Late Triassic radiolarians from the Grivska Formation, Internal Dinarides, SW Serbia

NIKITA Yu. BRAGIN¹, LIUBOV G. BRAGINA¹, NEVENKA DJERIĆ² & †NATAŠA GERZINA SPĂJÎC²

Abstract. Upper Triassic (upper Carnian – Rhaetian) grey cherty limestone are known in the Internal Dinarides under the name of “Grivska Formation”. Sediments of the Grivska Formation are characterized by microfossils only – conodonts and radiolarians, and did not yield any macrofossils. Micropaleontological research of Upper Triassic siliceous rocks was performed at the locality Lim River, in the vicinity of Bistrica Village in SW Serbia. Radiolarian assemblages are characterized by such species as Capnodoce anapetes De Wever, C. sarisa De Wever, Sarla hadrecaena (De Wever), Praehexasaturnalis tenuispinosus (Donofrio & Mostler), Xiphothecaellla longa (Kozur & Mocé). According to the radiolarian data, the investigated cherts are of latest Carnian to early Norian age.

Key words: Grivska Formation, cherts, radiolarians, Late Triassic, Internal Dinarides, SW Serbia.

Апстракт. Горњотријаски (горњи карн – рет) сиви кречњаци са рођнацима су у унутрашњим Динаридима познати под називом Формација Гривске. Седименте Формације Гривске карактерише присуство микрофосила – конодоната и радиоларија, као и одсуство макрофосила. На локалитету у долини реке Лим, у близини Бистрице (ЈЗ Србија), извршена су детаљна микропалеонтолошка истраживања радиоларијских седимената. У радиоларијским асоцијацијама доминирају следеће врсте: Capnodoce anapetes De Wever, C. sarisa De Wever, Sarla hadrecaena (De Wever), Praehexasaturnalis tenuispinosus (Donofrio & Mostler), Xiphothecaellla longa (Kozur & Mocé). На основу одређених радиоларијских асоцијација утврђена је горњокаријаска до доњоноријска старост истраживаних седимената.

Кључне речи: Формација Гривска, рођнаци, радиоларије, горњи тријас, Унутрашњи Динариди, ЈЗ Србија.

¹ Geological Institute of Russian Academy of Sciences, Pyzhevsky 7, Moscow 119017, Russia. E-mail: bragin.n@mail.ru
² University of Belgrade, Faculty of Mining and Geology, Serbia.
Introduction

The Triassic hemipelagic deposits of moderate thickness (up to several hundred meters), which are represented by platy cherty limestone intercalated with marl and clay, in parts with coarser-grained allogenic layers and common chert nodules and layers, are known in the Internal Dinarides under the name of “Grivska Formation”. This formation was informally established by Dimitrijević & Dimitrijević (1991) and supposed to be synchronous with the lower part of Wetterstein Formation (Ladinian) (Dimitrijević & Dimitrijević, 1991).

According to Dimitrijević (1997), the Grivska Formation is represented only by huge olistoplakes that are in tectonic contacts with the surrounding rocks. Therefore it was difficult to reconstruct primary stratigraphical relationships of these deposits without biostratigraphic control. Biostratigraphy of the Grivska Formation can be based only on microfauna; any macrofossils are unknown here. Sudar (1986, 1996) distinguished Ladinian, Carnian and Norian cherty limestones using conodont dating, but these data were rarely used in geological studies, and the Grivska Formation was defined and mapped mostly on the base of its macroscopic lithological attributes, without biostratigraphic and detailed microfacies investigations.

