Cf. 1975 Semiinvoluta sp. 1 (cf. S. clari Kristan) – Gušć, p. 30-31, Pl. 10, figs. 1-10; Pl. 11, figs. 8?-9?, 11?-12?

Cf. 1975 Semiinvoluta sp. 3 – Gušć, p. 31, Pl. 11, figs. 4-7, ?10.

Cf. 1975 Semiinvoluta sp. 4 – Gušć, p. 31, Pl. 10, fig. 12.


Cf. 1978 Semiinvoluta ? sp. – Piller, p. 88, Pl. 21, figs. 6-8.


Cf. 1987a Coronipora deminuta n. sp. – Blau, p. 504, Pl. 4, figs. 7-9.


Cf. 1987b Coronipora gusici n. sp. – Blau, p. 9, Pl. 3, figs. 10-13.

Cf. 1987b Coronipora sp. 1 cf. austriaca (Kristan, 1957) – Blau, p. 10, Pl. 4, figs. 8-11; Fig. 1e.

Cf. 1987b Semiinvoluta violae n. sp. – Blau, p. 10, Pl. 2, figs. 1-8.

Cf. 1991 Coronipora sp. 1 cf. austriaca (Kristan 1957) – Blau & Haas, p. 18, Figs. 7a-e.

2013 Coronipora Kristan – Rigaud et al., Figs. 6.2-6.4.

**Material:** Thin sections 325, 517, 522, 525, 526, 528, 534.

**Description:** The test is in low trochospiral, consisting of circular proloculus (0.03 mm in diameter) and undivided second chamber coiling in 4-6 coils (in one specimen 7 coils or more are visible). Calcareous material is added (?) from the outer coil towards umbilicus, leaving a shallow umbilical depression. In tangential or transverse sections, the lower side thus appears flat and completely filled, whereas a depression is seen in the axial plane. The upper side of the test is more or less convex, without secondary thickening. The chamber lumen is open towards the spiral (upper) side through wide perforations (canals?). The total test diameter is 0.24-0.40 mm (mostly around 0.31 mm), and the test height 0.06-0.17 mm (mostly 0.12 mm).

The wall is recrystallized into spar, originally aragonitic.

**Remarks:** The determination of this species is problematic at the genus and species level.

Kristan (1957) introduced two new genera: Semiinvoluta and Coronella. Semiinvoluta was described as planispiral, evolute and with sutural canals on one side and coated with secondary material on the other side. Its type species, S. clari Kristan, has diameter of 0.62 mm and 5-9 coils. Some of the figures draw by hand, show a very low trochospiral coil. The description of Coronella is practically the same as of Semiinvoluta, except that the test is evolute on the coated side also. The type species, C. austriaca, measures 0.93 mm in diameter has 5 coils. Later, Kristan (1958) substituted Coronella with Coronipora Kristan.

Gušć (1975) later changed the orientation of Semiinvoluta and reminded of the lack of appropriate comparative material for this “aberrant” group of involutinids. He emphasised that the type material was shown by hand-drawings only. His specimens were thus left in open nomenclature and species distinguished on the basis of different contour of the test, and the thickness of calcite deposits.
Piller (1978) defined Coronipora as having one evolute side and the other covered by lamellae; the coiling is planispiral. He hinted at the synonymy with Planispirillina Bermudez, but due to the lack of observation of the lamination in the latter, left both species valid. The distinction between Coronipora and Semiinvoluta was likewise questioned.

Rigaud et al. (2013) greatly revised the Trocholinidae family. The genus Coronipora was redefined as having ridge-like lamellae and large perforations or short canals on the spiral side, and interfingerling lamellae on the umbilical side, while Semiinvoluta possesses papillae on the umbilical side, shortened lamellae on the apical side and a depressed apical thickening. According to Rigaud et al. (2013), “Coronipora” serriforma Senowbari-Daryan et al. is a junior synonym of S. clari.

