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Lower Triassic (Olenekian) microfauna from Jadar Block (Gučevo Mt., NW Serbia)

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Abstract. Systematic study of microfossil associations on the Krivi Potok section (Gučevo Mt. area, NW Serbia) has been carried out to document and to refine the Lower Triassic stratigraphic correlations within Alpine-Mediterranean domain. Field investigation and laboratory process have enabled the identification of lowermost Olenekian (lower Smithian) conodonts, ostracodes and pyrite framboids. Two conodont zones are established in this region, in ascending order they are: *Pachycladina obliqua–Foliella gardenae* Assemblage Zone and *Neospathodus planus* Zone. A new ostracode species *Paracypris* ? *krivipotokensis* Forel n. sp. has been described, it co-occurs with conodont *Neospathodus planus* within the Zone of the same name. The pyrite framboids were formed within the ostracode carapaces after their death. The size distribution of pyrite framboids supports the former suggestion that large size (>6 μm in diameter) is not suitable for the reconstruction of seawater redox conditions.

Key words: Lower Triassic, Olenekian, conodonts, ostracodes, pyrite framboids, Jadar Block, Northwestern Serbia.

Апстракт. Систематско изучавање микрофосила профила Криви поток у области планине Гучево спроведено је ради документовања асоцијација и утврђивања детаљнијих доњотријаских стратиграфских односа у северозападној Србији, а у циљу корелација у оквиру Алпско-медитеранског региона. Након детаљног теренског рада и лабораторијских обрада узоркованог материјала, омогућена је идентификација старости конодоната, остракода и пиритских фрамбоида и добијен је најнижи олењок (доњи смит). У испитиваној области утврђене су две конодонтске зоне, *Pachycladina obliqua–Foliella gardenae* Assemblage Zone и *Neospathodus planus* Zone. Такође је описана нова остракодска врста *Paracypris* ? *krivipotokensis* Forel n. sp., која се појављује удружена са врстом *Neospathodus planus* у истоименој конодонтској зони. Присутни пиритски фрамбоиди су настали унутар остракодских љуштура после њиховог изумирања, а како су пречника већег од 6 μm потврђена је ранија сугестија да због тога нису били погодни за реконструкцију оксидо-редукционих услова у морској води.

Кључне речи: доњи тријас, олењок, конодонти, остракоди, пиритски фрамбоиди, Јадарски блок, северозападна Србија.

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Introduction

The Lower Triassic sediments are widespread in the Jadar Block of Northwestern Serbia. Together with the Upper Permian rocks and the Permian–Triassic boundary interval, they have been intensively studied especially because represent the only such formations of this age in Serbia. Generally, the Upper Permian sediments contain diverse macro- and micro-biocenoses, whereas the Lower Triassic microfossil associations are rather poor.

Gučevo Mt. is situated in the north-western part of the Jadar Block, on the eastern side of the Drina River and southern of the Loznica town (Fig. 1). It is predominantly built of Lower Triassic sediments, which the Serbian authors mostly divided in the older „Seisian” and the younger „Campilian” beds. After repeated numerous field investigations of this area, authors of the paper intended to document new geological data to refine existing stratigraphic and lithostratigraphic definitions.

Therefore, the aim of this paper was to confirm the presence of different microfossils (conodonts, foraminifera, ostracodes, etc.) and biostratigraphic data within the Lower Triassic sediments of the Jadar Block, NW Serbia. It represents the continuation of the ongoing geological study, started in 2005 year with micropaleontological/sedimentological investigations in P–T boundary interval of NW Serbia (SUDAR *et al.* 2007, NESTELL *et al.* 2009, CRASQUIN *et al.* 2010).

Geological settings

Geographically, the Jadar Block, is located at the southern margin of the Pannonian Basin, and belongs to the central part of the Balkan Peninsula. It occupied great parts of the northwestern Serbia, southern Srem (Vojvodina) and extends partly westward over the Drina River into eastern Bosnia (Fig. 1).

This tectonostratigraphic unit is today an exotic block, which was placed into the Vardar Zone before the late Cretaceous. It is surrounded by the Vardar Zone Western Belt, except on the farthest south-eastern part where it is in direct contact with the Kopaonik Block and the Ridge Unit (Fig. 1). 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).

In this area, the deposition occurred during the Variscan and Early Alpine evolution with a predomination of Dinaridic features. The later tectonic stage is characterized by sedimentation of Upper Permian and lowermost Triassic shallow-water marine carbonates, dolomites of the Anisian age, „porphyrites” and pyroclastics of Ladinian age, platform-reefal limestones of Middle and Late Triassic age and their gradual transition into Lower Jurassic limestones.

In the Jadar Block the Upper Permian is represented by the „Bituminous Limestone“ Formation and the Lower Triassic by the Svileuva and Obnica formations (FILIPOVIĆ *et al.* 2003).

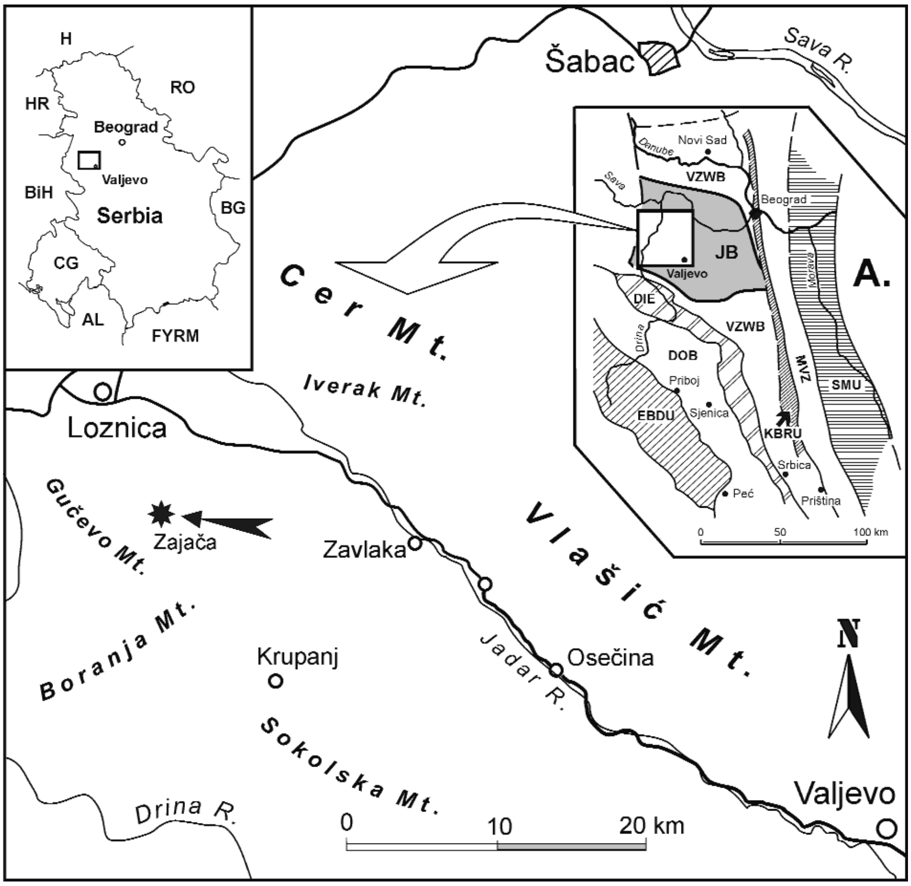

Fig. 1. Location map of the Krivi Potok section (asterisk) on the Gučevo Mt. (Jadar Block, NW Serbia) (modified after SUDAR *et al.* 2007). **A.** Terranes of a part of the Balkan Peninsula (KARAMATA *et al.* 2000; KARAMATA 2006): **SMU,** Serbian-Macedonian Unit; **MVZ,** Main Vardar Zone; **KBRU,** Kopaonik Block and the Ridge Unit; **VZWB,** Vardar Zone Western Belt; **JB,** Jadar Block; **DIE,** Drina–Ivanjica Element; **DOB,** Dinaridic Ophiolite Belt and **EBDU,** East Bosnian-Durmitor Unit.

