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Late Permian conodonts from Jadar Block (Vardar Zone, northwestern Serbia)

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Abstract: Conodonts of the *Hindeodus typicalis* group belonging to the Lower *praeparvus* Zone (Changhsingian), are found in the Permian–Triassic boundary interval in the Komirić section of the Jadar Block (Vardar Zone, NW Serbia). It is the first record of Late Permian conodonts from Serbia, that is from the central part of the Balkan Peninsula. A breccia, representing the tectonic contact between the "Bituminous Limestone" and the Svileuva Formations is found for the first time in NW Serbia.

Key words: Late Permian, Changhsingian, P–T interval, NW Serbia, Vardar Zone, biostratigraphy, conodonts.

Introduction

Permian and Triassic sediments are widespread in the Jadar Block of NW Serbia and they have been intensively studied. The shallow water marine carbonates of this block around the Permian-Triassic boundary in NW Serbia with different fossil associations, but lacking in ammonoids, are the only such carbonates in Serbia. However, diverse Late Permian macro- and micro-biocenoses (brachiopods, bivalves, gastropods, algae, foraminifers), as well as rather poor Early Triassic microfossil associations (foraminifers, ostracods) have been reviewed (Pantić-Prodanović & Radošević 1981; Pešić et al. 1988; Pantić-Prodanović 1989/90, 1994, 1996, etc.). These authors analysed relations across the Permian-Triassic (P-T) boundary in NW Serbia and concluded that there was continuity of the sequence.

The aim of this study was to confirm the presence of conodonts around the P–T interval beds of the Komirić section. It represents the first phase of an ongoing geological study of the NW Serbia that will include precise lithostratigraphic definition and documentation of other paleontological and biostratigraphic data.

Geological setting

The Jadar Block is located at the southern margin of the Pannonian Basin. It extends westward over the Drina River to eastern Bosnia (Fig. 1A).

The Jadar Block, as an exotic terrane was placed into the Vardar Zone before the Late Cretaceous. It is surrounded by the Vardar Zone Western Belt, except in the farthest southeastern part where it is in direct contact with the Kopaonik Block and Ridge Unit (Fig. 1A). The Jadar Block differs from the Vardar Zone Western Belt in lacking post-Liassic sediments, as well as in the absence of ultramafites, ophiolitic mélange, and Cretaceous flysch development (Filipović et al. 2003). It is characterized by: marine Carboniferous and Permian with shallow marine carbonates in the Late Permian and the earliest Triassic, Anisian dolomites, Ladinian "porphyrites" and pyroclastics, and Middle and Late Triassic platform-reefal limestones with gradual transition into Liassic limestone.

There are obvious similarities with coeval successions of the Carnic Alps, as well as with the "Bükkium" and Sana-Una Terranes (Protić et al. 2000; Filipović et al. 2003).

Komirić section

The Komirić section on the southern slopes of the Vlašić Mt, on the right side of the Valjevo-Loznica road SE of Komirić village (Fig. 1) was referred to in previous micropaleontological and sedimentological investigations as the Panića Cave section (Pantić-Prodanović 1996). In the same paper the transition between the Upper Permian and Lower Triassic deposits was assumed to be continuous. About 78 m of marine Upper Permian and Lower Triassic carbonates are exposed in the Komirić section. For the study presented herein, the lower part of the column (19 m thick) was investigated and sampled for conodonts (Fig. 2).

