GEOLOGIJA 66/1, 107-124, Ljubljana 2023
https://doi.org/10.5474/geologija.2023.004

Microfossils from Middle Triassic beds near Mišji Dol, central Slovenia

Mikrofosili iz srednjetriasnih plasti pri Mišjem Dolu, osrednja Slovenija

Katja OSELJ[1,2], Tea KOLAR-JURKOVŠEK[3], Bogdan JURKOVŠEK[3,4] & Luka GALE[2,3]

[1]Trboje 104, 4000 Kranj, Slovenia; e-mail: katja.oselj@gmail.com;
[2]Department of Geology, Faculty of Natural Sciences and Engineering, University of Ljubljana, Aškerčeva cesta 12, 1000 Ljubljana, Slovenia; e-mail: luka.gale@ntf.uni-lj.si
[3]Geological Survey of Slovenia, Dimičeva ulica 14, SI-1000 Ljubljana, Slovenia;
e-mail: tea.kolar-jurkovsek@geo-zs.si; luka.gale@geo-zs.si;
[4]Kamnica 27, 1262 Dol pri Ljubljani, Slovenia; e-mail: geolog.bj@gmail.com

Prejeto / Received 13. 3. 2023; Sprejeto / Accepted 29. 5. 2023; Objavljeno na spletu / Published online 4. 8. 2023

Key words: Dinarides, Sava Folds, Middle Triassic, upper Anisian, lower Ladinian, basin, volcaniclastics, conodonts, foraminifera
Ključne besede: Dinaridi, Posavske gube, srednji trias, zgornji anizij, spodnji ladinij, bazen, vulkanoklastiti, konodonti, foraminifere

Abstract

Middle Triassic beds exposed along the road between Mišji Dol and Poljane pri Primskovem (Posavje Hills) comprise marlstone, tuff, volcaniclastic sandstone, and thin- to medium-bedded limestone and dolostone. The succession was logged and sampled for conodonts. A relatively rich conodont assemblage was determined, consisting of *Budurovignathus gabrielae* Kozur, *Budurovignathus* sp., *Cratognathodus kochi* (Huckriede), *Gladigondolella malayensis* Nogami, *Gladigondolella tethydis* Huckriede, *Gladigondolella* sp., *Neogondolella balkanica* Budurov & Stefanov, *Neogondolella* cf. *excentrica* Budurov & Stefanov, *Neogondolella constricta* (Mosher & Clark), *Neogondolella cornuta* Budurov & Stefanov, *Neogondolella* sp., *Paragondolella excelsa* Mosher, *Paragondolella liebermani* (Kovacs & Kozur), *Paragondolella trammeri* (Kozur), *Paragondolella* cf. *alpina* (Kozur & Mostler), and *Paragondolella* sp. The assemblage correlates with the upper Anisian and lowermost Ladinian assemblages from the Global Boundary Stratotype Section and Point (GSSP) of the Ladinian at Bagolino in the Southern Alps in northern Italy. Along with conodonts, numerous specimens of benthic foraminifera *Nodobacularia*? *vujisici* Urošević & Gaździcki were recovered from the lowermost part of the succession. Previous research on this taxon is critically evaluated.

Izvleček

Zaporedje srednjetriasnih plasti, ki so razgaljene ob cestnem useku med Mišjim Dolom in Primskovim (Posavsko hribovje), sestavljajo laporovec, tuf, vulkanoklastični peščenjak in tanko do srednje plastnat apnenec in dolomit. Zaporedje je bilo popisano in vzorčeno za konodontne analize. Določena je bila relativno bogata združba, ki sestoji iz vrst *Budurovignathus gabrielae* Kozur, *Budurovignathus* sp., *Cratognathodus kochi* (Huckriede), *Gladigondolella malayensis* Nogami, *Gladigondolella tethydis* Huckriede, *Gladigondolella* sp., *Neogondolella balkanica* Budurov & Stefanov, *Neogondolella* cf. *excentrica* Budurov & Stefanov, *Neogondolella constricta* (Mosher & Clark), *Neogondolella cornuta* Budurov & Stefanov, *Neogondolella* sp., *Paragondolella excelsa* Mosher, *Paragondolella liebermani* (Kovacs & Kozur), *Paragondolella trammeri* (Kozur), *Paragondolella* cf. *alpina* (Kozur & Mostler) in *Paragondolella* sp. Združbo lahko koreliramo z zgornjeanizijsko do spodnjeladinijsko združbo iz globalnega mejnega stratotipskega profila in točke (GSSP) za ladinij v Bagolinu v Južnih Alpah, severna Italija. Poleg konodontov so bili v spodnjem delu zaporedja najdeni številni primerki bentoških foraminifer *Nodobacularia*? *vujisici* Urošević & Gaździcki. Podajamo kritični pregled dosedanjih raziskav tega taksona.

Introduction

The Middle Triassic tectonic and paleogeographic evolution of the present-day Southern Alps, Dinarides, Northern Calcareous Alps, and Transdanubian Range was strongly affected by crustal extension that accompanied the opening and spreading of the western Neotethys (Meliata-Maliac) Ocean (Schmid et al., 2008; Kovács et al., 2011). As a result, several smaller basins were created, mainly between late Anisian and early Ladinian (Buser, 1989; Haas & Budai, 1999; Budai & Vörös, 2006; Berra & Carminati, 2010; Stefani et al., 2010; Velledits et al., 2011; Gawlick et al., 2012; Celarc et al., 2013; Smirčić et al., 2020).

Tectonic activity was accompanied by volcanism, which is reflected in the local deposition of volcaniclastic and/or volcanic rocks, mostly within the basinal areas (Buser, 1989; Gianolla et al., 2019). Upper Anisian to Ladinian basinal successions are relatively widespread in the territory of Slovenia (see Dozet & Buser, 2009 and Kolar-Jurkovšek & Jurkovšek, 2019 for summary). Local differences among the successions evidence the existence of several basins of different depths and characters, ranging from open marine environments (Rakovec, 1950; Buser, 1986; Skaberne et al., 2003; Rožič et al., 2021), to ephemeral marshes, river systems, freshwater lakes, and shallow restricted lagoons (Čar, 2013). The ruggedness of the relief is well exemplified in the Idrija area, where at least three Ladinian sedimentary basins separated by topographic ridges were recognised (Čar, 2013). Determination of age is crucial for exact stratigraphic position and correlation of this plethora of different depositional environments. Limestones from open marine and well-aerated basins often contain conodonts (Celarc et al., 2013; Kolar-Jurkovšek & Jurkovšek, 2019), radiolarians (Goričan & Buser, 1990; Ramovš & Goričan, 1995; Skaberne et al., 2003; Celarc et al., 2013), and bivalves (Jurkovšek, 1984), while ammonoids are rarely found (Čar, 2010). Foraminifera are also present, but they are usually not abundant (Jurkovšek, 1984). Numerous Middle Triassic deposits, however, remain poorly dated (e.g., the shale- and sandstone-dominated Pseudozilian beds in the central and western Slovenia; Rakovec, 1950; Buser, 1986; Čar et al., 2021).

A Middle Triassic volcanoclastic unit between Mišji Dol and Poljane pri Primskovem in the central Posavje Hills was previously mentioned by Lipold (1858), Germovšek (1955), and Buser (1974). Some ammonoid and bivalve taxa were determined (Lipold, 1858; Germovšek, 1955; Buser, 1974; also Jurkovšek, 1984 for localities in vicinity). A detailed description of a volcano-sedimentary succession from Obla Gorica in the vicinity was given by Dozet (2006), who divided the succession into (from bottom/older to top/younger): bedded tuff with interbeds of limestone (1), lower platy dolostone with chert and tuff interbeds (2), light grey bedded dolostone with tuff interbeds (3), upper platy dolostone with cherts and tuff interbeds (4), dark marly limestone and marlstone (5); tuff with interbeds of volcaniclastic sandstone (6), and bedded and platy grained limestone (7). A renewed sampling of Middle Triassic beds between Mišji Dol and Poljane pri Primskovem yielded a relatively rich and well-preserved conodont and foraminiferal fauna. The aim of this paper is to present the recovered conodont and foraminiferal assemblages for a better stratigraphic assignment of the Upper Anisian to Ladinian beds in the researched area. The conodont assemblage is compared to other assemblages from the region.

Geological setting

According to Placer (1998a, 2008), the studied area structurally belongs to the External Dinarides and the Sava Folds (Placer, 1998b). The studied succession is a part of the Litija Anticline (Placer, 1998b), created by post-Miocene compression (Placer, 1998b; Tomljenović & Csontos, 2001). The pre-folding structure of the External Dinarides was largely governed by Oligocene–early Miocene thrusting in the NE-SW direction

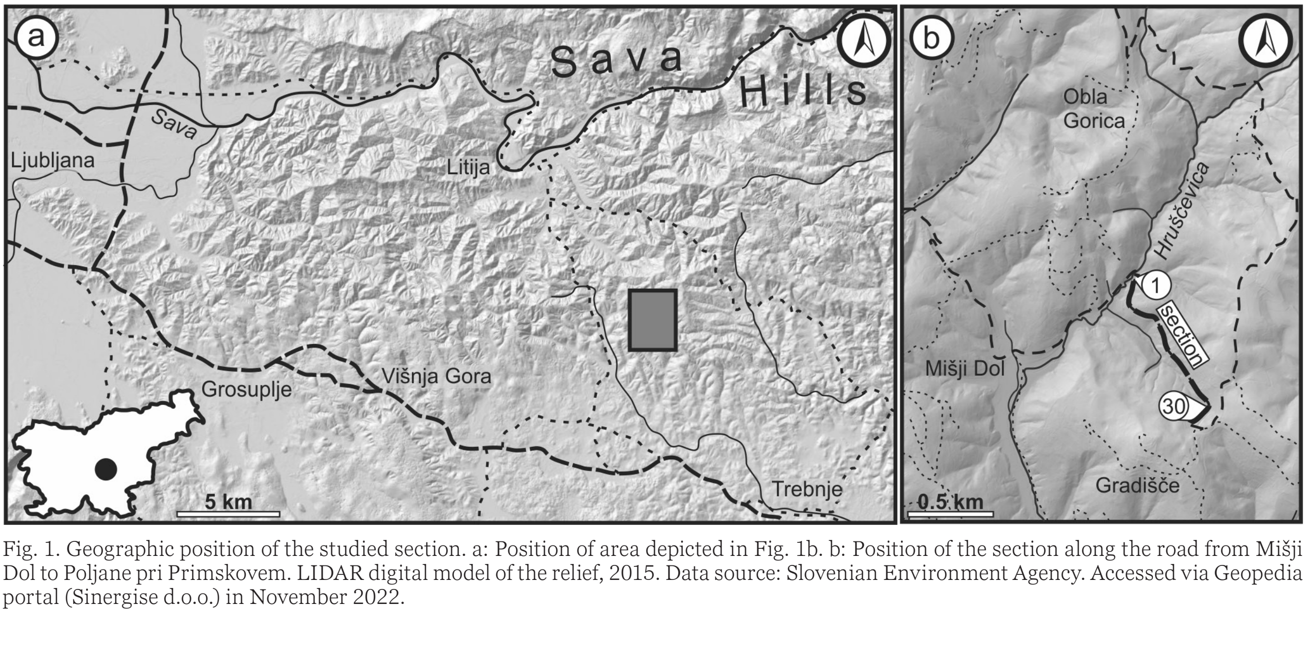

Fig. 1. Geographic position of the studied section. a: Position of area depicted in Fig. 1b. b: Position of the section along the road from Mišji Dol to Poljane pri Primskovem. LIDAR digital model of the relief, 2015. Data source: Slovenian Environment Agency. Accessed via Geopedia portal (Sinergise d.o.o.) in November 2022.