According to the emendation of Coronipora and Semiinvoluta (Rigaud et al., 2013), the specimen figured herein should belong to Coronipora, as no apical lamellae are visible. This distinction, however, is not obvious in the type material figured by Kristan (1957), and I consider this interpretation doubtful.

The species determination is likewise tentative. Considering a wide variety in size, Coronipora austriaca (Kristan), Semiinvoluta clari Kristan and Coronipora etrusca (Pirini) are likely candidates. The distinction from similar species is mostly lacking in the first description of these species, and the thorough revision seems necessary.

Geographic distribution and stratigraphic range: Poorly defined due to the unclarity of determination. The stratigraphic range is probably Rhaetian (?) – Early Jurassic.

Biostratigraphy

Several biostratigraphic schemes based on foraminifera exist for the Early Jurassic, and only a few more recent are discussed herein.

Kabal and Tasli (2003) named three zones in the Early Jurassic of Central Taurides. Late Sinemurian Lituosepta recoarensis lineage zone (1) starts with the first occurrence of L. recoarensis, and ends with the first occurrence of Orbitopsella primaeva. Amijiella amiji is also present, and Lituolipora termieri and Lituosepta compressa occur for the first time. The latest Sinemurian – Early Pliensbachian Orbitopsella lineage zone (2) starts with the first occurrence of O. primaeva and ends with the last occurrence of O. praecursor. Algae Palaeodosyludaceae mediterraneus Pia is present. The Lituolipora termieri interval zone (3) begins with the last occurrence of Orbitopsella. This zone also represents the acme of L. termieri. The upper boundary is poorly defined and the zone may reach into the Toarcian, below the early Middle Jurassic Bosniella croatica zone.

From the Apennines, Manchinelli et al. (2005) described three Early Jurassic zones. The Thaumatomoparella parvosculifera (Reineri) interval zone (1) is Hettangian – Early Sinemurian in age. The lower boundary is the last occurrence of Triasina hankeni Majzón, and the upper the first occurrence of P. mediterraneus. Duotaxis metula and Siphovalvulina variabilis first occur in the upper part of this zone. The Late Sinemurian P. mediterraneus local taxon range zone (2) starts with the first occurrence of its nominal species, and ends with its last occurrence. The Pliensbachian Orbitopsella local taxon range zone (3) follows.

Boudagher-Fadel and Boscience (2007) described five foraminiferal biozones for the Hettangian – Early Pliensbachian interval based on investigation of several complete sections in the Mediterranean area. In the Hettangian Siphovalvulina gibraltarensis zone (1) only a few foraminifera are present. Textularia and Siphovalvulina dominate. Involutina liassica first appears in this zone. Foraminifera remain rare also in the Early – Middle Sinemurian Siphovalvulina colomii zone (2), but biodiversity somewhat increases. Pseudopfenderina butleri first appears in this zone for the first time. Duotaxis metula is a Late Triassic Lazarus species. The first appearance of Everticlylaminina praevirguliana marks the beginning of Middle Sinemurian E. praevirguliana zone (3). The Late Sinemurian is recognized by the Lituosepta recoarensis and Orbitopsella sp. Zone (4). Lituosepta recoarensis and Orbitopsella praecursor appear for the first time, along with Amijiella amiji, Haurania deserta, and Bosniella oenensis. The following Early Pliensbachian Lituosepta compressa biozone is marked by the first appearance of its nominal species. Pseudeocyclamminia sp., Orbitopsella circumvulvulata, and Bucicrenatata first appear in this zone.

