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Pseudofurnishius (Conodonta) from the Triassic Drežnica section, Bosnia and Herzegovina

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ABSTRACT

Triassic strata in the Drežnica section, Bosnia and Herzegovina have been examined biostratigraphically. The limestone and dolostone strata were deposited in deep pelagic environment. The conodont faunas are marked by prevailing elements of the genus *Pseudofurnishius* including clusters that enabled to distinguish the *huddlei* (lower Longobardian) and *murcianus* (upper Longobardian–?Cordevolian) Zones, the later fauna is characterized by the presence of *Budurovignathus* with rare representation of *Gladigondolella* and *Paragondolella.* This is the first report on recovery of *Pseudofurnishius* in the region.

1. Introduction

The investigated Drežnica section, representing sedimentation at the transition from the Middle to the Upper Triassic interval, belongs to the large geotectonic unit – the External Dinarides. This unit (or the High Karst Zone: Petković, 1961; Aubouin et al., 1970; Grubić, 1980; Schmid et al., 2008) is a part of Alpine orogenetic belt striking from Slovenia in the northwest (NW) to Albania in the southeast (SE). To the NE External Dinarides are connected to the separate geotectonic unit - the Central Dinarides.

In the Middle Triassic the whole Dinarides area was positioned in the western Tethys. After the tectonically stable period in the Early Triassic, the vast epeiric ramp was disintegrated by wrench faulting or rift-type tectonics to uplifted and subsided blocks. The disintegration begun in the early Illyrian/late Pelsonian (Velledits et al., 2011; Smirčić et al., 2020; Gawlick et al., 2021; Karádi et al., 2022) in different parts of the western Tethyan coast. Some blocks were subaerially exposed and proved by bauxite occurrences, some remained shallow marine dominated by carbonate sediments, while the subsided area (basin) sediments have characteristic of open marine deposition (Buser et al., 2007, 2008; Celarc et al., 2013; Gale et al., 2015, 2019; Smirčić et al., 2018). Extensional rift-type tectonics (block faulting) was associated with volcanic activity. The main Middle Triassic magmatic phase in the External Dinarides has taken place from the Late Anisian (Illyrian) to Late Ladinian (Longobardian) as defined by Smirčić et al. (2018). In addition to wide-spread pyroclastic rocks (“Pietra Verde”), rare small bodies of subvolcanic calc-alcaline dolerites occur in the High Karst Zone. Their composition is compatible either with rifting driven by the subduction of the Paleotethys or with intracontinental rifting cutting through the Variscan orogeny but the second model is preferred due to the lack of evidence that Paleotethys existed in this region in the Middle Triassic (Slovenec et al., 2023). Specific style of wrench faulting created specific circumstances where small pelagic realms could develop as separate intraplatform basins revealing almost endemic faunal characteristics (Goričan et al., 2015, 2017). The global sea-level rise occurred in the Middle Triassic, documented in the whole western Tethys, caused drowning of the existing carbonate platforms (Gallet et al., 1998; Kovács et al., 2010, 2011; Lein et al., 2012; Sudar et al., 2013). The basins

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preserved in the present-day High Karst Zone were all relatively shallow and short-lived. At the beginning of the Late Triassic they were levelled and platform sedimentation was re-established. East of the High Karst Carbonate Platform, the Middle Triassic rifting created a much larger and deeper Bosnian Basin, where pelagic sedimentation continued in the Jurassic and Cretaceous.

A belt of thin bedded and platy limestones crops out in different tectonic units of the Dinarides but were formed in the same dynamic of the basinal environment, in the close proximity of the slopes. The pelagic strata are marked by the conodont fauna with *P. murcianus* that was previously documented in the sections in Slovenia and Croatia (for references see Kolar-Jurkovšek et al., 2018). The interpretation of the depositional environment of these strata was provided considering regional geologic development in the western Tethys.

In this study, paleontological and sedimentological data on the platy limestone section exposed at Drežnica in Bosnia and Herzegovina are presented. The recognized conodont data enabled us to distinguish two conodont zones, of which one enables correlation with two regions in the Dinarides as well as in the western Tethys. The biostratigraphic and paleogeographic significance of the determined taxa is also emphasized. The obtained conodont data contribute to the knowledge on distribution and composition of the faunas with *Pseudofurnishius* and is thus important for the reconstruction of the paleogeography of the Dinarides and for stratigraphic correlation of the Longobardian–Cordevolian sediments.

2. Geological setting

The section is located about 30 km north of Mostar and it is situated in the geotectonic unit of the External Dinarides, along the Glamoč-Drežnica–Gacko thrust front (part of the Una-Kuči thrust) on the northern edge of the Drežanka River canyon (Hrvatović, 2006) (Fig. 1). It has a length of about 20 km and it descends towards the Neretva fault. The Glamoč-Drežnica–Gacko thrust has a transitional position between the External and the Internal Dinarides. This thrust sheet consists largely of Triassic formations in which dolostones and limestones predominate over clastics and igneous rocks. To the southwest of this thrust is the High Karst thrust and to the northeast the Ključ–Raduša thrust (Central Dinarides) resulting from the movement of Paleozoic–Triassic units (Hrvatović and Pamić, 2005). The Ključ- Raduša thrust is largely composed of Triassic carbonates and subordinate coeval clastic and igneous rocks, and scarce Permian sediments.

The High Karst thrust sheet is the largest thrust sheet of the External Dinarides. It comprises the entire Dinaric karst region, and is largely composed of Mesozoic to Early Paleogene carbonate platform sequences. In the canyon, the units range from the Middle Triassic through the Upper Cretaceous strata with approximate thickness of 2500 m. According to Behlilović (1964), the Longobardian strata of the Drežnica section have been palaeontologicaly evidenced, from bottom to top as: 1) shale, chert, sandstone with *Avicula globulus* (Wissmann); 2) tuffs, volcanic breccia, limestone, marl and chert; 3) dark grey and black bituminous limestones with *Daonella tyrolensis* Mojsisovics, *Daonella lommeli* (Wismann) and *Posidonia wengensis* Wissmann, whereas grey to black bituminous dolostones correspond to the Cordevolian.