(Placer, 1998a, 1998b; Vrabec & Fodor, 2006). The logged succession of Middle Triassic beds lies along the road between Mišji Dol and Poljane pri Primskovem (Fig. 1), starting at 45°59´28.43´´N, 14°54´37.56´´E and ending at 45°59´0.71´´N, 14°54´54.15´´E. The succession is folded, dissected by numerous minor faults, and partly covered. According to Buser (1968) and Dozet (2006), the investigated succession unconformably overlies massive Anisian dolostone and is succeeded upwards by the massive Ladinian dolostone.

Material and methods

Due to the partial coverage of the succession, we were only able to reconstruct the succession by combining the outcropping segments. Thirty-one conodont samples were collected along the succession, weighting between 1.5 and 2.5 kg. The rock was dissolved in 10–15 % acetic acid and the residue was separated into light and heavy fractions with the use of bromoform. Conodonts from the heavy fraction and foraminifera from the light fraction were hand-picked under a binocular microscope. In some instances, the interior of foraminifera could be viewed by immersing them in glyceryl. We also prepared some oriented thin sections of foraminifera. Selected specimens of conodonts and foraminifera were photographed with a scanning electron microscope (SEM) JEOL JSM 6490LV. The macroscopic lithological description was supplemented by micropetrographic analysis of 49 thin sections using a polarizing optical microscope. Carbonate rocks were classified according to Dunham (1962), Embry and Klovan (1972), and Wright (1992). The terminology of volcaniclastics follows Di Capua et al. (2022). Similarities with other conodont assemblages from the same time interval were evaluated using the Dice similarity index using PAST v. 2.17c statistics software (Hammer et al., 2001). Preparatory work and SEM microscopy were performed at the Geological Survey of Slovenia. The conodont samples are stored at the Geological Survey of Slovenia under repository numbers 6247–6264. The thin sections are stored in repository of the co-author L.G. at the Department of Geology, Faculty of Natural Sciences and Engineering in Ljubljana.

Results

Description of section

The succession was investigated along 1100 m long road section. The contact with the massive Anisian dolostone is not exposed. The general orientation of bedding changes from 235/42 in the lower part of the succession, to 190/40 halfway along the roadcut, and to 200/50 near the top. Despite this relative consistency in the general orientation of the bedding, small-scale folds and faults are present, which makes the estimate of the thickness of individual sub-sections very difficult. We estimate that the entire succession is between 100 and 200 m thick. Figure 2 shows some better exposed parts of the succession, and Figure 3 the reconstructed generalized succession and position of conodont samples within it. The general succession starts with a variegated succession of marlstone, tuff, and thin-bedded limestone. Higher up in the succession thin- to medium-bedded limestone and dolostone predominate, commonly interchanging with volcaniclastic sandstone. The top of the roadcut is again dominated by poorly exposed variegated succession of tuff, volcaniclastic sandstone, marlstone, and limestone. The lithological composition of each sector along the road and the actual thickness of each part of the succession is presented in Table 1.

Fig. 2. Middle Triassic beds between Mišji Dol and Poljane pri Primskovem. a: Dolomitized cherty limestone with thin interbeds of volcaniclastic sandstone; sector 13. b: Thin bedded limestone (radiolarian-filament wackestone/packstone); sector 21.

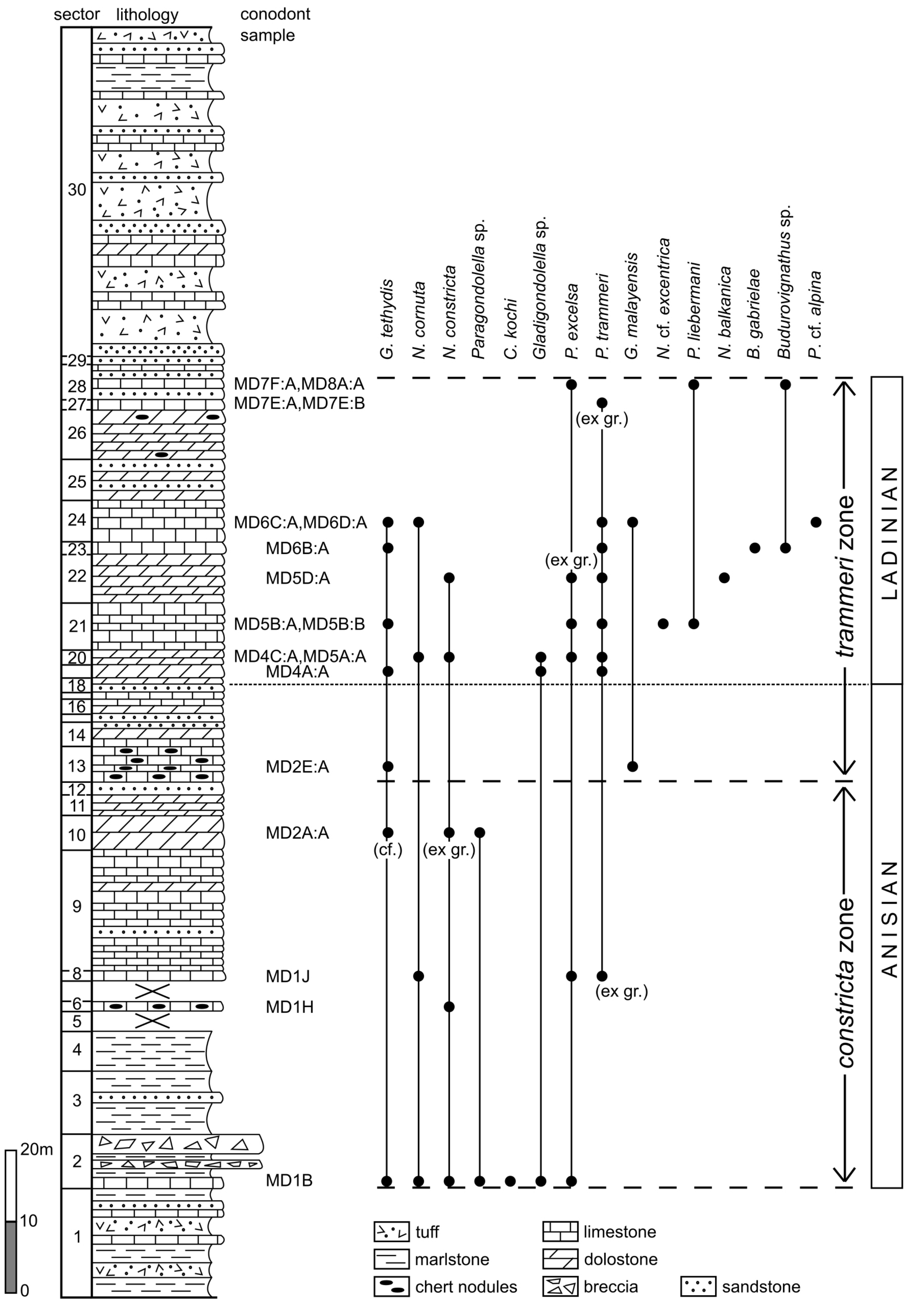

Fig. 3. Reconstruction of the Middle Triassic succession along the road between Mišji Dol and Poljane pri Primskovem. The true stratigraphic thickness of each sector is shown (see thicknesses in Table 1). The right-hand side presents the position of the conodont samples and the stratigraphic distribution of the conodont species. The Anisian/Ladinian boundary is within the *trammeri* zone.

Table 1. Lithological composition of Middle Triassic beds between Mišji Dol and Poljane pri Primskovem.

Sector	Lithology	Total thickness	Microfacies
1	Covered by soil. Marlstone and pelitic tuff (80 %) in 1–5 cm thick beds, locally with chert and thin-shelled bivalves, concordant to bedding. -Dark limestone in up to 7 cm thick beds (18 %); locally with bands with thin-shelled bivalves, concordant to bedding. Locally silicified. -Volcaniclastic sandstone (2 %) forms up to 3.5 cm thick beds. Weathered pieces are light yellow in colour.	16 m (estimated)	Limestone: -radiolarian-filament-peloid packstone; -bioclastic-intraclastic grainstone; -peloid-bioclastic packstone/grainstone
2	The lower part (1.2 m) is dominated by limestone, the next 4.2 m by tuff and volcaniclastic sandstone. Micritic limestone and breccia (45 cm thick) follow, then a 1.5 m thick bed of marlstone, and two more beds (20 cm and 25 cm thick) of breccia. -Limestone is dark grey to black, locally selectively silicified. Bed thickness is from 1 cm to 15 cm. Bivalve shells and radiolarians were recognised with a hand-lens. -Tuff and volcaniclastic sandstone is present in 1–15 cm thick beds. The colour is yellow, green, brownish green or greenish grey. -Marlstone is dark brown in colour and laminated. -Breccia is poorly sorted; the largest clasts from the top of the bed are 4 cm across.	8.2 m (logged in detail)	Limestone: -calcimudstone; -radiolarian-filament wackestone/packstone; -bioclastic-intraclastic rudstone Clastics: -calcareous mudstone; -volcaniclastic sandstone; -mud-supported sandy breccia
3	Mostly covered. Marlstone dominates (90 %) over a few beds of volcaniclastic sandstone and black pelitic tuff.	9 m (estimated)	Clastics: -calcareous mudstone; -volcaniclastic sandstone
4	Mostly covered. Marlstone.	6 m (2 m exposed, the rest estimated)	/
5	Covered.	? (estimated 3 m)	/
6	Black marly limestone, locally with chert.	1 m	/
7	Covered.	? (estimated 3 m)	/
8	Three beds of black micritic limestone.	1.5 m	/
9	Mostly covered. Fragments of black micritic limestone are found over 75 % of this interval; the rest is probably grey dolostone and volcaniclastic sandstone.	18 m (estimated)	/
10	Light grey dolostone, fractured and folded. Bedding is not clear.	? (estimated 5 m at most)	Dolostone: -dolomitized intraclastic grainstone/rudstone?; subhedral
11	Grey dolostone in 1.5–8 cm thick beds.	? (estimated 3 m)	Dolostone: -dolomitized intraclastic grainstone/rudstone?; subhedral
12	Covered. Fragments of volcaniclastic sandstone and dolostone.	? (estimated 2 m)	/
13	Bedded dolomitized cherty limestone with cleavage. Beds are 0.5–34.5 cm thick. They interchange with beds of volcaniclastic sandstone.	6 m	Dolostone: -subhedral; locally with chert
14	Covered. Fragments of dolostone and volcaniclastic sandstone.	? (estimated 3 m)	Clastics: -volcaniclastic sandstone; grains of volcanics, quartz, feldspar, microsparitic lithoclasts
15	Volcaniclastic sandstone.	? (estimated 1 m)	Clastics: -sandstone with grains of poli- and monocrystal quartz, chloritized volcanics, feldspar; sericitic matrix and dolomitic cement
16	Covered. Fragments of dolostone and limestone.	? (estimated 2 m)	Dolostone: - subhedral; 10% of terrigenous quartz, rare echinoderms are preserved
17	Dolomitized limestone in app. 5 cm thick beds.	1 m	/
18	Covered. Fragments of dolostone and volcaniclastic sandstone.	? (estimated 1–3 m)	/
19	Dolostone in 2–34 cm thick beds. Laterally pinching out and lateral amalgamation of beds suggest slumping.	2 m	Dolostone: - subhedral; dolomitized grainstone or rudstone (remains of echinoderms and intraclasts) and packstone with filaments
20	Folded thin-bedded (0.5–2 cm) dolostone, subordinately limestone.	2 m	Dolostone: -subhedral; chert nodules Limestone: -radiolarian-filament wackestone/packstone
21	Dark grey to black limestone in 3.5–12 cm thick beds. Parallel lamination and silicification are locally present. Subordinate are thin marlstone interlayers.	7 m	Limestone: -radiolarian-filament wackestone/packstone

