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10.2298/GABP1901017B

GEOLOŠKI ANALI BALKANSKOGA POLUOSTRVA
Volume 80 (1), July 2019, 17–27
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DOI: 10.2298/GABP1901017B

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

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Key words:

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

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. Micropalaeontological 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 & MOCK). According to the radiolarian data, the investigated cherts are of latest Carnian to early Norian age.

Кључне речи:

Формација Гривска, рожнаци, радиоларије, горњи тријас, Унутрашњи Динариди, ЈЗ Србија.

Апстракт. Горњотријаски (горњи карн – рет) сиви кречњаци са рожнацима су у унутрашњим Динаридима познати под називом Формација Гривске. Седименте Формације Гривске карактерише присуство микрофосила – конодоната и радиоларија, као и одсуство макрофауне. На локалитету у долини реке Лим, у близини Бистрице (ЈЗ Србија), извршена су детаљна микропалеонтолошка истраживања горњотријаских силицијских 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 & MOCK). На основу одређених радиоларијских асоцијација утврђена је горњокарнијска до доњоноричка старост истраживаних седимената.

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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 allodapic 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 mélange. 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 Dinaridic Ophiolite Belt, openmarine cherty limestones (= the Grivska Formation) of this type occur only as blocks in the ophiolitic mélange 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 (Meliata 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).

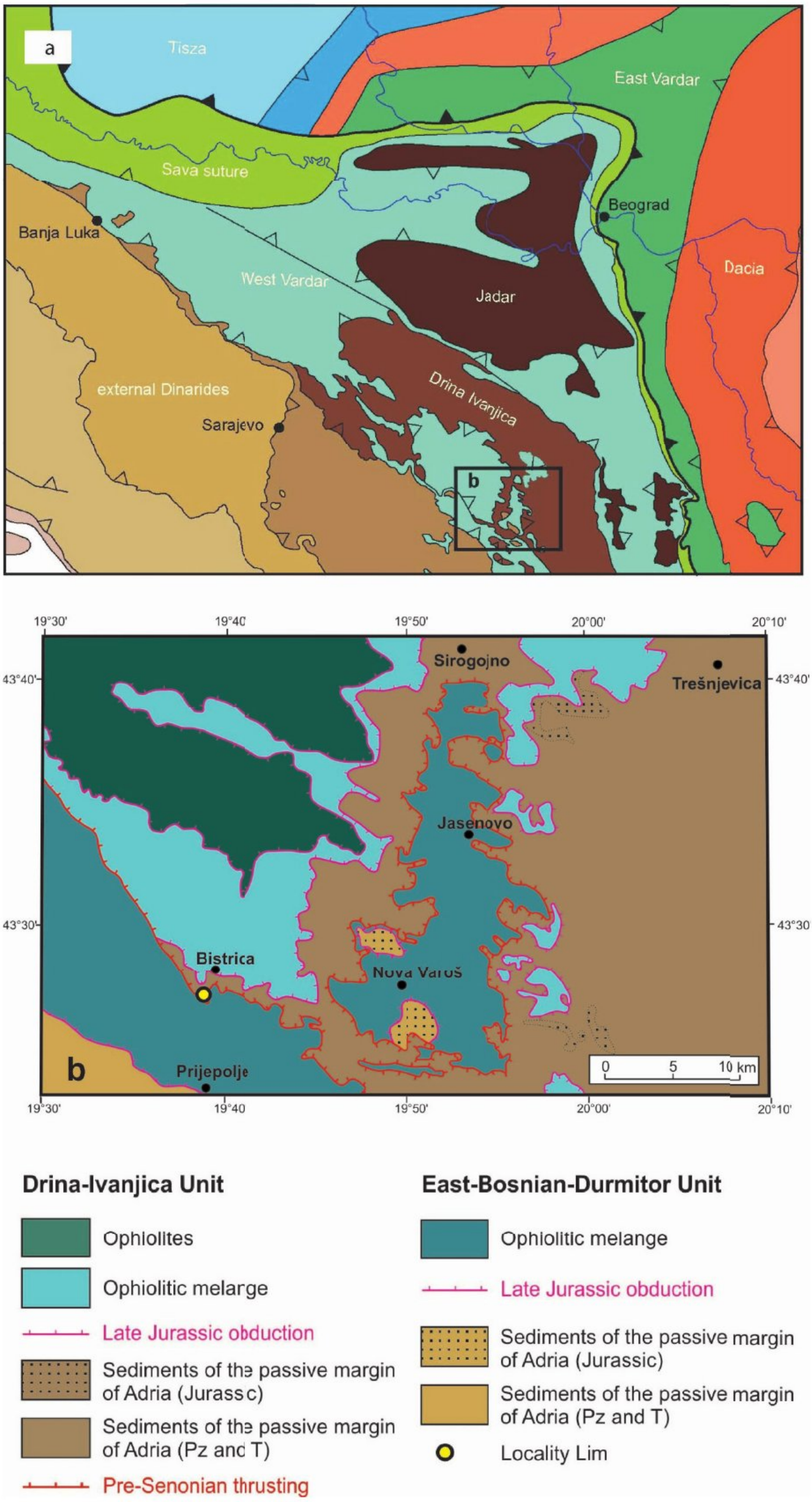

Fig. 1. a, *Main tectonic units in the central part of Balkan Peninsula (modified after* Bragin *et al., 2018);* ***b,*** *Simplified geologic map of the wider investigation area (modified after* Djerić *et al. 2012).*