Finally, the biostratigraphic scheme for the Karst Dinarides was devised by Velic (2007). The Late Rhaetian (?) – Early Sinemurian is marked by the Triasina hankeni – Mesoendothyra sp. interval zone (1). Only small valvulinids and lituloids (i.e., O. metula, A. amiji, S. variabilis, E. praevirguliana) are present. The first occurrence of Mesoendothyra sp. marks the beginning of its Early – Late Sinemurian lineage zone (2). The upper boundary is marked by the first occurrence of L. recoarensis. Lituolipora termieri is an important taxon of this zone. The early Late Sinemurian L. recoarensis lineage zone (3) ends with the first occurrence of O. primaeva. The O. primaeva lineage zone (4) ranges from Late Sinemurian to the early Early Pliensbachian. It ends with the first occurrence of O. praecursor. Velic (2007) divided this zone into Late Sinemurian – earliest Early Pliensbachian O. primaeva – L. recoarensis concurrent-range subzone, ranging from the first occurrence of O. primaeva to the last occurrence of L. recoarensis, and into Early Pliensbachian L. recoarensis – O. praecursor interval subzone. The following O. praecursor taxon-range zone (5) marks the Early Pliensbachian. Orbitopsella is represented.
by *O. primaeva*, as well as *O. praecursor*. In the late Early Pliensbachian *O. praecursor* – *O. primaeva* concurrent-range subzone (from the first occurrence of *O. praecursor* to the last occurrence of *O. primaeva*), *Biokovina gradacensis* (Gušić) and *Bosniella oenensis* also occur. The *O. praecursor* abundance subzone is late Early Pliensbachian to early Late Pliensbachian in age. The following *O. praecursor* – *Pseudocyclammina liassica* Hottinger interval zone (6) starts with the last occurrence of *O. praecursor* and ends with the first occurrence of *P. liassica*. It is Late Pliensbachian in age, but perhaps includes also the beginning of Toarcian. The *P. liassica* taxon-range zone (7) marks the late Late Pliensbachian. The Early Jurassic then ends with the *P. liassica* – *Gutnicella cayeuxi* interval zone (8), ranging from the last occurrence of *P. liassica* to the first occurrence of *G. cayeuxi*. *Bosniella croatica* is present. This zone is Toarcian – Earyl Aalenian in age (Velić, 2007).

According to biostratigraphic scheme of Velić (2007), the Podpeč and the Grad sections belong to *Orbitopsella praecursor* taxon range zone of the Early Pliensbachian. The highest occurrence of *Orbitopsella* is at the top of Podpeč 1 section, or at the 2nd metre of the lateral Podpeč 2 section, so there is a possibility that the uppermost part of the measured

### PLATE 1

1–2 *Duotaxis metula* Kristan. 1: Thin section 337. 2: Thin section 412.

3–9 *Bosniella oenensis* Gušić. 3–8: Thin section 510. Multiple aperture is indicated with arrowhead in figure 6. 9: Note clearly visible kerotheal structure of the wall (white arrowhead) and *Meandrovoluta* incorporated into the wall (black arrowhead). Thin section 526.


15–16 *Siphovalvulina gibraltarensis* BouDagher-Fadel et al.. Note the siphonal canal (arrowhead). 15: Thin section 328. 16: Thin section 321.

17–18 *Siphovalvulina variabilis* Septfontaine. Note the siphonal canal (arrowhead). 17: Thin section 412. 18: Thin section 525.
The section reaches the early Late Pliensbachian (the start of P. liassica zone). However, no index taxa of *P. liassica* zone were found to support this possibility. The Pliensbachian age of these three sections is in agreement with the previous determination of age on the basis of lithiotid bivalves (e.g., BUSER & DEBELJAK, 1996), although lithiotid bivalves are known also from Toarcian (DEBELJAK & BUSER, 1998; SABATINO et al., 2013).