Sector	Lithology	Total thickness	Microfacies
22	Dolostone in 5.5–19 cm thick beds. One bed shows cross-lamination. Subordinate are thin marly interlayers. Cleavage is present.	7 m	Dolostone: -dolomitized filament packstone/grainstone and intraclastic rudstone; subhedral
23	Covered. Fragments of limestone and volcaniclastic sandstone.	? (estimated 1.5 m)	Limestone: -peloid-bioclastic packstone/grainstone
24	Partly covered. Dolomitized limestone in 2–7.5 cm thick, folded beds. Large part of the succession covered by a concrete wall.	3 m + unknown + 3 m	Dolostone: -subhedral; remains of brachiopods/bivalves and echinoderms; selective silicification
25	Thin beds of dolostone (1.5–13 cm), interchanging with volcaniclastic sandstone.	6 m	Dolostone: -subhedral; remains of echinoderms, filaments; 5 % of terrigenous quartz
26	Dolostone in 4–22 cm thick beds. Nodules of chert and laminae are locally present.	7 m	Dolostone: -subhedral; selective silicification
27	Dark grey to black limestone in 4–20 cm thick beds. Cross-lamination is locally present.	1.5 m (estimated)	Limestone: -peloid-bioclastic packstone/grainstone
28	Mostly covered. Fragments of volcaniclastic sandstone and limestone. Exposed beds of limestone are 2–29 cm thick. Parallel lamination is locally visible.	? (estimated 5 m)	Limestone: -peloid-bioclastic packstone/grainstone; -bioclastic-intraclastic-peloid grainstone with terrigenous admixture
29	Volcaniclastic sandstone in 0.5–10 cm thick beds.	1 m	Clastics: -volcaniclastic sandstone
30	Covered. Variegated succession of tuff, volcaniclastic sandstone, limestone, dolostone.	? (estimated 50 m)	Clastics: -volcaniclastic sandstone

Table 2. Limestone microfacies types from Middle Triassic beds between Mišji Dol and Poljane pri Primskovem.

Microfacies	Description
Calcimudstone	Texture is homogenous. Micritic matrix strongly predominates. Only 5 % of the area is occupied by grains (radiolarians).
Radiolarian-filament wackestone/packstone	Texture is heterogenous, locally bioturbated. Matrix represents 50–70 % of the area, grains 30–50 %. Grains are well sorted, supported by matrix or in point contacts. The average grain size is 0.4 mm. Among grains, bioclasts predominate (90 % of grains). These are mostly filaments and radiolarians, while ostracods and benthic foraminifera (*Frondicularia woodwardia* Howchin, Lagenida) are rare.
Peloid-filament-radiolarian packstone	This microfacies interchanges with bioclastic-intraclastic grainstone in wide laminae. Texture is homogenous. Grains represent 85 % of the area, whereas matrix and spar represent 15 % of the area of thin section. Sorting is moderate. Grains are in point and long contacts, and they measure 0.03–1 mm in size. Spherical forms are the most common. Peloids and pellets represent 80 % of grains. Filaments (10 %) and radiolarians (7 %) are subordinate. Less abundant are echinoderms and foraminifera (*Krikoumbilica* sp.). Echinoderm plates are overgrown by syntaxial calcite cement. The calcite cement in intergranular space is fine-grained, locally drusy mosaic.
Bioclastic-peloid packstone/grainstone	Texture is homogenous. Grains form 80 % of the area, matrix and cement 20 %. Sorting is moderate. Grains are 0.11–4.9 mm large. They are in point and long contacts. Geopetal structures are present within gastropod shells. Biogenic grains represent 40–50 % of the grains. Peloids (35–40 %), aggregate grains (5–10 %), and intraclasts (5–15 %) are also commonly present. Less abundant are bivalves, echinoderms, foraminifera (sessile agglutinated foraminifera, *Glomospirella* sp., *Palaeolituonella meridionalis* (Luperto), *Endoteba* sp., *Endotriadella* sp., *Variostoma* sp., Duostominidae), microproblematica (*Plexoramea cerebriformis* Mello, *Tubiphytes obscurus* Maslov), gastropods (locally more common), brachiopods, *Terebella* tubes, and dasycladacean algae. Radiolarians are present where the micritic matrix is present. Terrigenous component is subordinate to allochems. Monocrystal quartz with uniform extinction is present in angular grains measuring 0.5–0.6 mm in size. Lithic grains of chert are locally also present. The cement is fine-grained and drusy mosaic calcite. Echinoderms are overgrown by syntaxial calcite.
Bioclastic-intraclastic grainstone	This microfacies interchanges with peloid-filament-radiolarian packstone in wide laminae. Texture is homogenous. Grains represent 80 % of the area; intergranular space is filled by fine-grained, locally drusy mosaic calcite cement. Sorting is poor. Grains are mostly in point or long contacts. Grains range from 0.06 to 1.55 mm in size. Filaments and radiolarians strongly predominate (80 % of grains). Intraclasts, peloids and pellets are subordinate (10 % and 8 %, respectively). Very rare are ostracods and problematic algae.
Peloid-intraclastic-bioclastic grainstone with terrigenous admixture	Texture is homogenous. Grains form 50 % of the area. Of these, terrigenous grains represent 20 % and allochems 30 %. Grains range 0.15–1 mm in size. They are moderately sorted. Small intraclasts and peloids are the most abundant among allochems. Approximately 5 % of the allochems are small bioclasts, which are partly or completely micritized. Benthic foraminifera (*Palaeolituonella meridionalis* (Luperto)) and echinoderms are recognisable. Terrigenous grains comprise chert, rhyolite-like volcanics, monocrystal quartz and plagioclase, and carbonate lithoclasts. Terrigenous grains are angular to very angular, between 0.15 mm and 0.55 mm in size. Plagioclase grains are partly sericitizied. Echinoderm plates are overgrown by syntaxial calcite cement.
Bioclastic-intraclastic rudstone	Texture is homogenous. Grains form 80 % of the area. They are very poorly sorted and measure 1 mm to 18.5 mm in size [within the thin section; several cm large clasts were observed in the field]. Subrounded clasts dominate. Grains are in stylolitic contacts. Allochems are dominated by intraclasts (oolithic packstone, wackestone with radiolarians and filaments, peloidal-bioclastic packstone, mudstone). Subordinate are echinoderm plates, ooids, peloids, benthic foraminifera and bivalve shells. Lithic grains are represented by recrystallised limestone. Other terrigenous grains are monocrystal quartz, plagioclase, and chert. These grains are angular to subangular, up to 5 mm large. The intergranular space is filled with spar. Silicification is locally present.

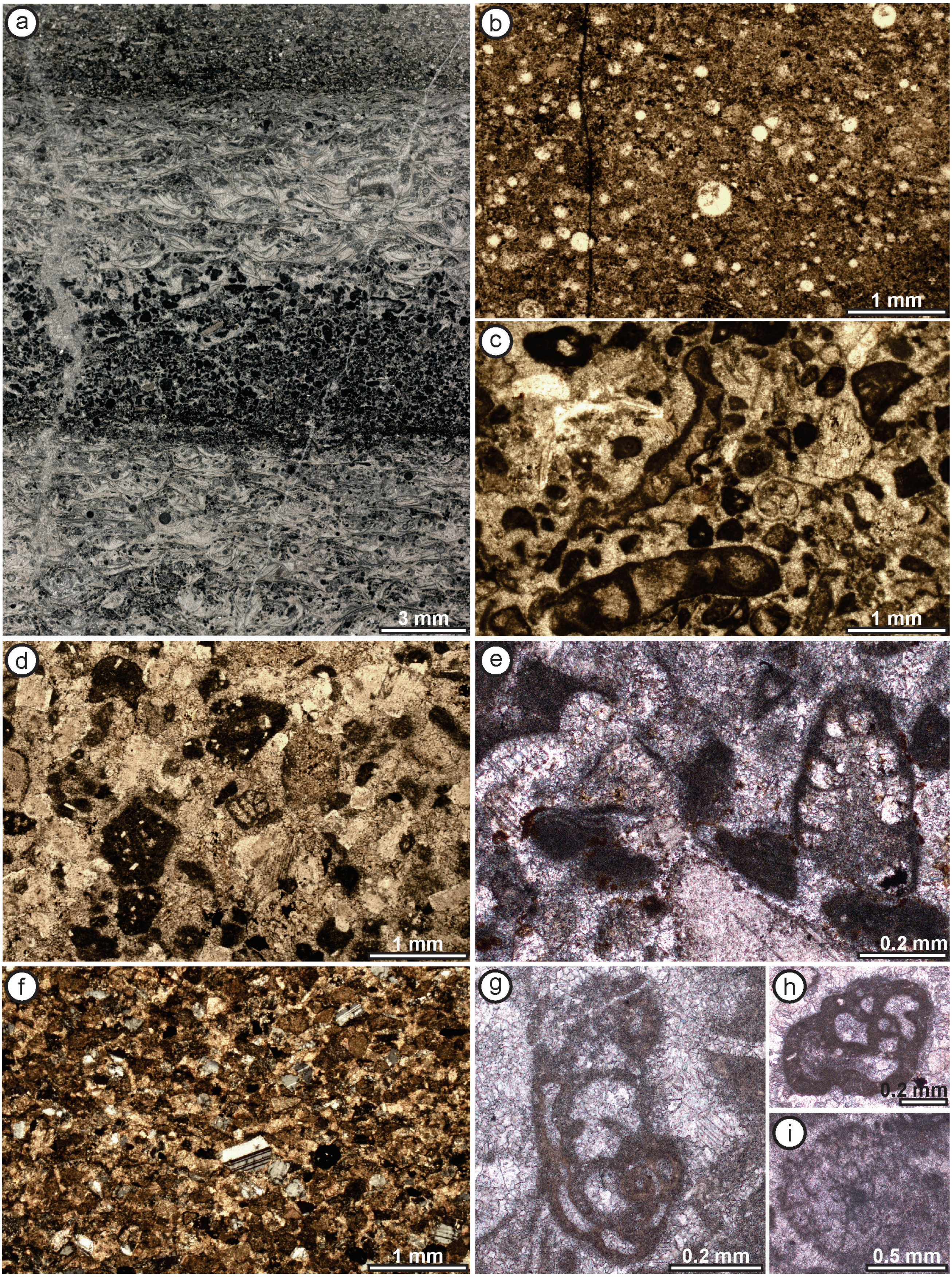

Fig. 4. Selected microfacies types and microfossils from Middle Triassic beds between Mišji Dol and Poljane pri Primskovem. a: Interchanging laminae of radiolarian-filament wackestone/packstone and peloid-filament-radiolarian packstone. Thin section 1758 (sample MD1A:B). b: Radiolarian-filament wackestone-packstone. Thin section 1790 (sample MD5A:A). c: Bioclastic-peloid grainstone. Thin section 1763 (sample MD1A:C). d: Peloid-intraclastic-bioclastic grainstone with terrigenous admixture. Note foraminifer *Palaeolituonella meridionalis* (Luperto) in the centre. Thin section 1796 (sample MD7F:B). e: *Variostoma* sp. (right) and *Ophthalmidium* sp. (left) in bioclastic-peloid grainstone. Thin section 1763 (sample MD1A:C). f: Volcaniclastic sandstone. Thin section 1766 (sample MD1C:B). g: *Endotriadella* sp. in bioclastic-peloid grainstone. Thin section 1763 (sample MD1A:C). h: *Endoteba* sp. in bioclastic-peloid grainstone. Thin section 1763 (sample MD1A:C). i: *Plexoramea cerebriformis* Mello in bioclastic-peloid grainstone. Thin section 1786 (sample MD8A:A).