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 facial 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; Radovanović et al., 2004; Chiari 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 mélange; 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-

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 (Sudar & 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 ($Na_4P_2O_7$) to remove clay particles. Radiolarians were picked from dried residues under light binocular microscope LOMO-MBS-10,

Fig. 2. *Limestones of the Grivska Formation in the valley of Lim River near the mouth of Bistrica River (**A,** outcrops of the Triassic limestones on the left side of Lim River valley; **B,** outcrops of the Triassic limestones on the right side of Lim River valley; note intensive folding; **C,** thin-bedded limestones with single bed of thick-bedded massive limestone; **D,** chert nodules in limestones; large pink nodule in the lower part of photo; small dark-grey nodule above the hammer).*

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°28'03,8" E 019°39'03,6"), four samples were collected, while second point is located in SW direction from the bridge (coordinates N 43°27'59,0" E 019°38'59,3") 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 ruesti of Western Europe (Kozur, 2003) and Zone Capnodoce crystallina of Eastern Russia (Bragin, 2000).

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

Radiolarian taxa \ Samples	15-20-1	15-21-2
Capnodoce anapetes De Wever		R
Capnodoce sarisa De Wever		C
Capnodoce sp.	C	C
Capnuchosphaera sp. cf. *C. tricornis* De Wever		R
Sarla hadrecaena (De Wever)		C
Sarla ? sp.	R	R
Ellisus ? sp.		R
Ellisus sp. cf. *E. siscwaiensis* (Carter)		R
Monocapnuchosphaera sp. B sensu Tekin, 1999		R
Eptingiidae ? gen. et sp. indet.	R	R
Palaeosaturnalis sp.		R
Praehexasaturnalis tenuispinosus (Donofrio & Mostler)	R	
Paronaella sp.	C	C
Triassocrucella sp. cf. *T. triassica* (Kozur & Mostler)		R
Corum sp.	C	C
Spinosicapsa spp.	C	C
Xiphothecaella longa (Kozur & Mock)		C

Final remarks

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 & Gawlick, 2018). The radiolarian associ-

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 (Sugiyama, 1997) and Eastern Russia (Bragin, 2000).

Acknowledgments

The authors gratefully acknowledge Ugur Kagan Tekin and Hazim Hrvatović for their constructive comments on the manuscript. The study was supported by Ministry of Education, Science and Technological Development of the Republic of Serbia, Project No. 176015. The study was made in the framework of Governmental Program 0135-2018-0033 of Geological Institute RAS, Moscow, Russia.

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Резиме

Горњотријаске радиоларије Формације Гривска, Унутрашњи Динариди, ЈЗ Србија

Тријаски хемипелашки седименти унутрашњих Динарида, који су представљени услојеним кречњацима са прослојцима лапораца и глинаца, честим нодулама рожнаца и местимично крупнозрним алодапским слојевима, познати су под називом „Формација Гривске". Ову формацију су неформално установили Dimitrijević & Dimitrijević (1991). Према Dimitrijević (1997), ове стене представљају велике олистоплаке, које се налазе у тектонском контакту са подинским и повлатним стенама. У унутрашњим Динаридима термин „Формација Гривска" све до скоро је погрешно употребљиван за све средњотријаске до средњо (?горњо) јурске сиве кречњаке са рожнацима.

Missoni et al. (2012) предлажу коришћење термина „Гривска група", која би обухватила различите средњо- и горњотријаске хемипелашке услојене кречњаке са рожнацима и остатке плитководних седимената. Касније, Gawlick et al. (2016, 2017) и Sudar & Gawlick (2018) врше ревизију Формације Гривска, користећи новодобијене биостратиграфске и микрофацијалне податке. Sudar & Gawlick (2018) одређују горњотријаску (карнијски кат – ретски кат) старост Формације Гривска на основу конодонтске микрофауне. Значајно је истаћи да се седименти Формације Гривска карактеришу само присуством микрофауне – конодонти и радиоларије, и не садрже представнике макрофауне.

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 прослојцима и нодулама беличастих до ружичастих рожнаца.

