Rivista Italiana di Paleontologia e Stratigrafia	volume 117	no. 3	5 pls.	pp. 375-397	December 2011

DUOSTOMINIDAE (FORAMINIFEREA, ROBERTINIDA) FROM THE UPPER TRIASSIC BEDS OF THE SLOVENIAN BASIN (SOUTHERN ALPS, SLOVENIA)

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Received: April 11, 2011; accepted: July 6, 2011

Key words: Foraminifera, Duostominids, Taxonomy, Norian and Rhaetian, "Bača Dolomite", Slatnik Formation.

Abstract. Twelve species of genera *Diplotremina* Kristan-Tollmann, 1960, *Duostomina* Kristan-Tollmann, 1960, and *Variostoma* Kristan-Tollmann, 1960 have been described from the Norian and Rhaetian strata of the Slovenian Basin (eastern Southern Alps). A lamellar wall structure has been confirmed for *Duostomina* and observed for the first time in *Variostoma*. The multi-layered nature of the lamellae of *Diplotremina* and *Duostomina* may be a result of a diagenetic alteration of the single-layered lamellae. The position of *Variostoma* in the family Duostominidae remains doubtful due to the alveolar nature of its wall.

Riassunto. Nel presente lavoro vengono descritte dodici specie riferite ai generi *Diplotremina* Kristan-Tollmann, 1960, *Duostomina* Kristan-Tollmann, 1960 e *Variostoma* Kristan-Tollmann, 1960, rinvenute nei livelli triassici (Norico-Retico) del Bacino Sloveno (Alpi Meridionali orientali). La struttura lamellare di *Duostomina* viene confermata e per la prima volta è stata osservata nei rappresentanti del genere *Variostoma*. La presenza di più strati nelle lamellae osservate in *Diplotremina* e *Duostomina* potrebbe rappresentare una struttura originaria, ma non è escluso che possa essere il risultato di una trasformazione diagenetica a partire da un'originaria struttura monolamellare. La posizione sistematica del genere *Variostoma* nella famiglia Duostominidae rimane ancora dubbia a causa della struttura alveolare della parete.

Introduction

Duostominids are an easily recognizable group of Triassic foraminifera, covering a wide spectrum of environments from shallow (e.g., Röhl et al. 1991; Villeneuve et al. 1994; Bérczi-Makk 1996a, 1996b) to deep water environments (e.g., Kristan-Tollmann 1960, 1964c, 1990; Senff 1992; di Bari & Rettori 1996; di Bari & Baracca 1998; di Bari & Laghi 1998) of the Tethyan and (sub) tropical Panthalassa Oceans (Kristan-Tollmann 1988; Senff 1992). They first appeared during the Early Triassic (Rettori et al. 1994; di Bari & Rettori 1996) and became extinct at the Triassic-Jurassic boundary (Kristan-Tollmann 1960; Chiocchini et al. 1994; di Bari & Rettori 1996; Hillebrandt & Urlichs 2008).

The family Duostominidae comprises the genera *Variostoma* Kristan-Tollmann, 1960, *Diplotremina* Kristan-Tollmann, 1960, *Duostomina* Kristan-Tollmann, 1960, *Krikoumbilica* He, 1984, and *Cassianopapillaria* di Bari & Rettori, 1998. The distinguishing criteria for the genera are the shape and position of the aperture, the presence/absence and the size of the umbilical opening, the shape of the umbilical side, and the presence of papillae on the umbilical side of the test. The great majority of the species has been established from isolated material (e.g. Kristan-Tollmann 1960; di Bari & Rettori 1996). The identification of duostominids at the species, sometimes even at the genus level, presents a great difficulty in thin section studies (Fugagnoli & Posenato 2004). Benjamini (1988) attributed duostominids with an open umbilical area to the genus *Diplotremina*, while moderately biconvex or plano-convex forms with a

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SPECIES	SPECIMEN	DIAMETER (MM)	HEIGHT (MM)
Di. subangulata	*holotype (Kristan-Tollmann 1960)	0.50	0.23
	thin section 70322 (Pl. 1, fig. 1)	0.96	0.43
	thin section 70329 (Pl. 1, fig. 2)	1.03	0.50
Di. placklesiana	*holotype (Kristan-Tollmann 1960)	0.72	0.29
	thin section K2-70.40 (Pl. 1, fig.3)	0.57	0.36
	? thin section 70246 (Pl. 1, fig. 4)	1.18	0.45
	? thin section 70250 (Pl. 1, fig. 5)	0.39	0.21
Di. astrofimbriata	*holotype (Kristan-Tollmann 1960)	0.28	0.15
	? thin section 70329 (Pl. 1, fig. 6)	0.71	0.39
Du. turboidea	*holotype (Kristan-Tollmann 1960)	0.49	0.26
	thin section 69858	0.56	0.42
	thin section K2-70.40 (Pl. 1, fig. 7)	0.62	0.57
	thin section 70304, no. 1 (Pl. 1, fig. 8)	0.50	0.39
	thin section 70304 (Pl. 2, fig. 1)	0.78	0.39
	thin section 70307 (Pl. 2, fig. 2)	0.77	0.46
Du. biconvexa	*holotype (Kristan-Tollmann 1960)	0.30	0.16
	thin section K2-76.30, no. 1 (Pl. 2, fig. 3)	0.91	0.64
	thin section K2-76.30, no. 2 (Pl. 2, fig. 4)	0.67	0.38
	? thin section K2-87.60 (Pl. 2, fig. 5)	0.82	0.55
	? thin section 70070	(0.77)	(0.46)
	thin section 70078	0.67	0.39
	thin section 70254	0.54	0.36
	thin section 70293	(0.62)	0.37
	? thin section 70326 (Pl. 2, fig. 6)	0.77	0.46
	? thin section S66 (Pl. 2, fig. 7)	0.59	0.32
Duostomina? sp. A	thin section 69847 (Pl. 2, fig. 8)	0.54	0.28
	thin section 70067	0.53	0.21
	thin section 70228 (Pl. 3, fig.1)	1.01	0.69
	thin section 70247, no. 1 (Pl. 3, fig. 2)	0.94	0.69
	thin section 70247, no. 2 (Pl. 3, fig. 3)	(1.01)	0.53
	thin section 70254 (Pl. 3, fig. 4)	0.82	0.54
	thin section 70262 (Pl. 3, fig. 5)	0.91	0.84
	thin section 70287 (Pl. 3, fig. 6)	0.53	0.32
	thin section 70304 (Pl. 3, fig. 7)	0.80	0.50
Du. multangulata	*type material (He 1999)	0.22-0.28	0.08
	? thin section (Pl. 3, fig. 8)	0.32	?
V. coniforme	*holotype (Kristan-Tollmann 1960)	0.52	0.36
	thin section 70077 (Pl. 4, fig. 1)	0.46	0.40
	? thin section 70228 (Pl. 4, fig. 2)	0.91	0.73
	? thin section 70247 (Pl. 4, fig. 3)	0.71	0.78
	thin section 70293	0.46	0.36
	thin section 70298, no. 1 (Pl. 4, fig.4)	0.50	0.43
	thin section 70298, no. 2 (Pl. 4, fig. 5)	0.62	0.43
	thin section 70298, no. 3	0.46	0.36
	thin section 70304	0.49	0.48
	thin section 70306	0.43	0.36
	thin section 70322	0.38	0.26
	thin section 70326 (Pl. 4, fig. 6)	0.47	0.43
	thin section 70327 (Pl. 4, fig. 7)	0.43	0.32
V. catilliforme	*holotype (Kristan-Tollmann 1960)	0.67	0.33
	thin section 70277 (Pl. 4, fig. 8)	0.60	0.36
	? thin section 70322 (Pl. 5, fig. 1)	0.55	0.27
V. cochlea	*holotype (Kristan-Tollmann 1960)	0.72	0.92
	thin section 70232 (Pl. 5, fig. 2)	0.71	0.82
V. falcata	*holotype (Kristan-Tollmann 1973)	0.70	0.90
	? thin section 69859 (Pl. 5, fig. 3)	0.41	0.50
V. helicta	*holotype (Tappan 1951)	0.83	0.57
	V. crassum (Kristan-Tollmann 1960)	1	0.80
	thin-section K2-70.40 (Pl. 5, fig.4)	0.79	0.87
	thin-section K2-91.30 (Pl. 5, fig. 5)	0.82	0.82
	thin-section K2-94.20 (Pl. 5, fig. 6)	0.92	1.10
	thin-section 70085 (Pl. 5, fig. 7)	0.82	0.73
	thin-section 70267 (Pl. 5, fig. 8)	0.91	0.82

Tab. 1 - Table of measurements for the duostominids gathered from the Norian-Rhaetian strata of the Slovenian Basin.

closed umbilicus were attributed to the genus *Duostomina*. The species were determined on the basis of the overall test shape (Benjamini 1988). In thin section studies, it is thus necessary to determine duostominids in axial sections, i.e., sections cut along the coiling axis, though determining the genus *Cassianopapillaria* remains impossible because of nearly undetectable papillae.

The Norian-Rhaetian allodapic limestones deposited in the proximal part of the Slovenian Basin yielded a rich foraminiferal assemblage. Duostominidae represent an important constituent of this assemblage (Tab. 1) and have proven useful for determining the Triassic-Jurassic boundary because of their high abundance and recognisability. Among several species of the Duostominidae, only few have been illustrated and described since their establishment, resulting in their poorly understood stratigraphic ranges.

This paper aims to illustrate and describe duostominids from the Slovenian Basin. We thus make significant contribution to the determination of duostominids from thin sections and improve the current knowledge of their stratigraphic ranges. Several remarks on the family and genera are given and the description of the family is emended.

Geological setting

The investigated Mt. Kobla and Mt. Slatnik sections are located in the eastern part of the Bohinj Range that defines the southern boundary of the Julian Alps (NW Slovenia; Fig. 1A, B). The Julian Alps are structurally composed of the Julian and the Tolmin Nappes, and represent the eastern part of the Southern

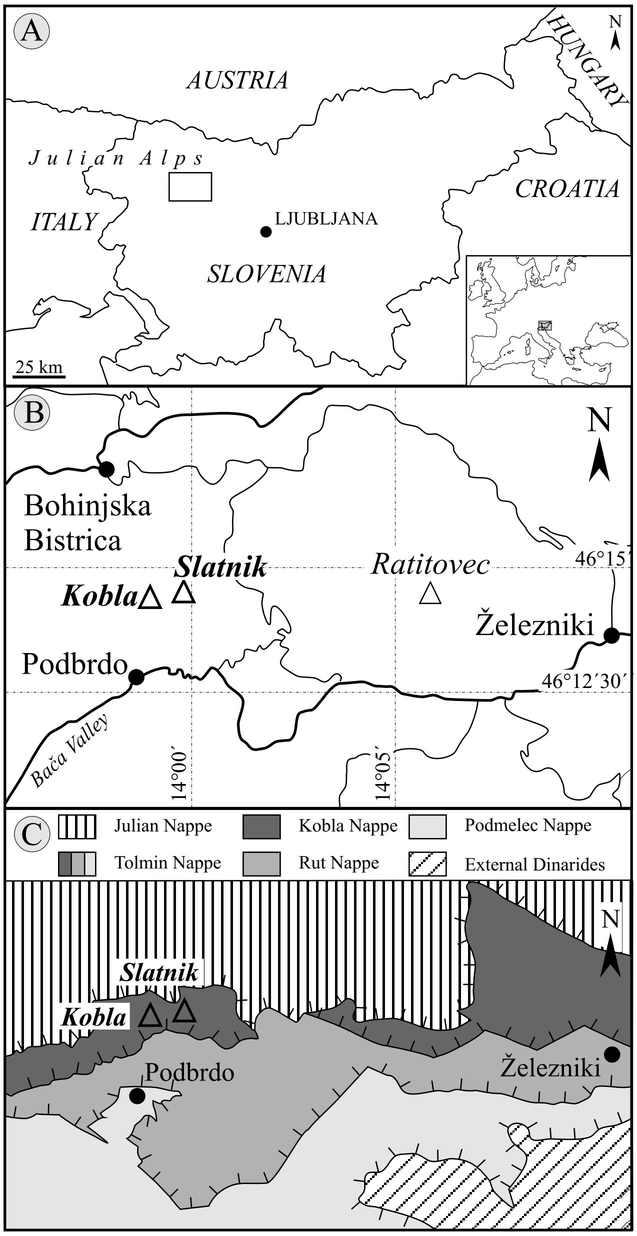


Fig. 1 - A, B: Geographic position of the Mt. Kobla and Mt. Slatnik sections. C: Simplified structural map of area shown in Figure 1B (after Buser 1986; M. Demšar, pers. com.).