Carbonate microfacies

The textures and composition of the limestone samples are described in more detail in Table 2. Selected microfacies types and microfossils from thin sections are shown in Figure 4.

Microfossil assemblage

The microfossil assemblage from the residue consists of conodonts, benthic foraminifera, gastropods, echinoderms, brachiopods, green algae, radiolarians, microproblematica, and ostracods. A total of 16 conodont taxa were determined (Fig. 5):

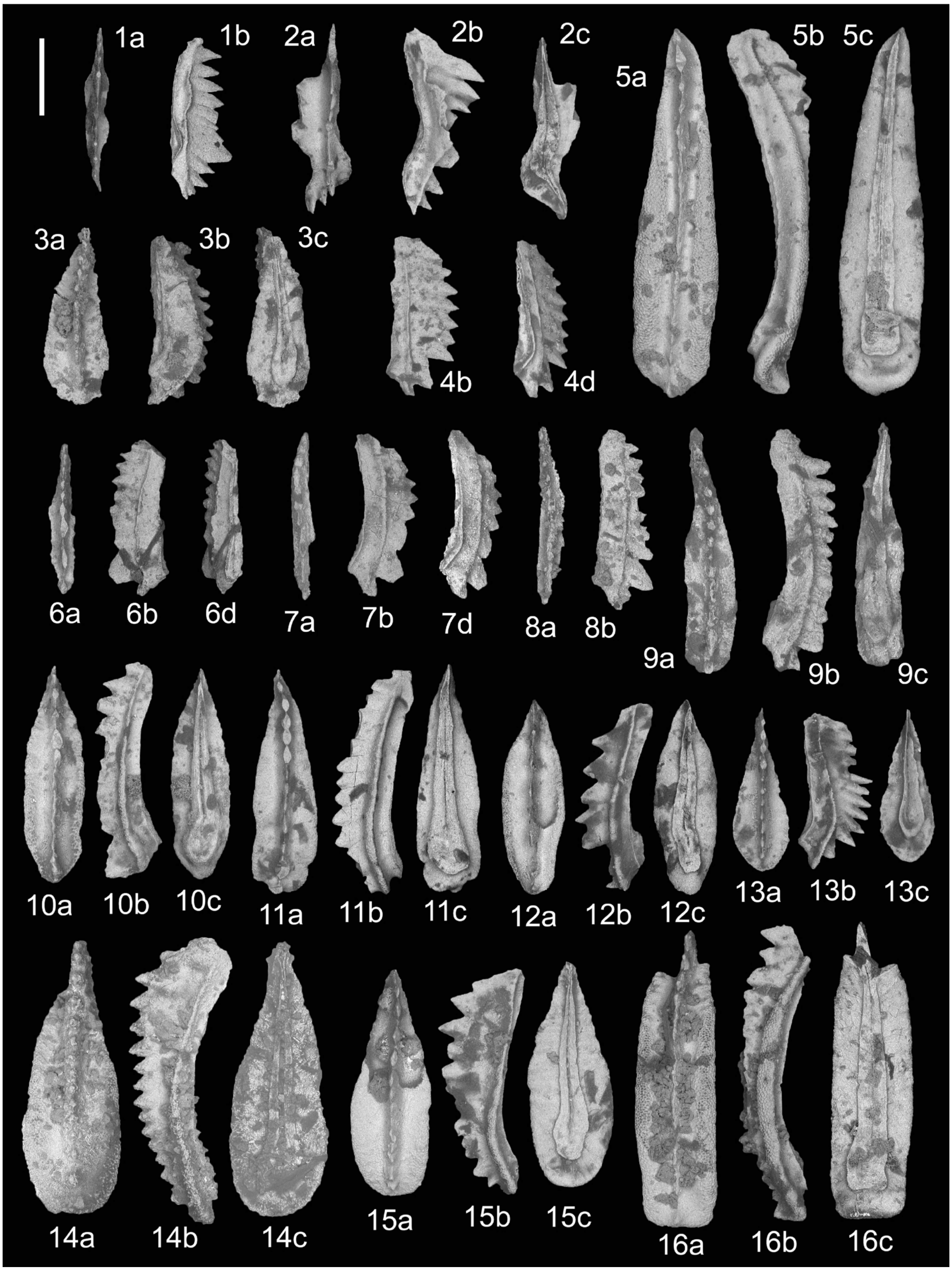

Fig. 5. Conodont taxa from Middle Triassic beds between Mišji Dol and Poljane pri Primskovem. SEM images. 1 – *Budurovignathus* sp., juvenile specimen, sample MD 6B:A (GeoZS 6260). 2 – *Budurovignathus* sp., sample MD 7F:A (GeoZS 6263). 3 – *Paragondolella excelsa* Mosher, sample MD 1J (GeoZS 6251). 4 – *Paragondolella* sp., juvenile specimen, sample MD 1B komp 0–0.25 (GeoZS 6247). 5 – *Neogondolella cornuta* Budurov & Stefanov, sample MD 1B komp 0–0.25 (GeoZS 6247). 6 – *Paragondolella* ex gr. *trammeri* (Kozur), sample MD 1J (GeoZS 6251). 7–9 – *Paragondolella trammeri* (Kozur), sample MD 5B:B (GeoZS 6258). 10 – *Paragondolella trammeri* (Kozur), samples MD 6C:A and MD 6D:A (GeoZS 6261). 11 – *Paragondolella* ex gr. *trammeri* (Kozur), samples MD 7E:A and MD 7E:B (GeoZS 6262). 12 – *Budurovignathus gabrielae* Kozur, sample MD 6B:A (GeoZS 6260). 13, 15 – *Paragondolella* ex gr. *excelsa* Mosher, sample MD 5D:A (GeoZS 6259). 14 – *Paragondolella liebermani* (Kovacs & Kozur), sample MD 5B:B (GeoZS 6258). 16 – *Neogondolella balkanica* Budurov & Stefanov, sample MD 5D:A (GeoZS 6259). Scale bar: 200 μm; a – upper, b – lateral, c – lower, d – oblique lower views.

Budurovignathus gabrielae Kozur (Fig. 5.12), *Budurovignathus* sp. (Fig. 5.1–5.2), *Cratognathodus kochi* (Huckriede), *Gladigondolella malayensis* Nogami, *G. tethydis* Huckriede, *Gladigondolella* sp., *Neogondolella balkanica* Budurov & Stefanov (Fig. 5.16), *N.* cf. *excentrica* Budurov & Stefanov, *N. constricta* (Mosher & Clark), *N. cornuta* Budurov & Stefanov (Fig. 5.5), *Neogondolella* sp., *Paragondolella excelsa* Mosher and *P.* ex gr. *excelsa* (Fig. 5.3, 5.13, 5.15), *P. liebermani* (Kovacs & Kozur) (Fig. 5.14), *P. trammeri* (Kozur) and *P.* ex gr. *trammeri* (Fig. 5.6–5.11), *P.* cf. *alpina* (Kozur & Mostler), and *Paragondolella* sp. (Fig. 5.4). Juveniles dominate, while adult specimens are mostly fragmented. Conodont elements are black and have a Colour Alteration Index (CAI) of 5.5 (Epstein et al., 1977).

The foraminiferal assemblage is relatively sparse, except for a high number of *Nodobacularia? vujisici* Urošević & Gaździcki recovered from the residue of dissolved limestone from the lower part of the succession (sector 2; see Table 1). *Ophthalmidium exiguum* Koehn-Zaninetti and very rare *Pseudonodosaria* sp. were present in the same sample. Along with the mentioned species, foraminifera include sessile agglutinated foraminifera, *Palaeolituonella meridionalis* (Luperto), *Glomospirella* sp., *Endoteba* sp., *Endotriadella* sp., *Krikoumbilica* sp., *Variostoma* sp., Duostominidae, and small Lagenida. All were determined from thin sections. A taxonomic description of *Nodobacularia? vujisici* Urošević & Gaździcki, which is a rarely noted species, is given below.