"Bituminous Limestone" Formation

The sediments of this formation, equivalent to the Badiota facies of the Bellerophon Formation of the Southern Alps, and the Nagyvisnyó Limestone Formation of the Bükk Mts, NE Hungary, represent the lowest 7 m of the column (Fig. 2). It consists of dark grey and black, massive to thick-bedded bituminous bioclastic limestones (wackestones, packstones) with abundant foraminifers, algae, os-

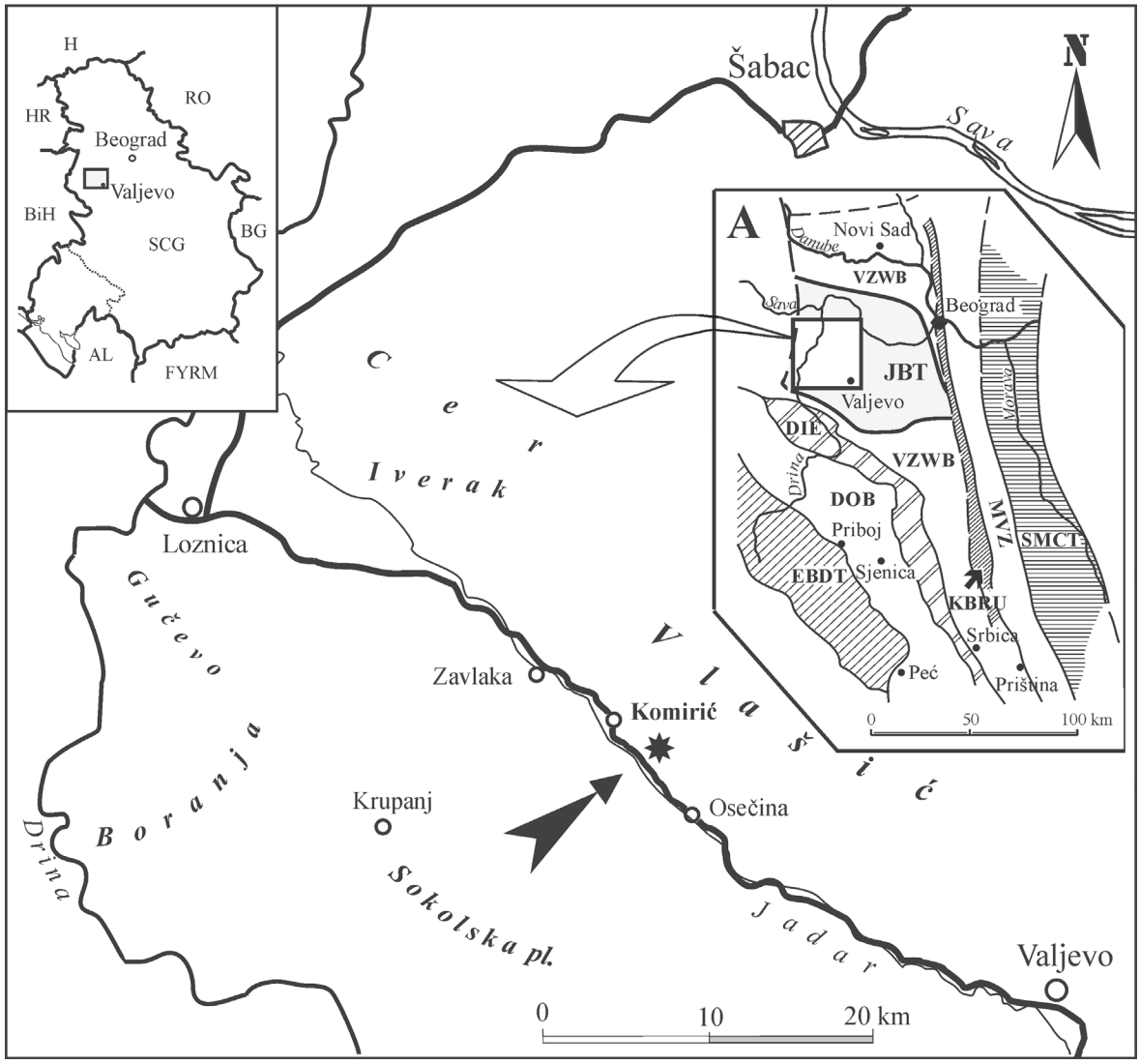

Fig. 1. Location of the Komirić section, NW Serbia. **A** — Terranes of part of the Balkan Peninsula (Karamata et al. 2000): SMCT — Serbian–Macedonian Composite Terrane; MVZ — Main Vardar Zone; KBRU — Kopaonik Block and Ridge Unit; VZWB — Vardar Zone Western Belt; JBT — Jadar Block Terrane; DIE — Drina-Ivanjica Element; DOB — Dinaridic Ophiolite Belt; EBDT — East Bosnian-Durmitor Terrane.