Krivi Potok section

On the central parts and on the eastern slopes of the Gučevo Mt. there are mostly exposed

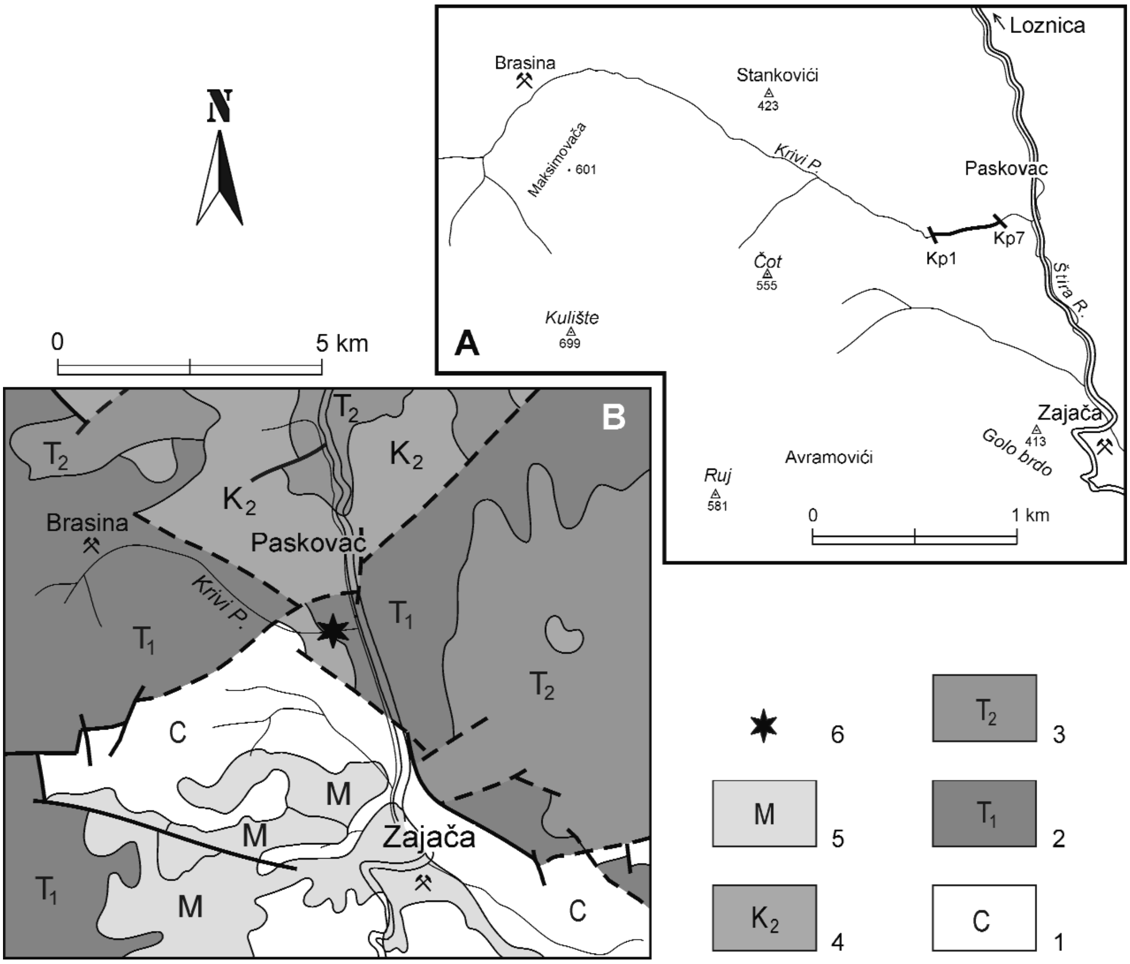

Fig. 2. Geographic position of the studied section on the eastern slopes of the Gučevo Mt. (**A**) simplified and modified geological map after MOJSILOVIĆ *et al*. 1975 of the same areas (**B**). Legend: **1,** Carboniferous rocks; **2,** Lower Triassic sediments; **3,** Middle Triassic rocks; **4,** Upper Cretaceous sediments; **5,** Miocene dacites, andesites and pyroclastics; **6,** Location of the Krivi Potok section.

grey thin bedded to bedded limestones, in alteration with siltstones and sandstones of the upper Lower Triassic Obnica Formation (FILIPOVIĆ *et al.* 2003) generally thick about 200–350 m (MOJSILOVIĆ *et al.* 1975). These sediments, especially in surroundings of the old mine Brasina and in the source part of the stream Krivi Potok, were frequently micropaleontologically and sedimentologically investigated in the previous years (PANTIĆ 1971; BUDUROV & PANTIĆ 1973, 1974; UROŠEVIĆ & SUDAR 1980; PANTIĆ-PRODANOVIĆ & RADOŠEVIĆ 1981; SUDAR 1986, etc.).

In the Krivi Potok section, for the study presented herein, was investigated and sampled for microfauna only 11 m thick rock section near to the mouth of this stream in the rivulet Štira and on the northern side of the Loznica–Zajača road (N 19°14’13.8”, E 44°28’9.8”; figs. 1, 2). The field researches were undertaken in 2010 (samples SRB-1 and SRB-2) and 2012 (samples Kp1 – Kp7) years. The section (Fig. 3) consists of:

- Unit 1, bedded bioturbated limestones, 70 cm thick only with conodonts;
- Unit 2, bedded, sandy, ferruginous ooidal grainstone, 1 m thick, and only with conodonts;
- Unit 3, bioturbated micrites 30 cm thick with conodonts;
- Unit 4, *ca.* 5.5 m thick can be separated into the lower (4a) and upper part (4b) with covered part between. The lower part of this first entity of subunit 4a (*ca.* 3 m) is built of thick bedded limestones (beds are mostly 25 cm thick). Than, last 1 m is consisted of thin bedded laminated limestones (beds are less than 5 cm thick). Here in the subunit 4a are present abundant conodont and ostracode microfaunas, pyrite framboids (especially in sample SRB-1) and rare foraminifera.
  After covered 6 m, also to the same unit (subunit 4b) belongs 1.5 m thick part, mostly made of change of red and grey siltstones and sandstones, but in the upper part also contains sandy, ferruginous wackestone-packstone with one characteristic 20 cm thick bed of ooidal dolomitic limestones. Ooids are rare, sometimes filled with dolomite.