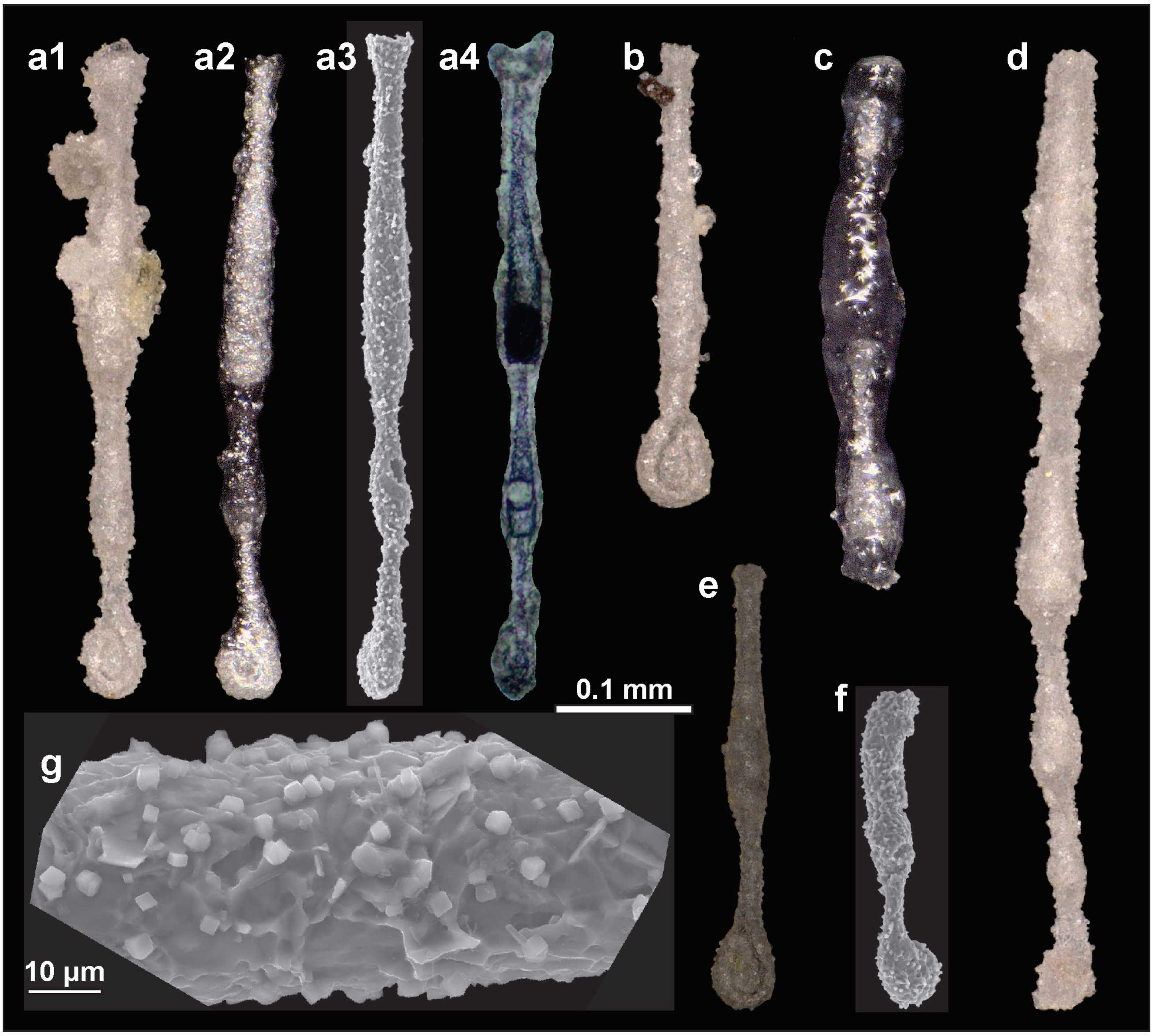

Fig. 6. *Nodobacularia? vujisici* Urošević & Gaździcki from Middle Triassic beds between Mišji Dol and Poljane pri Primskovem. a: The same specimen viewed in reflected light (a1), immersed in glyceryl (a2), under SEM (a3), and in thin section (a4). b–f: Different specimens showing variability in size and length of the chambers. g: Detail of the wall seen under SEM. All specimens are from sample MD1B (GeoZS 4268).

Subphylum Foraminifera d'Orbigny, 1826
Class Tubothalamea Pawlowski et al., 2013
Order Miliolida (Delage & Hérouard, 1896), emend Pawlowski et al., 2013
Superfamily Cornuspiroidea Schultze, 1854
Family Nubeculariidae Jones in Griffith and Henfrey, 1875
Subfamily Nodobaculariinae Cushman, 1927
Genus ?*Nodobacularia* Rhumbler, 1895
Nodobacularia? vujisici Urošević & Gaździcki, 1977
Fig. 6a–g

1977 *Nodobacularia vujisići* nov. sp., Urošević & Gaździcki, p. 97, pl. 1, fig. 1–6.
1980 *Nodophthalmidium elenae* n.sp., Gheorghian, p. 38, pl. 1, fig. 1–11; pl. 2, fig. 1–6; pl. 3, fig. 1–2.
1983 *Nodobacularia vujisići* Urošević et Gaździcki, 1977 – Salaj et al., p. 113, pl. 141, fig.1–2.
1984 *Nodophthalmidium vujisici* (Urošević & Gazdzicki, 1977) – Kristan-Tollmann, p. 285, fig. 8.1–8.7; pl. 11, fig. 1–29; pl. 8, fig. 9.
1987 *Nodobacularia vujisici* Urošević et Gaźd. – Oravecz-Scheffer, pl. 31, fig. 4.
1988 *Nodophthalmidium vujisici* Urošević et Gaździcki – Salaj et al., pl. 3, fig. 25, 26, 34.
1991 *Nodobacularia vujisici* Urošević et Gaździcki – Kolar-Jurkovšek, pl. 2, fig. 3–4.
1993 *Gheorghianina vujisici* (Urošević & Gaździcki, 1977) – Trifonova, p. 50, pl. 8, fig. 1–2.
1996 *Gheorghianina vujisici* (Urosevic et Gazdzicki, 1977) – Bérczi-Makk, p. 435, pl. 1, fig. 6–7.

Material: Approximately 500 isolated specimens from the residue of radiolarian-filament wackestone/packstone from the bottom of sector 2 (Sample MD1B; GeoZS 4268; see Table 1).

Description: The foraminiferal test is free, unattached, and very elongated. Ovoid proloculus (diameter 0.018 mm, length 0.032 mm) is followed by two (?) elongated tubular chambers. The first of these is one-half of the whorls long, and shaped like in *Ophthalmidium*. The second chamber leads to a rectilinear or curvilinear part of the test, which consists of up to four elongated chambers. These are pyriform or flask-like in shape, but with the largest constriction two-thirds of the way up the chamber, so that the chamber again gains in width towards the simple circular aperture. The third chamber in the uniserial part measures approximately 0.041–0.054 mm in width and 0.135–0.230 mm in length. Although both, the length and width of the chambers increase continuously, they do so at different and inconstant rates. However, since the chambers are always much longer than they are wide, the test is always very elongated and narrow. Specimens with three chambers in the linear part are between 0.39 and 0.63 mm long, whereas the specimens with four chambers in the linear part measure 0.40 to 0.695 mm in length. The largest length of the chamber is 0.31 mm. The widest (usually third or fourth) chamber in the linear part is usually equal in width to the planispiral part. However, deviations are possible in both directions. The wall is silicified.

Remarks: The first description of *N. vujisici* was based on specimens in the thin sections, and was originally thought to have lived fixed to a substrate. It was also interpreted that the planispiral part, which follows the proloculus, consists of a single tubular chamber, which later straightens up to form the initial part of the linear series of chambers (Urošević & Gaździcki, 1977). The new species was placed in the genus *Nodobacularia*, which, however, is characterised by two chambers in the planispiral part, and has some agglutinated particles within its wall (Loeblich & Tappan, 1988). Gheorghian (1980) later introduced two new species from the Middle and Upper Triassic of Romania, with both attributed to the genus *Nodophthalmidium* Macfayden, 1939; of these species, *Nodophthalmidium elenae* Gheorghian represents a junior synonym of *N. vujisici*, but *Nodophthalmidium anae* Gheorghian represents a distinct species characterised by longitudinal costae. Gheorghian (1980, pl. 2) provided hand-drawings of the specimens, showing a tubular second chamber, that completely envelops the proloculus and continues to the linear part of the test. These illustrations led Loeblich and Tappan (1986) to establish a new genus, *Gheorghianina*, that differs from *Nodobacularia* in the mentioned feature, and from *Nodophthalmidium* in having more elongated chambers and a simple circular aperture. Both valid species, *Nodobacularia vujisici*, and *Nodophthalmidium anae* were attributed to this genus. However, we believe that the microphotograph in Gheorghian's (1980) plate 3 shows two chambers in the planispiral part, and that the second chamber is only one-half of a whorl long. Trifonova (1993) also noted that there are two chambers in the planispiral part of *Nodobacularia vujisici* and *Nodophthalmidium anae*. Moreover, this observation can be confirmed in the specimens from Mišji Dol. Bérczi-Makk (1996) stated that *Gheorghianina* possesses a long, tapered neck, which is absent in both *Nodobacularia* and

Nodophthalmidium. Bérczi-Makk (1996) still considered *Gheorghianina* to have a planispiral part one-chamber long, and also stated that the planispiral part is much smaller in *Gheorghianina* than in the other two genera.

Whatever the generic assignment, *Gheorghianina* has been reported from the literature quite rarely. This could also be due to its small size and the brittle nature of its test. Imperfect sections could lead to confusion with *Earlandia amplimuralis* (Pantić). Salaj et al. (1983) described another species, *Nodobacularia cylindriformis* Salaj, Borza & Samuel, from Anisian beds, which lacks costae but is otherwise similar to *N. anae*. On the same plate, they figured also *Nodophthalmidium cylindriformis* n. sp. (perhaps a misnomer for *Nodobacularia cylindriformis*), creating some confusion, as no description is given under this name. *Nodobacularia? vujisici* is often found in facies with daonellids or some undetermined thin-shelled bivalves (Urošević & Gaździcki, 1977; Gheorghian, 1980; Kristan-Tollmann, 1984; Kolar-Jurkovšek, 1991).

Stratigraphic range: Illyrian to upper Carnian of Carpathians; Ladinian of Himalayas; Ladinian of Transdanubian Range and the Alsó Hill in Hungary; lower Ladinian to Carnian of Balkan Mountains and Dobrogea; and upper Anisian and Ladinian of Slovenia.

Discussion

Biostratigraphy and comparison with other conodont assemblages

All of the studied conodont samples are marked by *P. excelsa* that is present throughout the sampled succession. This species is accompanied by *G. tethydis*, *N. cornuta* and *N. constricta* that occur in most samples, except in the three samples from the uppermost part of the succession. *Paragondolella excelsa* ranges from the Illyrian to the Fassanian (Chen et al., 2015). The species *N. constricta* (sensu Kozur), ranges in the Illyrian, and possibly even in the Pelsonian; *N. cornuta*, with a distinct cusp fused with the posterior platform end, is also common in the Illyrian faunas (Kozur et al., 1994).

The upper part of the section is marked by the first occurrence of *G. malayensis*. Moreover, a successive appearance of *N.* cf. *excentrica*, *P. liebermani*, *N. balkanica* and *P.* cf. *alpina* is noted in this zone; all of these species range in the Illyrian and the Fassanian (Chen et al., 2015). Moreover, an introduction of budurovignathids is noteworthy. They first appear in the sample MD6B:A, from which a single specimen of *B. gabrielae* is determined. It reveals a slightly sigmoidal platform, bent, and a forward shifted basal cavity. This species was first described from the upper Fassanian of Karavanke, Southern Alps, and was interpreted to be the oldest *Budurovignathus* representative as it retained some features of *Neogondolella*, i.e., broadly rounded platform end and relatively separated carina denticles (Kozur et al., 1994). The *Budurovignathus* specimens from the uppermost part of the section are more advanced, having typical high carina with fused denticles, as well as significant sigmoidal bending and thus a forward-shifted basal cavity.

The specimens of *P. trammeri* predominate in the faunas of the upper part of the section. Juvenile and intermediate forms prevail over adults. It should be noted here that some other taxa (*P. eotrammeri* Krystyn, *P. preaetrammeri* (Kozur)) were described from the *P. trammeri* group, where only adult specimens can be distinguished among each other. For a long time, *P. trammeri* was one of the most important Ladinian markers found in open pelagic and more restricted settings of the Tethys.

Based on the composition of the faunas, two conodont zones can be distinguished. The older is the *constricta* Zone that encompasses the interval from the sample MD1B to the sample MD2A:A. The zonal marker *N. constricta* is accompanied by *C. kochi*, *G. tethydis*, *N. cornuta*, *P. excelsa*, *P.* ex gr. *trammeri* (juvenile), and *Paragondolella* sp. The range of this zone in Slovenia is lower Illyrian (Kolar-Jurkovšek & Jurkovšek, 2019).

Upward follows the *trammeri* Zone. It is characterized by the index species in association with some holdover species from the previous zone, which are *G. tethydis*, *N. cornuta*, *N. constricta*, and *P. excelsa*. The lower boundary of this zone is identified by the first appearance of *G. malayensis* in the sample MD2E:A. Other species that are introduced in this zone are: *B. gabrielae*, *N. balkanica*, *N.* cf. *excentrica*, *P. liebermani*, *P.* cf. *alpina*. The *trammeri* zone in Slovenia ranges from the upper Illyrian to the lower Fassanian (Kolar-Jurkovšek & Jurkovšek, 2019). The colour of the conodont elements suggests that the rocks were subjected to temperatures between 300 °C and 550 °C (Epstein et al., 1977).