Alps. The Tolmin Nappe is further subdivided into three subunits: the Kobla, the Rut, and the Podmelec nappes (Buser 1986; Placer 1999, 2008; Fig. 1C).

The Southern Alps belong to the Adria tectonic microplate, which was bordered during the Triassic by the Meliata Ocean to the east (Stampfli & Borel 2004), forming part of its passive continental margins. The Middle-Triassic extensional tectonics caused disintegration of the previously uniform shallow-water environment into a complex array of small platforms surrounded by trenches (Buser 1986, 1996; Čar 2010). Tectonic activity ceased in the late Middle Triassic, and later, the carbonate platforms prograded over the adjacent trenches (Šmuc & Čar 2002). The following major palaeogeographic units were established: the Dinaric (Friuli or Adriatic) Carbonate Platform to the south (Buser 1986, 1996; Ogorelec & Rothe 1993), the Julian Carbonate Platform to the north (Buser 1989, 1996; Šmuc 2005; Celarc & Ogorelec 2006; Celarc & Kolar-Jurkovšek 2008), and the deeper intermediate Slovenian Basin (Winkler 1923; Cousin 1970, 1973, 1981; Buser 1979, 1986, 1989, 1996; Buser et al. 1982, 2007, 2008; Rožič 2009; Rožič et al. 2009; Gale 2010).

The Norian-Rhaetian succession of the Slovenian Basin is mainly represented by the "Bača Dolomite", comprising bedded late-diagenetic dolomite with chert nodules and dolomite breccias (Buser 1986; Gale 2010). Only in the northern part of the basin is the upper part of the Norian-Rhaetian succession represented by non-dolomitized hemipelagic and resedimented limestones with chert nodules of the Slatnik Formation (Rožič et al. 2009). The upper boundary with the Lower Jurassic Krikov Formation is marked by a few meters thick horizon of thin bedded hemipelagic limestones (Rožič et al. 2009).

Short description of the sections

Foraminifera described in this paper were found in the "Bača Dolomite" and the Slatnik Formation of the Mt. Slatnik section and in the Slatnik Formation of the Mt. Kobla section. Both sections belong to the Kobla Nappe (Fig. 1C) and were palaeogeographically situated in the northernmost part of the Slovenian Basin, i.e., proximal to the Julian Carbonate Platform (Buser 1986; Rožič 2009; Rožič et al. 2009; Gale 2010).

Of the two sections, the Mt. Slatnik section (Fig. 2A) exhibits a more proximal facies association. The "Bača Dolomite" comprises two intervals of massive channelized dolomitic breccias, separated by bedded dolomite with or without chert nodules, and a few limestone packages. The Mt. Slatnik section is thus one of the few exposures of the "Bača Dolomite" with non-dolomitized parts. Limestones indicate hemipelagic deposition intermixed with turbidity current deposits (calcarenites). The deposition of the "Bača Dolomite" in the Mt. Slatnik section thus took place on the basin plain, the base of the slope and the slope (Gale 2010). The overlying Slatnik Formation is predominantly composed of calcarenites and channelized limestone breccias. Clasts in the breccias are mainly eroded slope and basinal limestones, and the calcarenites consist of intraclasts, peloids, and bioclasts (predominantly echinoderm fragments). The differences from the limestones of the "Bača Dolomite" are the thicker bedding and the presence of corals and even boulders of reef limestones (see Rožič et al. 2009). The presence of reef-dwelling

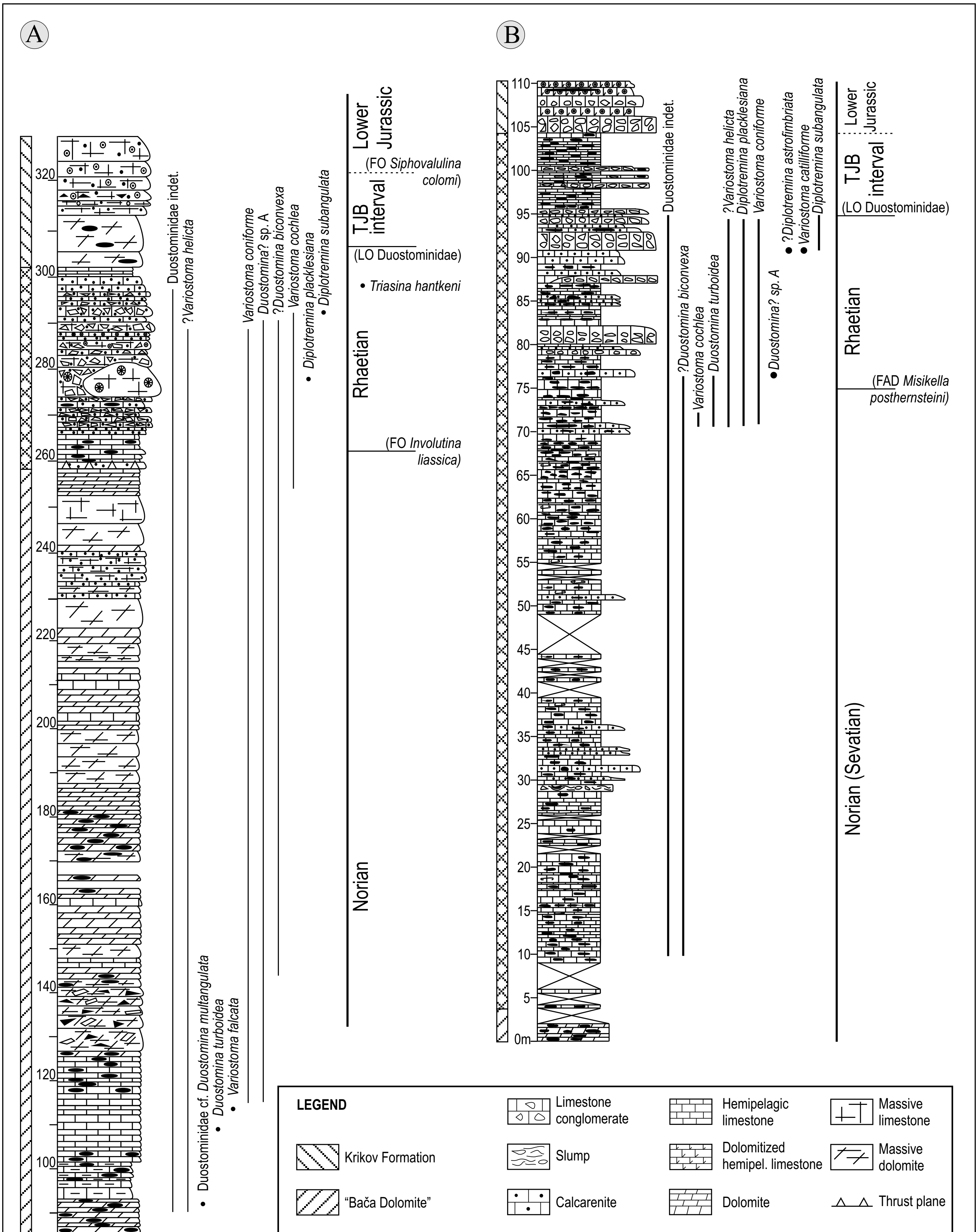


Fig. 2 - Simplified sections from Mt. Slatnik (A) and Mt. Kobla (B). Local stratigraphic ranges of duostominids are indicated with bars. Simplified and highly modified after Rožič et al. (2009), Gale (2010) and Gale et al. (submitted).
Abbreviations: FO – first occurrence; LO – last occurrence; FAD – first appearance datum; TJB – Triassic-Jurassic boundary.

foraminifera throughout the section and the reef-builders in the Slatnik Formation indicate the existence of reefs on the margin of the adjacent Julian Carbonate Platform (see also Buser et al. 1982; Turnšek & Buser 1991; Turnšek 1997).

A more distal facies association is present in the Slatnik Formation on Mt. Kobla (Fig. 2B). The Slatnik Formation is here dominated by hemipelagic limestones composed of pellets and bioclasts, of which the calcified radiolarians are the most abundant. Calcarenites and limestone breccias become more abundant towards the top of the section, indicating a change from the basin plain to the lower slope sedimentary environment. The composition of the coarser beds corresponds to that of the Mt. Slatnik section (Rožič et al. 2009).

For further details on both sections see Rožič et al. (2009) and Gale (2010).

Systematic palaeontology

The taxonomy adopted in this paper follows Loeblich & Tappan (1987, 1992) with minor adjustments following Kaminski (2004). Explanations to the authors' remarks in the synonymy list can be found in Granzow (2000). The base of the Rhaetian has not been unequivocally accepted (Ogg 2004; Krystyn et al. 2007; Lucas 2010). It is placed at the First Appearance Datum (FAD) of the conodont *Misikella posthernsteini* in the Mt. Kobla section (Rožič et al. 2009), and at the First Occurrence (FO) of the foraminifera *Involutina turgida* in the Mt. Slatnik section where conodonts are scarce. The Triassic-Jurassic boundary (TJB) is approximated with the Last Occurrence (LO) of the Duostominidae, and perfectly matches the LO of conodonts. All the material is stored at the Geological Survey of Slovenia. The repository numbers are recorded under the species description.

Class **Foraminiferea** J.J. Lee, 1990
Order **Robertinida** Mikhalevich, 1980
Superfamily Duostominoidea Brotzen, 1963
Family Duostominidae Brotzen, 1963

Emended description. Test free, low to high trochospirally coiled; wall aragonitic, hyaline, fibrous-radiate and perforated; lamellar, often diagenetically altered and appearing layered; papillae are sometimes present; aperture interiomarginal or double and separated by a tenon or a chamber flap.

Remarks. The family was erected by Brotzen (1963) in order to group the genera *Duostomina*, *Diplotremina*, and *Variostoma* described by Kristan-Tollman (1960) from the Ladinian-Carnian strata of Dolomites. Two more genera were later included in the family: *Krikoumbilica* He, 1984, and *Cassianopapillaria* di Bari & Rettori, 1998 (nom. subst. for *Papillaria* di Bari & Rettori, 1996). The original composition and the structure of the wall, rarely preserved in the fossil material because of its diagenetic alteration, have been debated ever since, hindering the suprageneric classification of this group.

Kristan-Tollmann (1960) originally referred the genera *Duostomina*, *Diplotremina*, and *Variostoma* to the family Discorbidae considering their wall as calcareous perforate, and in the case of *Variostoma* also coarse-grained calcareous with some quartz grains embedded in calcareous matrix. Kristan-Tollmann (1963) later introduced a distinct family Variostomidae. She described the wall as calcareous agglutinated with an inner pseudochitinous layer. Brotzen (1963) instead established the family Duostominidae, noting the complex structure of the wall, with an inner pseudolamellar and an outer agglutinated layer with quartz particles, i.e., a double-layered wall. Loeblich & Tappan (1964) corrected the family name Variostomidae Kristan-Tollmann, 1963 to Variostomatidae. During studies of the genus *Duostomina*, Kristan-Tollmann (1966) observed an agglutinated wall with quartz and calcareous particles embedded in a calcareous matrix. The presence of an outer opaline layer was considered doubtful. Despite the aragonitic wall, Kristan-Tollmann (1966) at the time believed that *Duostomina* phylogenetically belongs to the families Epistominidae or Ceratobuliminidae. Koehn-Zaninetti (1969) assigned Duostominidae to the superfamily Miliolidea. She recognised a three-layered wall in *Duostomina* and *Diplotremina*. The innermost pseudochitinous membrane is covered by a middle calcareous hyaline layer of fibrous-radial calcite. The outermost layer is agglutinated. The three-layered structure is obscured during diagenesis, with the inner two layers being the least resistant. Premoli Silva (1971) confirmed the observations of Koehn-Zaninetti (1969) and discussed the placement of Duostominidae in higher taxonomic units, but she could not draw reliable conclusions and left the family as *incertae sedis*. Fuchs (1975) described the wall of *Variostoma* as calcareous microgranular, having an organic matrix and small perforations. Hohenegger & Piller (1975) mentioned Fusulinina-like wall in *Diplotremina* and a perforated wall in *Variostoma*. Zaninetti (1976) placed Variostomatidae into the superfamily Duostominacea and with doubt into the suborder Rotaliina. He (1984) introduced a new genus, *Krikoumbilica* He, 1984, from the Middle Triassic of China, and included it in the family Duostominidae. Although similar to *Diplotremina*, this genus has a broad circular umbilicus, the margin of which is not lobate as in the later genus (He 1984). Kristan-Tollmann (1988) described the wall of duostominids as agglutinated calcareous. Benjamini (1988) placed the family Duostominidae into the superfamily Endothyracea (suborder Fusulinina), an option considered also by Premoli Silva (1971). Loeblich & Tappan (1987) included Duostominidae and the superfamily Duostominacea in the suborder Robertinina, although they did not strictly meet the criteria for this suborder given in the same work. They described the wall of duostominids as aragonitic, non-lamellar (not to be confused with a layered wall – see Discussion and conclusions), appearing granular and sometimes including foreign particles. *Krikoumbilica* was placed into the family Oberhauserellidae, which was retained in the same superfamily (Duostominacea) as the family Duostominidae. Rettori et al. (1994) returned *Krikoumbilica* into Duostominidae. Di Bari & Rettori (1996) introduced a new genus *Papillaria* (later substituted with *Cassianopapillaria* di Bari & Rettori, 1998) for a Carnian duostominid found in the San Cassiano Formation (northeastern Dolomites, Italy). They confirmed the assignment of the family Duostominidae and the superfamily Duostominacea to the suborder Robertinina. Di Bari & Laghi (1998) thoroughly investigated the first three genera of the Duostominidae family. They concluded that the wall of *Duostomina* and *Diplotremina* is made of aragonitic lamellae and perforated. The wall of *Variostoma* is also aragonitic and perforated, but non-lamellar and instead of alveolar type (di Bari & Laghi 1998). They confirmed the placement of the family Duostominidae into Robertinina.