As a result, the term Grivska Formation has been used broadly for the all Ladinian to Late Jurassic stratified cherty limestones in all units that derived from the Adriatic passive margin. Due to the fact that in this case the Grivska Formation includes genetically different sedimentary successions, Missoni et al. (2012) restrict the name Grivska to Triassic hemipelagic sequences and advocate the term Grivska Group, which comprises different Middle and Late Triassic hemipelagic bedded cherty limestones with layers of calciturbidites with shallow-water debris. Later, Gawlick et al. (2016, 2017) and Sudar & Gawlick (2018) revised the Grivska Formation using new biostratigraphic and microfacial data. The age of Grivska Formation was determined on the base of conodonts as Late Triassic (Carnian–Rhaetian) (Sudar & Gawlick, 2018). It should be noted that limestones of the Grivska Formation are characterized by microfossils only – conodonts and radiolarians, and did not yield any macrofossils.

This work deals with the first study of radiolarian assemblage from the Grivska Formation with its biostratigraphic analysis and correlation.

Geological setting and previous studies

The Triassic limestones described here, observed on the both sides of Lim River near mouth of Bistrica River in SW Serbia (Fig. 1) were previously mapped as Middle Triassic, Ladinian (Ćirić, 1980), and were shown as surrounded by ophiolitic mélangé. Actually they are interpreted as large olistoliths. First corrections of the estimated Ladinian age range were made by Sudar & Gawlick (2018) based on conodont investigations.

According to Sudar & Gawlick (2018) in the Dinaric Ophiolite Belt, openmarine cherty limestones (= the Grivska Formation) of this type occur only as blocks in the ophiolitic mélangé and are therefore very important for palaeogeographic reconstructions and the reconstruction of the Triassic-Jurassic geodynamic history of the Inner Dinarides. The sedimentary rocks that derived from the continental slope (Grivska Formation) and the outer shelf region (Hallstatt facies) are found only in sedimentary mélanges and are incorporated in the deep-water troughs in front of an advancing nappe stack. The thrust sheets of the former passive margin were successively fragmented and incorporated into the nappe stack in front of the westward obducting ophiolites. Deposits of the continental slope (Melita facies, Grivska Formation) became a part of the nappe stack in the first stage of obduction, while the outer shelf region (Hallstatt facies) were added later.

Alternatively, these bedded grey to reddish-grey bedded cherty limestones preserved along both sides of the Lim river, could also represent the Triassic stratigraphical cover of a carbonate platform sequence, which belongs to the Drina–Ivanjica Unit (Fig. 1), i.e. part of a continental margin formation (Schmid et al., 2008). Grey cherty limestone sequences occur quite common in the Triassic and Jurassic sedimentary successions of the Western Tethys realm: similar depositional and diagenetic conditions led to the formation of grey cherty limestones elsewhere (Sudar & Gawlick, 2018).
The Grivska Formation was informally introduced by Dimitrijević & Dimitrijević (1987, 1991): the definition of this formation was not based on chronostratigraphy only, but it also took into account lithostratigraphic and facies aspects. Sediments of the Grivska Formation were interpreted as hemipelagic sedimentary rocks, deposited on the platform slope, the toe-of-slope and in the basin near to the slope by Dimitrijević & Dimitrijević (1991) and Kovács et al. (2010, 2011), based on the distinguished lithofacies. The term “Grivska Formation” in the Inner Dinarides has been used until nowadays in a confusing and misleading way for all Middle Triassic to Middle (?) Jurassic grey cherty limestone successions (e.g. Dimitrijević, 1997; Dimitrijević et al., 2003; Radić et al., 2011). Gawlick et al. (2017) offered definitions and emendations of some formations in the Inner Dinarides, including some parts of the Grivska Group. According to Gawlick et al. (2017) the Grivska Formation is represented by Upper Triassic (lower Carnian – Rhaetian) cherty limestones that represent blocks in ophiolitic mélangé; some of these blocks are even several hundreds of meters large. The most common are wackestones with radiolarians and filaments. Thin layers of fine-grained turbiditic limestone are rela-

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**Fig. 1. a,** Main tectonic units in the central part of Balkan Peninsula (modified after Bragin et al., 2018); **b,** Simplified geologic map of the wider investigation area (modified after Djerić et al. 2012).
tively rare, while shallow-water, platform-derived sediments are practically missing. It was concluded that cherty limestones of the Grivska Fm. were deposited on a continental slope or on a proximal oceanic bottom. They are comparable with the Pötschen Formation (type locality) in the Northern Calcareous Alps or with grey cherty limestone of Meliata unit (type locality) in the Western Carpathians (GAWLICK et al., 2016).