tracods, holothurian sclerites, crinoids, echinoids, brachiopods, gastropods and ophiuroids. Only samples MS 1203/2, 1203/3, 1203/4 and 1180 from the middle part of the first 4.5 m of limestones produced conodonts: *Ellisonia* sp., *Hindeodus praeparvus*, *H. typicalis*, *H.* cf. *latidentatus*, and *Hindeodus* sp. (Table 1).

Table 1: Numerical distribution of conodonts in the Komirić section.

		1180	1203/2	1203/3	1203/4
Ellisonia sp.	Pb				1
	M				2
	Sc				5
H. praeparvus	Pa	1	1		4
H. typicalis	Pa				1
H. cf. *latidentatus*	Pa				2
Hindeodus sp.	Pa		1		4
indet. fragm.				2	

A hypothesized fault, which may reflect later tectonic movements, follows with 15 cm of breccia (Fig. 2). It means that the sequence across the P-T boundary could not be continuous as it was traditionally believed for many places in NW Serbia, including the Komirić section. We suppose that the missing interval of the uppermost part of the "Bituminous Limestone" Formation (together with the "boundary shale") is included in this tectonic part of the Komirić section. This conclusion derives from the observed great similarity to the P-T sections of the Bükk Mts, NE Hungary, particularly to the lithological succession in the composite Bálvány section (Bálvány-North and Bálvány-East; Haas et al. 2004; Pelikán 2005; cf. Filipović et al. 2003).

Svileuva Formation

In this paper we present only the first 12 m of the lower part of the thick- to thin-bedded light grey and grey fine