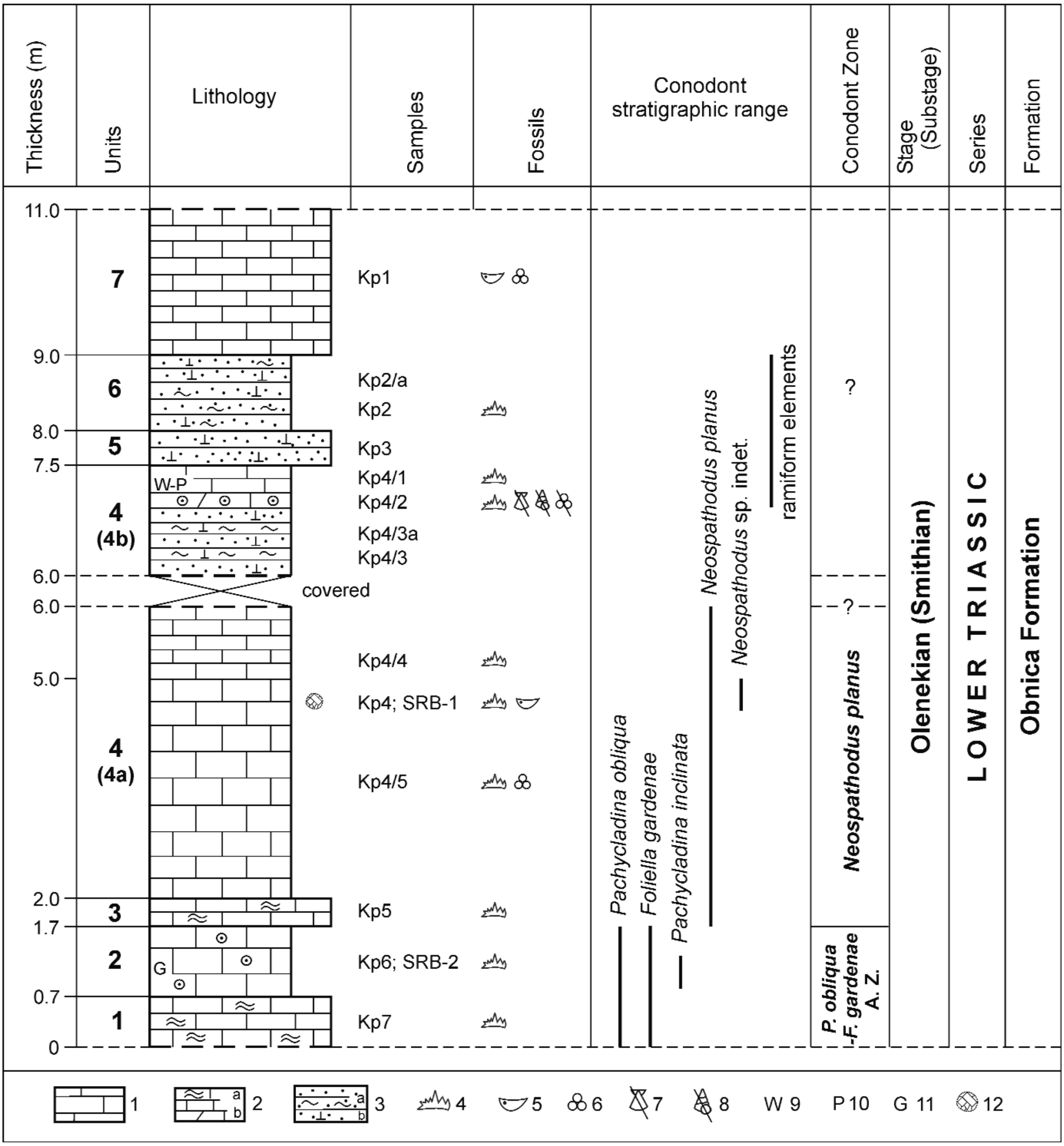

Fig. 3. Geological column, conodont stratigraphic ranges and zones of the Lower Triassic (Olenekian, Smithian) sediments in the Krivi Potok section on the Gučevo Mt. (Jadar Block, NW Serbia). Legend. **1,** thin to thick-bedded limestones; **2,** bioturbated (**a**) and dolomitic (**b**) limestones; **3,** bedded quartz sandstones, silty (**a**) and calcareous (**b**); **4,** conodonts; **5,** ostracodes; **6,** foraminifera; **7,** detritus of bivalves; **8,** detritus of gastropods; **9,** wackestone; **10,** packstone; **11,** grainstone; **12,** pyrite framboids.

Beside conodonts, detritus of bivalves, gastropods, and foraminifera, also fine quartz grains and dispersed ferruginous matter characterize bed.

- Unit 5, quartz sandstones thick 0.5 m;
- Unit 6, thin bedded micaceous quartz sandstones 1 m thick, and
- Unit 7, made of grey, thin bedded, 2 m thick limestones (thickness of beds is 2–15 cm) with ostracodes and rare pyritized foraminifera. This unit make the final part of the section.

The deposition of the fine carbonate mud, characteristic for low energy regime of the shallow water, relatively restricted environment, probably shallow subtidal (traces of bioturbations in lower part, fine laminated and thin bedded limestones in middle and upper part of the section) predominates in the section. Appearance of the bed with ooids in thin bioturbated micrites in lower part (Kp6; SRB-2) and also in 20 cm bed thick in subunit 4b (Kp4/2) with change of thin bedded siltstones and sandstones in lower part of subunit indicate high water energy. Possible explanation is existing of some topographic highs (normal relief or as a result of local tectonic uplift) were is water energy like in typical tidal regime, or occassionally influence of storm (wind) currents. In upper part of section (Kp3, Kp2, K2/a) is characteristic presence of siliciclastics imput, caused by some local tectonic event or change of climate (ferruginous pigments in sediments).

Conodont microfauna

Material and methods

Fourteen composite rock samples, each *ca*. 2.5 kg, are collected from the Krivi Potok section for conodont study, and same number of thin sections were also done from each level with the conodont samples for the petrographic purposes. The laboratory work was carried out at Geological Survey of Slovenia. All samples were prepared using standard laboratory techniques: dissolved in diluted formic and acetic acid, after dissolution, the residue was collected, sieved and dried. High density liquid (*ca*. 2.8 g/cm^3) is used for gravity enrichment; the density of conodont is larger than 2.8 g/cm^3, while the density of most of the other residues is smaller than 2.8 g/cm^3. The collected materials (samples, thin sections etc.) and collections of conodonts, ostracodes and pyrite framboids from investigated section are deposited in the Geological Survey of Slovenia under the catalogue numbers GeoZS 4768-4769 and 5104-5112, corresponding to numbers of the samples (SRB-1, SRB-2 and Kp1–Kp7) from the section. The illustrated pictures presented herein were taken with an Scanning Electron Microscope at the University of Graz, Nawi Graz, Institute of Earth Sciences.

Conodont dating

Six samples out of these fourteen yield conodonts which enable taxonomic identification: P_1 elements of *Neospathodus planus* Chen & Kolar-Jurkovšek, P_1 elements of *Neospathodus* sp. indet., P_2, S_1, S_2, S_3 or S_4 and M elements of multielement apparatus of *Neospathodus planus*, elements of the *Pachycladina–Foliella* conodont microfauna: *Pachycladina obliqua* Staesche, *Pachycladina inclinata* Staesche, *Foliella gardenae* (Staesche) and *Pachycladina* sp. (Fig. 3). Other three samples from the upper part of the section contain only ramiform elements and some undeterminated fragments of the conodonts (Fig. 3).

In the lower part of the presented Krivi Potok section, before the covered part of column, beside of stratigraphic ranges of determinated conodonts, two conodont zones can be recognized. They confirm the conodont sequence which has been proposed in the Idrija–Žiri area, Slovenia (Chen *et al*. in preparation). These zones are: *Pachycladina obliqua–Foliella gardenae* Assemblage Zone and *Neospathodus planus* Zone and both they are of the lowermost Olenekian (lower Smithian) in age (Fig. 3).

From the source part of the Krivi Potok, Sudar (1986) reported the results of the micropaleontological investigations of conodonts and foraminifera where it was determinated the *Parachirognathus–Furnishius* Z. in the Smithian and *triangularis–homeri*–C.R.Z. of the Spathian age.

Pachycladina obliqua–Foliella gardenae Assemblage Zone

Originally is introduced by Chen *et al*. (in preparation) in the type-section Žiri 29 of the Idrija–Žiri area, Slovenia as the *Pachycladina obliqua-Foliella gardenae* A. Z. in the interval between *Eurygnathodus costatus* and *Neospathodus planus* zones within the lower part of the Smithian (lowermost Olenekian).

In the Krivi potok locality the lower limit of this A. Z. lies on the beginning of the Unit 1 at the base of section. It is characterized by the first appearance of *Pachycladina obliqua* and *Foliella gardenae.* The upper limit of the Zone is marked with the first occurrence (FO) of *Neospathodus planus* in the Unit 3 at 1.7 m from the beginning of the section (Fig. 3).