The continuation of the studied section is not exposed (tectonically cut-off) but all Upper Triassic deposits in a wider area are shallow-water carbonates suggesting that the pelagic episode was restricted to the mid-Triassic *syn*- and early post-rift deposits similarly as elsewhere in the

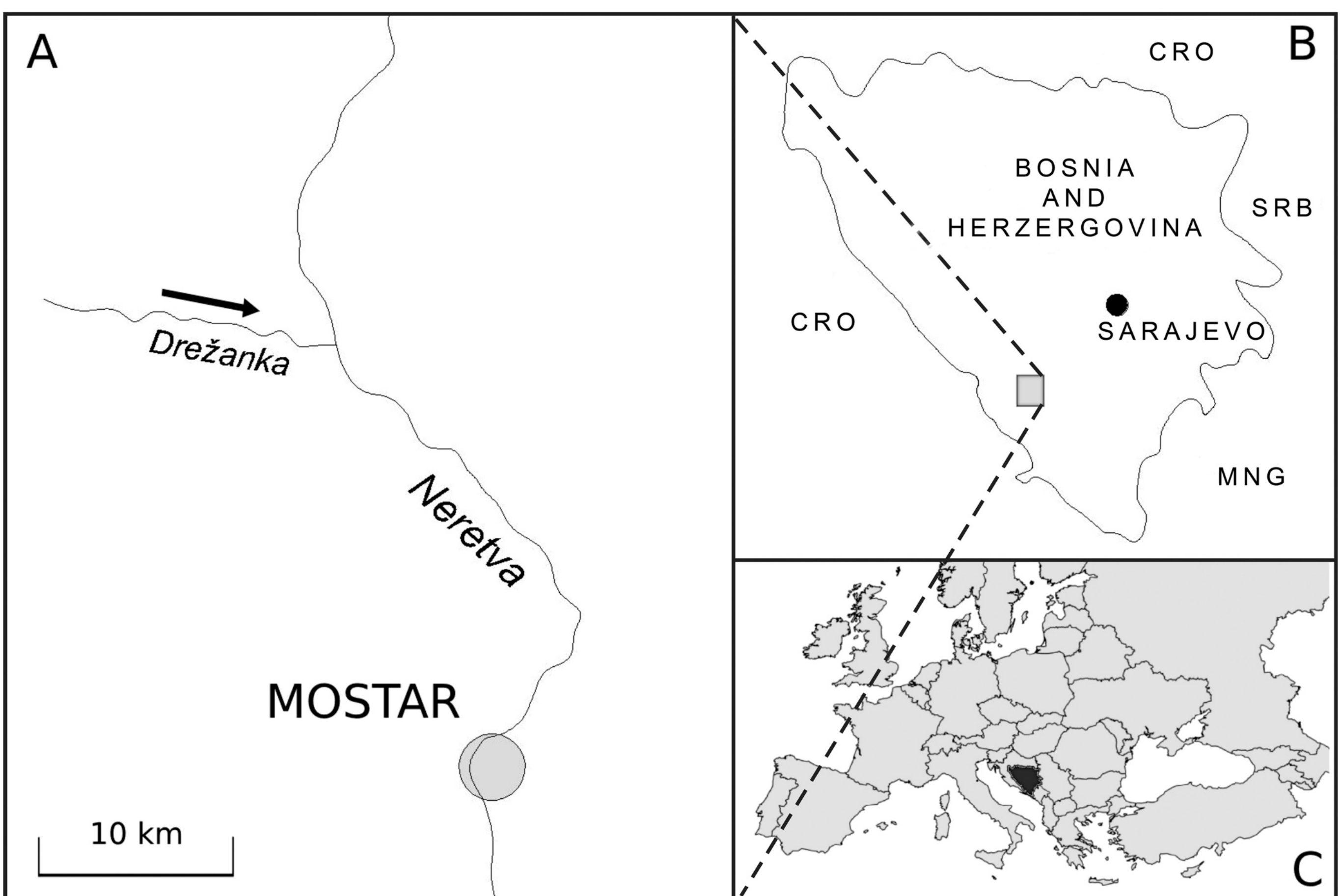

Fig. 1. Maps showing location of the studied Drežnica section in Bosnia and Herzegovina. Location of the studied section is marked by arrow.

High Karst Zone (e.g. Jelaska et al., 2003).

3. Materials and methods

The field work for this study with measuring and sampling of the Drežnica section was carried out in a frame of a bilateral scientific cooperation between Slovenia and Bosnia and Herzegovina in 2013 and 2015. The section begins with the coordinates DR 1 Y – 6,464,357, X – 4,822,375 (DR 2: Y – 6,465,237, X – 4,822,054) and ends DR 10: Y – 6,468,968, X – 4,821,607. (Fig. 1).

Altogether 11 carbonate conodont samples were collected. Conodont preparation with use of a standard techniques and application of diluted acetic acid (5–8%) was carried out. Conodonts in the dried residues were enriched by heavy liquid separation applying bromoform and picked out from the heavy fraction under a binocular microscope using a wet brush pen. The obtained fossil material is inventoried and catalogued in the micropaleontologic collection of the Geological Survey of Slovenia under inventory numbers 5425–5435 (DR 1 – DR 10) and abbreviated GeoZS. Along the measured section 51 thin sections were analysed. Thin sections were stained by standard procedure by K-ferricyanide and