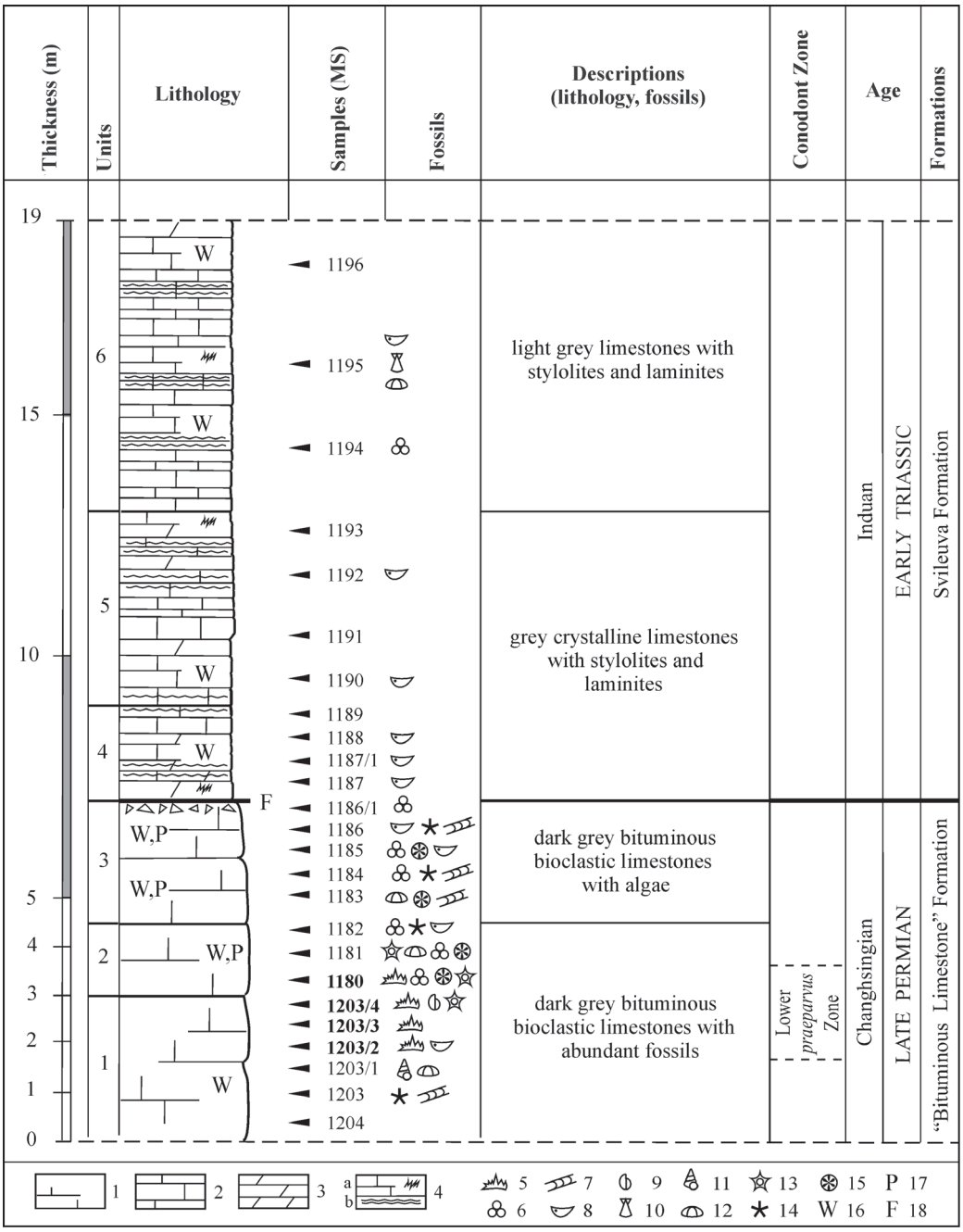

Fig. 2. Geological column of the Upper Permian and Lower Triassic sediments of the Komirić section in NW Serbia (Jadar Block, Vardar Zone). **1** — massive to thick-bedded limestones; **2** — thick- to thin-bedded limestones; **3** — dolomitic limestones; **4a** — limestones with stylolites; **4b** — laminated limestones; **5** — conodonts; **6** — foraminifers; **7** — algae; **8** — ostracods; **9** — brachiopods; **10** — bivalves; **11** — gastropods; **12** — echinoids; **13** — crinoids; **14** — ophiuroids; **15** — holothurian sclerites; **16** — wackestones; **17** — packstones; **18** — fault.

crystalline limestones (wackestones) of the Svileuva Formation; these are laminated and stylolitic in some levels (Fig. 2). Dolomitic limestones are less frequent. All the above mentioned limestones contain rare ostracods, foraminifers and echinoids but no conodonts were found. The analysed interval was referred to the Svileuva Formation (equivalent to the Tesero and Mazzin Members of the Werfen Formation of the Southern Alps, and to the Gerennavár Limestone Formation from the Bükk Mts, NE Hungary), according to its superposition and preliminary facial investigations, as well as results obtained previously (Pantić-Prodanović 1996; Filipović et al. 2003).

Conodont fauna

Thirty-three limestone samples were acid-leached in quest of conodonts; only four samples were productive.

Thin sections were also prepared. The Colour Alteration Index (CAI values) of the identified conodonts is 3–3.5 (*sensu* Epstein et al. 1977). The distribution of other faunal elements is shown in Fig. 2.

SEM photographs were prepared at the Institute of Biology, University of Ljubljana, and at the Ivan Rakovec Institute of Paleontology ZRC SAZU, also in Ljubljana, Slovenia. Illustrated specimens and thin sections are deposited at the Department of Paleontology, Faculty of Mining and Geology, University of Belgrade, Belgrade, Serbia, under numbers MS 1180–1196 and 1203–1203/4, 1204 (Fig. 2).