In the present paper we consider the Duostominidae as a family of the Order Robertinida Mikhalevich, 1980.

Composition of the family. *Diplotremina* Kristan-Tollmann, 1960 (type-species: *Diplotremina astrofimbriata* Kristan-Tollmann, 1960); *Duostomina* Kristan-Tollmann, 1960 (type-species: *Duostomina biconvexa* Kristan-Tollmann, 1960); *Variostoma* Kristan-Tollmann, 1960 (type-species: *Variostoma spinosum* Kristan-Tollmann, 1960); *Krikoumbilica* He, 1984 (type-species: *Krikoumbilica pileiformis* He, 1984); *Cassianopapillaria* (type-species: *Cassianopapillaria laghii* di Bari & Rettori, 1998).

Stratigraphic and geographic distribution. Early to Late Triassic (Rettori et al. 1994; di Bari & Rettori 1996) of the Tethyan domain, the tropical and subtropical area of the Panthalassa Ocean (Kristan-Tollmann 1987). The family became extinct at the Triassic-Jurassic boundary (Kristan-Tollmann 1960; Chiocchini et al. 1994; di Bari & Rettori 1996; Hillebrandt & Urlichs 2008).

Genus *Diplotremina* Kristan-Tollmann, 1960

Type-species: *Diplotremina astrofimbriata* Kristan-Tollmann, 1960

Remarks. The genus was established by Kristan-Tollmann (1960) for duostominids having an umbilical depression with radial extensions along the sutures and a double aperture with the primary opening midway between the umbilicus and the periphery, separated from the second opening situated centrally by a chamber flap or a tenon (Kristan-Tollmann 1960; Loeblich & Tappan 1987).

According to di Bari & Laghi (1998), this genus has an aragonitic, finely perforated wall with a lamellar structure.

Diplotremina subangulata Kristan-Tollmann, 1960

Pl. 1, figs 1, 2

* 1960 *Diplotremina subangulata* Kristan-Tollmann, p. 67-68, pl. 15, fig. 3, 4.

• 1964b *Diplotremina subangulata* Kristan-Tollmann– Kristan-Tollmann, p. 51-52, pl. 39, fig. 8-10.

non 1983 *Diplotremmina* [sic] *subangulata* Kristan-Tollmann – Salaj et al., p. 152-153, pl. 131, fig. 9-13; pl. 132, fig. 1-3.

? 1987 *Diplotremina subangulata* Kristan [sic] – Oravecz-Scheffer, pl. 93, fig. 6.

? 1988 *Diplotremina subangulata* Kristan-Tollmann– Vettorel, p. 173-174, pl. 2, fig. 3, 4.

• 1988 *Diplotremina subangulata* Kristan-Tollmann – Kristan-Tollmann, pl. 1, fig. 11-14; pl. 2, fig. 6-8.

non 1988 *Diplotremina subangulata* Kristan-Tollmann – Benjamini, pl. 2, fig. 5.

? 1990 *Diplotremina subangulata* Kristan-Tollmann – Kristan-Tollmann, p. 245, pl. 15, fig. 3, 4.

pars 1991 *Diplotremina subangulata* Kristan-Tollmann – Kristan-Tollmann, pl. 3, fig. 5 [cet. excl.].

pars 1991 Duostominidae – Röhl et al., pl. 62, fig. 15 [sine pl. 62, fig. 14].

pars 1992 Duostominidae – Zaninetti et al., pl. 4, fig. 8 [cet. excl.].

PLATE 1

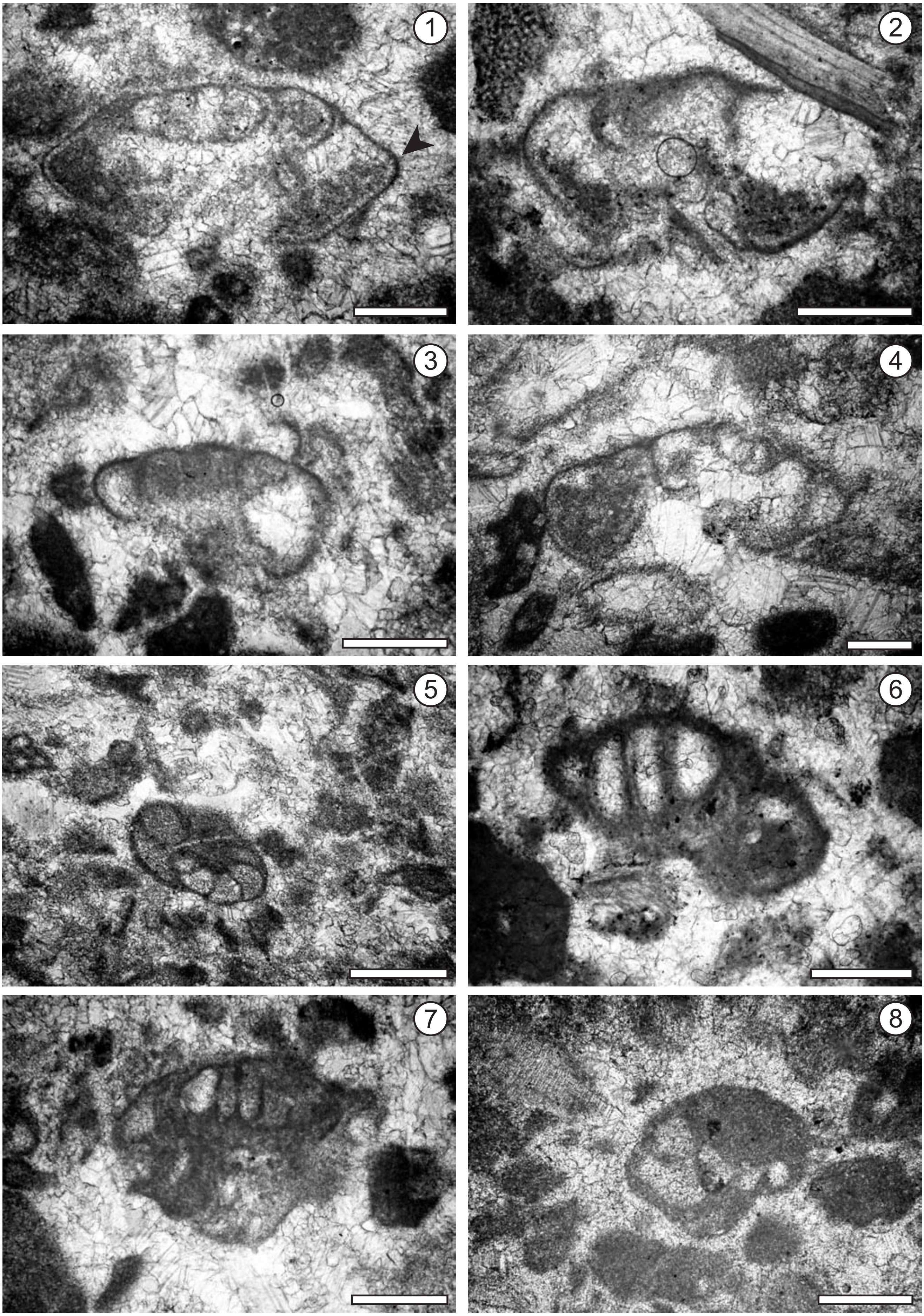
Fig. 1, 2? - *Diplotremina subangulata* Kristan-Tollmann, 1960. Samples: 1) thin section 70322; axial section; arrowhead points at the subangular margin; 2) thin section 70329; tangential section; Mt. Kobla, Rhaetian.

Fig. 3, 4?, 5? - *Diplotremina placklesiana* Kristan-Tollmann, 1960. Samples: 3) thin section K2-70.40, slightly tangential section; Mt. Kobla, Norian; 4) thin section 70246, axial section; Mt. Slatnik, Rhaetian; 5) thin section 70250, oblique section; Mt. Slatnik, Rhaetian.

Fig. 6 - ?*Diplotremina astrofimbriata* Kristan-Tollmann, 1960; thin section 70329, tangential section; Mt. Kobla, Rhaetian.

Fig. 7, 8 - *Duostomina turboidea* Kristan-Tollmann, 1960. Samples: 7) thin section K2-70.40, axial section; 8) thin section 70304, oblique section; Mt. Kobla, Norian.

Scale bar: 250 μm.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? 1992 *Diplotremina subangulata* Kristan-Tollmann – Senff, p. 686-688, pl. 3, fig. 1-5, 7.

non 1994 *Diplotremina subangulata* Kristan-Tollmann – Trifonova, p. 56-57, pl. 9, fig. 2.

? 1996b *Diplotremina subangulata* Kristan-Tollmann – Bérczi-Makk, pl. 32, fig. 4.

Material: Thin sections 70322, ?70329, 70254.

Locality and age: Mt. Kobla, Rhaetian; Mt. Slatnik, Rhaetian.

Description. Test equally biconvex, in axial section having the shape of a vertically flattened hexagon; maximum width in the middle, with a subangular margin (Pl. 1, fig. 1); umbilical opening large, one-third of the test diameter; only two whorls are visible, the second one having chambers twice as large as in the first coil.

Test diameter 0.96-1.03 mm; test height 0.43-0.50 mm.

Remarks. Our specimens have larger tests than the type specimen. *Diplotremina subangulata* differs from *Diplotremina placklesiana* Kristan-Tollmann, 1960 in having a subangular margin of the test. It differs from *Duostomina biconvexa* Kristan-Tollmann, 1960 in the hexagonal shape of the test. It differs from other duostominids in the equal heights of the spiral and umbilical side of the test.

The specimens figured by Salaj et al. (1983) are unequally biconvex and have a rounded margin, so their determination as *Di. subangulata* is wrong. Their specimen on pl. 131, fig. 10 is *Du. biconvexa*. The specimens in Senff (1992) have equally biconvex shape and closed umbilicus, so they could also belong to *Du. biconvexa*. Specimen figured by Trifonova (1994) has an unequally biconvex test. Kristan-Tollmann (1991) attributed specimens from several species to *Di. subangulata*. We believe the specimens on her pl. 4, fig. 4, ?5 are *Diplotremina astrofimbriata* Kristan-Tollmann, 1960, the specimen on pl. 4, fig. 10 *Du. biconvexa*, while the specimen on pl. 4, fig. 9 is identical with our *Duostomina*? sp. A. Benjamini's (1988) specimen and part of the material figured by Röhl et al. (1991) should be regarded as *Diplotremina placklesiana* (see description below). Specimens figured by Kristan-Tollmann (1990) could also belong to the latter species. Oravecz-Scheffer's (1987) and Bérczi-Makk's (1996b) specimens are in transverse sections, unsuitable for determination. The correctness of Vettorel's (1988) determination cannot be confirmed due to lack of figure showing his specimen in the axial view.

Distribution and stratigraphic range. Japan, undivided Norian to Rhaetian (Kristan-Tollmann 1991); Northern Calcareous Alps, Austria, Rhaetian (Kristan-Tollmann 1960, 1964b, 1988); Wombat Plateau, Australia, Rhaetian (Röhl et al. 1991; Zaninetti et al. 1992).

Diplotremina placklesiana Kristan-Tollmann, 1960

Pl. 1, figs 3,?4,?5

*1960 *Diplotremina placklesiana* Kristan-Tollmann, p. 65-66, pl. 15, fig. 1, 2; pl. 16, fig. 6.