На основу анализиране радиоларијске асоцијације, утврђена је горњокарнијска до доњоноричка старост узоркованих рожнаца. Новодобијени подаци су у потпуности сагласни са подацима добијеним анализом конодонтске микрофауне (норички кат; Sudar & Gawlick, 2018). Радиоларијске асоцијације изоловане из седимената локалитета Лим карактеришу се присуством добро познатих таксона бројних светских локалитета горњокарнијске до доњоноричке старости: алпско-медитеранска област (De Wever, 1982; Kozur, 2003 Tekin, 1999; Bragin, 2007), Северна Америка (Blome, 1984), Јапан (Sugiyama, 1997) и источни део Русије (Bragin, 2000).

Manuscript recieved May 05, 2019
Revised manuscript accepted June 23, 2019

Plate 1.

Latest Carnian to Early Norian radiolarian associations from the Lim locality
(Sample 15-20-1: Figs. 3, 6, 13; Sample 15-21-2: Figs. 1, 2, 4, 5, 7-12).
Scale bar A (1–3, 5–7, 10–13); B (4, 8, 9).

Fig. 1. *Capnodoce anapetes* De Wever;
Fig. 2. *Capnodoce sarisa* De Wever;
Fig. 3. *Capnodoce* sp.;
Fig. 4. *Capnuchosphaera* sp. cf. *C. tricornis* De Wever;
Fig. 5. *Sarla hadrecaena* (De Wever);
Fig. 6. *Ellisus* ? sp.;
Figs. 7, 11. Eptingiidae gen. et sp. indet.;
Fig. 8. *Monocapnuchosphaera* sp. B sensu Tekin, 1999;
Fig. 9. *Sarla* ? sp.;
Fig. 10. *Ellisus* sp. cf. *E. siscwaiensis* (Carter);
Figs. 12, 13. *Paronaella* sp.