Conodont dating

Conodonts from the Komirić section include *Ellisonia* sp., *Hindeodus praeparvus* Kozur, *Hi. typicalis* (Sweet), *Hi.* cf. *latidentatus* (Kozur, Mostler et Rahimi-Yazd), and *Hindeodus* sp. Except for *Ellisonia*, they belong to the *Hindeodus typicalis* group of the *Hindeodus-Isarcicella* lineage, of prime importance for biostratigraphy of the Permian-Triassic transition. The absence of gondolellids is noteworthy.

Hindeodids were favoured for defining the base of the Triassic System (Yin 1993; Yin et al. 1996). Nevertheless, the determined taxa from the Komirić section do not allow the identification of the Triassic base because of absence of the marker *H. parvus*. *H. praeparvus* is a widely distributed species ranging in the latest Changhsingian, but it is also rarely present in the earliest Triassic (Kozur 1996; Perri & Farabegoli 2003). In the Southern Alps, *H. praeparvus* and *H. typicalis* have been recorded in the both *praeparvus* (Late Permian) and *parvus* (Early Triassic) Zones (Perri & Farabegoli 2003). Recently Kozur (2004) reported *H. praeparvus* as extending from the latest Permian *C. meishanensis–H. praeparvus* (or *H. praeparvus)* Zone to the Early Triassic Lower *I. isarcica* Zone. The Changhsingian occurrences of *H. latidentatus* are well documented in central Asia and India (Kozur 1996; Orchard & Krystyn 1998), but in China, it ranges the *praeparvus* through the *isarcica* Zone (latest Permian–earliest Triassic) according to Nicoll et al. (2002).

Yin's (1993) suggestion to use the first appearance datum (FAD) of *H. parvus* to define the lower limit of the Triassic System (i.e. the Paleozoic-Mesozoic boundary) was subsequently ratified with the Global Stratotype Section and Point (GSSP) for the Permian-Triassic boundary being specified in the Meishan D section, China (Yin et al. 2001). Unfortunately, *H. parvus* is not present in the Komirić section so it is not possible to define the P-T boundary there.

There has been no evidence of *Isarcicella* in the studied section. *Isarcicella* is the typical earliest Triassic genus, but it makes its first appearance already in the latest Permian (Upper *praeparvus* Zone) (Perri & Farabegoli 2003).

Considering all the above presented conodont data, the middle part of the uppermost "Bituminous Limestone" Formation in the Komirić section is referred to the Lower *praeparvus* Zone of the Changhsingian (Perri & Farabegoli 2003). It is the first record of an Late Permian conodont fauna from Serbia, that is from central part of the Balkan Peninsula.

Comparison of conodont faunas of adjacent areas

Ammonoid-free shallow water marine sediments are widely distributed near the P-T boundary. Conodont faunas from the Southern Alps (Italy, Austria) and Hungary (Bükk Mts) consist of *Hindeodus–Isarcicella* populations devoid of gondolellids. According to Orchard (1996), *Hindeodus* flourished in nearshore, shallow warmer regions, contrasting with gondolellids more common in offshore, deeper, cooler water marine environments. It is shown that due to very high facies or ecological tolerance the *H. typicalis* group occurred in shallow subtidal- to intratidal deposits, in cold water and/or warm water and is therefore suited for defining the P-T boundary.

Results presented by Perri & Farabegoli (2003) for the uppermost Bellerophon Formation and lower Werfen Formation (Tesero and Mazzin Members), are important for making correlation with conodont faunas from the Komirić section. These consist mainly of hindeodids and isarcicellids showing gradual morphological change up-section enabling establishment of four new species and seven conodont biozones in the interval between the latest Permian and earliest Triassic.

For the P–T boundary interval of the Southern Alps, the paper of Schönlaub (1991) who presented the earliest Triassic conodonts from the Werfen Formation in the Carnic Alps (Austria) should also be mentioned. On the basis of his results, mostly from the presence of *H. parvus*, *H. turgidus* and *I. isarcica*, five distinct assemblages were discriminated.