In the investigated section of the Jadar Block the age of the Zone is the lower part of the Smithian in the lowermost Olenekian, and as associated conodont is present only *Pachycladina inclinata*.

This Assemblage Zone Chen *et al*. (in preparation) roughly correlate with the stratigraphic range within the lower part of Smithian belonging to the *Parachirognathus-Furnishius* conodont fauna by Sweet *et al*. (1971) and Budurov & Sudar (1995). They change only the name of the Zone according to the dominating presence of the species of the genera *Pachycladina* Staesche and *Foliella* Budurov & Pantić what is also obvious in the Krivi potok section.

The same interval, characterized by dominating *Pachycladina obliqua* joined with elements of *Hadrodontina* Staesche, was in External Dinarides attributed to the *Pachycladina obliqua* Zone (Kolar-Jurkovšek & Jurkovšek 1995, 1996, Aljinović *et al*. 2006, 2011) and correlated to the Lower Smithian Zone 7 (*Parachirognathus-Furnishius* Zone) of Sweet *et al*. (1971). In North Italy, *Pachycladina*

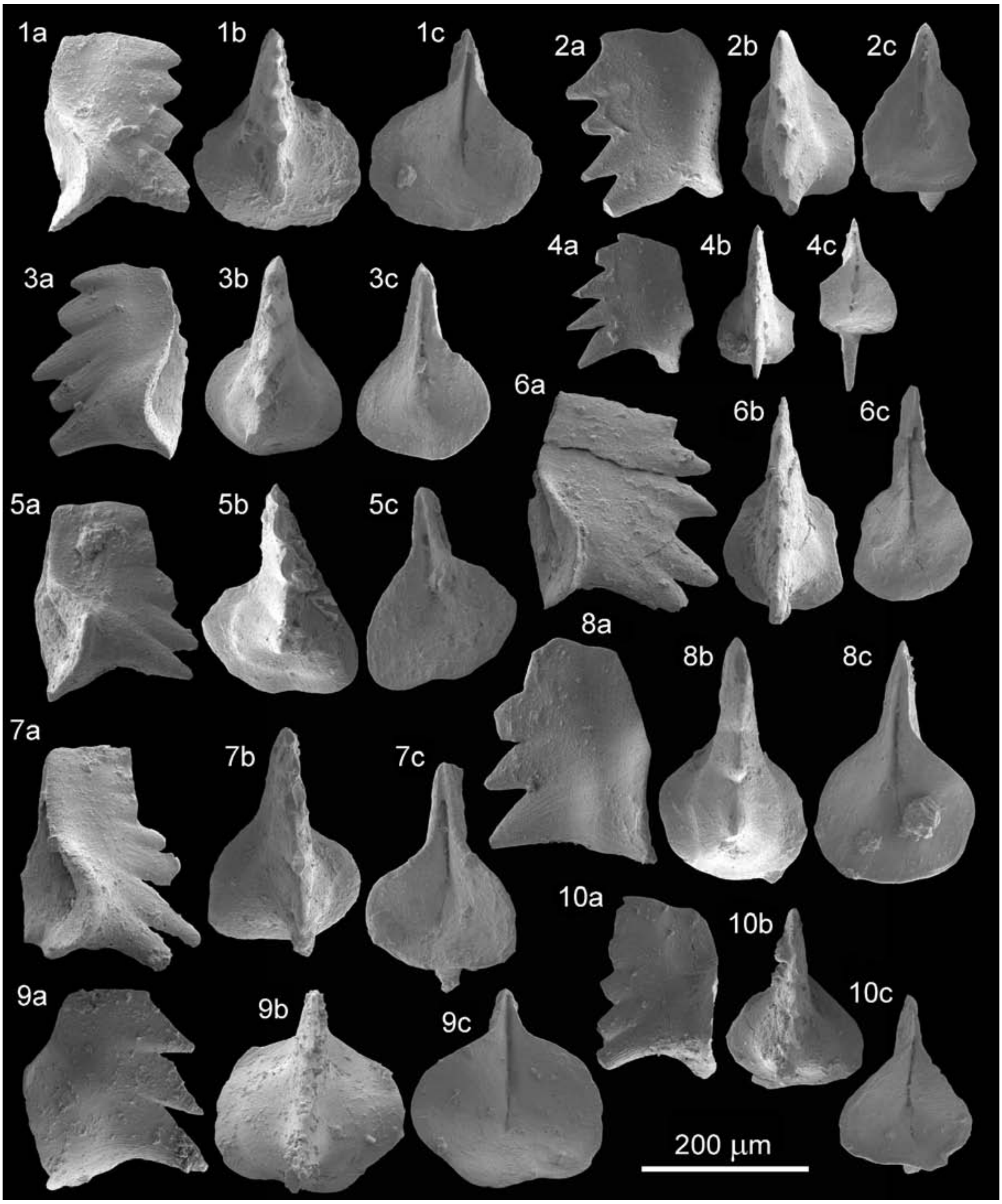

Fig. 4. Conodonts from the Krivi Potok Section, Gučevo Mt., Jadar Block, NW Serbia; middle part of the Obnica Formation, lowermost part of Olenekian (lower Smithian), *Neospathodus planus* Zone; a. lateral view; b. oral view; c. aboral view. **1–6.** P_1 elements of *Neospathodus planus* CHEN & KOLAR-JURKOVŠEK, sample SRB-1 (GeoZS 4768); **8–10.** P_1 elements of *Neospathodus planus* CHEN & KOLAR-JURKOVŠEK, sample KP4/4 (GeoZS 5108); **7.** P_1 elements of *Neospathodus* sp. indet., sample SRB-1 (GeoZS 4768).

obliqua Zone ranges within the almost whole Smithian and the Spathian (PERRI 1991).

In conodont zonation by BUDUROV & SUDAR (1995) exist the *Platyvillosus-Foliella* Beds with the range of both genera in the oldest parts of Spathian. ORCHARD (2007) indicated that species of the genera *Parachirognathus* CLARK*, Furnishius* CLARK*, Hadrodontina*, *Pachycladina* or *Foliella*, belonging to the family Ellisoniidae, are not present in the Spathian, but nearly only in the same time interval of the lower and middle Smithian. These facts were applied by CHEN *et al*. (in preparation) when define *Pachycladina obli-*

qua–Foliella gardenae Assemblage Zone in the lower part of the Smithian.

Neospathodus planus Zone

Neospathodus planus Zone was originally reported from the type-section Žiri 61 in the Idrija–Žiri region, Slovenia (CHEN *et al*., in preparation), where it lies between *Pachycladina obliqua–Foliella gardenae* A. Z. and *Neospathodus robustus* Zone. It is lower Smithian in age.

In the presented locality on the Gučevo Mt. their lower limit is marked with the first appearance of *Neospathodus planus* without elements of genus *Pachycladina* and *Foliella gardenae*, in the Unit 3 at 1.7 m above the base of the section. The upper limit is set at the end of the first part of the Unit 4 (subunit 4a), because the strata after covered part of 6 m, contain only ramiform conodonts without stratigraphic importance (Fig. 3).

In the Krivi Potok section this stratigraphic interval characterizes the lower part of the Smithian (lowermost Olenekian) only with the occurrence of the taxa *Neospathodus planus* and *Neospathodus* sp. indet.

Taxonomic notes

Neospathodus planus CHEN & KOLAR-JURKOVŠEK
Fig. 4.1–6, 8–10; Fig. 5.1, 2

P_1 elements of *Neospathodus planus* is characterized by 3–6 denticles and sometimes a large basal cavity that occupies almost the whole length of the unit (e.g., Fig. 4.9). The outer side of the basal cavity is always greatly expanded. It is similar to *Neospathodus robustus* KOIKE, but *Neospathodus robustus* commonly has more denticles, which are 6–10 (KOIKE 1982). *Neospathodus planus* can be differentiated from *Triassospathodus hungaricus* (KOZUR & MOSTLER) by much wider and inflated basal cavity, and by relatively longer and stronger unit. So far, it is only recognized from Slovenia and Serbia, and it could be a species controlled by local environment.