The age of Lim river succession is dated by means of conodonts as early to late Norian (SUĐAR & GAWLICK, 2018). First preliminary study of radiolarians from the Grivska Formation gave results that are well concordant with conodont studies – we found latest Carnian to early Norian radiolarians from the locality in the Lim River near Bistrica (BRAGIN et al., 2017).

Methods

Samples of cherts and cherty limestones were processed in diluted (10%) hydrofluoric acid (HF) following the method by PESSAGNO & NEWPORT, 1972 and DUMITRICA, 1970, residues were washed by water, then cleaned by hot water (10–15 g) with 0.5 g tetrasodium pyrophosphate (Na₄P₂O₇) to remove clay particles. Radiolarians were picked from dried residues under light binocular microscope LOMO-MBS-10,
then mounted, studied and photographed under scanning electron microscope TESCAN 2300 in the Geological Institute RAS, Moscow.

**Description of stratigraphic section with radiolarian biostratigraphy**

Outcrops in the right side of Lim River valley were observed, sampled and studied. The Grivska Formation is represented here by grey to yellowish-grey platy, sometimes thick-bedded micritic limestones, usually recrystallized, with calcite veins and with common layers and nodules of white and pink cherts. Thin-platy limestones (with thickness of layers less than 10 cm) are predominant, while the beds with thickness of more than 0.5 m are represented by massive grey limestones. Rocks are intensively folded, numerous faults are present (Fig. 2). The total thickness can be estimated as more than 100 meters. Contacts of limestones and matrix of mélange were not observed.

First sampling point is on the right side of valley directly near the bridge (coordinates N 43°28ʹ03,8ʺ E 019°39ʹ03,6ʺ), four samples were collected, while second point is located in SW direction from the bridge (coordinates N 43°27ʹ59,0ʺ E 019°38ʹ59,3ʺ) where two samples were collected.

Radiolarians were recovered from two chert samples: 15-20-1 and 15-21-2. The preservation is moderate to poor and some individuals are determined in open nomenclature or only in generic level. The taxonomic diversity of radiolarian assemblages is low due to selective and poor preservation. Radiolarian tests are commonly recrystallized. Anyway, obtained results allow us to date limestone deposits of Grivska Formation.

According to the presence of characteristic taxa (Table 1) both samples can be assigned to the uppermost Carnian to lower Norian. This stratigraphic interval is well-known worldwide in low latitudes by the presence of *Capnodoce, Capnuchosphaera, Xiphothecaella* and other taxa (De Wever, 1982; Blome, 1984; Sugiyama, 1997; Tekin, 1999; Bragin, 2007; O’Dogherty et al., 2010). Studied interval correlates with the lower part of Zone Capnodoce of North America (Blome, 1984), Zone TR6A of Japan (Sugiyama, 1997), Zone Capnodoce crustallina of Eastern Russia (Bragin, 2000).