P-T marine boundary sections are known in Hungary, in the Bükk Mts and northeastern part of the Transdanubian Range. New data important for defining the P–T boundary interval by conodonts, and other co-occurring rich macro- and microassociation, was studied in certain P-T sections (Bálvány-North, Bálvány-East, Gerennavár, Kemesnye Hill, etc.) (Haas et al. 2004). Several conodont taxa from the Upper *praeparvus* Zone in the upper Changhsingian Nagyvisnyó Limestone Formation (Bálvány-North and Gerennavár sections) and from the *parvus* Zone in the Lower Induan Gerennavár Limestone Formation (Bálvány-East, Bálvány-North and Gerennavár sections) have been collected (Sudar et al. in print).

During the last few decades, conodont study of the P–T interval and Early Triassic has been intensified in many regions of the world, as well as in the Balkan Peninsula, where only Early Triassic conodonts have been found until now.

Early Triassic (Olenekian) conodonts have been identified in the Gučevo Mt (NW Serbia). The conodonts from this area of the Jadar Block were dated as "Campilian" (Pantić 1971; Urošević & Sudar 1980), or were assigned to the *costatus* and *gardenae* Zones of the same age (Budurov & Pantić 1973, 1974) or to the Smithian *Parachirognathus–Furnishius* Zone and Spathian *triangularis–homeri* Concurrent-range Zone (Sudar 1986).