1979 Duostominidae (gen. et sp. indet.) – Babić et al., pl. 1, fig. 5.

? 1986 *Diplotremina astrofimbriata* Kristan-Tollmann – Bérczi-Makk, pl. 2, fig. 4.

1987 *Duostomina*? sp. – Oravecz-Scheffer, pl. 41, fig. 12, 13.

1987 Duostominidae (*Diplotremina*?) – Ciarapica et al., pl. 21, fig. 1-13.

1988 *Diplotremina subangulata* Kristan-Tollmann – Benjamini, pl. 2, fig. 5.

? 1988 *Diplotremina placklesiana* Kristan-Tollmann – Vettorel, p. 175, pl. 2, fig. 1, 2, 5.

? 1990 *Diplotremina subangulata* Kristan-Tollmann – Kristan-Tollmann, p. 245, pl. 15, fig. 3, 4.

non 1991?*Diplotremina plackleslana* [sic] Kristan-Tollmann – Kristan-Tollmann, pl. 3, fig. 6.

pars 1991 Duostominidae – Röhl et al., pl. 62, fig. 14 [sine pl. 62, fig. 15].

pars 1996 *Diplotremina astrofimbriata* Kristan-Tollmann – Kobayashi, 538, fig. 5.32 [non fig. 5.31, 5.33-5.36].

Material: Thin sections K2-70.40; K2-94.20 (B. Rožič, University of Ljubljana, Faculty of Natural Sciences and Engineering); ?70246, ?70250.

Locality and age: ? Mt. Slatnik, Rhaetian; Mt. Kobla, Norian and Rhaetian.

Description. Test equally biconvex; test margin broadly rounded; large umbilical opening of one-third of the test diameter; two to three coils visible, the last one having ventrally elongated chambers.

Test diameter 0.57 (?0.39-1.18) mm; test height 0.36 (0.21-0.45) mm.

Remarks. *Diplotremina placklesiana* differs from *Di. subangulata* and *Du. biconvexa* in its completely rounded margin. *Duostomina rotundata* Kristan-Tollmann, 1960 is more strongly convex on the spiral side than on the umbilical side.

Confirmation of the species determination was not possible for the specimens figured by Vettorel (1988) as the specimens are oriented perpendicular to the coiling axis. Specimen figured by Kristan-Tollmann (1991) is placed in *Duostomina*? sp. A. Part of the material figured by Kobayashi (1996) as *Di. astrofimbriata* in our opinion belongs to *Di. placklesiana*, while other specimens are in transverse sections, unsuitable for determination. Röhl et al. (1991) avoided species determination and named some specimens simply as "Duostominidae". Some of his material also belongs to *Di. placklesiana*.

Distribution and stratigraphic range. Japan, Anisian (Kobayashi 1996); Transdanubian Range, Hungary, Carnian (Oravecz-Scheffer 1987); Croatia, undivided Anisian to Rhaetian (Babić et al. 1979); Israel, Carnian (Benjamini 1988); Wombat Plateau, Australia, Rhaetian (Röhl et al. 1992); Northern Calcareous Alps, Rhaetian (Kristan-Tollmann 1960); Apennines, Rhaetian (*Triasina hantkeni* zone; Ciarapica et al. 1987).

?Diplotremina astrofimbriata Kristan-Tollmann, 1960

Pl. 1, fig. 6

*1960 *Diplotremina astrofimbriata* Kristan-Tollmann, p. 64-65, pl. 14, fig. 1-4.

pars 1971 *Diplotremina austrofimbriata* [sic] Kristan-Tollmann, 1960 – Premoli Silva, p. 340-341, pl. 27, fig. 1 [?], 5, 6 [?]; pl. 28, fig. 1 [?], 2.

? 1977 *Diplotremina astrofimbriata* Kristan-Tollmann – Gázdzicki & Smit, pl. 10, fig. 9.

? 1979 Duostominidae (cf. *Diplotremina astrofimbriata* Kristan-Tollmann) – Babić et al., pl. 1, fig. 4.

? 1983 *Diplotremina astrofimbriata* Kristan-Tollmann – Kristan-Tollmann, pl. 4, fig. 9.

? 1983 *Diplotremmina* [sic] *astrofimbriata* Kristan-Tollmann – Salaj et al., p. 152, pl. 131, fig. 3, 4, 5-8.

non 1984 *Diplotremina astrofimbriata* Kristan-Tollmann – He, pl. 4, fig. 1-7.

pars 1987 "*Diplotremina* cf. *astrofimbriata*" Kristan-Tollmann – Oravecz-Scheffer, pl. 22, fig. 3, 4 [? pl. 22, fig. 1, 2, 5, 6].

? 1988 *Diplotremina astrofimbriata* Kristan-Tollmann – Benjamini, p. 134, pl. 2, fig. 1-3 [?], 4.

? 1988 *Diplotremina astrofimbriata* Kristan-Tollmann – Vettorel, p. 174-175, not figured.

pars 1991 *Diplotremina subangulata* Kristan-Tollmann – Kristan-Tollmann, pl. 4, fig. 4, 5.

? 1994 *Diplotremina astrofimbriata* Kristan-Tollmann – Trifonova, p. 55-56, pl. 9, fig. 3-5, 8.

? 1996a *Diplotremina astrofimbriata* Kristan-Tollmann – Bérczi-Makk, pl. 6, fig. 5, 6.

? 1996a *Diplotremina* cf. *astrofimbriata* Kristan-Tollmann – Bérczi-Makk, pl. 9, fig. 7.

? 1996b *Diplotremina astrofimbriata* Kristan-Tollmann – Bérczi-Makk, pl. 14, fig. 2, 3, 6; pl. 19, fig. 6; pl. 20, fig. 6; pl. 38, fig. 10.

non 1996 *Diplotremina astrofimbriata* Kristan-Tollmann – Kobayashi, p. 538, fig. 5.31-5.36.

? 1999 *Diplotremina astrofimbriata* Kristan-Tollmann – He, pl. 1, fig. 11, 12.

? 1999 *Variostoma helicta* (Tappan), 1951 – He, pl. 2, fig. 13a,b.

pars 2005 *Diplotremina astrofimbriata* Kristan-Tollmann – Kobayashi et al., fig. 10.37-10.38 [? fig. 10.36].

Material: Thin section 70329.
Locality and age: Mt. Kobla, Rhaetian.

Description. Test with a moderately convex spiral side and a lower umbilical side; margin subangular; last whorl evolute, separated from the rest of the test by a deepening; lumen of the last chamber almost circular.

Test diameter 0.71 mm; test height 0.50 mm.

Remarks. Our specimen differs from the holotype in a much larger test. It differs from *Duostomina turboidea* Kristan-Tollmann, 1960 in the height of the trochospire, the plane of the maximum diameter set oblique to the axis of coiling, the shape of the lumen of the last chamber, and the evolute last whorl.

Diplotremina astrofimbriata has been reported by several authors, but most of these specimens are in transverse section, which is in this work considered unsuitable for species determination, i.e. Gazdzicki & Smit (1977), Babić et al. (1979), Trifonova (1994), Bérczi-Makk (1996a, 1996b), part of the material figured by Premoli Silva (1971), Salaj et al. (1983), Benjamini (1988), Kobayashi et al. (2005).

Specimens figured by He (1999) and Kristan-Tollmann (1983) cannot be confirmed to belong to *Di. astrofimbriata* because they are not figured in axial view. Specimen figured by Bérczi-Makk (1996b) on his pl. 38, fig. 10 could belong to the genus *Krikoumbilica*. The specimens figured by Kristan-Tollmann (1991) on pl. 4, fig. 9 and fig. 10 are *Duostomina*? sp. A and *Du. biconvexa* respectively. Kobayashi's (1996) specimen on fig. 5.32 is reinterpreted as *Di. placklesiana*, while other specimens are in unsuitable orientation. Vettorel (1988) did not figure his specimen on plates.

Distribution and stratigraphic range. Transdanubian Range, Hungary, Anisian (Oravecz-Scheffer 1987); Japan, Anisian (Kobayashi et al. 2005); Judicarian Alps, Italy, Anisian (Premoli Silva 1971); Northern Calcareous Alps, Austria, Ladinian (Kristan-Tollmann 1960); Japan, Rhaetian (Kristan-Tollmann 1991).

Genus *Duostomina* Kristan-Tollmann, 1960

Type species: *Duostomina biconvexa* Kristan-Tollmann, 1960, p. 68

Remarks. *Duostomina* comprises duostominids with a double aperture positioned as in *Diplotremina*, but bordered by a thickened and radially grooved lip (Kristan-Tollmann 1960; Loeblich & Tappan 1987). The inner structure of the test was studied in detail by Kristan-Tollmann (1966), soon after its establishment (Kristan-Tollmann 1960). The wall is aragonitic, finely perforated, and characterised by a lamellar structure (di Bari & Laghi 1998).

Duostomina turboidea Kristan-Tollmann, 1960

Pl. 1, figs 7, 8; Pl. 2, figs 1, 2

*1960 *Duostomina turboidea* Kristan-Tollmann, p. 71-72, pl. 18, fig. 3, 4; pl. 19, fig. 1-9.

● 1988 *Duostomina turboidea* Kristan-Tollmann, 1960 – Vettorel, p. 182-184, pl. 3, fig. 2.

? 1996b *Duostomina turboidea* Kristan-Tollmann – Bérczi-Makk, pl. 15, fig. 1-3.

Material: Thin sections K2-70.40 (B. Rožič, University of Ljubljana, Faculty of Natural Sciences and Engineering); 69858, 70304 (two specimens), 70307.
Locality and age: Mt. Slatnik, Norian; Mt. Kobla, Norian and Rhaetian.

Description. Coiling nearly planispiral, but with a trapezoid last chamber that is ventrally elongated, resulting in a drop-shaped, but asymmetrical test, with a more convex umbilical side; relative thickness of the test variable; test margin subangular; last whorl almost involute (Pl. 2, fig. 1).

Test diameter 0.50-0.78 mm; test height 0.39-0.57 mm.

Remarks. *Duostomina turboidea* differs from our ?*Di. astrofimbriata* in the position and the shape of the last chamber, an almost planispiral coiling, and in the absence of a deepening on the umbilical side due to the involute coiling.

Distribution and stratigraphic range. Northern Calcareous Alps, Austria, Ladinian and Carnian (Kristan-Tollmann 1960); Dolomites, Italy, Carnian (Vettorel 1988).

?**Duostomina biconvexa** Kristan-Tollmann, 1960

Pl. 2, figs 3, 4,?5-?7

*1960 *Duostomina biconvexa* Kristan-Tollmann, p. 68-69, pl. 17, fig. 1, 2; pl. 18, fig. 2.

pars 1982 Duostominidae – Tuzcu et al., pl. 2, fig. 12 [cet. excl.].

pars 1983 *Diplotremmina* [sic] *subangulata* Kristan-Tollmann – Salaj et al., p. 152-153, pl. 131, fig. 10 [cet. excl.].

? 1983 *Duostomina biconvexa* Kristan-Tollmann – Kristan-Tollmann, pl. 4, fig. 11.

1987 *Duostomina*? sp. – Oravecz-Scheffer, pl. 31, fig. 12, 13.

• 1987 *Duostomina biconvexa* Kristan-Tollmann – Oravecz-Scheffer, pl. 36, fig. 1, 2.

? 1988 *Duostomina biconvexa* Kristan-Tollmann – Vettorel, p. 177, pl. 2, fig. 6, 7.

pars 1991 *Diplotremina subangulata* Kristan-Tollmann – Kristan-Tollmann, pl. 4, fig. 10 [cet. excl.].

1992 Duostominidae – Zaninetti et al., pl. 4, fig. 15.

? 1992 *Diplotremina subangulata* Kristan-Tollmann – Senff, p. 686-688, pl. 3, fig. 1-5, 7.

• 1993 *Duostomina* cf. *biconvexa* Kristan-Tollmann – Bérczi-Makk et al., pl. 7, fig. 11.

? 1996b *Duostomina biconvexa* Kristan-Tollmann 1971 [sic] – Bérczi-Makk, pl. 15, fig. 4.

• 1998 *Duostomina biconvexa* Kristan-Tollmann – di Bari & Baracca, p. 126, pl. 2, fig. 2.

• 1998 *Duostomina biconvexa* Kristan-Tollmann – di Bari & Laghi, pl. 1, fig. 2.

non 2005 *Duostomina biconvexa* Kristan-Tollmann – Kobayashi et al., fig. 10.39-10.44.

• 2009 *Duostomina biconvexa* Kristan-Tollmann – Martini et al., pl. 1, fig. 26-28.

Material: Thin sections ?S66, K2-76.30 (two specimens),?K2-87.60 (B. Rožič, University of Ljubljana, Faculty of Natural Sciences and Engineering); ?70070, 70078, ?70254, 70293, ?70326.