Multielement apparatus of ***Neospathodus planus***
CHEN & KOLAR-JURKOVŠEK
Fig. 4.1–6, 8–10; Fig. 5.1–8

The multielement apparatus of *Neospathodus planus* has also been discussed here, categories of conodont elements follow SWEET (1988), they are assigned to segminate, angulate, breviform, etc., and orientation of elements follows PURNELL *et al*. (2000).

Multielement apparatuses of conodont play an important role in the conodont taxonomy system (e.g., ORCHARD 2005), thus it is expected that conodont workers illustrate these ramiform elements together with P_1 elements. Conodont clusters and nature assemblages have demonstrated that there are three types of apparatuses in the geological record of earth history, they comprise of 15, 17 and 19 elements respectively (ALDRIDGE *et al*. 2013). Early Triassic conodont composed mainly three families: Gondolellidae, Anchignathodontidae, and Ellisoniidae (ORCHARD, 2007), nature assemblages or clusters have shown that apparatuses of all these three families consist of 15 elements (RIEBER 1980; ORCHARD & RIEBER 1999, KOIKE *et al*. 2004, ORCHARD 2005, GOUDEMAND *et al*. 2012, AGEMATSU *et al*. 2014), paired P_1, P_2, S_1, S_2, S_3, S_4 and M; unpaired S_O. ORCHARD (2005) has reconstructed 26 Triassic apparatuses, including several Early Triassic species, and all his apparatuses consist of 15 elements, belong to the family Gondolellidea. Later, GOUDEMAND *et al*. (2012) revise these S_1 and S_2 elements of Gondolellidea apparatuses as occupied S_2 and S_1 position, the S_3 and S_4 elements of subfamily Novispathodinae (family Gondolellidea) occupied S_4 and S_3 position.

The monospecies *Neospathoides planus* in Zone of the same name provides a chance for the reconstruction its apparatus. Apart from P_1 elements, P_2, S_1, S_2, $S_{3–4}$, and M elements are also identified, as they are shown in Fig. 5.3–8. However, S_O element has been found from neither Krivi Potok section, Serbia nor the Idrija–Žiri section, Slovenia (CHEN *et al*., in preparation).

Elements of *Neospathodus planus* are characterized as follow: P_2 element is angulate, relatively slender, has a cusp in the middle part of the unit. S_1 element is breviform digyrate, with well-developed rostral process, but lacks caudal-ventral process, the largest denticle located on the caudal end of the unit and caudally pointed. These characters of S_1 elements are similar to that of many Triassic conodont species which are illustrated by ORCHARD (2005). S_2 element is breviform digyrate, with a large rostral process but a very short caudal-lateral process which only bears 2 to 3 denticles. Only caudal part of the S_3 or S_4 element is found, as it is illustrated in Fig. 5.7, character of rostral part in not clear so far. M elements is also breviform digyrate, similar to S_1 element, however, it has a short ventral process which bears one denticle. Over all, elements of *Neospathodus planus* show high similarity with elements of *Triassospathodus homeri* (BENDER) which are figured by ORCHARD (2005), especially for P_2 and S_1 elements. Since we lack well preserved S_3 and S_4 elements, their relationship can not be decided presently.

Neospathodus sp. indet.
Fig. 4.7

In the sample SRB-1 from the *Neospathodus planus* Zone in the Krivi potok section exists one speci-