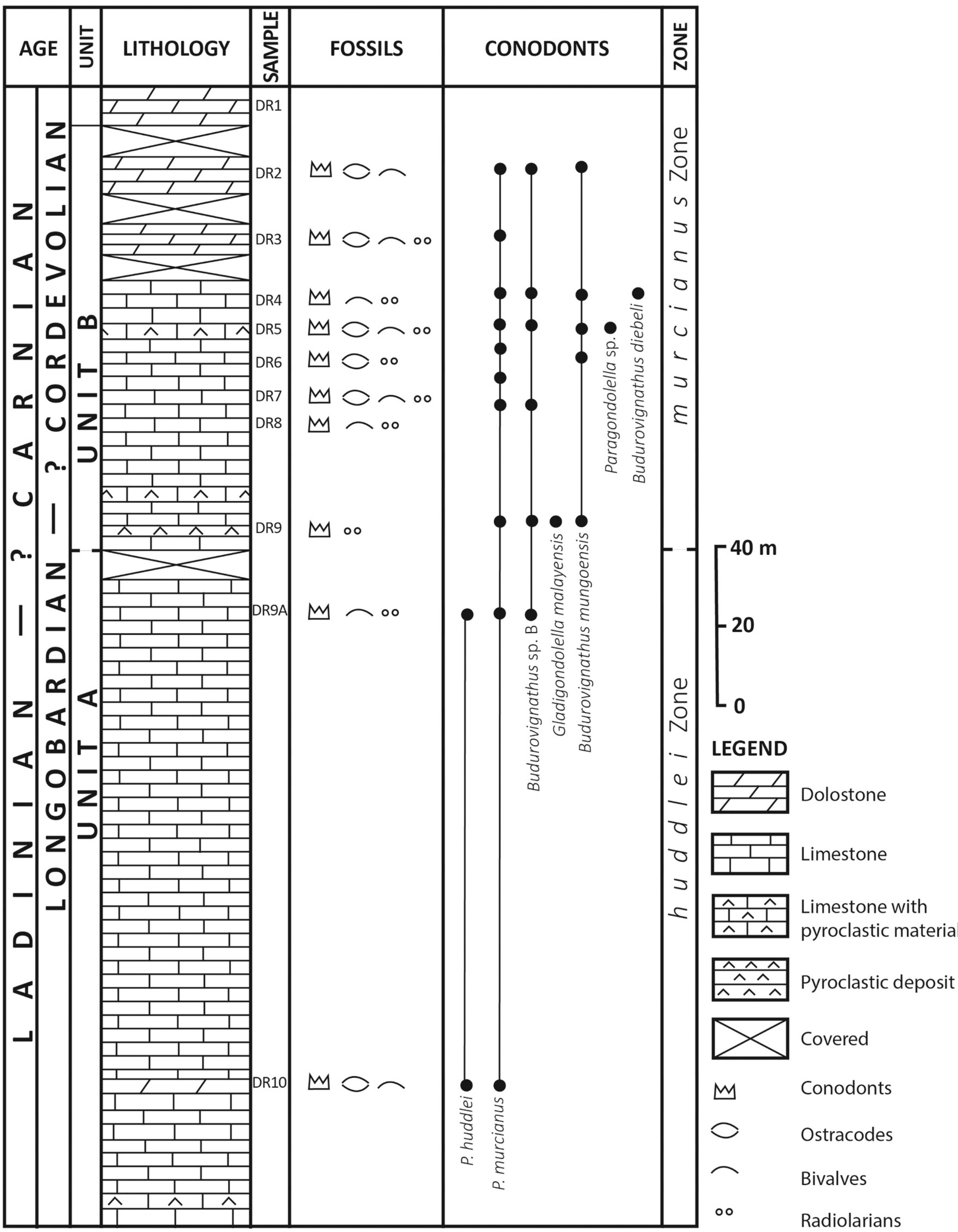

Fig. 2. Geological column of the studied strata with sample position in the Drežnica section, Bosnia and Herzegovina.

Alizarin Red S and examined using a polarising microscope.

4. Results

4.1. Facies and depositional environment

The Drežnica section represents a continuous deposition of carbonate rocks from Longobardian to Cordevolian. Thickness of the sampled section attains 148 m (Fig. 2). The succession consists of various types of limestone and dolostone. Layers are thin to medium thick, tabular or wavy bedded, with occasionally fairly preserved parallel lamination. Slump structure has been observed in the bed DR 9.

The section is divided into two units: unit A (Longobardian deposits) and unit B (Longobardian–?Cordevolian deposits). The sedimentation seems to be continuous and represent overall pelagic conditions. The short covered interval disable observation of the exact depositional characteristics between these two stratigraphic units.

Unit A consists of limestone and dolostone that contain thinshell bivalves and ostracodes (wackestone-type). Dolostone reveals macrocrystalline texture suggesting diagenetic (burial) origin but primary composition (usually bioclastic) is fairly preserved occasionally. Recrystallization of limestone is severe. Various intense of silicification occurred. The strata are characterized by the presence of mono- and biplatform *Pseudofurnishius* types, *P. huddlei* and *P. murcianus*. Abundance of thinshell bivalves as well as the occurrence of *Pseudofurnishius* indicate deposition in the pelagic environment.

Unit B consists of various types of limestone and dolostone rich in lame mud: laminated mudstone, wackestone and packstone containing thin shell bivalves and ostracods as dominant constituents (Fig. 3a). The main difference related to the unit A is abundance of calcified radiolarians (Fig. 3b) and the conodont occurrence of the cosmopolitan genus *Budurovignatus* throughout the whole unit B. Limestone represented by samples DR 4 and DR 5 reveal slightly different composition. It is determined as packstone consisting of thinshelld bivalves and lime clasts (Fig. 3c). Lime clasts indicate their shallow marine origin, thus resedimentation processes from shallow to deep marine environment are supposed. In the same samples small amount of quartz and feldspar crystalloclasts are present (Fig. 3c) as well as coalified wood fragments (Fig. 3d). Increased amount of organic matter was recognized in the interval from DR 5 to DR 2.

Dolostones of the unit B has macro- to microcrystalline homogenous to laminated textures. Some of the microcrystalline varieties correspond