The conodont assemblage from the Mišji Dol section is similar to the assemblage recorded from Bagolino in the Southern Alps of the northern Italy, the GSSP for the Ladinian (Brack & Nicora, 1998; Brack et al., 2005). The similarity is especially

Table 3. Illyrian – Fassanian conodont assemblages from Slovenia (based on Kolar-Jurkovšek & Jurkovšek, 2019). Localities Slugovo and Rižnikar feature slightly younger, late Fassanian, and Fassanian – Longobardian assemblages, respectively.

	Mišji Dol	Topla	Prisojnik	Kamna Gorica	Idrijske Krnice	Šentjošt	Hrastenice	Šmarna gora	Jagršče	Rižnikar	Rob & Ortnek	Bučka	Sremič	Loke	No.
Budurovignathus sp.	•										•		•		3
Budurovignathus gabrielae Kozur	•														1
B. hungaricus Kozur										•	•				2
B. mirautae (Kovacs)										•					1
B. mungoensis (Diebel)										•					1
Cratognathodus kochi (Huckriede)	•												•		2
Gladigondolella malayensis Nogami	•		•												2
G. tethydis Nogami	•				•				•	•		•			5
Gondolella hanbulogi (Sudar & Budurov)					•										1
Neogondolella balkanica Budurov & Stefanov	•		•												2
N. bifurcata (Budurov & Stefanov)					•										1
N. bulgarica (Budurov & Stefanov)					•				•						2
N. constricta (Mosher & Clark)	•						•	•				•		•	5
N. cornuta Budurov & Stefanov	•	•					•	•					•		5
N. excelsa (Mosher)					•							•		•	3
N. excentrica Budurov & Stefanov	•	•			•										3
N. mombergensis (Tatge)		•												•	2
N. transita (Kozur & Mostler)							•						•		2
Paragondolella alpina (Kozur & Mostler)	•										•		•		3
P. excelsa Mosher	•					•	•	•		•					5
P. liebermani (Kovacs & Kozur)	•														1
P. navicula (Huckriede)		•												•	2
P. prealpina Ramovš & Goričan							•	•							2
P.? pridaensis posteroacuta Kozur, Krainer & Mostler			•					•							2
P. trammeri (Kozur)	•		•	•				•		•	•				6
P. praeszaboi bystricky Kovács et al.										•					1
Total no. species at locality:	13	4	4	1	6	1	5	6	2	7	4	3	5	4	

evident for the elements belonging to the latest Anisian *constricta* zone, and in the presence of budurovignathids in the Ladinian part. Eight taxa are common to both sections: *N. balkanica, N. constricta, N. cornuta, P. excelsa, P. liebermani, P. trammeri, P.* ex gr. *alpina*, and *G. malayensis*. Their occurrence is similar in both sections. It should be noted here that different taxonomies have been used for the determination of some neogondolellids, and in Bagolino some of them were determined at subspecies level: *N. constricta cornuta* Budurov & Stefanov, *N. constricta postcornuta* (Kovacs), *N. constricta balkanica* Budurov & Stefanov (Brack & Nicora, 1998). The lower part of the *reitzi* Zone in the Bagolino section yields *N. constricta, N. cornuta* and *P. excelsa* that can be compared to the lower part of the Mišji Dol section belonging to the *constricta* Zone. The upper part of the *reitzi* Zone and the *secedensis* Zone of the Bagolino section is marked by the appearance of *G. malayensis* and *P. trammeri*; this part is also characterized by the occurrence of the precursor of *B. gabrielae*, determined as *N.* sp. A, whereas early budurovignathids are represented by three taxa in the Ladinian part of the section. The difference between the composition of the faunas in the two sections is the earlier appearance of *P. liebermani* in the Bagolino section, where *P.* ex gr. *alpina* is present in most of the Anisian part of the section and continues also in the *curionii* Zone; in the Mišji Dol section, *P.* ex gr. *alpina* is very rare and has been encountered only in the *trammeri* Zone.

Based on the conodont faunas the age of the studied section thus is Illyrian-Fassanian. Exact position of the base of the *trammeri* zone cannot be determined based on the recovered material, but it is tentatively marked by the first occurrence of *G. malayensis*. The Anisian-Ladinian boundary could be therefore placed between samples MD2E:A and MD4A:A, most probably after the facies change within the sector 18 (Fig. 3). The fauna of the upper part of the *trammeri* zone reveals Ladinian character due to the presence of budurovignathids. In the studied Mišji Dol section they are first encountered approximately 20 m above the occurrence of *G. malayensis*, whereas in the Bagolino section budurovignathids (*B. truempyi, B. hungaricus*) occur in the layers corresponding the Ladinian level (Brack et al., 2005).

Table 3 lists other localities from Slovenia with common conodont species from the Illyrian – Fassanian interval (see Kolar-Jurkovšek and Jurkovšek, 2019 for an overview of the localities and existing references). These successions were deposited in different palaeogeographic situations

Table 4. The Dice similarity index for different localities with latest Anisian – earliest Ladinian conodont assemblages in Slovenia (based on Kolar-Jurkovšek & Jurkovšek, 2019).

	Mišji Dol	Topla	Prisojnik	Kamna Gorica	Šentjošt	Hrastenice	Šmarna gora	Jagršče	Rižnikar	Rob & Ortnek	Bučka	Sremič	Loke	Idrijske Krnice
Mišji Dol	1	0.24	0.35	0.14	0	0.33	0.42	0.13	0.3	0.35	0.25	0.44	0.11	0.21
Topla	0.24	1	0	0	0	0.22	0.2	0	0	0	0	0.22	0.4	0.2
Prisojnik	0.35	0	1	0.4	0	0	0.4	0	0.18	0.25	0	0	0	0
Kamna Gorica	0.14	0	0.4	1	0	0	0.29	0	0.25	0.4	0	0	0	0
Šentjošt	0	0	0	0	1	0	0	0	0	0	0.5	0	0.29	0.29
Hrastenice	0.33	0.22	0	0	0	1	**0.73**	0	0.17	0	0.25	0.4	0.18	0
Šmarna gora	0.42	0.2	0.4	0.29	0	0.73	1	0	0.31	0.2	0.22	0.18	0.17	0
Jagršče	0.13	0	0	0	0	0	0	1	0.22	0	0.4	0	0	0.5
Rižnikar	0.3	0	0.18	0.25	0	0.17	0.31	0.22	1	0.36	0.2	0	0	0.15
Rob & Ortnek	0.35	0	0.25	0.4	0	0	0.2	0	0.36	1	0	0.44	0	0
Bučka	0.25	0	0	0	0.5	0.25	0.22	0.4	0.2	0	1	0	0.44	0.44
Sremič	0.44	0.22	0	0	0	0.4	0.18	0	0	0.44	0	1	0	0
Loke	0.11	0.4	0	0	0.29	0.18	0.17	0	0	0	0.44	0	1	0.17
Idrijske Krnice	0.21	0.2	0	0	0.29	0	0	0.5	0.15	0	0.44	0	0.17	1

Table 5. The Dice similarity index for the correlation among the determined conodont taxa.

	Budurovignathus sp.	*B.mirautae*	*B.gabrielae*	*B.hungaricus*	*B.mungoensis*	*C.kochi*	*G.malayensis*	*Go.hanbulogi*	*G.tethydis*	*N.balkanica*	*N.bifurcata*	*N.bulgarica*	*N.constricta*	*N.cornuta*	*N.excelsa*	*N.excentrica*	*N.mombergensis*	*N.transita*	*P.alpina*	*P.excelsa*	*P.liebermani*	*P.navicula*	*P.prealpina*	*P.pridaensis*	*P.trammeri*	*P.praeszaboi*
Budurovignathus sp.	1	0	0.5	0.4	0	0.8	0.4	0	0.25	0.4	0	0	0.25	0.5	0	0.33	0	0.4	1	0.3	0.5	0	0	0	0.44	0
B.mirautae	0	1	0	0.67	1	0	0	0	0.33	0	0	0	0	0	0	0	0	0	0	0.4	0	0	0	0	0.29	1
B.gabrielae	0.5	0	1	0	0	.67	0.67	0	0.33	0.67	0	0	0.33	0.33	0	0.5	0	0	0.5	0.4	1	0	0	0	0.29	0
B.hungaricus	0.4	0.67	0	1	0.67	0	0	0	0.29	0	0	0	0	0	0	0	0	0	0.4	0.33	0	0	0	0	0.5	0.67
B.mungoensis	0	1	0	0.67	1	0	0	0	0.33	0	0	0	0	0	0	0	0	0	0	0.4	0	0	0	0	0.29	1
C.kochi	0.8	0	0.67	0	0	1	0.5	0	0.29	0.5	0	0	0.29	0.57	0	0.4	0	0.5	0.8	0.33	0.67	0	0	0	0.25	0
G.malayensis	0.4	0	0.67	0	0	0.5	1	0	0.29	1	0	0	0.29	0.29	0	0.4	0	0	0.4	0.33	0.67	0	0	0.5	0.5	0
Go.hanbulogi	0	0	0	0	0	0	0	1	0.33	0	1	0.67	0	0	0.4	0.5	0	0	0	0	0	0	0	0	0	0
G.tethydis	0.25	0.33	0.33	0.29	0.33	0.29	0.29	0.33	1	0.29	0.33	0.57	0.4	0.2	0.44	0.5	0	0	0.25	0.44	0.33	0	0	0	0.36	0.33
N.balkanica	0.4	0	0.67	0	0	0.5	1	0	0.29	1	0	0	0.29	0.29	0	0.4	0	0	0.4	0.33	0.67	0	0	0.5	0.5	0
N.bifurcata	0	0	0	0	0	0	0	1	0.33	0	1	0.67	0	0	0.4	0.5	0	0	0	0	0	0	0	0	0	0
N.bulgarica	0	0	0	0	0	0	0	0.67	0.57	0	0.67	1	0	0	0.33	0.4	0	0	0	0	0	0	0	0	0	0
N.constricta	0.25	0	0.33	0	0	0.29	0.29	0	0.4	0.29	0	0	1	0.6	0.44	0.25	0.29	0.29	0.25	0.67	0.33	0.29	0.57	0.29	0.36	0
N.cornuta	0.5	0	0.33	0	0	0.57	0.29	0	0.2	0.29	0	0	0.6	1	0	0.5	0.29	0.57	0.5	0.67	0.33	0.29	0.57	0.29	0.36	0
N.excelsa	0	0	0	0	0	0	0	0.4	0.44	0	0.4	0.33	0.44	0	1	0.29	0.33	0	0	0	0	0.33	0	0	0	0
N.excentrica	0.33	0	0.5	0	0	0.4	0.4	0.5	0.5	0.4	0.5	0.4	0.25	0.5	0.29	1	0.4	0	0.33	0.29	0.5	0.4	0	0	0.22	0
N.mombergensis	0	0	0	0	0	0	0	0	0	0	0	0	0.29	0.29	0.33	0.4	1	0	0	0	0	1	0	0	0	0
N.transita	0.4	0	0	0	0	0.5	0	0	0	0	0	0	0.29	0.57	0	0	0	1	0.4	0.33	0	0	0.5	0	0	0
P.alpina	1	0	0.5	0.4	0	0.8	0.4	0	0.25	0.4	0	0	0.25	0.5	0	0.33	0	0.4	1	0.29	0.5	0	0	0	0.44	0
P.excelsa	0.29	0.4	0.4	0.33	0.4	0.33	0.33	0	0.44	0.33	0	0	0.67	0.67	0	0.29	0	0.33	0.29	1	0.4	0	0.67	0.33	0.6	0.4
P.liebermani	0.5	0	1	0	0	0.67	0.67	0	0.33	0.67	0	0	0.33	0.33	0	0.5	0	0	0.5	0.4	1	0	0	0	0.29	0
P.navicula	0	0	0	0	0	0	0	0	0	0	0	0	0.29	0.29	0.33	0.4	1	0	0	0	0	1	0	0	0	0
P.prealpina	0	0	0	0	0	0	0	0	0	0	0	0	0.57	0.57	0	0	0	0.5	0	0.67	0	0	1	0.5	0.25	0
P.pridaensis	0	0	0	0	0	0	0.5	0	0	0.5	0	0	0.29	0.29	0	0	0	0	0	0.33	0	0	0.5	1	0.5	0
P.trammeri	0.44	0.29	0.29	0.5	0.29	0.25	0.5	0	0.36	0.5	0	0	0.36	0.36	0	0.22	0	0	0.44	0.6	0.29	0	0.25	0.5	1	0.29
P.praeszaboi	0	1	0	0.67	1	0	0	0	0.33	0	0	0	0	0	0	0	0	0	0	0.4	0	0	0	0	0.29	1