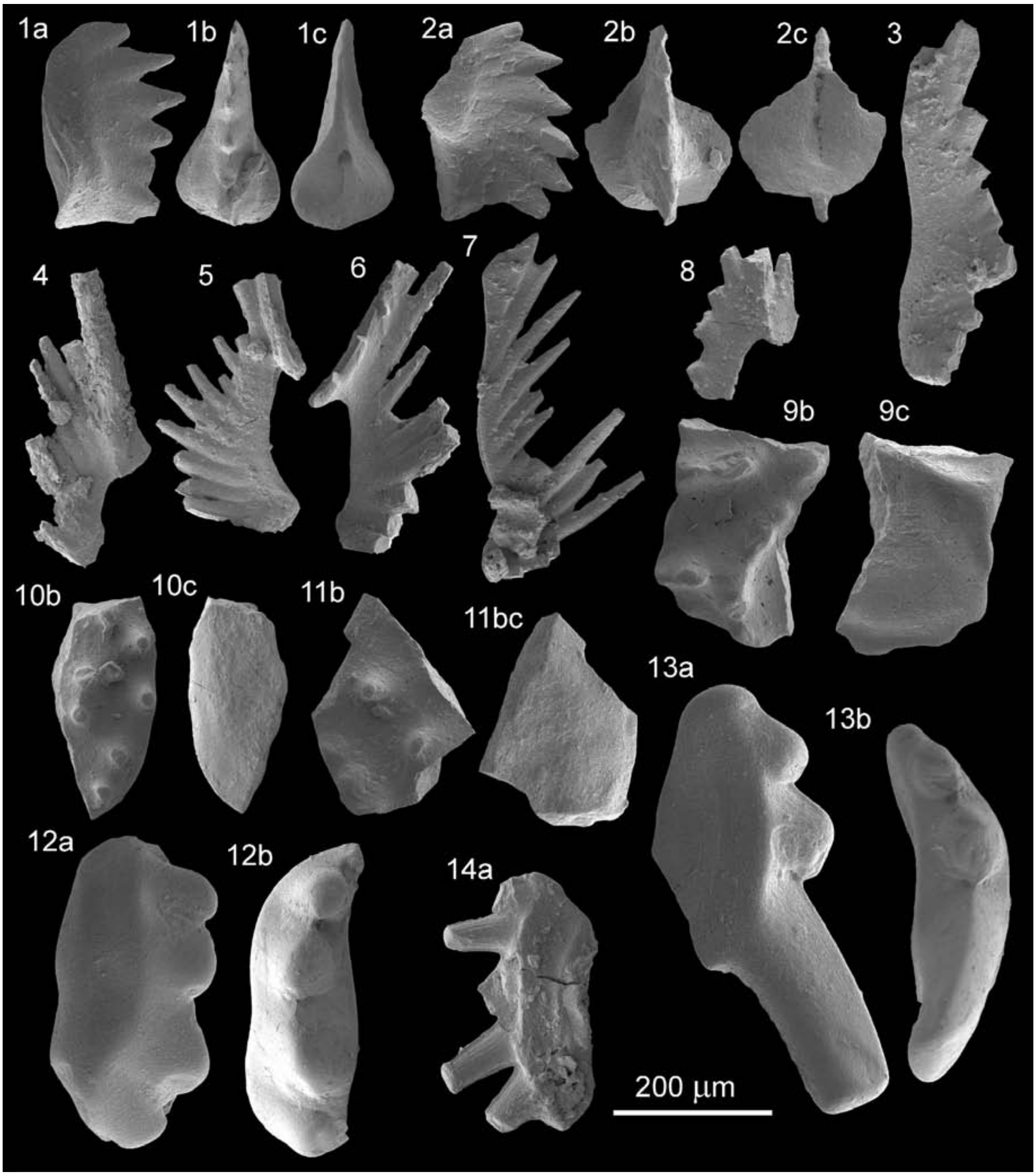

Fig. 5. Conodonts from the Krivi Potok Section, Gučevo Mt., Jadar Block, NW Serbia; middle part of the Obnica Formation, lowermost part of Olenekian (lower Smithian), *Neospathodus planus* Zone; a. lateral view; b. oral view; c. aboral view. **1, 2,** P_1 elements of *Neospathodus planus* Chen & Kolar-Jurkovšek, sample Kp4/5 (GeoZS 5109); **3-8,** P, M and S elements of *Neospathodus planus* Chen & Kolar-Jurkovšek, **3,** P_2 element, sample SRB-1 (GeoZS 4768). **4,** S_1 element, sample SRB-1, KP4/4 (GeoZS 4768, 5108). **5, 6,** S_2 elements, **5,** sample SRB-1 (GeoZS 4768), **6,** sample Kp4/4 (GeoZS 5108). **7.** distal part of S_3 or S_4 element, sample Kp4/4 (GeoZS 5108). **8,** M element, sample SRB-1 (GeoZS 4768). **9–14,** Elements of the *Pachycladina–Foliella* conodont microfauna from the *Pachycladina obliqua–Foliella gardenae* Assemblage Zone. **9-11,** *Foliella gardenae* (Staesche) (different fragments) sample SRB-2 (GeoZS 4769). **12,** *Pachycladina* sp., sample SRB-2 (GeoZS 4769). **13,** *Pachycladina obliqua* Staesche (fragment), sample SRB-2 (GeoZS 4769). **14,** *Pachycladina inclinata* Staesche, sample SRB-2 (GeoZS 4769).

men showing characters between *Neospathodus planus* and *Neospathodus robustus*. The ventral (anterior) part of the element lost some denticels, thus it is possible the specimen has seven or more denticles which probably should be identified as *Neospathodus robustus*. In this moment, because of the bad preservation of the fossil and since occur only one, ilustrated, specimen it is determinated in the open nomenclature like *Neospathodus* sp. indet.

Elements of the ***Pachycladina–Foliella*** conodont microfauna

The elements determinated within this conodont microfauna, *Pachycladina obliqua*, *Pachycladina inclinata* and *Foliella gardenae* were first reported from the middle to upper part of Campil Member in North Italy (STAESCHE 1964) with higher stratigraphic distributions than *Eurygnathodus costatus* STAESCHE.

Both, species of *Pachycladina*, were also reported from North Italy (PERRI & ANDRAGHETTI 1987, PERRI 1991), Slovenia (KOLAR-JURKOVŠEK 1990, KOLAR-JURKOVŠEK & JURKOVŠEK 1995, 1996, DOZET & KOLAR-JURKOVŠEK 2007, CHEN *et al*. in preparation), Croatia (ALJINOVIĆ *et al*. 2006), Bosnia (ALJINOVIĆ *et al*. 2011), NW Serbia (BUDUROV & PANTIĆ 1973, 1974; SUDAR 1986), and South China (WANG & CAO 1981, YANG *et al*. 1986).

Foliella gardenae was also reported from different localities in Slovenia (KOLAR-JURKOVŠEK 1990, KOLAR-JURKOVŠEK & JURKOVŠEK 1995, 1996, CHEN *et al*. in preparation), Croatia (ALJINOVIĆ *et al*. 2006), NW Serbia (BUDUROV & PANTIĆ 1973, 1974), and South Primorye, Eastern Russia (ZAKHAROV *et al*. 2009, IGO 2009).

Conodont Colour Alteration Index

The Conodont Colour Alteration Index (CAI values *sensu* EPSTEIN *et al*. 1977) of the conodonts from the presented Krivi Potok section are in the range of CAI from 5 to 6–7 (5, 5.5, 6, 6–7), with the tendency that conodonts from the middle parts of the section (*Neospathodus planus* Zone) have the highest values of CAI. It is in correspondance to the earleir data of CAI values from the Krivi Potok section which are 5.5 (unpublished information for the conodonts determinated by SUDAR 1986). All these mentioned data where CAI values are between 5 and 6–7 correspond to temperatures from 300–490 °C and characterize very low to low grade metamorphism (GAWLICK *et al*. 1994, SUDAR & KOVÁCS 2006).

Ostracode microfauna

From the fourtheen samples treated for conodonts extraction, two were productive with ostracodes (SRB-1 and Kp1; Fig. 3). A total of fifty-nine specimens have been recovered, illustrating a new species described below. Most of the specimens are represented by complete carapaces, testifying the absence or limitation of post-mortem transportation with low wave energy and/or rapid burial by high sedimentation ratio (OERTLI 1971).

During the earlier phases of micropaleontological investigations of the Lower Triassic and P-T boundary interval in the Jadar Block were published only few papers dealing with ostracodes: PANTIĆ-PRODANOVIĆ (1979), KRSTIĆ (1980) and CRASQUIN *et al*. (2010). In paper of PANTIĆ-PRODANOVIĆ (1979), only five species of ostracodes were cited (three in open nomenclature) from „Campilan” substage in the Valjevo area. In the southern and eastern slopes of the Gučevo Mt., KRSTIĆ (1980) in detail described and illustrated rich ostracode microfauna of the „Campilan” age: *Judahella tsorfatia*, „*Cultella*” cf. *laevis*, *Spinocypris nepalensis*, „*Bythocypris*” aff. *bijieensis*, *Bythocypris* cf. *pricei*, etc. Studying very abundant ostracode assemblages not found earlier in the P–T beds of this region, CRASQUIN *et al*. (2010) also introduced three new species. All together, were the first record of the youngest Upper Permian age microfaunas not only from NW Serbia, but also from the whole Serbia and the central part of the Balkan Peninsula.

In the present study, we follow the systematic classification of MOORE (1961) modified after LETHIERS (1981) and HORNE *et al*. (2002).

Abbreviations used in the text: AB, anterior border; DB, dorsal border; H, height; H_{max}, maximal height; L, length; L_{max}, maximal length; LV, left valve; PB, posterior border; RV, right valve; VB, ventral border.

Class Ostracoda LATREILLE, 1806
Subclass Podocopa MÜLLER, 1894
Order Podocopida MÜLLER, 1894
Suborder Podocopina SARS, 1866
Superfamily Cypridoidea BAIRD, 1845
Family Paracyprididae SARS, 1923

Genus ***Paracypris*** SARS, 1910

Type species. *Paracypris polita* SARS, 1866

Paracypris* ? *krivipotokensis FOREL n. sp.
Fig. 6.1–6

Derivation of name. From the type locality, Krivi Potok section.

Holotype. One complete carapace figured on Fig. 6.1, sample SRB-1, collection number GeoZS 4768.

Paratype. One complete carapace figured on Fig. 6.2, sample SRB-1, collection number GeoZS 4768.

Type locality. Krivi Potok section, Gučevo Mt., Jadar Block, Northwestern Serbia.

Type level. Unit 4 (4a), sample SRB-1, Obnica Formation of the Krivi Potok section, Upper Lower Triassic, lowermost part of Olenekian (lower Smithian), *Neospathodus planus* conodont Zone.