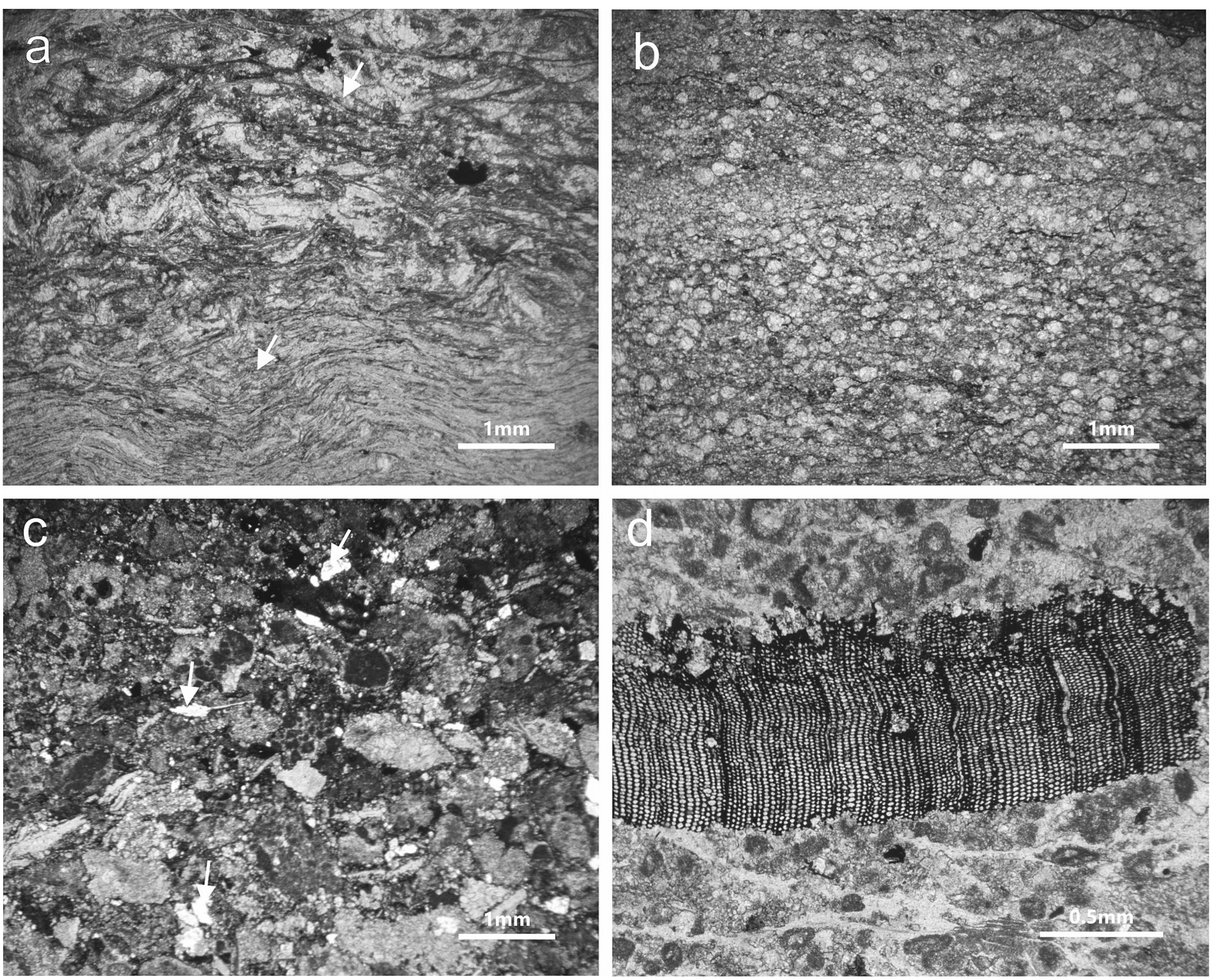

Fig. 3. Micropetrographic characteristic of the sedimentary rocks of Drežnica section; a) Thinshell bivalves as a main constituent in the deposits of the unit A and unit B (sample DR 9); b) Abundant calcified radiolarians present in the unit B (sample DR 9); c) Resedimented lime clasts of the shallow marine origin represent the main constituent of the sample DR 5. Crystalloclasts of quartz and feldspar (arrows) occur in the same sample and indicate volcanic activity prior to resedimentation; d) Coalified wood fragment in the sample DR 5.

to lime mud precursor. Diagenetic dolomitization influenced primary composition of limestone of the unit B and can be thorough, partial or patchy. Silicification was also noticed and was occasionally very intense (sample DR 9). Recrystallization of calcite is common. According to composition and the presence of the thinshelled bivalves and ostracods the depositional conditions for the sedimentary rocks in the unit B were apparently deep marine as in unit A. Nevertheless, the presence of more abundant radiolarians only in the unit B may support the assumption of deepening (related to the unit A) and establishing better connection to wider oceanic realm. This can be supported also by appearance of the cosmopolitan conodont genus *Budurovignathus* present in the unit B, whereas *Pseudofurnishius* is present in various environments; as an opportunist taxon it can rapidly invade restricted environments and occupy the niche not taken by other taxa and is thus usually related to pelagic but more restricted deep marine areas. Radiolarians extracted from samples DR 4 to DR 9 are rare and the assemblages have an extremely low diversity. Spongy spherical forms, many of them with numerous short spines (*Triassospongosphaera*?), are the most abundant. Discoidal forms with four spines (*Plafkerium*? and *Muelleritortis*) are also common but nassellarians are entirely missing. Since most specimens show a fairly well-preserved shell structure and since dissolution-resistant morphotypes are not markedly abundant, we assume that the taxonomic composition is not fundamentally biased by diagenesis. Such impoverished Middle Triassic assemblages lacking multicyrtid nassellarians have already been described and are characteristic of restricted basins with low oxygen content (Stockar et al., 2012; Goričan et al., 2015). We also note that sponge spicules, usually associated in radiolarian-bearing limestone samples, are virtually missing at Drežnica. Their absence is in line with the inferred oxygen-deficient bottom waters that would be unsuitable for life of benthic organisms. A stratigraphically important radiolarian species *Muelleritortis cochleata* (Nakaseko & Nishimura) has been identified in sample DR 9. This species begins simultaneously with the conodont *Budurovignathus mungoensis* (Diebel) and defines the Upper Ladinian *Muelleritortis cochleata* Radiolarian Zone (Kozur and Mostler, 1994). This radiolarian date agrees well with the conodont stratigraphy of the Drežnica section (Fig. 2).

The deepening in the already pelagic environment (unit B) may be interpreted as prolonged subsiding of some blocks due to rift-type tectonics in the overall extension of the Tethys. Slump structure interpreted as synsedimentary deformation, was also related to subsidence. Formation of wide and fairly connected deep marine pelagic realm can be finally confirmed by the occurrence of *Budurovignatus* and *Gladigondolella*.

Shallow water lime clasts present in sample DR 4 and DR 5 indicate resedimentation from the shallow water marine conditions on the uplifted blocks. Thus, in the Middle Triassic rift- related realm shallow marine areas (on the uplifted blocks) and pelagic realm (on the subsided areas) contemporary existed (Smirčić et al., 2018; Gale et al., 2023). Resedimentation was enabled possibly because carbonate platforms that developed on the uplifted blocks lack organic rims. Large olistoliths possible formed due to break off the platform edge. Thus arenite- and rudite-sized lime clasts as well as large olistolith were easily resedimented to the deep marine areas (the subsided blocks) in the close proximity.

Tectonic activity was accompanied by volcanism. The severe silicification, recrystallization of calcite and possibly dolomitization can be attributed to the threatening effects of volcanism (increase of temperature and input of silica), although the contribution of biogenic silica (radiolarians) also has to be considered. The direct consequence of volcanic events is the presence of quartz and feldspar crystalloclasts thus proving the volcanic activity in the Dinarides area even in the Longobardian–Cordevolian times.