**Table 1. Presence and abundance of radiolarian taxa in samples.**

<table>
<thead>
<tr>
<th>Radiolarian taxa</th>
<th>Samples 15-20-1</th>
<th>Samples 15-21-2</th>
</tr>
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<tbody>
<tr>
<td><em>Capnodoce anapetes</em> De Wever</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td><em>Capnodoce sarisa</em> De Wever</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td><em>Capnodoce</em> sp.</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td><em>Capnuchosphaera</em> sp. cf. <em>C. tricornis</em> De Wever</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td><em>Sarka hadrecaena</em> (De Wever)</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td><em>Sarka</em> ? sp.</td>
<td>E</td>
<td>R</td>
</tr>
<tr>
<td><em>Ellisus</em> ? sp.</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td><em>Ellisus</em> sp. cf. <em>E. siscwaiensis</em> (Carter)</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td><em>Monocapnuchosphaera</em> sp. B sensu Tekin, 1999</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td><em>Eptingiidae</em> ? gen. et sp. indet.</td>
<td>E</td>
<td>R</td>
</tr>
<tr>
<td><em>Pakneosaturnalis</em> sp.</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td><em>Præhexasaturnalis tenuispinosus</em> (Donofrio &amp; Mostler)</td>
<td>E</td>
<td></td>
</tr>
<tr>
<td><em>Paronaella</em> sp.</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td><em>Triassocrucella</em> sp. cf. <em>T. triassica</em> (Kozur &amp; Mostler)</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td><em>Corum</em> sp.</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td><em>Spinosiscapsa</em> spp.</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td><em>Xiphothecaella longa</em> (Kozur &amp; Mock)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The Grivska Formation is represented, on the right side of Lim River valley, by grey to yellowish-grey platy micritic limestones with common layers and nodules of white and pink cherts. Based on the radiolarians, the analyzed cherts were deposited between the uppermost Carnian and lower Norian. These results are well concordant with conodont studies (Early to Late Norian; Sudar & Gawlack, 2018). The radiolarian assci-
ations from the locality Lim River are correlatable with the radiolarian associations identified from numerous low-latitude localities of the uppermost Carnian to lower Norian: Alpine-Mediterranean (De Wever, 1982; Kozur, 2003 Tekin, 1999; Bragin, 2007). North America (Blome, 1984), Japan (Sugiyma, 1997) and Eastern Russia (Bragin, 2000).

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References


Resime

Горњотријаске радиоларии Формације Гривска, Унутрашњи Динариди, ЈЗ Србија

Тријаски хемипелашки седименти унутрашњих Динарида, који су представљени услојеним кречњацима са прослојцима глинаца и глиница, честим нодулама рожнаца и местимично крупноусложеним кречњакама са рожнацима и остатке плитких мина “Гривска група”, која би обухватала разни Динариди, који су представљени услојеним кречњакама са рожнацима. У унутрашњим Динаридима термин „Формација Гривска“ све до скоро је погрешно употребљаван за све средњотријаске до средњојуричке радиоларије у Црноморском базину.

У циљу добијања нових података извршена су истраживања карбонатно-радиоларитских седимената на десној обали реке Лим, у близини ушћа реке Бистрице. Истраживани седименти представљени су сивим до жућкасто-сивим услојеним микритичним кречњацима са честим прослојом и нодулама беличастих до ружичастих рожнаца. На основу анализиране радиолариске асоцијације, утврђена је горњокарнијска до доњоноричка старост узоркованих рожнаца. Новодобијени подаци су у потпуности сагласни са подацима добијеним анализом конодонтске микрофауне (норички кат; Sudar & Gašlick, 2018). Радиолариске асоцијације изоловане из седимената локалитета Лим карактеришу се присуством добро познатих таксона бројних светских локалитета: алпско-медитеранска област (De Wever, 1982; Kozur, 2003 Tekin, 1999; Bragin, 2007), Северна Америка (Blome, 1984), Јапан (Sugiyma, 1997) и источни део Русије (Bragin, 2000).
Plate 2.
Latest Carnian to Early Norian radiolarian associations from the Lim locality
(Sample 15-20-1: Figs. 2, 4, 9; Sample 15-21-2: Figs. 1, 3, 5–8, 10, 11).
Scale bar A (1, 4–7); B (2, 3, 8–11).

Fig. 1. *Triassocrucella* sp. cf. *T. triassica* (Kozur & Mostler);
Fig. 2. *Praehexasaturnalis tenuispinosus* (Donofrio & Mostler);
Fig. 3. *Palaeosaturnalis* sp.;
Fig. 4, 5. *Corum* sp.;
Figs. 6–9. *Spinosicapsa* spp.;
Figs. 10, 11. *Xiphothecaella longa* (Kozur & Mock).