Locality and age: Mt. Slatnik, Norian and (?) Rhaetian; Mt. Kobla, Norian and (?) Rhaetian.

Description. Test lenticular, equally biconvex; test margin subangular; umbilical side closed.

Test diameter 0.62-0.91 mm; test height 0.37-0.64 mm.

Remarks. Our specimens differ from the type material in much larger tests, thus their attribution to this species is uncertain. Our material could alternatively be divided into two species, one having a large oval proloculus, followed by elongated chambers oblique to the coiling axis, with more pronounced sutures on the spiral side and an unclear closure of the umbilical side (Pl. 2, fig. 6, 7). These specimens are also attributed to *Du. biconvexa*, but are marked with an additional question mark, as they could not be placed in any other species.

Duostomina biconvexa differs from *Du. rotundata* and *Di. placklesiana* in the angular test margin. *Diplotremina subangulata* has the shape of a flattened hexagon with a large umbilical opening. Kristan-Tollmann (1960) figured transitional forms with *Duostomina alta* Kristan-Tollmann, 1960, the later ranging from a flat to highly convex umbilical side, until both sides of the test are of equal height (*Du. biconvexa*). This trend further continues in *Du. turboidea* in the opposite direction, with an increasing relative height of the umbilical side. If the mentioned species should be synonymised, *Du. biconvexa* holds the priority.

In addition to accepted specimens in the synonymy list, Kristan-Tollmann (1983) and Bérczi-Makk (1996b) figured specimens in transverse sections, from which characteristics of the species cannot be seen. Unfortunately, Vettorel (1988) chose to figure his specimen in unsuitable orientation as well, so we cannot confirm his determination. Part of the material figured by Kristan-Tollmann (1991) belongs to *Di. astrofimbriata* (pl. 4, fig. 4, ?5) and part to *Duostomina*? sp. A (pl. 4, fig. 9). Instead, the specimen on her pl. 4, fig. 10, determined as *Du. subangulata* is regarded by us as *Du. biconvexa*. Some specimens figured by Senff (1992) have equally biconvex test with subangular margin and closed umbi-

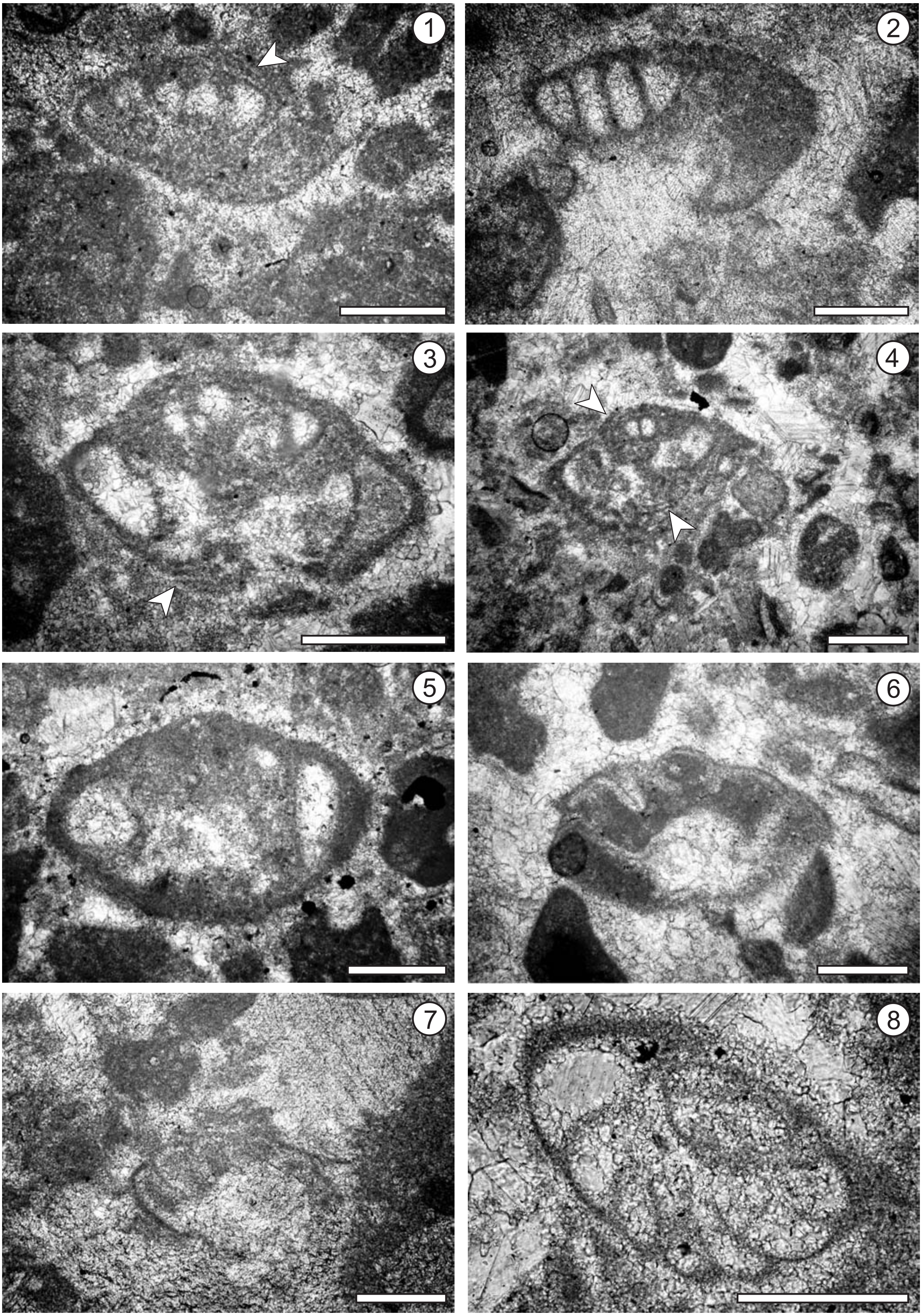
PLATE 2

Fig. 1, 2 - *Duostomina turboidea* Kristan-Tollmann, 1960. Samples: 1) thin section 70304, slightly tangential section, arrowhead points at lamellae; 2) thin section 70307, slightly tangential section; the "opening" is interpreted as damaged test, not as the umbilical opening; Mt. Kobla, Norian.

Fig. 3, 4?, 5?, 6?, 7 - ? *Duostomina biconvexa* Kristan-Tollmann, 1960. Samples: 3, 4) thin section K2-76.30; axial and slightly tangential sections respectively; arrowheads point at lamellae; Mt. Kobla, Rhaetian; 5) thin section K2-87.60, slightly tangential section; Mt. Kobla, Rhaetian; 6) thin section 70326, axial section; Mt. Kobla, Norian; 7) thin section S 66, tangential section; Mt. Slatnik, Rhaetian.

Fig. 8 - *Duostomina*? sp. A, thin section 69847, oblique section; Mt. Slatnik, Norian.

Scale bar: 250 μm.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licus area, so they could also belong to *Du. biconvexa*. Most of the specimens figured by Kobayashi et al. (2005) as *Du. biconvexa* are not in suitable orientation for species determination, while the specimen on his fig. 10.39 probably belongs to *Di. subangulata*.

Distribution and stratigraphic range. Northern Calcareous Alps, Austria, upper Ladinian to lower Carnian (Cordevolian) (Kristan-Tollmann 1960); Dolomites, Italy, Ladinian to Carnian (di Bari & Baracca 1998; di Bari & Laghi 1998); Transdanubian Range, Hungary, Carnian (Oravecz-Scheffer 1987; Bérczi-Makk et al. 1993); Cyprus, undivided Carnian to Rhaetian (Martini et al. 2009); Western Carpathians, Norian (Salaj et al. 1983); Taurus, Turkey, undivided Norian to Rhaetian (Tuzcu et al. 1982); Wombat Plateau, Australia, undivided Norian to Rhaetian (Zaninetti et al. 1992); Japan, Rhaetian (Kristan-Tollmann 1991). Di Bari & Baracca (1998) cite Anisian to Carnian age.

Duostomina? sp. A

Pl. 2, fig. 8; Pl. 3, figs 1-7

1991 ?*Diplotremina plackleslana* [sic] Kristan-Tollmann – Kristan-Tollmann, pl. 3, fig. 5.

cf. pars 1991 *Diplotremina subangulata* Kristan-Tollmann – Kristan-Tollmann, pl. 4, fig. 9 [cet. excl.].

cf. pars 1996b *Duostomina turboidea* Kristan-Tollmann – Bérczi-Makk, pl. 15, fig. 2 [cet. excl.].

cf. pars 1996b *Variostoma acutoangulata* Kristan-Tollmann – Bérczi-Makk, pl. 16, fig. 2, 3, 6 [cet. excl.].

Material: Thin sections 69847, 70067, 70228, 70247 (two specimens), 70254, 70262, 70287, 70304.

Locality and age: Mt. Slatnik, Norian and Rhaetian; Mt. Kobla, Rhaetian.

Description. Spiral side of the test almost flat; the umbilical side strongly convex, very wide and well rounded; test margin rounded; elliptical proloculus followed by two whorls: three to five transected chambers visible in the first one, five to seven larger chambers in the second coil; umbilicus closed.

Test diameter 0.53-1.01 mm; test height 0.21-0.84 mm.

Remarks. Our specimens differ from *Du. turboidea* in a larger test and a completely rounded umbilical side. *Variostoma spinosum* Kristan-Tollmann, 1960 with a similarly well rounded umbilical side, has thorn-like projections. *Variostoma coniforme* Kristan-Tollmann, 1960 and *Variostoma catilliforme* Kristan-Tollmann, 1960 possess angular and keeled margins respectively.

Some of the material figured by Kristan-Tollmann (1991) as *Di. subangulata*, and by Bérczi-Makk (1996b) as *Du. turboidea* and *Variostoma acutoangulata* Kristan-Tollmann, 1960 is included in the synonymy of *Duostomina*? sp. A. Determination of specimens in transverse sections figured by Bérczi-Makk (1996b) is considered unreliable. The specimen on his pl. 16, fig. 4 is *Variostoma coniforme* Kristan-Tollmann, 1960.

Distribution and stratigraphic range. Seemingly the same duostominids were figured by Kristan-Tollmann (1991) from the undivided Norian to Rhaetian and Rhaetian strata of Japan. Bérczi-Makk (1996b) found similar forms in the Carnian of Hungary.

?Duostominidae cf. **Duostomina multangulata** He, 1999

Pl. 3, fig. 8

cf. 1999 *Duostomina multangulata* He, p. 46, pl. 3, fig. 3, 4, 15 a, b.

Material: Thin section 69902.

Locality and age: Mt. Slatnik, Norian.

Description. Test largely recrystallized; seven or eight chambers in the last whorl; chambers angular, rhomboid in shape, strongly projecting and tapering, but without a keel or a spine.

Test diameter 0.32 mm.

Remarks. An unsuitable orientation and a strong recrystallization do not allow an unambiguous assignment of this specimen to the family Duostominidae, let alone the species determination. The size of the specimen, as well as the shape of the chambers correspond to *Du. multangulata*, described from Norian beds of China (He 1999).