4.2. Conodont fauna of the Drežnica section

Most recovered conodonts from the platy limestone of the units A and B of the Drežnica section belong to Pseudofurnishiinae Ramovš, 1977 which is one out of six subfamilies of the family Gondolellidae Lindstroem, 1970 (Chen et al., 2015). For this subfamily a term Sephardiellinae Plasencia et al., 2007 was introduced but Pseudofurnishiinae Ramovš, 1977 (transcribed from Pseudofurnishiidae Ramovš, 1977) as the prior legitimate name is retained herein (see also Chen et al., 2015). Representatives of two genera are present in our material, i.e. *Budurovignathus* Kozur, 1989 (= *Sephardiella* March et al., 1990; Plasencia et al., 2007) and *Pseudofurnishius* van den Boogaard, 1966. Both genera have very similar stratigraphic range that is from the Fassanian to the Cordevolian (lowest Julian), but *Pseudofurnishius* has somewhat shorter range (Chen et al., 2015, Fig. 2); the last *Budurovignathus* representatives survived into the Cordevolian (Kozur, 1989; Rigo et al., 2007) and they constitute the associations of the earliest Carnian *Paragondolella polygnathiformis* 1 Subzone sensu Rigo et al. (2018).

The conodont fauna from the units A and B of the studied section is characterized by the elements with a CAI 4.5–5 sensu Epstein et al. (1977). It is dominated by isolated P_1 elements of the species *Pseudofurnishius murcianus* van den Boogaard (Fig. 2). This species is present in most part of the section, 10 out of 11 samples processed. The recovered specimens of *Pseudofurnishius* are represented by mono- and biplatform types (Figs. 4, 5). The later occur quite frequently in the unit A, which means the biplatform types of *Pseudofurnishius* characterize the older strata in the Drežnica section. Therefore the species name *Pseudofurnishius huddlei* is retained here for the bi-platform type that demonstrates also its importance for stratigraphy of the region (see also Discussion). According to Kovács and Kozur (1980) it ranges only in the Longobardian (from the middle *poseidon* zone and in the *meginae* zone), whereas after Chen et al. (2015) it appears already in the Fassanian and it partly ranges with *P. murcianus*.

The representation of the genus *Budurovignathus* is recorded in 7 samples (DR 2, DR 4, DR 5, DR 6, DR 8, DR 9, DR 9A) (Fig. 6). The entrace of budurovignathids in the sample DR 9A in the uppermost part of the unit A is documented by a single specimen, on the contrary to their frequent occurrence higher up, in the unit B. Budurovignathids which include also *Budurovignathus mungoensis* with several morphotypes, whereas *Budurovignathus diebeli* is recorded with a single specimen in the sample DR 4. It is noteworth that all budurovignathids, with the exception of a single specimen in the sample DR 9A are confined to the strata of the unit B. Species *Budurovignathus mungoensis* ranges from upper Ladinian to lowermost Carnian (Longobardian–Cordevolian) (Kovács and Kozur, 1980; Kolar-Jurkovšek, 1991; Chen et al., 2015; Kolar-Jurkovšek et al., 2018). According to some authors *Budurovignathus diebeli* ranges only in the Cordevolian (Kovács and Kozur, 1980; Chen et al., 2015), however, it has been reported to occur already in the late Longobardian (Rigo et al., 2018; Karádi et al., 2022).

The determined conodont taxa enable to distinguish two conodont zones, of which both are marked by dominance of *P. murcianus*. The lower *huddlei* zone is characterized by co-ocurrence of two *Pseudofurnishius* species, i.e. *P. huddlei and P. murcianus* and is lower Longobardian in age. The upper *murcianus* zone is next to the prevailing nominate species constituted by budurovignathids with very rare *Gladigondolella* and *Paragondolella* that is upper Longobardian-Cordevolian in age. All collected conodont taxa, i.e. *Budurovignathus diebeli, B. mungoensis, Gladigondolella malayensis, Paragondolella* sp., *P. huddlei* and *P. murcianus* are for the first time reported from the Dinarides of Bosnia and Herzegovina. So far, the only budurovignathid taxon determined as *B. mostleri* (Kozur) has been reported to occur elsewhere in Bosnia, i. e. in the Upper Longobardian strata of the Ljubija area (Ramovš, 1994). Very significant is recovery of *Pseudofurnishius* as a typical element that occurs only in the southern Tethys and its marginal seas (Kozur, 1993). The cosmopolitan genus *Budurovignathus* occurs in the pelagic faunas

Conodonts \ Sample	2	3	4	5	6	7	8	9	9A	10
Budurovignathus diebeli			1							
Budurovignathus mungoensis	1		6	1	1			8		
Budurovignathus sp.			10	18+1C			8	4	2	
Gladigondolella malayensis								3		
Paragondolella sp.				1						
Pseudofurnishius huddlei									8	3
Pseudofurnishius murcianus	9+3C	8	21	7	10+4C	21+1C	5	30+2C	31	4
Radiolarians			R	R	R	R	F	F		

Fig. 4. Numerical distribution of isolated platform elements and clusters of conodont taxa in the Drežnica section. Abbreviations; C – clusters, F – frequent, R – rare.

and is stratigraphically meaningful due to its rapid evolution that includes several zonal markers (Kozur, 2003; Ogg et al., 2016). The presence of *Gladigondolella malayensis* and *Paragondolella* sp., however rare, in the collections marked by subordinate *Budurovignathus* and dominated by *Pseudofurnishius* suggests to more open environment and indicating a fairly good communication with open sea in the unit B. This evidence is supported by the presence of radiolarians in most samples of the unit B. The more frequent abundance of radiolarians in the samples DR 9 and DR 8 also indicates to stronger influence of pelagial at the beginning of the unit B.

The collections also produced clusters of articulated conodont elements of *P. murcianus* (samples DR 2, DR 6, DR 7) (Fig. 7) and *Budurovignathus* sp. (DR 5). Majority of clusters are represented by a small number of fused elements, between 2 and 4, although a few clusters show a great number of elements. Clusters provide information of the structure and distribution of elements in the conodont apparatus and therefore they provide insight into the set of elements that enable apparatus reconstruction. The composition of the multielement species if the two taxa, *Budurovignathus* sp. and *P. murcianus* confirmed the general scheme for the conodont Gondolelloidea family during the Triassic (Orchard, 2005).

5. Discussion

Pseudofurnishius is an important element of the southern Tethys and/or its marginal seas (Kozur, 1993). The occurrence of *P. murcianus* in the southern Tethys is well documented, but the reports outside this area are rare (Fig. 8). On the other hand, genus *Budurovignathus* is cosmopolitan and stratigraphically important for its rapid evolution; its presence together with *Gladigondolella malayensis* and *Paragondolella* sp., however very rare, suggests to more open environment. A good communication with open sea in the unit B is indicated also by the accompanied radiolarians.