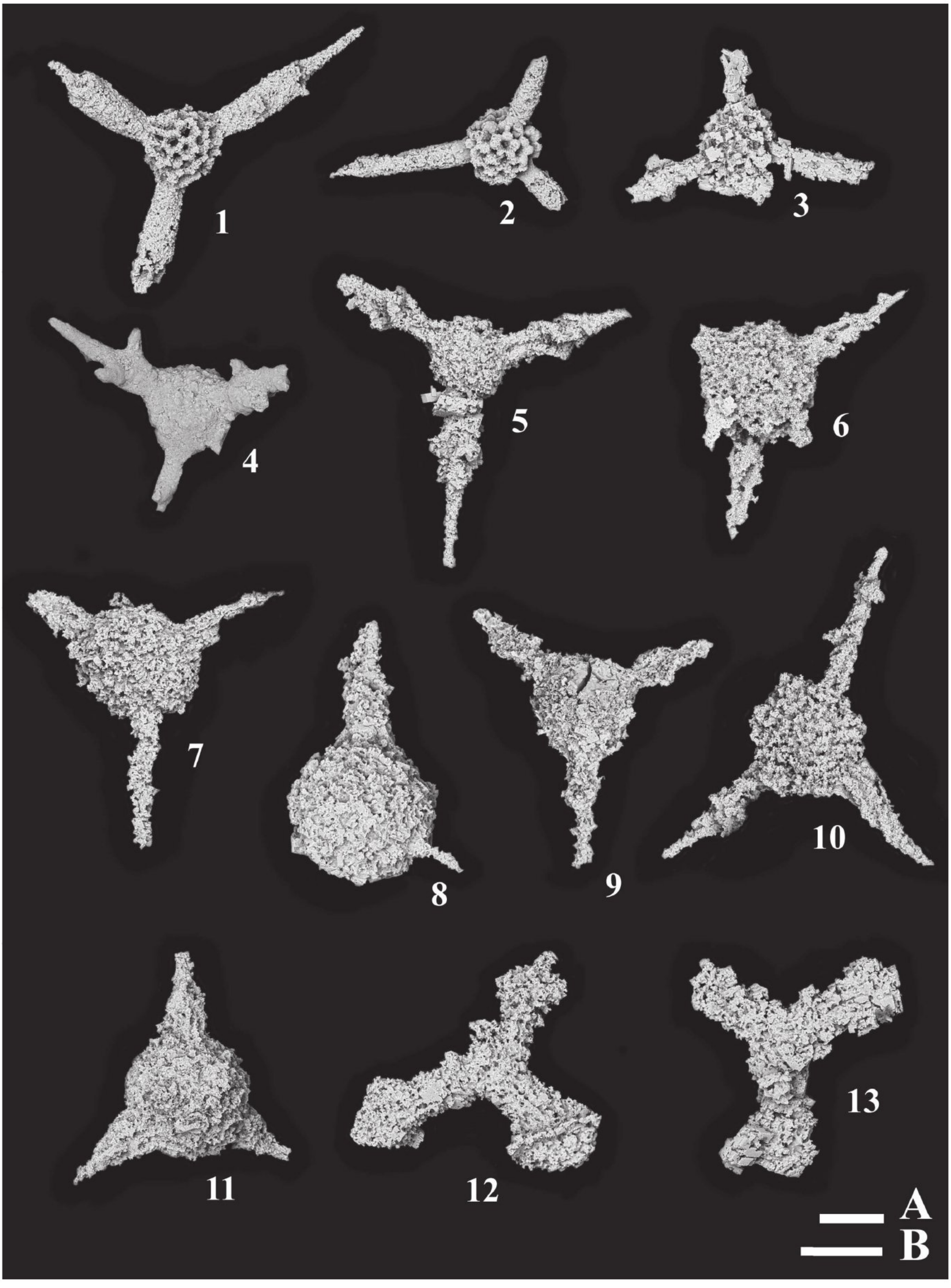
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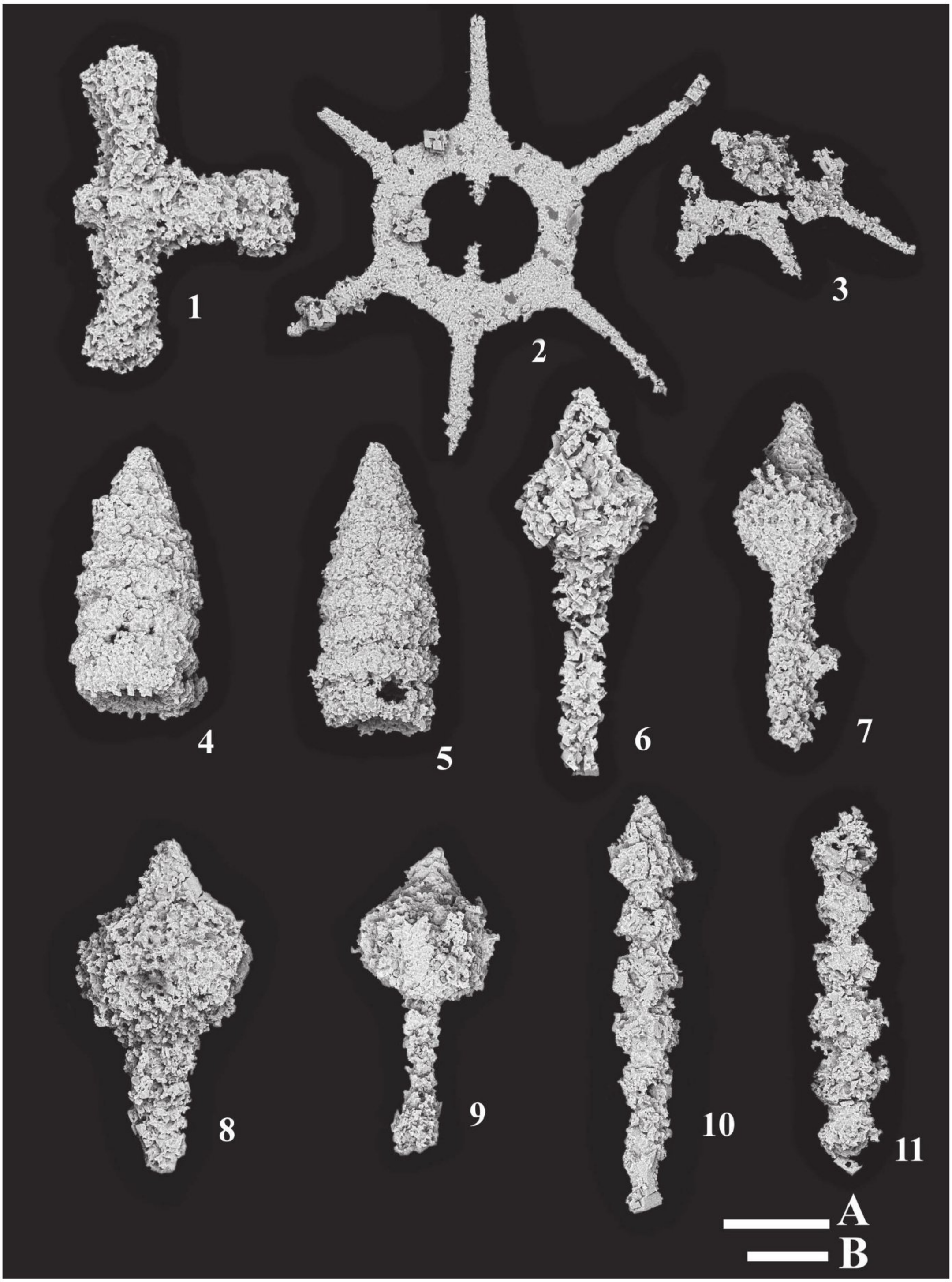
Plate 2.

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).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