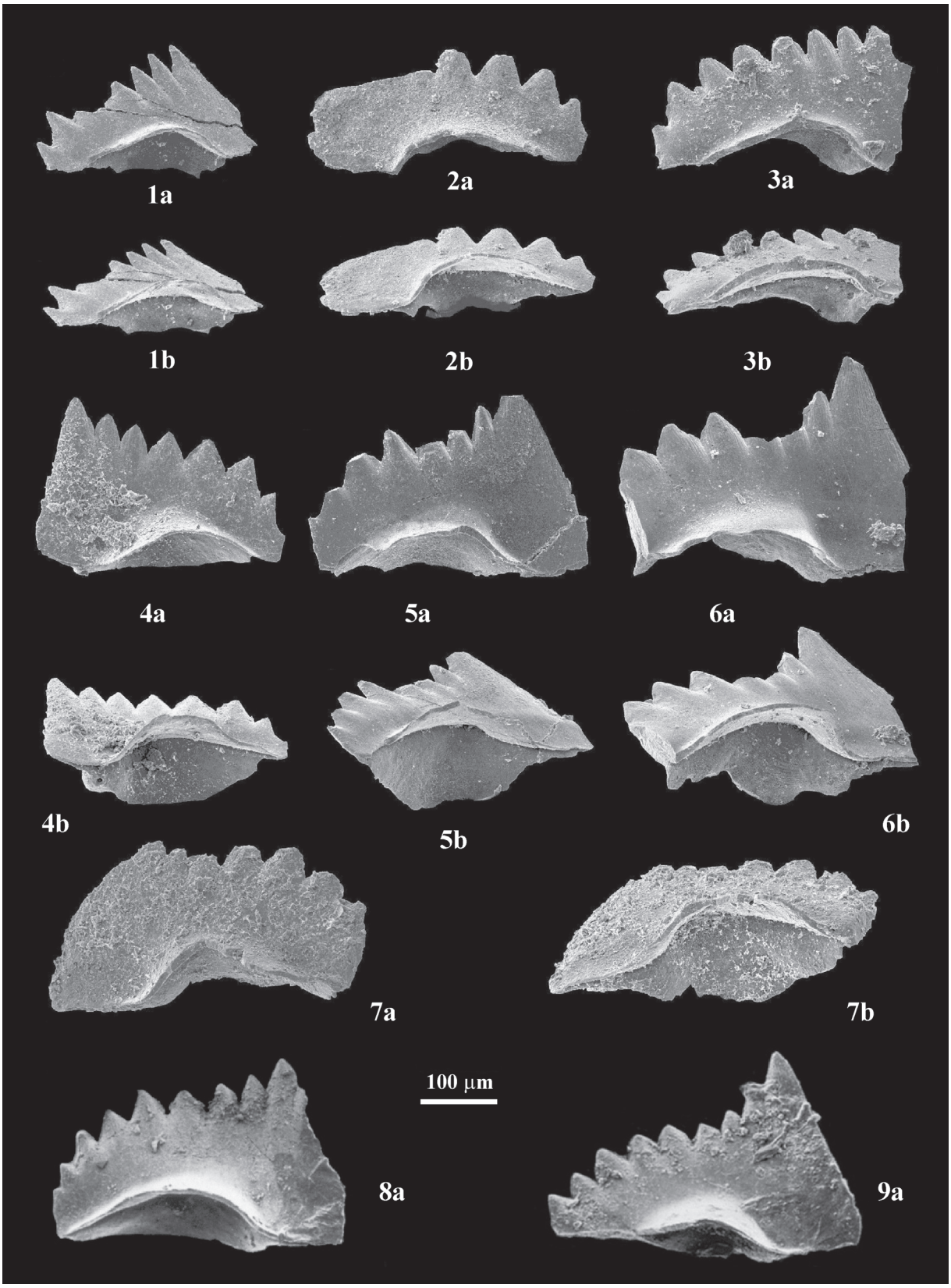

Fig. 3. Conodonts from the Late Permian, Changhsingian, Lower *praeparvus* Zone; "Bituminous Limestone" Formation; Komirić, Jadar Block, Vardar Zone, NW Serbia. **1, 4–6, 8a, 9a** — *Hindeodus praeparvus* Kozur, 1996. **2, 3** — *Hindeodus* cf. *latidentatus* (Kozur, Mostler et Rahimi-Yazd, 1975). **7** — *Hindeodus* sp. 1–7 — sample MS 1203/4, 8a — sample MS 1180, 9a — sample MS 1203/2. **a** — lateral views, **b** — lower-oblique views.

Early Triassic conodont fauna from Slovenia (Želin-Vrlejca, Iška and Draga Valleys, Tržič, Tehovec) and Croatia (Svilaja) were mainly attributed to the Smithian *Parachirognathus–Furnishius (*Zone 7) or *obliqua* Zones and to the Spathian *triangularis* Zone (Herak et al. 1983; Kolar-Jurkovšek & Jurkovšek 1995, 2001; Jelaska et al. 2003).

Representatives of *Hindeodus* were recently described from the Outer Dinarides. In Croatia, lithostratigraphic and biostratigraphic studies of the Lower Triassic shallow marine succession in the Gorski Kotar region were undertaken; *H. parvus* occurs in the Školski Brijeg section and was recorded from the lower part of the basal, dolomitized, oolitic bar facies (F-1) (Aljinović et al. 2006).

In the Outer Dinarides of the western Slovenia, the Permian–Triassic interval is indicated by a rich *Hindeodus–Isarcicella* population. *H. parvus* was also identified and its first occurrence indicates the base of the Triassic System in the lowermost Werfen Formation of the Idrija-Žiri area. The determined taxa *H. parvus*, *H. typicalis, Hindeodus* sp., *I. isarcica*, *I. lobata*, *I. staeschei*, *I. turgida* and *Isarcicella* sp. A enable recognition of at least three faunas that provide a basis for worldwide correlation (Kolar-Jurkovšek & Jurkovšek 2007).

Comments on conodont taxa

Ellisonia sp.

Some Pb (digyrate), M (digyrate) and Sc (bipennate) elements of the multielement *Ellisonia* Sweet's (1970) model were recovered. Specific discrimination of *Ellisonia* requires white matter. The relatively high CAI, as well as fragmentary preservation of the material from the Komirić section does not help in this regard. The collected elements display similar denticulation: the upper edge of lateral processes has a set of small, needlelike denticles as in *E. teicherti* Sweet.