In the westernmost Dinarides, *P. murcianus* is abundantly represented in a belt of the Ladinian-Carnian strata that crop out in central Slovenia known from several sections (Kolar-Jurkovšek and Jurkovšek, 2019). This has been confirmed also in the Svilaja section of Croatia where the Triassic strata form the basement of the Adriatic-Dinaric Carbonate Platform (Jelaska et al., 2003). In these sections of the Dinarides a monospecific assemblage of *P. murcianus* has been documented that represents stressful and/or specialized environmental conditions that were unfavourable for other conodont taxa and it probably represents a real biological association as interpreted by Kolar-Jurkovšek et al. (2018).

The species *P. murcianus* was described by van den Boogaard (1966), but it was first documented as an unnamed species by Diebel (1956). The P_1 elements are formed of a blade with denticulated platform on one or both sides (mono-, biplatform types). The taxa belonging to this genus currently comprise the following species: *P. huddlei* van den Boogaard & Simon, *P. murcianus* van den Boogaard, *P. priscus* Saddedin, *P. shagami* Benjamini and Chepstow-Lusty, 1986, *P. siyalensis* Saddedin & Kozur and *P. sosioensis* Gullo & Kozur (Chen et al., 2015). However, due to different views regarding morphologic variation of the named *Pseudofurnishius* species, certain species are regarded as junior synonyms, for instance *P. huddlei* (Plasencia et al., 2015) and therefore their relationships are not yet completely resolved, nor their precise stratigraphic correlation. It should be noted here that *P. huddlei* is regarded a separate species by some authors (Kovács and Kozur, 1980; Chen et al., 2015) and this view is applied also in this study. Furthermore, it also defines the *huddlei* conodont zone (Kozur, 1980; Budurov and Petrunova, 2000) that corresponds to the lower *mungoensis* zone of the standard conodont zonation (Gullo and Kozur, 1991). *P. murcianus* zone in the External Dinarides (Slovenia, Croatia, Bosnia and Herzegovina) ranges from the upper Longobardian (ammonoid zone *Protrachyceras longobardicus*) and lower Cordevolian (ammonoid zone *Daxatina canadensis*) (Kolar-Jurkovšek and Jurkovšek, 2019).

Genus *Budurovignathus* is stratigraphically meaningful due to a rapid evolution and it spans from Fassanian through Cordevolian (Kozur, 1989; Chen et al., 2015). Type species *Budurovignathus mungoensis* was selected to define this genus and full documentation on its ontogenetic stages was previously documented (Bandel and Waksmundzki, 1985; March et al., 1990). Origin of the genus *Budurovignathus* stems out from *Neogondolella aequidentata* Kozur, Krainer & Lutz through *B. hungaricus* (Orchard, 2010). A multielement reconstruction of Triassic Gondolelloidea was provided by Orchard (2005) and it consists of 15 elements (octomembrate apparatus); in the mentioned work the apparatuses of *B. mungoensis* and *Pseudofurnishius murcianus* are presented. On the other hand, there exist also another view on apparatus composition of *Budurovignathus* and *Pseudofurnishius* that is septimembrate (13-element); for example the apparatus based on *B. truempyi* (Bagnoli et al., 1985) was later adopted by Plasencia et al. (2007) and applied on the subfamily level.

According to Chen et al. (2015) nine species are included in a volume of *Budurovignathus* that are: *B. diebeli, B. hungaricus, B. japonicus, B. longobardicus, B. mirautae, B. mostleri, B. mungoensis, B. praehungaricus, B. truempyi*. Moreover, in our opinion also *B. gabriellae* (Kozur et al., 1994) as a transitional form from *Neogondolella* as well as *B. lipoldi* (Ramovš, 1996) should be considered in a volume of budurovignathids; a study on the later species from the type locality section at Slugovo in Slovenia is being in progress in order to confirm its existence. An evolutionary trend