? Family Duostominidae Brotzen, 1963

Genus *Variostoma* Kristan-Tollmann, 1960 emend. Fuchs, 1975

Type species: *Variostoma spinosum* Kristan-Tollmann, 1960, p. 55

Remarks. The genus was introduced by Kristan-Tollmann (1960). The aperture was interpreted as com-

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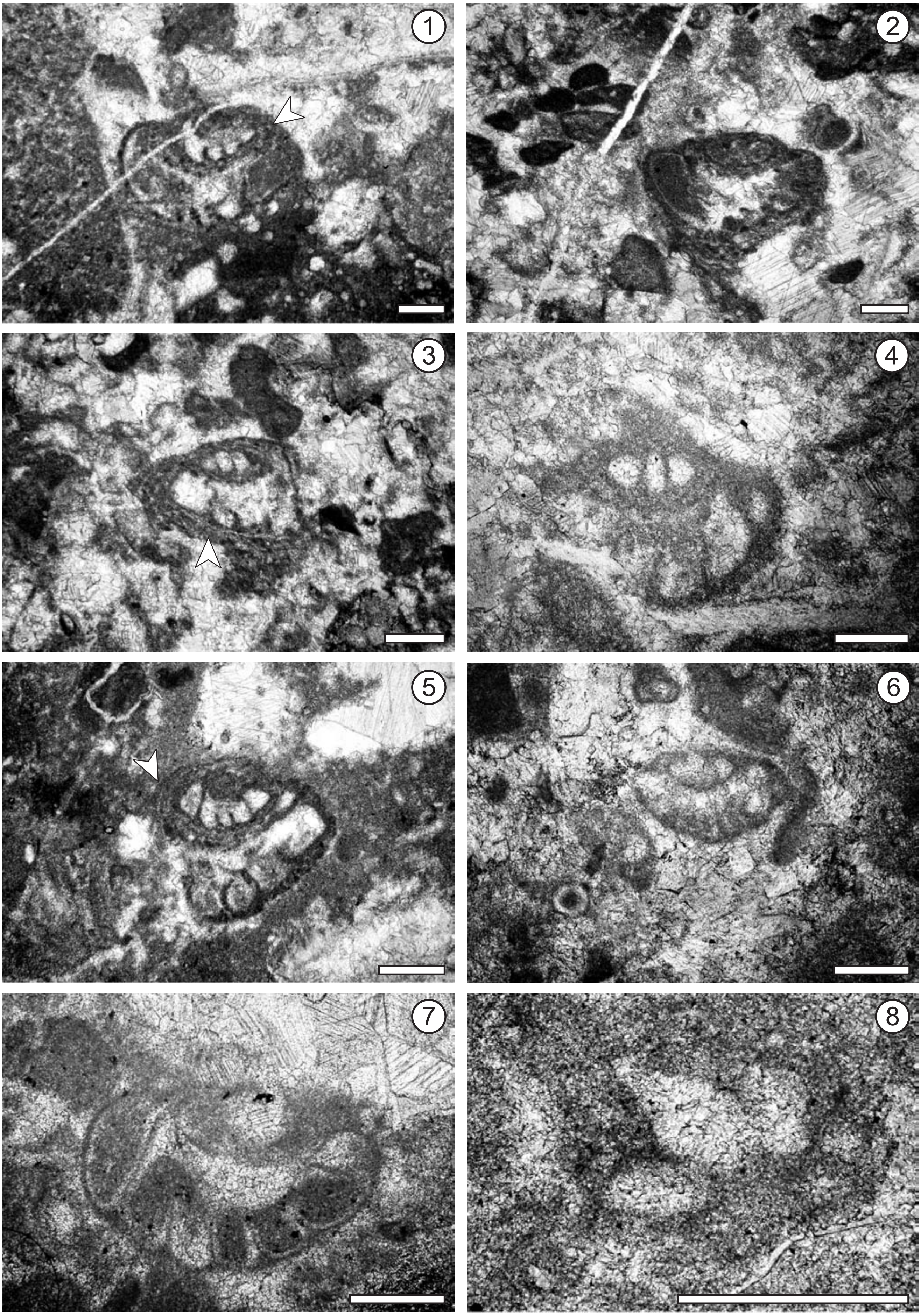
PLATE 3

Fig. 1-7 - *Duostomina*? sp. A. Samples: 1) thin section 70228, slightly oblique axial section; arrowhead points at lamellae; Mt. Slatnik, uppermost Norian; 2, 3) thin section 70247, axial and axial oblique sections respectively; arrowhead points at lamellae; Mt. Slatnik, Rhaetian; 4) thin section 70254, tangential section; Mt. Slatnik, Rhaetian; 5) thin section 70262, axial oblique section; arrowhead points at lamellae; Mt. Slatnik, Rhaetian; 6) thin section 70287, axial section; Mt. Slatnik, Rhaetian; 7) thin section 70304, axial oblique section; Mt. Kobla, Rhaetian.

Fig. 8 - ? Duostominidae cf. *Duostomina multangulata* He, 1999; thin section 69902, transverse section; Mt. Slatnik, Norian.

Scale bar: 250 μm.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plex, divided into three lobes. The description was later emended by Fuchs (1975), stating that the primary aperture was simple, rounded or broadly elliptical and that the complex structure observed by Kristan-Tollmann (1960) resulted from the partial dissolution of the test.

According to di Bari & Laghi (1998) the mineralogical composition of the wall of *Variostoma* is aragonitic although its structure is alveolar. Di Bari & Laghi (1998) nevertheless retained *Variostoma* in Duostominidae.

The alveolar wall and the simple aperture are not in agreement with the current description of the family, though a clearly lamellar structure of the wall is noted (see below). Further research may lead to another emendation of the family Duostominidae, or to the exclusion of *Variostoma* from it. We thus dubiously agree with di Bari & Laghi (1998) and retain *Variostoma* among duostominids until further notice.

Variostoma coniforme Kristan-Tollmann, 1960

Pl. 4, figs 1,?2,?3, 4-7

*1960 *Variostoma coniforme* Kristan-Tollmann, p. 62-63, pl. 12, fig. 1-5.

1962 *Trochammina*? *angulata* n. sp. – Trifonova, p. 167, pl. 4, fig. 7-9.

● 1964b *Variostoma coniforme* Kristan, 1960 [sic] – Kristan-Tollmann, p. 50-51, pl. 39, fig. 6.

● 1964c *Variostoma coniforme* Kristan, 1960 [sic] – Kristan-Tollmann, p. 139, abb. 4, fig. 2.

? 1964c *Variostoma* ? sp. – Kristan-Tollmann, p. 51, pl. 39, fig. 7.

● 1979 *Variostoma coniforme* Kristan-Tollmann – Schäfer, Pl. 19, fig. 1.

? 1987 *Variostoma coniforme* Kristan [sic] – Oravecz-Scheffer, pl. 90, fig. 1-2.

pars 1987 *Variostoma* cf. *coniforme* Kristan [sic] – Oravecz-Scheffer, pl. 90, fig. 11, 12 [?], 13 [?], 15 [?].

● 1988 *Variostoma coniforme* Kristan-Tollmann – Kristan-Tollmann, pl. 2, fig. 1-5.

● 1988 *Variostoma* cf. *coniforme* Kristan-Tollmann – Trifonova & Čatalov, pl. 2, fig. 4.

pars 1990 *Variostoma angulata* (Trifonova) – He & Wang, pl. 14, fig. 7-8 [? non pl. 14, fig. 4-6].

● 1990 *Variostoma coniforme* Kristan-Tollmann– Kristan-Tollmann, p. 244-245, pl. 15, fig. 1, 2.

? pars 1991 *Variostoma cochlea* Kristan-Tollmann – Kristan-Tollmann, pl. 4, fig. 7, 8 [sine pl. 4, fig. 3].

? 1991 *Variostoma coniforme* Kristan-Tollmann – He & Norling, p. 34, pl. 2, fig. 15.

● 1992 *Variostoma coniforme* Kristan-Tollmann – Kristan-Tollmann & Gramann, pl. 1, fig. 13.

● 1994 *Variostoma coniforme* Kristan-Tollmann– Trifonova, p. 58, pl. 10, fig. 4; pl. 12, fig. 15, 16.

pars 1996b *Variostoma acutoangulata* Kristan-Tollmann – Bérczi-Makk, pl. 16, fig. 4 [cet. excl.].

● 1999 *Variostoma angulata* (Trifonova) – He, pl. 2, fig. 11, 14, 15.

● 1999 *Variostoma coniforme* Kristan-Tollmann– He, pl. 2, fig. 12a,b.

Material: Thin sections 70077,?70228,?70247, 70298 (three specimens), 70304, 70306, 70322, 70326, 70327.

Locality and age: Mt. Slatnik, Norian and Rhaetian; Mt. Kobla, Norian and Rhaetian.

Description. Test in shape of an inverted dome, with an only slightly convex spiral side and a highly convex, broadly rounded umbilical side; test symmetrical around the coiling axis; test margin angular; two whorls visible, with few chambers; chamber lumen ventrally elongated; umbilical part appears closed or slightly opened, probably depending on the orientation of the section and diagenetic processes; wall appears finely agglutinated or microgranular, probably due to recrystallization.

Test diameter 0.38-0.62 (?0.91) mm; test height 0.26-0.48 (?0.78) mm.

Remarks. *Variostoma coniforme* differs from *Du. turboidea* in having a low spiral side of the test and an angular margin. *Variostoma spinosum* has thorn-like projections on the upper side of the chambers. *Variostoma helicta* (Tappan, 1951) has a rounded margin. The test of *V. catilliforme* is more flattened, its spiral side flat or slightly concave, while its margin possesses a keel. *Variostoma angulata* Kristan-Tollmann, 1960 has a flatter test with more chambers. According to Trifonova (1994), *Trochammina*? *angulata* Trifonova, 1962 is a junior synonym of *V. coniforme* and not of *Variostoma acutiangulata* Kristan-Tollmann, 1960 as suggested by He & Norling (1991). Our specimens from thin sections 70228 and 70247 are attributed to the species *V. coniforme* with a question mark because of their large size. They are close to *Variostoma*? sp. of Kristan-Tollmann (1964c).

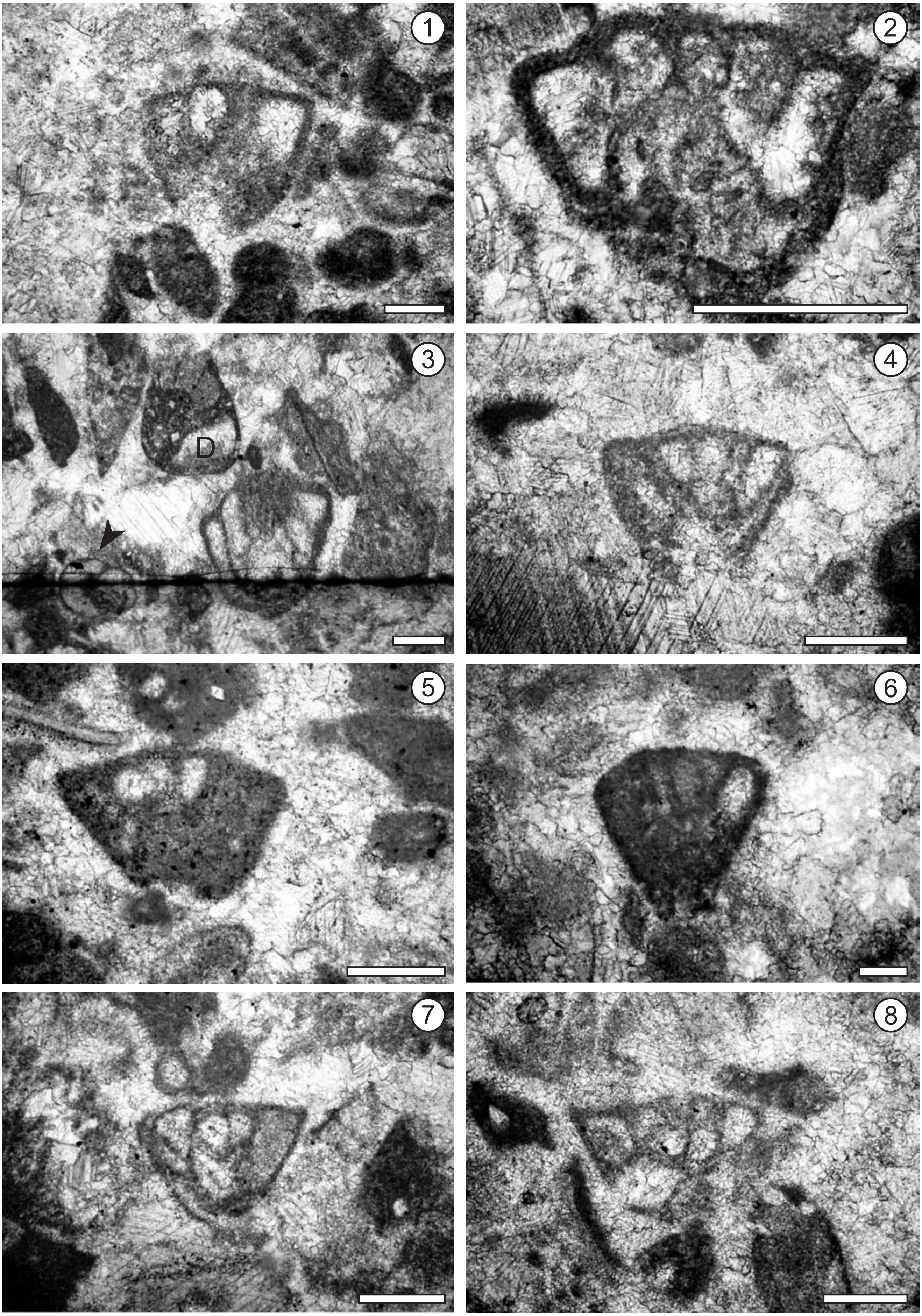
Part of the material figured by Kristan-Tollmann (1991) as juvenile specimens of *V. cochlea* are here re-

PLATE 4

Fig. 1, 2, ?3, ?4, 5-7- *Variostoma coniforme* Kristan-Tollmann, 1960. Samples: 1) thin section 70077, tangential section; Mt. Slatnik, Norian; 2) thin section 70228, axial or slightly tangential section; Mt. Slatnik, uppermost Norian; 3) with recrystallized *Galeanella* sp. (arrowhead) and another duostominid (D), thin section 70247, axial section; Mt. Slatnik, Norian; 4, 5) thin section 70298, axial or slightly tangential sections; Mt. Kobla, Rhaetian; 6), thin section 70326, axial or slightly tangential section; Mt. Kobla, Norian; 7), thin section 70327, axial or slightly tangential section; Mt. Kobla, Norian.