Hindeodus praeparvus Kozur, 1996
(Fig. 3.1,4–6,8–9)

Kozur (1996) distinguished two subspecies, *H. latidentatus latidentatus* and *H. latidentatus praeparvus* discriminated mainly by the profile of the posterior end, with the posterior denticles being widely separated by U-shaped spaces in *H. latidentatus latidentatus*, but in *H. latidentatus praeparvus* more densely arranged with V-shaped spaces. This characteristic feature has been noted in material from Spiti (Orchard & Krystyn 1998) who elevated the two subspecies to the species-level; this has been accepted by numerous authors (Nicoll et al. 2002; Perri & Farabegoli 2003; Kozur 2004). Two morphotypes can be observed in *H. praeparvus* based on the profile of the posterior end: morphotype 1 with an abrupt and morphotype 2 with a denticulate posterior end (Perri & Farabegoli 2003). In the material from the Komirić section only elements with a denticulate posterior end (morphotype 2) can be observed; they compare well with certain specimens from the Southern Alps (Perri & Farabegoli 2003: pl. 2, figs. 25, 33).

Hindeodus typicalis (Sweet, 1970)

A single specimen of medium size fits description of this species. The height of blade increases gradually toward the cusp. The latter is only slightly stronger than other denticles.

Hindeodus cf. *latidentatus*
(Kozur, Mostler et Rahimi-Yazd, 1975)
(Fig. 3.2,3)

Specimens from the Komirić section do not show the main characteristic. The posterior end is denticulate but the U-shaped space is only indicated in some elements. Here separated elements are rather low blades with markedly looser denticulation as well as long basal cavity. Similar specimens were presented in the material from Spiti (Orchard & Krystyn 1998: pl. 6, figs. 27, 28) and South China (Nicoll et al. 2002: fig. 13–1a–f).

Hindeodus sp.
(Fig. 3.7)

Few incompletely preserved specimens. A figured specimen (Fig. 3.7) lacks a cusp as well as tips of the denticles. The profile of the blade is similar to the specimens of *H. praeparvus* as the posterior denticles are wider but the anterior are more closely spaced. The specimen also shows certain similarity to *H. typicalis* of Orchard & Krystyn (1998: pl. 6, fig. 19) but has fewer denticles. In our opinion specimen illustrated here stands closer to *H. praeparvus* due to the shape and size of cup.

Conclusions

In the initial phase of biostratigraphic investigations conducted in the Permian–Triassic boundary interval of the Komirić section in the Jadar Block (Vardar Zone, NW Serbia) some conclusions can be reached.

1. Conodonts of the Lower *praeparvus* Zone (Changhsingian, Late Permian) were found for the first time in the area, as well as in Serbia and in central part of the Balkan Peninsula. The following conodont taxa are present: *Ellisonia* sp., *H. praeparvus* Kozur, *H. typicalis* (Sweet), *H.* cf. *latidentatus* (Kozur, Mostler et Rahimi-Yazd), and *Hindeodus* sp. The collected conodonts, except *Ellisonia*, belong to the *H. typicalis* group, representatives of the *Hindeodus–Isarcicella* population. This conodont group is widely distributed in ammonoid-free shallow water marine sediments near the P-T boundary from all marine sequences of the western Tethys, in many parts of Asia, in western North America, in the Southern Alps (Italy, Austria), in Hungary (Bükk Mts), etc. Absence of gondolellids is noteworthy. Present finding of conodonts in NW Serbia gives a possibility to make biostratigraphic correlation of this area with other localities of the western Tethys, especially with the territory of the Southern Alps and Hungary.

2. Tectonic disturbance (breccia of tectonic origin) between the "Bituminous Limestone" and Svileuva Formations is noticed in the Komirić section. This is also new information from NW Serbia, because the transition from Upper Permian to Lower Triassic deposits has been interpreted exclusively as continuous until now. Further investigations conducted in other parts of NW Serbia will probably explain whether this tectonic interval is a local phenomenon or it is present in other localities across the P-T boundary beds as well.

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