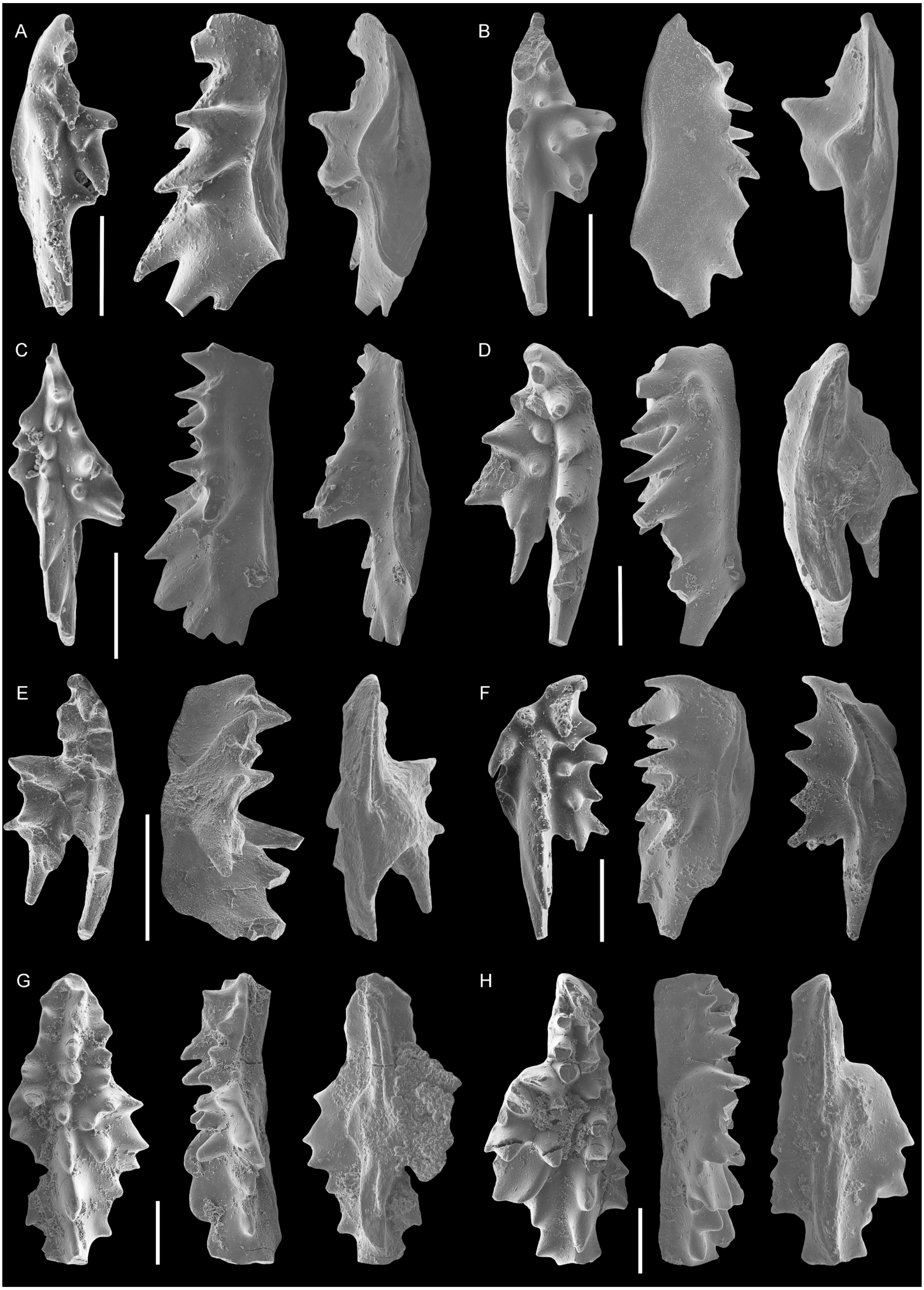

Fig. 5. *Pseudofurnishius* from the Drežnica section shown in upper, lateral and lower view. Scale bar 200 μm. A, B, D, E *Pseudofurnishius murcianus* van den Boogaard: A - sample DR 6, B, E – sample DR 7, D – sample DR 9. C, F – H *Pseudofurnishius huddlei* van den Boogaard: C, F – sample DR 10, G, H – sample DR 9A.

Fig. 6. *Budurovignathus* from the Drežnica section shown in upper and lower view. Scale bar 100 μm. A, B, L *Budurovignathus mungoensis* (Diebel): A, L – sample DR 4, B – sample DR 9. C – J *Budurovignathus* sp.: C, G, I, J – sample DR 5, D, K – sample DR 9, E, F – sample DR 4, H – sample DR 2.

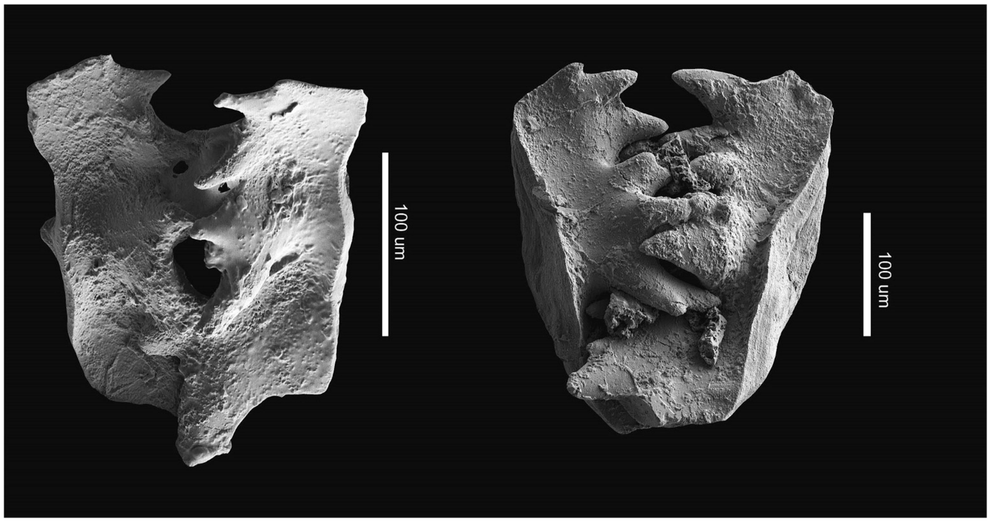

Fig. 7. Cluster of *Pseudofurnishius murcianus* van den Boogaard from the Drežnica section.