Fig. 8 - *Variostoma catilliforme* Kristan-Tollmann, 1960; thin section 70277, axial section; Mt. Kobla, Rhaetian.

Scale bar: 250 μm.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garded as *V. coniforme*. Specimens figured by Oravecz-Scheffer (1987) are in transverse sections.

Distribution and stratigraphic range. Hungary, Carnian (Bérczi-Makk 1996b) and undivided Carnian to Rhaetian (Oravecz-Scheffer, 1987, for part of the material herein considered as conspecific); Bulgaria, Norian (Trifonova 1962, 1994; Trifonova & Čatalov 1988); China, Norian (He & Wang 1990; He 1999); Northern Calcareous Alps, Austria, Rhaetian (Kristan-Tollmann 1960, 1964b, 1964c, 1988; Schäfer 1979); Papua New Guinea, Rhaetian (Kristan-Tollmann 1988, 1990); Japan, Rhaetian (Kristan-Tollmann1991); Exmouth Plateau, Australia, Rhaetian (Kristan-Tollmann & Gramann 1992); Nevada and Oregon, USA, Norian (Kristan-Tollmann 1988).

Variostoma catilliforme Kristan-Tollmann, 1960

Pl. 4, fig. 8; Pl. 5, fig. 1

*1960 *Variostoma catilliforme* Kristan-Tollmann, p. 61-62, pl. 10, fig. 5-7; pl. 11, fig. 1-4.

non 1987 *Variostoma* cf. *catilliformis* Kristan – Oravecz-Scheffer, pl. 71, fig. 8.

non 1983 *Variostoma catilliforme* Kristan-Tollmann– Salaj et al., p. 154, pl. 134, fig. 6, 8; pl. 135, fig. 7, 8 [? pl. 136, fig. 1-6].

Material: Thin sections 70277, ?70322.
Locality and age: Mt. Kobla, Rhaetian.

Description. Test in shape of an inverted dome, flattened, two-times wider then high; spiral side slightly convex, umbilical side strongly convex, but very wide; test symmetrical around the coiling axis; test margin angular, with a short keel; up to three whorls are visible, the first one having two, the second four and the last coil five chambers visible in the plane of transection; wall thick, apparently agglutinated.

Test diameter (0.55?)-0.60 mm; test height (0.27?)-0.36 mm.

Remarks. *Variostoma catilliforme* differs from *V. spinosum* in the lack of thorn-like projections. *Variostoma helicta* has a rounded test margin, while *V. coniforme* lacks the keel, has a relatively higher test and less chambers per whorl.

Salaj et al. (1983) determined several specimens as *V. catilliforme*, but their spiral side is too high, and the determination is not possible for part of their material due to unsuitable orientation.

Specimen figured by Oravecz-Scheffer (1987) has a seemingly involutinid wall and is not considered a *V. catilliforme*.

Distribution and stratigraphic range. Northern Calcareous Alps, Austria, Norian (Kristan-Tollmann 1960).

Variostoma cochlea Kristan-Tollmann, 1960

Pl. 5, fig. 2

*1960 *Variostoma cochlea* Kristan-Tollmann, p. 63-64, pl. 12, fig. 6; pl. 13, fig. 1-12; pl. 14, fig. 5.

• 1964a *Variostoma cochlea* Kristan [sic] – Kristan-Tollmann, pl. 7, fig. 6.

• 1977 *Variostoma cochlea* Kristan-Tollmann– Gupta et al., p. 12, pl. 2, fig. 11, 12.

? 1983 *Variostoma cochlea* Kristan-Tollmann– Salaj et al., p. 154, pl. 136, fig. 7, 8.

• 1986a *Variostoma cochlea* Kristan-Tollmann – Kristan-Tollmann, abb. 1, fig. 9-14.

• 1986b *Variostoma cochlea* Kristan-Tollmann– Kristan-Tollmann, p. 303, pl. 2, fig. 5.

? 1986b ?*Variostoma cochlea* Kristan-Tollmann– Kristan-Tollmann, p. 303, pl. 4, fig. 11.

1987 *Variostoma crassum* Kristan – Oravecz-Scheffer, pl. 90, fig. 4, 10.

• 1988 *Variostoma cochlea* Kristan-Tollmann – Kristan-Tollmann, pl. 1, fig. 1-10; pl. 2, fig. 11-13.

non 1988 *Variostoma cochlea* Kristan-Tollmann, 1960 – Vettorel, p. 168-170, pl. 1, fig. 3.

• 1990 *Variostoma cochlea* Kristan-Tollmann, 1960 – Kristan-Tollmann, p. 242-244, abb. 15, fig. 1-16; pl. 14, fig. 1-6; [? pl. 14, fig. 3, 4; pl. 15, fig. 5].

? non 1991 *Variostoma cochlea* Kristan-Tollmann – Kristan-Tollmann, pl. 4, fig. 3, 7, 8.

non 1998 *Variostoma cochlea* Kristan-Tollmann – di Bari & Baracca, p. 129, pl. 3, fig. 7-9.

Material: Thin section 70232, ?70247, 70252, 70254, 70326.
Locality and age: Mt. Slatnik, Norian and Rhaetian; Mt. Kobla, Norian.

Description. Test incomplete, highly trochospiral with a strongly undulating side; apical end rounded; chambers kidney-like in shape, positioned oblique to the coiling axis; wall very thick, agglutinated and lamellar (Pl. 5, fig. 2).

PLATE 5

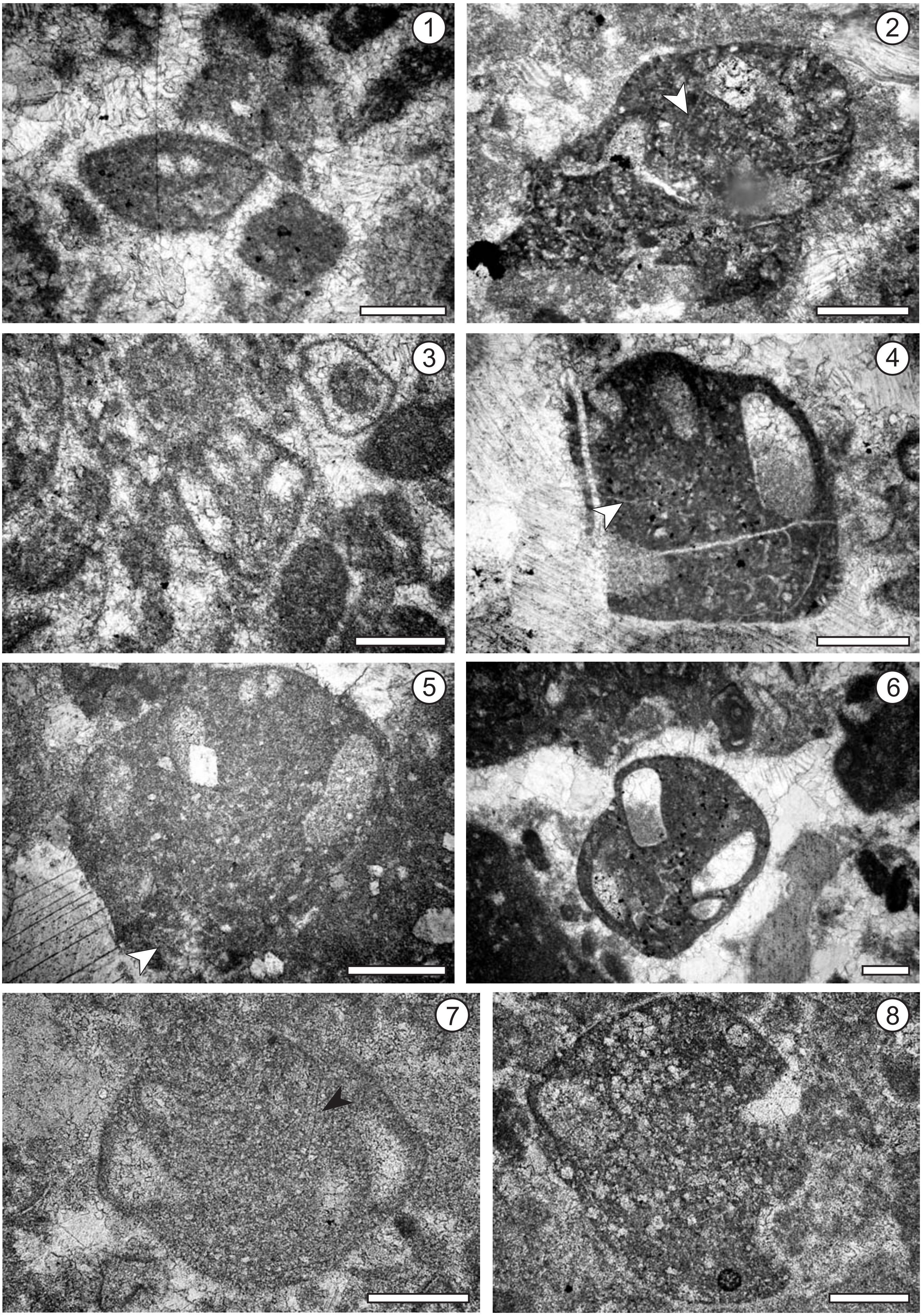
Fig. 1 - ? *Variostoma catilliforme* Kristan-Tollmann, 1960; thin section 70322, tangential section; Mt. Kobla, Rhaetian.

Fig. 2 - *Variostoma cochlea* Kristan-Tollmann, 1960; thin section 70232, axial oblique section; arrowhead points at lamellae; Mt. Slatnik, Rhaetian.

Fig. 3 - ? *Variostoma falcata* Kristan-Tollmann, 1973; thin section 69859, axial section; Mt. Slatnik, Norian.

Fig. 4-8 - ? *Variostoma helicta* (Tappan, 1951). Samples: 4), thin section K2-70.40, axial section; arrowhead points at lamellae; Mt. Kobla, Norian; 5) thin section K2-91.30, axial or slightly tangential section; Mt. Kobla, Rhaetian; 6) thin section K2-94.20, axial section; Mt. Kobla, Rhaetian; 7) thin section 70085, axial oblique section; arrowhead points at lamellae; Mt. Slatnik, Norian; 8) thin section 70267, axial section; Mt. Slatnik, Norian.

Scale bar: 250 μm.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Test diameter 0.71 mm; test height 0.82 mm.

Remarks. *Variostoma cochlea* can be easily distinguished from *Variostoma pralongense* Kristan-Tollmann, 1960 and *Variostoma exile* Kristan-Tollmann, 1960 based on the general appearance of the test and rounded ends. *Variostoma helicta* has a more robust test that is often wider than it is high, but has the same wall structure, as shown here.

Kristan-Tollmann (1964a, 1991) gave no indication of size of her specimens. Determination is not possible for specimens figured by Salaj et al. (1983). Specimen determined by Vettorel (1988) as *V. cochlea* is regarded as *V. pralongense*. Di Bari & Baracca (1998) perhaps wrongly oriented their specimens (upside-down) and they could belong to *Du. turboidea* instead.

Distribution and stratigraphic range. Transdanubian Range, Hungary, undivided Carnian-Rhaetian (Oravecz-Scheffer 1987); Northern Calcareous Alps, Austria, Rhaetian (Kristan-Tollmann 1960, 1964a, 1988); Himalaya, India, Rhaetian (Gupta et al. 1977; Kristan-Tollmann 1988); Papua New Guinea, Sevatian 2 or Rhaetian s.s. (Kristan-Tollmann 1986a, 1988, 1990). The species has been cited as a guide fossil for Sevatian to Rhaetian by Kristan-Tollmann (1964a, 1986a, 1990), and is found in the basinal, slope, and fore-reef sediments (Kristan-Tollmann 1990).

?Variostoma falcata Kristan-Tollmann, 1973

Pl. 5, fig. 3

1964a Variostomatidae – Kristan-Tollmann, pl. 7, fig. 3.

*1973 *Variostoma falcata* Kristan-Tollmann, p. 425-426, abb. 2, fig. 1.

Material: Thin section 69859.

Locality and age: Mt. Slatnik, Norian.