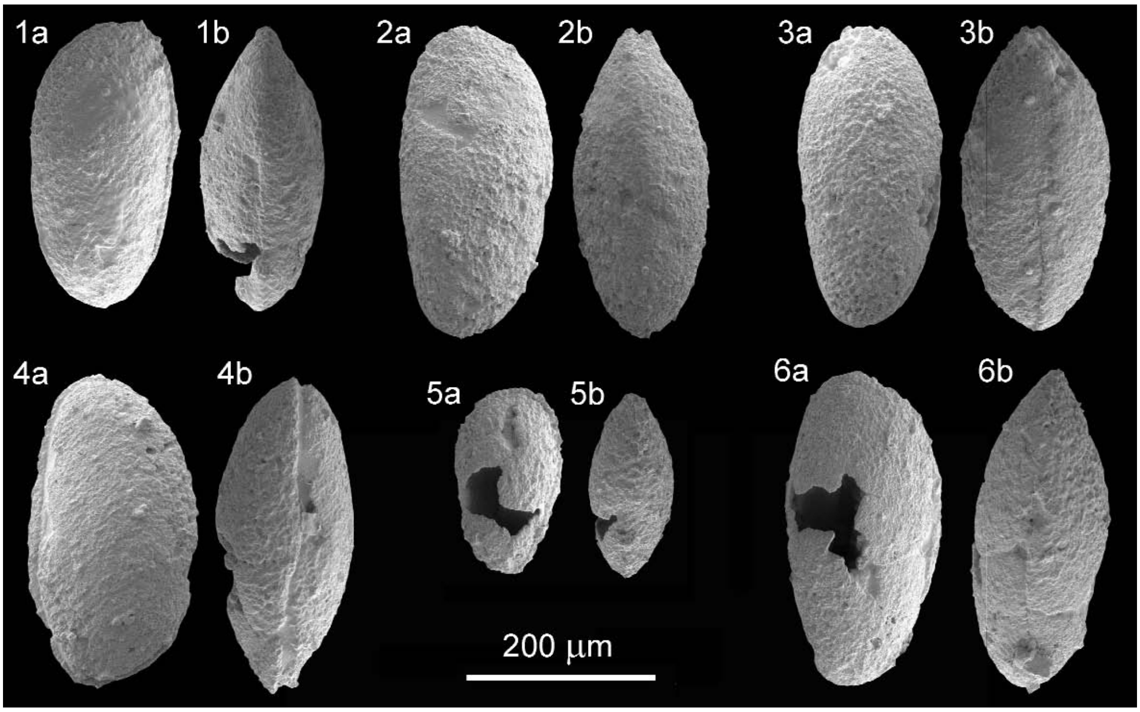

Fig. 6. Ostracodes from the Krivi Potok Section, Gučevo Mt., Jadar Block, NW Serbia; middle part of the Obnica Formation, lowermost part of Olenekian (lower Smithian), *Neospathodus planus* conodont Zone; a. lateral view; b. dorsal view of a complete carapace. All specimens belong to *Paracypris* ? *krivipotokensis* FOREL n. sp. **1,** holotype, carapace, sample SRB-1 (GeoZS 4768). **2,** paratype, carapace, sample SRB-1 (GeoZS 4768). **3,** carapace, sample SRB-1 (GeoZS 4768). **4,** carapace, sample SRB-1 (GeoZS 4768). **5,** carapace, sample SRB-1 (GeoZS 4768). **6,** carapace, sample SRB-1 (GeoZS 4768).

Material. Fifty-nine complete carapaces and several fragments.

Diagnosis. A species attributed with doubt to the genus *Paracypris*, with AB and PB maximum of convexity symmetrically located in the lower 1/3rd of the carapace, upper portion of AB straight.

Description. Carapace elongate ($0.48 < H/L < 0.58$), surface smooth, LV slightly overlaps RV all around the carapace.

DB long (50–65% of L_{max}), regularly convex, smoothly sloping to PB; PB rounded with narrow radius of curvature, maximum located in the lower 1/3rd of H_{max}; posterior half of the carapace slightly wedge-shaped; VB flat to slightly concave at both valves; upper part of AB long and straight to slightly convex, resulting in a shouldering of the transition to VB larger than PB: anterior maximum of convexity located symmetrically to PB in the lower 1/3rd of H_{max}.

Remarks. The present species differs from *Paracypris gaetanii* CRASQUIN-SOLEAU from the Griesbachian? of the Guangxi Province, South China (CRASQUIN-SOLEAU *et al.* 2006) by its asymmetrical and shouldered AB with maximum of convexity located in the lower 1/3rd of H_{max} It differs from the species *Paracypris jinyaensis* CRASQUIN-SOLEAU from the Smithian-Spathian of the Guangxi Province, South China (CRASQUIN-SOLEAU *et al.* 2006) by its larger H/L ratio. The abundant specimens of *Paracypris gaetanii* CRASQUIN-SOLEAU from the Late Permian–Early Triassic of several localities worldwide recently allowed the recognition of five ontogenetic stages (FOREL 2014). The specimens might correspond to at least two ontogenetic stages but more material is needed to confirm this hypothesis.

Until now, eleven Smithian ostracode species were known from South China (CRASQUIN-SOLEAU *et al.* 2006) and Tibet (FOREL *et al.* 2011; FOREL & CRASQUIN 2011). *Paracypris* ? *krivipotokensis* FOREL n. sp. is the first record of Smithian ostracodes on the north-

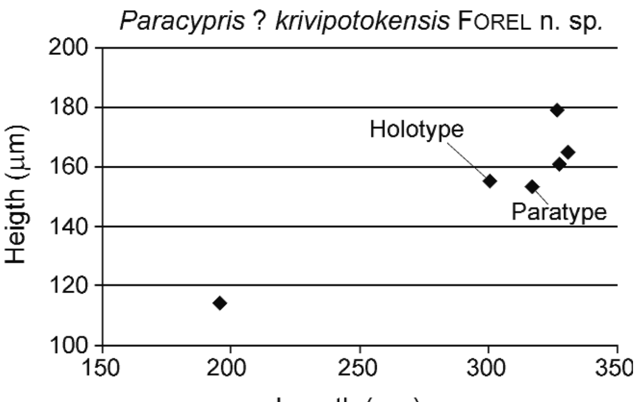

Fig. 7. Length/height scatter plot of *Paracypris* ? *krivipotokensis* FOREL n. sp.

ern border of the Paleo-Tethys ocean. The absence of ostracodes from twelve of the fourteen samples can't be interpreted in terms of environmental/ecological forcing since diluted formic and acetic acids were used: acid attack of the carbonated carapaces of ostracods can't be ruled out. A traditional hot acetolysis (LETHIERS & CRASQUIN-SOLEAU 1988; CRASQUIN-SOLEAU *et al.* 2005) processing of the samples might help have a more complete view of the Krivi Potok ostracode faunas and their implications in terms of environmental conditions.

Size. L=196–331 μm; H=114–179 μm; W=90–156 μm; H/L=0.48–0.58 (Fig. 7).

Occurrence. Lowermost part of Olenekian (lower Smithian) of the Krivi Potok section, Gučevo Mt., Jadar Block, Northwestern Serbia.

Pyrite framboids

Plentiful studies indicate that this kind of pyrite can be a proxy for redox conditions in the paleoseawater and sediments (e.g., WILKIN & BARNES 1996; SHEN *et al*. 2007; WIGNALL *et al*. 2005; TIAN *et al*. 2014). They form in dysoxic and sulfidic conditions which is close to the redox boundary (WILKIN & BARNES 1996). The diameters of pyrite framboids are very sensitive to the water depth between the redox boundary and the sediments, as they sink down rapidly after formation if they are formed in the water column and thus smaller (< 6 μm in diameter) and has a narrower size variation range (WILKIN & BARNES 1997; WIGNALL & NEWTON 1998; WIGNALL *et al*. 2005). However, larger sized and wider range of size variation of pyrite framboids indicate a formation within the sediments, as they have longer time and slower rate for their formation (WILKIN & BARNES 1996, 1997).

Pyrite framboids have been found in Unit 4 (subunit 4a, sample SRB-1) in the Krivi Potok section. This is the first discovery of pyrite framboids from the Lower Triassic of the Jadar Block and also from Serbia. They are attached on the ostracode shells and are mainly 12–21 μm in diameter, as shown in Fig. 8. These large amount of pyrite framboids found within octracode shells definitely formed in the sediments after the death of these ostracodes. Their size distribution (8–35 μm, Fig. 9) supports the former suggestion that the large pyrite framboids are not suitable for the diagnosis of the paleoseawater redox condition, but they only indicate a dysoxic and sulfidic micro-environment within the shells after the death of these ostracodes.