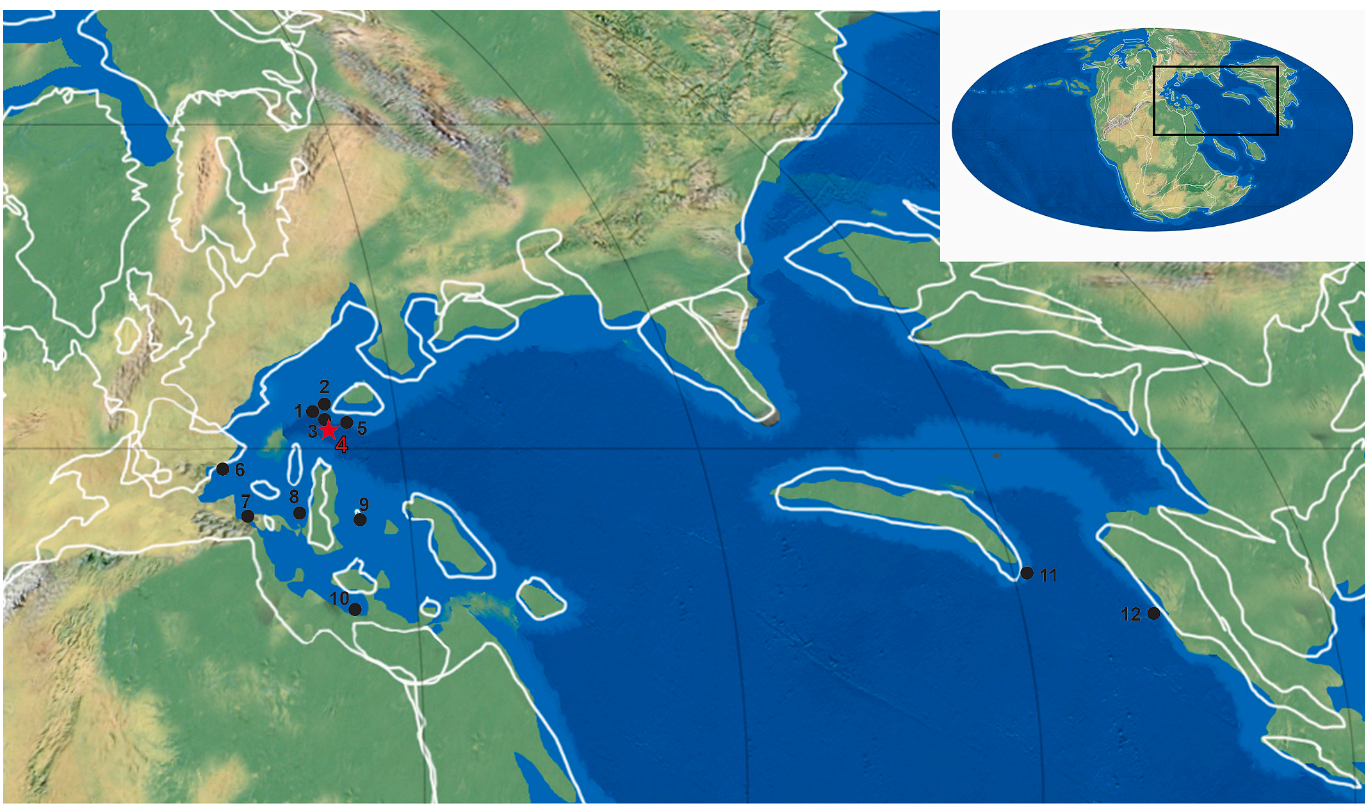

Fig. 8. Paleogeographic distribution of *Pseudofurnishius murcianus* in the Tethys during the Middle Triassic. 1 Italy / Slovenia; 2 Hungary; 3 Croatia, 4 Bosnia and Herzegovina; 5 Romania; 6 Spain, 7 Tunisia; 8 Sicily; 9 Turkey; 10 Israel / Jordan; 11 South China; 12 Malaysia (modified after Plasencia et al., 2015).

of budurovignathids is mainly noted in forward shifting of the basal cavity parallel to changes in platform ornamentation along with different degree of carina bending: the earlier representatives (Fassanian) are marked by slight sigmoidal bending that becomes more pronounced in the Longobardian species, whereas the last representatives in the late Longobardian–Cordevolian interval reveal very weak bending in which the platform tends to become more bilateral symmetric that is confirmed also in our material. In the development of budurovignathids a forward shifting of the pit is obvious and this trend was observed also in some other Middle and Upper Triassic gondolellids (Kozur, 1989; Karádi, 2021). A notion on evolution in different branches before extinction was pointed out by Budurov and Petrunova (2000). Moreover, a subdivision of a basal cavity into two pits connected by a furrow exists both in *Budurovignathus* and *Pseudofurnishius* as offsprings of *Neogondolella* which is a feature of highly evolved gondolellids (Kozur, 1989). Evolution of budurovignathids is not yet fully resolved; the relationship among the Fassanian and Longobardian species is mainly well documented but their relationship with the highly evolved representatives of the Longobardian and Cordevolian is missing. A detailed taxonomic revision with the application of unified criteria should be therefore undertaken in which a great morphologic variability of the genus should be taken into account. The Drežica material evidence a presence of subsymmetric forms and evolution of the forms with shorter and wider platform comparing to earlier budurovignathids with longer and slender platform as well as the presence of extensive keel and it seems to represent an ultimate stage in evolution of this genus.

In the recovered population of budurovignathids a variety of morphotypes with subsymmetric platform or at least a tendency to subsymmetric shape are present. Some of them reveal a prolonged and uniform keel behind the pit probably represent forms within highly variable *B. mungoensis*. On the other hand the material consists also of some other specimens that show tendency to bilateral symmetry, and feature very wide keel that occupies greater part of the lower surface and they seem to reveal radiate development in budurovignathids. Due to inadequate material a detailed taxonomic study of these specimens has not been done and are therefore attributed to *Budurovignathus* sp.

6. Conclusions

The Triassic strata of the Drežnica section in Bosnia and Herzegovina were studied sedimentologically and biostratigraphically by means of conodonts. The Ladinian–?Carnian (Longobardian–?Cordevolian) bedded limestone of the units A and B evidence the conodont fauna with the predominating *Pseudofurnishius murcianus* and good representation of *Budurovignathus* in the upper part of the section with a noted presence of radiolarians, includes also a several clusters of both genera of excellent preservation.

Interpretation of the depositional environment based on petrographic sediment features is provided. The Drežnica section represents a continuous deposition of limestone and dolostone (occassionaly strongly silicified) in an overall deep pelagic conditions. The deposition of limestone and dolostone that consists dominantly of thinshell bivalves and ostracods (unit A) indicate deep marine conditions. The deepening in the already pelagic environment occurred during deposition of the unit B (enriched in radiolaria) and may be interpreted as prolonged subsiding of some blocks due to rift-type tectonics and the extension of the Tethys.

A conodont fauna consists of *Budurovignathus diebeli, B. mungoensis, Budurovignathus* sp., *Gladigondolella malayensis, Paragondolella* sp., *Pseudofurnishius huddlei* and *Pseudofurnishius murcianus*. Within the stratigraphic range of *Pseudofurnishius* population a mono- and biplatform types occur and this morphological difference exhibits its use for geology of the region that enables to distinguish the *huddlei* (lower Longobardian) and *murcianus* (upper Longobardian–?Cordevolian) Zones as well as more precise age determination of the investigated strata. A recovery of *Budurovignathus* with representatition of variety of morphotypes demonstrates great potential for phylogenetic study of this genus prior its extinction.

The introduced conodont biozonation in the Drežnica section is for the first time proposed for the region and it enables correlation with the hitherto studied sections in the Dinarides (Slovenia, Croatia) as well as other equivalent sequences in the western Tethys. The results contribute to the composition of the faunas with *Pseudofurnishius* together with its geographic distribution. The acquired data are a valuable source of paleontological evidence that provide an important contribution for better definition of the environment during the Ladinian–early Carnian times. The Drežnica section is defined as an important fossil locality that manifests significant prospect for the finding of new complete conodont clusters and because of the relevance, this geological profile is proposed for admission to the Natural Heritage Registry of the state's significance.

CRediT authorship contribution statement

Tea Kolar-Jurkovšek: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Resources, Data curation, Writing – original draft, Writing – review & editing, Visualization, Supervision, Project administration, Funding acquisition. **Carlos Martínez-Pêrez:** Conceptualization, Methodology, Investigation, Writing – original draft, Writing – review & editing. **Hazim Hrvatović:** Conceptualization, Methodology, Validation, Investigation, Resources, Data curation, Writing – original draft, Writing – review & editing. **Dunja Aljinović:** Methodology, Validation, Formal analysis, Investigation, Data curation, Writing – original draft, Writing – review & editing. **Špela Goričan:** Methodology, Validation, Formal analysis, Investigation, Data curation, Writing – original draft, Writing – review & editing. **Ferid Skopljak:** Validation, Investigation, Writing – original draft, Writing – review & editing. **Bogdan Jurkovšek:** Conceptualization, Validation, Investigation, Writing – original draft, Writing – review & editing.

Declaration of Competing Interest

There are no actual or perceived conflicts of interests for the authors regarding this publication.

Data availability

Data will be made available on request.

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