and presently belong to different structural units. The conodont assemblage from Prisojnik, Šentjošt, Hrastenice, Šmarna gora, Sremič, Idrijske Krnice, and Bučka derive from red nodular limestone deposited within smaller grabens on top of a drowned upper Anisian carbonate platform. Successions from Kamna Gorica, Jagršče, Rižnikar, Rob and Ortnek, and Loke are lithologically more similar to the succession at Mišji Dol, namely featuring grey hemipelagic limestone in association with volcaniclastics and marlstone. The succession from Topla comprises bedded limestone with chert. It must be reminded that samples were (at least partly) collected by different authors, at different times, and that the size of the exposures and the number of collected samples vary as well. In addition, assemblages from Hrastenice, Loke and Idrijske Krnice represent only one conodont zone (*constricta*), section at Kamna Gorica only spans Fassanian, whereas sections at Rižnikar, Rob and Ortnek contain elements from the *trammeri*, as well as the succeeding *hungaricus* zones. The diversity of the conodont assemblages from these localities is generally low to moderate (Kolar-Jurkovšek & Jurkovšek, 2019). The diversity and composition of the conodont assemblages seems unrelated to the lithological composition of the sampled sites. Based on the current data and without regard for the issues mentioned above, the assemblage from Mišji Dol has a notably more diverse range of conodonts (13 species) than other sampled assemblages. The beta diversity of the conodont assemblages seems rather large, since only five species are present in a significant number of sampling sites: out of 14, *Paragondolella trammeri* has been found at 6 localities, and *Gladigondolella tethydis*, *Neogondolella constricta*, *N. cornuta* and *Paragondolella excelsa* at 5 localities. Consequently, the similarity between localities is relatively low (Table 4). The largest similarity can be found between the localities of Šmarna gora and Hrastenice (Dice index 0.73), the first being late Anisian – early Ladinian in age, the latter late Anisian. The assemblage from Mišji Dol is most similar to the assemblages from Sremič and Šmarna gora (Dice indices 0.44 and 0.42, respectively), both spanning the same, late Anisian – early Ladinian time interval.

Table 5 shows correlation among species. Some of the species seem to associate (e.g., *Paragondolella alpina* and *Budurovignathus* sp., *Paragondolella liebermani* and *Budurovignathus gabrielae*, *Neogondolella mombergensis* and *Paragondolella navicula*; Table 5), which indicates that they had similar ecological preferences. However, said correlation would be more reliable if it were based on data obtained from samples of the same weight and collected in a similar density. The correlation also cannot be confirmed for the pairs of species that are listed in the Table 5 only once, for example *Budurovignathus mungoensis*, *Budurovignathus mirautae* and *Paragondolella praeszaboi, Neogondolella balkanica* and *Neogondolella bifurcata*.

Depositional environment

The investigated succession roughly consists of segments, in which there is a variable mixture of lithologies, namely the thin-bedded limestone, marlstone, tuff and volcaniclastic sandstone, and segments that are dominated by thin- to medium-thick beds of carbonates (limestone and/or dolostone). The first are attributed to times of more intense volcanic activity and/or deposition in a more distal part of the basin, while the latter indicate periods of substantial platform production and export of the material down-slope to the more proximal parts of the basin, and/or periods of the quiescence of volcanic activity. The mudstone and radiolarian-filament wackestone-packstone present background hemipelagic/pelagic sedimentation. Other microfacies types are interpreted as sediments of distal (in the case of rudstone also more proximal) turbidity currents, which brought some platform-derived material (biogenic grains with micritised margins, green algae) into the basin and mixed it with components characteristic for open-marine waters (e.g., radiolarians, thin-shelled bivalves). The volcaniclastic sandstone also results from mass flow deposition, but the source of the material was volcanic rocks or tuff layers. The paleogeographic extent of the basin cannot be determined, but numerous smaller basins with a similar type of sedimentation can be envisioned for the late Anisian – early Ladinian for the External Dinarides (e.g., Kolar-Jurkovšek, 1983; Jurkovšek, 1983; Kolar-Jurkovšek, 1991; Demšar & Dozet, 2003; Čar, 2010; Kocjančič et al., 2022).

Conclusions

A succession of marlstone, tuff, volcaniclastic sandstone, and thin- to medium-bedded limestone and dolostone between Mišji Dol and Poljane pri Primskovem contains a relatively rich assemblage of conodonts of the lower Illyrian *constricta* Zone and the upper Illyrian to lower Fassanian *trammeri* Zone. The associated foraminifera include numerous representatives of the species *Nodobacularia*? *vujisici* Urošević & Gaździcki. The conodont assemblage is similar to the assemblage recorded from Bagolino in northern Italy. On the other hand, assemblages from other localities in

Slovenia have few taxa in common, which is in accordance with the presence of numerous smaller basins characterised by different conditions and communities.

Acknowledgements

The presented paper is the result of the master thesis written by the first author (K. Oselj). The thesis was defended at the Department of Geology, Faculty of Natural Sciences and Engineering. Preparation of the material and the field work was financed by the Slovenian Research Agency (research core funding No. P1-0011; authors T. Kolar-Jurkovšek, B. Jurkovšek and L. Gale). Thin sections were prepared and the microfossils were photographed at the Geological Survey of Slovenia. We thank the reviewers for the thorough reading of the manuscript and constructive remarks.

References

Bérczi-Makk, A. 1996c: Foraminifera of the Triassic formations of Alsó Hill (Northern Hungary). Part 3: Foraminifer assemblage of the basinal facies. Acta Geol. Hungarica, 39/4: 413–459.

Berra, F. & Carminati, E. 2010: Subsidence history from a backstripping analysis of the Permo-Mesozoic succession of the Central Suthern Alps (northern Italy). Basin Res., 22/6: 952–975. https://doi.org/10.1111/j.1365-2117.2009.00453.x

Brack, P. & Nicora, A. 1998: Conodonts from the Anisian-Ladinian succession of Bagolino, Brescian Prealps (Brescia, Lombardy, Northern Italy). Giornale Geol., 60/3: 314–325.

Brack, P., Rieber, H., Nicora, A. & Mundil, R. 2005: The Global boundary Stratotype Section and Point (GSSP) of the Ladinian Stage (Middle Triassic) at Bagolino (Southern Alps, Northern Italy) and its implications for the Triassic time scale. Episodes, 28/4: 233–244. https://doi.org/10.18814/epiiugs/2005/v28i4/001

Budai, T. & Vörös, A. 2006: Middle triassic platform and basin evolution of the Southern Bakony mountains (Transdanubian Range, Hungary). Riv. Ital. Paleontol. Strat., 112/3: 359–371. https://doi.org/10.13130/2039-4942/6346

Buser, S. 1969: Osnovna geološka karta SFRJ 1: 100 000. List Ribnica. Zvezni geološki zavod, Beograd.

Buser, S. 1974: Osnovna geološka karta SFRJ 1: 100 000. Tolmač lista Ribnica. Zvezni geološki zavod, Beograd: 60 p.

Buser, 1986: Osnovna geološka karta SFRJ 1: 100 000. Tolmač za lista Tolmin in Videm (Udine). Zvezni geološki zavod, Beograd: 103 p.

Buser, S. 1989: Development of the Dinaric and the Julian carbonate platforms and of the intermediate Slovenian Basin (NW Yugoslavia). Boll. Soc. Geol. Ital., 40: 313–320.

Celarc, B., Goričan, Š. & Kolar-Jurkovšek, T. 2013: Middle Triassic carbonate-platform break-up and formation of small-scale half-grabens (Julian and Kamnik-Savinja Alps, Slovenia). Facies, 59: 583–610. https://doi.org/10.1007/s10347-012-0326-0

Chen, Y.L., Krystyn, L., Orchard, M.J., Ali, X.L. & Richoz, S. 2015: A review of the evolution, biostratigraphy, provincialism and diversity of Middle and early Late Triassic conodonts. Pap. Palaeontol., 2/2: 235–263. https://doi.org/10.1002/spp2.1038

Cushman, J.A. 1927: An outline of a re-classification of the foraminifera. Contributions from the Cushman Laboratory for Foram. Res., 3: 1–105. https://doi.org/10.1126/science.65.1689.473.b

Čar, J. 2010: Geological structure of the Idrija – Cerkno hills: Explanatory book to the Geological map of the Idrija – Cerkljansko hills between Stopnik and Rovte 1: 25 000. Geological Survey of Slovenia, Ljubljana: 127 p.

Čar, J. 2013: Ladinian skonca beds of the Idrija Ore Deposit (W Slovenia). Geologija, 56/2: 151–174. https://doi.org/10.5474/geologija.2013.010

Čar, J., Jež, J. & Milanič, B. 2021: Structural setting at the contact of the Southern Alps and Dinarides in western Cerkljansko region (western Slovenia). Geologija, 64/2: 189–203. https://doi.org/10.5474/geologija.2021.011

Delage, Y. & Hérouard, E. 1896: Traité de Zoologie Concrète, Volume 1, La Cellule et les Protozoaires. Schleicher Frères, Paris: 584 p. https://doi.org/10.5962/bhl.title.11672

Demšar, M. & Dozet, S. 2003: Anisian and Ladinian beds in the cross-section above Srednik Valley at Križna Gora, central Slovenia. Geologija, 46/1: 41–48. https://doi.org/10.5474/geologija.2003.002

Di Capua, A., De Rosa, R., Kereszturi, G., Le Pera, E., Rosi, M. & Watt, S.F.L. 2022: Volcanically-derived deposits and sequences: a unified terminological scheme for application in modern and ancient environments. Geol. Soc. London, Spec. Publ., 520: 11–27. https://doi.org/10.1144/SP520-2021-201

Dozet, S. 2006: Ladinian beds in the Obla Gorica area, central Slovenia. RMZ – Mater. Geoenviron., 53/3: 367–383.