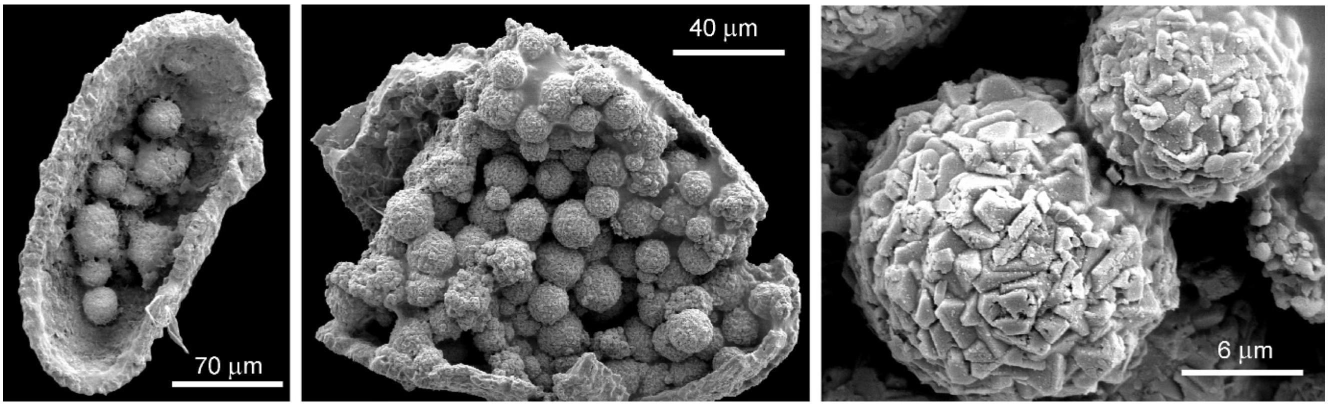

Fig. 8. Pyrite framboids from the Krivi Potok section, Gučevo Mt., Jadar Block, NW Serbia; middle part of the Obnica Formation, lowermost part of the Olenekian (lower Smithian), *Neospathodus planus* conodont Zone; sample SRB-1 (GeoZS 4768).

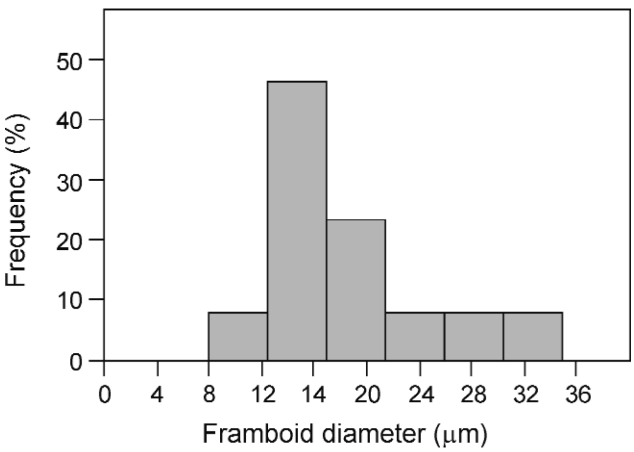

Fig. 9. Size distributions of pyrite framboids, sample SRB-1.

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Резиме

Микрофауна доњег тријаса (олењок) Јадарског блока (планина Гучево, СЗ Србија)

Област планине Гучево (Јадарски блок, северозападна Србија) је прилично палеонтолошки неистражена, нарочито кад су у питању стене доњотријаске старости, раније третиране као „сајски“ и „кампилски“ кластити и карбонати. Комплекснија истраживања на овим просторима вршена су тек последњих година и то у седиментима на граници горњи перм–доњи тријас (Sudar *et al*. 2007, Nestell *et al*. 2009, Crasquin *et al*. 2010), али су настављена и на седименте доњотријаске старости Формације Обнице.

У региону планине Гучева, на локалитету Криви поток који се налази у доњем делу истоименог потока, у седиментима доњег тријаса снимљен је стуб дебљине 11 m. Опробовање је вршено у два маха (2010. и 2012. године). Стуб се састоји из седам пакета, у прва три пакета изграђена од танко слојевитих микритских кречњака је присутан ооидни кречњак дебљине 1 m (Кр6, SRB-2). Четврти пакет је делом покривен, па је подељен у два дела. У целом доњем делу (4а) обилује конодонтима, а остракоди и пиритски фрамбоиди су нарочито присутни у дебело банковитим кречњацима (Кр4, SRB-1). У горњем делу пакета у слоју дебљине 0,2 m такође су нађени ооиди. Пакете 5 и 6 изграђују кварцни пешчари, а преко њих је пакет 7 изграђен од слојевитих кречњака различите дебљине. Депозиција се углавном одвијала у плитком субтајдалу, у ниско енергетском режиму, али присуство ооида, карактеристично за плимни режим, указује на постојање топографских узвишица на терену што је узроковано нормалним рељефом или локалним издизањима. Повремено је долазило и до прилива силицикластичног материјала, услед локалне тектонике или климатских промена.

На стубу је узето четрнаест композитних проба за конодонте, а урађени су и петрографски препарати. Шест узорака садржи конодонте који су омогућили таксономску идентификацију: P_1 елементе *Neospathodus planus* Chen & Kolar-Jurkovšek, P_1 елеменат недетерминисаног конодонта *Neospathodus* sp., P_2, S_1, S_2, S_3 или S_4 и M елементе од мултиелементарног апарата *Neospathodus planus*, елементе од *Pachycladina–Foliella* конодонтске микрофауне: *Pachycladina obliqua* Staesche, *Pachycladina inclinata* Staesche, *Foliella gardenae* (Staesche) и *Pachycladina* sp. Остала три узорка из горњег дела стуба садрже само рамиформне (гранате) елементе и неодредљиве фрагменте конодоната. У делу пакета 4 пре покривеног дела стуба препознате су две конодонтске зоне: *Pachycladina obliqua–Foliella gardenae* Assemblage

Zone и *Neospathodus planus* Zone и обе су по старости најнижи олењок (доњи смит). Иначе, CAI вредности испитиваних конодоната из Кривог потока су од 5 до 6–7 (5, 5,5, 6, 6–7), са тенденцијом да конодонти из средњег дела стуба (*Neospathodus planus* Zone) имају више вредности. Ове CAI вредности одговарају температурама од 300–490 °C карактеристичним за веома низак до низак степен метаморфизма (GAWLICK *et al*. 1994, SUDAR & KOVÁCS 2006).

Од четрнаест проба третираних за екстракцију конодоната, две садрже и остракоде (SRB-1 и Kp1). Од укупно педесет девет примерака одређена је и нова остракодска врста *Paracypris* ? *krivipotokensis* FOREL n. sp., која се појављује заједно са врстом *Neospathodus planus* у истоименој конодонтској зони. Већина узорака је представљена са целим љуштурама, указујући на одсуство или постмортални транспорт при ниској енергији и/или брзо затрпавање услед високог режима седиментације (OERTLI 1971).

У пакету 4 (део 4a, узорак SRB-1) нађени су пиритски фрамбоиди, који су по први пут констатовани у доњотријаским стенама како Јадарског блока, тако и Србије. Већи део фрамбоида је нађен унутар остракодских љуштура (капака) где су дефинитивно настали у седиментима након умирања остракода. Неуједначеност у величини њиховог пречника (8–35 μm) потврђује раније сугестије да нису погодни за дијагнозу палео оксидоредукционог потенцијала морске воде, и да само индицирају диоксичну и сулфидну микросредину унутар љуштура остракода након њихове смрти.

Приказана микрофауна конодоната и остракода, дефинисано конодонтско зонирање, као и пиритски фрамбоиди су скоро у целости по први пут утврђени у просторима Јадарског блока северозападне Србије. Зато су ови наласци врло значајни за овај део Алпско-медитеранског региона јер представљају микропалеонтолошки добро документоване доказе доњотријаске старости – најнижи олењок (доњи смит).