Description. Test trapezoid in shape, with a cone-like, moderately high spiral side and an angular apex; umbilical side highly conical, elongated; test margin slightly rounded; three whorls visible; chambers kidney-like; umbilicus filled; wall thick, agglutinated.

Test diameter 0.41 mm; test height 0.50 mm.

Remarks. Our specimen is much smaller than the type specimen. *Variostoma falcata* is very similar to *V. cochlea*. It differs from the latter in a trapezoid shape of the test, the absence of depressed sutures on the spiral side, and a less broadly rounded test margin.

Distribution and stratigraphic range. Northern Calcareous Alps, Austria, Carnian (Kristan-Tollmann 1964a, 1973).

?Variostoma helicta (Tappan, 1951)

Pl. 5, figs 4-8

*1951 *Trochammina helicta* Tappan, p. 9-10, pl. 1, fig. 7-9.

1960 *Variostoma crassum* nov. gen. nov. spec. – Kristan-Tollmann, p. 59-60, pl. 9, fig. 9-11; pl. 10, fig. 1-4.

• 1964a *Variostoma crassum* Kristan – Kristan-Tollmann, pl. 7, fig. 5.

• 1977 *Variostoma crassum* Kristan-Tollmann, 1960 – Gupta et al., p. 13, pl. 2, fig. 4, 5?, 7?.

? 1983 *Variostoma crassum* Kristan-Tollmann, 1960 – Salaj et al., p. 154-155, pl. 136, fig. 9-11; pl. 137, fig. 1-3.

? 1987 *Variostoma crassum* Kristan – Oravecz-Scheffer, pl. 90, fig. 1-3, 5, 6.

non 1987 *Variostoma crassum* Kristan – Oravecz-Scheffer, pl. 90, fig. 4, 7, 8, 9, 10 [pars *V. cochlea*].

? 1988 *Variostoma crassum* Kristan-Tollmann – Salaj et al., pl. 9, fig. 6.

? 1988 *Variostoma helictum* (Tappan) – Kristan-Tollmann, pl. 1, fig. 15; pl. 2, fig. 9, 10.

? 1988 *Variostoma* cf. *helictum* (Tappan) – Trifonova & Čatalov, pl. 2, fig. 2.

? 1990 *Variostoma crassum* Kristan-Tollmann – He & Wang, pl. 3, fig. 1.

1990 *Variostoma helicta* (Tappan) – He & Wang, pl. 14, fig. 1, 2.

L 1991 *Variostoma crassum* Kristan-Tollmann – He & Norling, p. 34.

? 1991 *Variostoma helicta* (Tappan) – He & Norling, p. 34, pl. 2, fig. 16.

pars 1994 *Variostoma helictum* (Tappan, 1951) – Trifonova, p. 59, pl. 12, fig. 18-20 [? pl. 10, fig. 1; non pl. 10, fig. 2].

• 1999 *Variostoma crassum* Kristan-Tollmann, 1960 – He, pl. 2, fig. 8.

? 1999 *Variostoma helicta* (Tappan) – He, pl. 2, fig. 13a,b.

Material: Thin sections K2-70.40, K2-91.30, K2-94.20 (B. Rožič, University of Ljubljana, Faculty of Natural Sciences and Engineering); 70085, 70267.

Locality and age: Mt. Slatnik, Norian and Rhaetian; Mt. Kobla, Norian and Rhaetian.

Description. Test large, moderately to highly trochospiral, with a slightly projecting and filled umbilical part; apical and umbilical ends rounded; proloculus globular, later chambers kidney-like in shape, positioned oblique to the coiling axis; small umbilical opening rarely visible; wall very thick, agglutinated and lamellar.

Test diameter 0.79-0.92 mm; test height 0.73-1.10 mm.

Remarks. *Variostoma crassum* is treated by some (e.g., Trifonova 1994) as a junior synonym of "*Trochammina*" *helicta* Tappan, 1951. Kristan-Tollmann (1960) described the aperture of her species *V. crassum* as split, while Tappan (1951) illustrates a simple aperture. Fuchs (1975) in his emended description of the genus *Variostoma* stated that the aperture of Kristan-Tollmann's (1960) specimens should be viewed as simple, round to oval. Both mentioned species thus have the same aperture and can truly be viewed as synonyms. However, the aperture of Tappan's (1951) specimen is not clearly visible and any conclusions without the re-examination of the type material are tentative (see also Kristan-Tollmann 1988).

GENUS	SPECIES	DIAGNOSIS
Variostoma Kristan-Tollmann, 1960	*V. helicta* (Tappan, 1951)	Spiral side low convex, umbilical strongly convex; test margin well rounded; wall thick; umbilicus very wide
	V. spinosum Kristan-Tollmann, 1960	Spiral side low to high convex, umbilical strongly convex; thorny projections on the spiral side; umbilicus wide
	V. pralongense Kristan-Tollmann, 1960	Test elongated; umbilical side wide, spiral side pointed; test width:height ratio 1:1.6 to 1:1.7
	V. exile Kristan-Tollmann, 1960	Test similar to *V. pralongense*, but narrower, with width:height ratio 1:20 to 1:2.6
	V. catilliforme Kristan-Tollmann, 1960	Spiral side flat, umbilical wide and strongly convex; test margin keeled; test flatter than in *V. coniforme*
	V. coniforme Kristan-Tollmann, 1960	Spiral side flat to low convex, umbilical strongly convex and wide; test margin angular;
	V. cochlea Kristan-Tollmann, 1960	Elongated; spiral side wide dome-shaped, very high; apical side flat and wide; umbilicus small; rounded margin; chambers ventrally strongly elongated; juvenile specimens very similar to *V. helicta* (see Kristan-Tollmann 1990), but are smaller
	V. acutoangulata Kristan-Tollmann, 1973	Spiral side flat or very low convex; umbilical side wide and rounded; test margin angular; lower than *V. coniforme*, with wider umbilicus and more numerous chambers (12-14 in last whorl compared to 7-8)
	V. falcata Kristan-Tollmann, 1973	Test elongated; spiral side moderately convex, narrowing towards the apex; spiral side very elongated, narrowing towards umbilicus; test margin rounded
Diplotremina Kristan-Tollmann, 1960	*Di. astrofimbriata* Kristan-Tollmann, 1960	Spiral side mostly strongly convex than umbilical; test margin slightly keeled to rounded
	Di. placklesiana Kristan-Tollmann, 1960	Spiral and umbilical sides low convex; test margin completely rounded
	Di. subangulata Kristan-Tollmann, 1960	Spiral and umbilical side moderately convex; test margin slightly angular
Duostomina Kristan-Tollmann, 1960	*Du. biconvexa* Kristan-Tollmann, 1960	Biconvex, with spiral and umbilical sides of the same height; test margin angular
	Du. alta Kristan-Tollmann, 1960	Spiral side strongly convex, always higher than the umbilical one; test margin angular (see remark in figure caption)
	Du. turboidea Kristan-Tollmann, 1960	Spiral side lower than umbilical; test margin well rounded (see remark in figure caption)
	Du. rotundata Kristan-Tollmann, 1960	Spiral side always higher than umbilical, but the test remains flattened; umbilical side very low; test margin well rounded
	Du. magna Trifonova, 1977	Low trochiform; 2 ½ whorls with very large chambers, 5 in the last whorl
	Du. multangulata He, 1999	Spiral side strongly convex than the umbilical; chambers angular, projecting above the test outline
Papillaria di Bari & Rettori, 1996	*P. altoconica* (Kristan-Tollmann, 1973)	High conical in shape, with flat umbilical side; apex slightly rounded
	P. laghii di Bari & Rettori, 1996	Spiral side moderately high, dome shaped; umbilical side flat; apex rounded
Krikoumbilica He, 1984	*K. pileiformis* He, 1984	Spiral side low to moderately convex, domed, well rounded; umbilical side flat

Tab. 2 - Short description of genera and species of the family Duostominidae. The emphasis is given to features useful in determining species in thin sections. Some species also attributed to these genera, but which are considered as wrongly identified, are not included in the table due to their uncertain status, e.g., *Diplotremina stenocamerata* He, 1999, *Duostomina tamarinense* di Bari & Baracca, 1998, and *Variostoma oberhauseri* Vettorel, 1988 (considered by us a junior synonym of *V. exile*). Kristan-Tollmann (1983) placed the genus *Kollmannita* Fuchs, 1967 with several species under the synonymy of *Diplotremina*. However, Loeblich & Tappan (1987) consider it synonym with *Oberhauserella* Fuchs, 1967. *Variostoma cochlea* has been synonymized with *V. helicta* (see text). *Variostoma oberhauseri* Vettorel (1988) is here considered a junior synonym of *V. exile*.

Our specimens are not easily distinguished from *V. cochlea* because both have well rounded apical and umbilical ends, as well as kidney-like chambers. *Variostoma helicta* is the stouter and larger of the two. Agglutinated lamellae are clearly visible in our specimens (Pl. 5, fig. 4, 5, 7). Kristan-Tollmann (1960) wrote about overlapping flaps in the umbilical area, while Gupta et al. (1977) reported only of the granular wall.

Determination is not possible for the specimens figured by Salaj et al. (1983), Oravecz-Scheffer (1987), Salaj et al. (1988), Trifonova & Čatalov (1988), and He & Wang (1990). Part of the material figured by Orevecz-Scheffer (1987) belongs to *V. cochlea*. The specimen figured by Trifonova (1994) on her pl. 10, fig. 2 could be a *Diplotremmina* or a *Duostomina*, while the specimen on her pl. 10, fig. 1 truly belongs to *Variostoma*, but the species determination remains questionable. The specimen figured by He (1999) could belong to *Di. astrofimbriata*.

Distribution and stratigraphic range. Alaska, Upper Triassic (Tappan 1951); Northern Calcareous Alps, Austria, Norian (Kristan-Tollmann 1960, 1964a); Eastern Balkan, Bulgaria, Norian (Trifonova 1994); Himalaya, India, Rhaetian (Gupta et al. 1977); China, Norian (He & Wang 1990; He 1999). Kristan-Tollmann (1964a) treated this species as a guide fossil for the Norian.

Discussion and conclusions

Eleven species of the genera *Diplotremina*, *Duostomina*, and *Variostoma* (Duostominidae) were determined from thin sections from the "Bača Dolomite" and the Slatnik Formation of the Slovenian Basin. To a certain degree, axial sections of duostominids allow determination to the species level. Species were determined mostly on the basis of the overall test shape, the height of the trochospire, the ratio between the height of the dorsal and ventral sides of the test, the shape of the umbilical area, and the shape of the test margin (Tab. 2). *Duostomina*? sp. A could not be unambiguously compared to the previously described species.

In contrast with the previous studies (e.g. Loeblich & Tappan 1987; di Bari & Laghi 1998), our specimens determined as *Variostoma cochlea* and *V. helicta* also display a lamellar wall, which seems agglutinated (Pl. 5, fig. 2, 4, 5, 7, 8). The lamellar structure was also observed in *Duostomina turboidea* (Pl. 2, fig. 1), *Duostomina biconvexa* (Pl. 3, fig. 3, 4) and *Duostomina*? sp. A (Pl. 3, fig. 1, 3, 5), which is in accordance with the studies carried out by di Bari & Laghi (1998). Some of our specimens of the genera *Duostomina* and *Diplotremina* have what appears to be a layered wall, a feature observed by Brotzen (1963), Koehn-Zaninetti (1969), and Premoli-Silva (1971): a bright, inner layer is overlain by a dark, microgranular or finely agglutinated layer (Pl. 1, fig. 1, 3 left, 4; Pl. 2, fig. 6, 7; Pl. 3, fig. 7). We interpret this "multi-layered" appearance as a diagenetic result, i.e. a partial recrystallization and the growth of the cement on the test wall. The diagenetic alteration thus, in our opinion, led to the virtual "complication" of the wall structure. On the contrary, Koehn-Zaninetti (1969) and Premoli Silva (1971) suggested the virtual "simplification" of the wall structure during diagenesis.

Though the position of the genus *Variostoma* in the family Duostominidae remains doubtful due to the alveolar nature of its wall, the lamellar structure shown herein supports its position close to genera *Duostomina* and *Diplotremina*.

Acknowledgements. This work is part of the ongoing PhD study of the corresponding author, financially supported by the Slovenian Research Agency. The collaboration of authors was partially supported by the Swiss National Science Foundation (R. Martini grant #200020-124402). Technical staff of the Geological Survey of Slovenia is gratefully acknowledged for the preparation of thin sections. The authors also wish to express their gratitude to the reviewers I. Premoli Silva (University of Milano), D. K. Ivanova (Bulgarian Academy of Sciences, Sofia) and J. Blau (Rosbach-Rodheim, Germany) for their most useful comments which greatly improved this paper.

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