Dozet, S. & Buser, S. 2009: Triassic. In: Pleničar, M., Ogorelec, B. & Novak, M. (eds.): Geology of Slovenia. Geological Survey of Slovenia, Ljubljana: 161–214.

Dunham, R.J. 1962: Classification of carbonate rocks according to depositional texture. In: Han, W.E. (ed.): Classification of carbonate rocks, A symposium. American Ass. Petrol. Geol. Mem., Tulsa: 108–121.

Embry, A.F. & Klovan, J.E. 1972: Absolute water depth limits of late Devonian paleoecological zones. Geol. Rundschau, 61: 672–686. https://doi.org/10.1007/BF01896340

Epstein, A.G., Epstein, J.B. & Harris, L.D. 1977: Conodont colour alteration – an index to organic metamorphism. Geol. Survey Am. Prof. Paper, 995: 1–27.

Gawlick, H.-J., Goričan, Š., Missoni, S. & Lein, R. 2012: Late Anisian platform drowning and radiolarite deposition as a consequence of the opening of the Neotethys ocean (High Karst nappe, Montenegro). Bull. Soc. géol. France, 183: 349–358. https://doi.org/10.2113/gssgfbull.183.4.349

Germovšek, C. 1955: O geoloških razmerah na prehodu Posavskih gub v Dolenjski kras med Stično in Šentrupertom. Geologija, 3: 116–135.

Gheorghian, D. 1980: Note concernant quelques espèces de *Nodophthalmidium* dans le Trias Moyen-Supérieur de Roumanie. Dări de Seamă ale Şedinţelor, Institutul de Geologie si Geofizica, Paleontologie, 65/3: 37–41.

Gianolla, P., Caggiati, M. & Pecorari, M. 2019: Looking at the timing of Triassic magmatism in the Southern Alps. Geo.Alp, 16: 65–68.

Goričan, Š. & Buser, S. 1990: Middle Triassic radiolarians from Slovenia (Yugoslavia). Geologija, 31–32 (1988/1989): 133–197.

Griffith, J.W. & Henfrey, A. 1875: The micrographic dictionary: a guide to the examination and investigation of the structure and nature of microscopic objects. Van Voorst, London.

Haas, J. & Budai, T. 1999: Triassic sequence stratigraphy of the Transdanubian Range (Hungary). Geol. Carpathica, 50/6: 459–475.

Hammer, Ø., Harper, D.A.T. & Ryan, P.D. 2001: PAST: Paleontological statistics software package for education and data analysis. Palaeontol. electronica, 4/1: 1–9.

Jurkovšek, B. 1983: Fassanian beds with daonellas in Slovenia. Geologija, 26/1: 29–70.

Jurkovšek, B. 1984: Langobardian beds with daonellas and posidonias in Slovenia. Geologija, 27/1: 41–95.

Kocjančič, A., Rožič, B., Gale, L., Vodnik, P., Kolar-Jurkovšek, T. & Celarc, B. 2022: Facies analysis of Ladinian and Carnian beds in the area of Rute Plateau (External Dinarides, central Slovenia). In: Rožič, B. & Žvab Rožič, P. (eds): 15th Emile Argand Conference on Alpine Geological Studies: 12–14 September 2022, Ljubljana, Slovenia: abstract book & fieldtrip guide. Faculty of Natural Sciences and Engineering, Department of Geology, Ljubljana: 37. https://doi.org/10.5194/egusphere-alpshop2022-37

Kolar-Jurkovšek, T. 1983: Middle Triassic conodonts from Slovenia. Rudarsko-metalurški zbornik, 30/4: 323–364.

Kolar-Jurkovšek, T. 1991: Microfauna of Middle and Upper Triassic in Slovenia and its biostratigraphic significance. Geologija, 33/1: 21–170. https://doi.org/10.5474/geologija.1990.001

Kolar-Jurkovšek, T. & Jurkovšek, B. 2019: Conodonts of Slovenia. Geological Survey of Slovenia, Ljubljana: 259 p.

Kovács, S., Sudar, M., Grădinaru, E., Gawlick, H.-J., Karamata, S., Haas, J., Péro, C., Gaetani, M., Mello, J., Polák, J., Aljinović, D., Ogorelec, B., Kolar-Jurkovšek, T., Jurkovšek, B. & Buser, S. 2011: Triassic evolution of the tectonostratigraphic units of the Circum-Pannonian Region. Jb. Geol. B.-A., 151: 199–280.

Kozur, H., Krainer, K. & Mostler, H. 1994: Middle Triassic Conodonts from the Southern Karawanken Mountains (Southern Alps) and Their Stratigraphic Importance. Geol.-Paläontol. Mitt. Innsbruck, 19: 165–200.

Kristan-Tollmann, E. 1984: Trias-Foraminiferen von Kumaun im Himalaya. Mitt. Österr. Geol. Ges., 77: 263–329.

Lipold, M. 1858: Bericht über die geologische Aufnahmen in Unter-Krain im Jahnre 1857. Jb. Geol. Reichsanst., 9/2: 257–276.

Loeblich, A.R.Jr. & Tappan, H. 1986: Some new and redefined genera and families of Textulariina, Fusulinina, Involutinina, and Miliolina (Foraminiferida). J. Foram. Res., 16/4: 334–346. https://doi.org/10.2113/gsjfr.16.4.334

Macfayden, W.A. 1939: On *Ophthalmidium*, and two new names for Recent foraminifera of the family Ophthalmidiidae. J. Royal Microscop. Soc., 59: 162–169.

Oravecz-Scheffer, A. 1987: Triassic foraminifers of the Transdanubian Central Range. Geol. Hungarica, 50: 3–134.

Orbigny, A. d' 1826: Tableau méthodique de la classe des Céphalopodes. Ann. Sci. Natur., 7: 245–314.

Pawlowski, J., Holzmann, M. & Tyszka, J. 2013: New supraordinal classification of Foraminifera: Molecules meet morphology. Marine Micropal., 100: 1–10. https://doi.org/10.1016/j.marmicro.2013.04.002

Placer, L. 1998a: Structural meaning of Sava Folds. Geologija, 41/1: 191–221. https://doi.org/10.5474/geologija.1998.012

Placer, L. 1998b: Contribution to the macrotectonic subdivision of the border region between Southern Alps and External Dinarides. Geologija, 41/1: 223–255. https://doi.org/10.5474/geologija.1998.013

Placer, L. 2008: Principles of the tectonic subdivision of Slovenia. Geologija, 51/2: 205–217. https://doi.org/10.5474/geologija.2008.021

Rakovec, I. 1950: Pseudozilian strata in Slovenia (NW Yugoslavia). Geogr. Vestnik, 22: 1–24.

Ramovš, A. & Goričan, Š. 1995: Late Anisian – Early Ladinian radiolarians and conodonts from Šmarna gora near Ljubljana, Slovenia. Razprave IV. razreda SAZU, 36/9: 179–221.

Rhumbler, L. 1895: Entwurf eines naturlichen Systems des Thalamophoren. Nachrichten Gesell. Wiss. Göttingen, Math.-Physik, 1: 51–98.

Rožič, B., Kocjančič, A., Gale, L., Popit, T., Žvab Rožič, P., Vodnik, P., Zupančič, N., Kolar-Jurkovšek, T. & Celarc, B. 2021: Arhitektura in sedimentarni razvoj ladinijskega bazena na območju Rutarske planote. Geol. zbornik, 26: 111–116.

Salaj, J., Borza, K. & Samuel, O. 1983: Triassic foraminifers of the West Carpathians. Geol. ústav Dionýsa Štúra: 213 p.

Salaj, J., Trifonova, E., Gheorghian, D. & Coroneou, V. 1988: The Triassic foraminifera microbiostratigraphy of the Carpathian – Balkan and Hellenic realm. Mineralia slov., 20/5: 387–415.

Schmid, S. M., Bernoulli, D., Fügenschuh, B., Matenco, L., Schefer, S., Schuster, R., Tischler, M. & Ustaszewski, K. 2008: The Alpine-Carpathian-Dinaridic orogenic system: correlation and evolution of tectonic units. Swiss J. Geosci. (Geol. Rundsch.), 101/1: 139–183. https://doi.org/10.1007/s00015-008-1247-3

Schultze, M.S. 1854: Über den Organismus der Polythalamien (Foraminiferen), nebst Bermerkungen über die Rhizopoden im Allgemeinen. Wilhelm Engelmann, Leipzig: 68 p.

Skaberne, D., Goričan, Š. & Čar, J. 2003: Kamnine in fosili (radiolariji) iz kamnoloma Kamna Gorica. Vigenjc, glasilo Kovaškega muzeja v Kropi, 3: 85–96.

Smirčić, D., Aljinović, D., Barudžija, U. & Kolar-Jurkovšek, T. 2020: Middle Triassic syntectonic sedimentation and volcanic influence in the central part of the External Dinarides, Croatia (Velebit Mts.). Geol. Quarterly, 64/1: 220–239. https://doi.org/10.7306/gq.1528

Stefani, M., Furin, S. & Gianolla, P. 2010: The changing climate framework and depositional dynamics of Triassic carbonate platforms from the Dolomites. Palaeogeogr., Palaeoclimatol., Palaeoecol., 290: 43–57. https://doi.org/10.1016/j.palaeo.2010.02.018

Tomljenović, B. & Csontos, L. 2001: Neogene–Quaternary structures in the border zone between Alps, Dinarides and Pannonian Basin (Hrvatsko zagorje and Karlovac Basins, Croatia). Int. J. Earth Sciences (Geol. Rundsch.), 90: 560–578. https://doi.org/10.1007/s005310000176

Trifonova, E. 1993: Taxonomy of Bulgarian Triassic foraminifera. II. Families Endothyriidae to Ophthalmidiidae. Geol. Balcanica, 23/2: 19–66.

Urošević, D. & Gaździcki, A. 1977: *Nodobacularia vujisici* nov. sp. ladinskog kata unutrašnjeg-karpatskog pojasa (istočna Srbija). Bull. Mus. Hist. Natur., Ser. A, 32: 97–101.

Velledits, F., Péró, C., Blau, J., Senowbari-Daryan, B., Kovács, S., Piros, O., Pocsai, T., Szügyi-Simon, H., Dumitrică, P. & Pálfy, J. 2011: The oldest Triassic platform margin reef from the Alpine-Carpathian region (Aggtelek, NE Hungary): platform evolution, reefal biota and biostratigraphic framework. Riv. Ital. Paleontol. Stratigr., 117/2: 221–268. https://doi.org/10.13130/2039-4942/5973

Vrabec, M. & Fodor, L. 2006: Late Cenozoic tectonics of Slovenia: Structural styles at the northeastern corner of the Adriatic microplate. In: Pinter, N., Grenerczy, G., Weber, J., Stein, S. & Medek, D. (eds.): The Adria microplate: GPS geodesy, tectonics and hazards. NATO Sci. Ser., IV, Earth Environ. Sci., 61: 151–168.

Medak, D. & Stein, S. (eds.): The Adria Microplate: GPS geodesy, tectonics and hazards. Kluwer Academic Publ.: 151–168.

Wright, V.P. 1992: A revised classification of limestones. Sed. Geology, 76: 177–185. https://doi.org/10.1016/0037-0738(92)90082-3