On the other hand, the Zalopate section, at least from the 6th meter up, to the 34th meter belongs to the early Late Sinemurian *L. recoarensis* zone sensu VELIČ (2007), marked by the presence of *L. recoarensis* and absence of *Orbitopsella*. The section from the 34th meter up could belong to the next, *O. primaeva* lineage zone of Late Sinemurian age. It has to be noted here, that no lithiotid bivalves were recorded in the Zalopate section and that the attribution to the “Podpeč limestone” lies solely on lithological similarity and the geological map. The lack of a proper, lithostratigraphic definition of this unit is here obvious, and we would either have to correct the geological map, using a more strictly defined “Podpeč limestone”, or extend the stratigraphic span of the “Podpeč limestone” to the Late Sinemurian. The Late Sinemurian – Pliensbachian age is also established for the Rotzo Member of the Calcarri Grigi Formation of the Trento Plateau in Italy (FUGAGNOLI & LORIGA BROGLIO 1998; MASETTI et al., 1998; FUGAGNOLI et al., 2003), which lithologically corresponds to the “Podpeč limestone” (BUSER & DEBELJAK, 1996).

Conclusions

The foraminiferal assemblage of the “Podpeč limestone” was investigated in three sections located in the wider Mt. Krim area, south of Ljubljana.

The Zalopate section spans the lower part of the “Podpeč limestone”. No lithiotid bivalves were found. *Orbitopsella* first occurs 34 meters from the base of the section. Based on the presence of its nominal taxon, this part of the section belongs to the *Lituosepta recoarensis* zone of early Late Sinemurian age. The upper part of the section, marked by the presence of *Orbitopsella primaeva*, belongs to Late Sinemurian *O. primaeva* lineage zone. The Podpeč 1 and Podpeč 2 sections sample the classical locality of the “Podpeč limestone”. Numerous lithiotid bivalve coquinas are present. The presence of *Orbitopsella praecursor* and *Bosniella oenensis* indicate Early Pliensbachian *Orbitopsella praecursor* taxon range zone. The same zone was determined in the Grad section.

The results of this study thus confirm the Pliensbachian age of the “Podpeč limestone” at its classical locality. The lower boundary of the “Podpeč limestone” is now extended to the Late Sinemurian.

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References


**PLATE 2**

1–2 *Siphovalvulina variabilis* Septfontaine. Arrowhead is pointing at twisted siphonal canal. 1: Thin section 329b. 2: Thin section 337.

3 *Siphovalvulina* sp., transverse section. Note the siphonal canal (arrowhead). Thin section 519.

4 *Siphovalvulina* sp. A. Thin section 336.

5–8 "9, 10: *Amijella amiij* (Henson). 5: Thin section 424b. Arrowhead pointing at Duotaxis metula. 6: Thin section 413. 7: Thin section 513. 8: Thin section 424b. 9: Radial beams are indicated by the arrowhead. Thin section 330. 10: Thin section 535b.


14–16 *Lituosepta* sp. var. A. Note the endoskeletal pillars (arrowheads). 14: Thin section 328. 15 Thin section 422. 16: Thin section 333.

17 *Lituosepta* sp. var. B. Thin section 329.

18 *Orbitopsella primaeva* Henson. Thin section 413.
Orbitopsella primaeva Henson. One of the stolon axis is indicated by an arrowhead.

Orbitopsella praecursor (Gümbel). 6: Thin section 427. 7: Arrow pointing at Bosniella oenensis. Thin section 528. 8: Thin section 535b.


PLATE 3
PLATE 3
18 Trocholina sp. Thin section 325.

6–17 Coronipora sp. or oblique section of “Involutina farinacciae”.


PLATE 4


4–5 Coronipora sp. or oblique section of “Involutina farinacciae”.

6–17 Coronipora sp. Thin section 528. Arrowhead in figure 5 is pointing at proloculus.

18 Trocholina sp. Thin section 325.
1–2  *Ophthalmidium* sp. 1: Thin section 522. 2: Thin section 528.
3  *Reophax* sp. Thin section 429.
4  *Ammobaculites* sp. Thin section 324.
5–9  Dasycladales. 5: Thin section 325. 6: Thin section 420. 7: Thin section 413. 8: Thin section 428. 9: Thin section 324.


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