GEOLOŠKI ANALI BALKANSKOGA POLUOSTRVA
Volume 82 (1), July 2021,1–25
–
https://doi.org/10.2298/GABP201230001D
Original scientific paper
Оригинални научни рад

Early-Middle Jurassic stepwise deepening in the transitional facies belt between the Adriatic Carbonate Platform Basement and Neo-Tethys open shelf in northeastern Montenegro evidenced by new ammonoid data from the early Late Pliensbachian (Lavinianum Zone)

Martin Đaković[1], Hans-Jürgen Gawlick[2] & Milan Sudar[3]

Key words:
Western Tethys, Dinarides, Pliensbachian, ammonoids, biostratigraphy, NE Montenegro

Abstract. New ammonoid data prove an early Late Pliensbachian deepening event above the ?Late Hettangian-Sinemurian shallow-subtidal gray-reddish micro-oncoidal-foraminifera grainstone facies and the ?Early Pliensbachian deeper-marine micro-oncoidal-crinoidal-ammonoid wacke- to packstone facies. Based on the presence of *Fuciniceras lavinianum* (Fucini), *Lytoceras ovimontanum* Geyer and Arieticeratinae gen. indet. from a hardground above the deeper-water micro-oncoidal limestones in the Mihajlovići section (north-eastern Montenegro) a Late Pliensbachian to Early Toarcian condensation horizon is proven. The Middle Toarcian ammonoid-bearing horizon also yielded species not known from previous studies: *Calliphylloceras capitanii* (Catullo), *Harpoceras subplanatum* (Oppel) and *Furloceras* aff. *chelussii* (Parisch & Viale), also described in the present paper. These new data prove a stepwise deepening of the depositional area during the Early and the Middle Jurassic reflected in detail in four sedimentary members: 1) ?Late Hettangian to Sinemurian/?earliest Pliensbachian open-marine shallow subtital micro-oncoidal limestones; 2) ?Early to Late Pliensbachian open-marine condensed limestones with few micro-oncoids and more open-marine influence; 3) Toarcian open-marine condensed red limestones with hardgrounds; and 4) condensed red nodular *Bositra* Limestone. These four members are separated by hardrounds representing stratigraphic gaps in deposition. The stepwise deepening during the Early-Middle Jurassic follows the general trend of deposition as known in the whole Western Tethys Realm above the Late Triassic Dachstein Carbonate Platform.

Апстракт. Нови подаци о амоноидима доказују рано касноплинзбашко продубљивање изнад плитке субтајдалне сиво-црвенкасте микроонкоидно-фораминиферске грејнстон фације ?каснохетаншко-синемурског доба и дубоководне микроонкоидно-криноидско-амонитске векстон до пекстон фације ?раног плинзбашког доба. На основу врста *Fuciniceras lavinianum* (Fucini), *Lytoceras ovimontanum* Geyer и Arieticeratinae gen. indet. из хардграунда који се налази изнад онкоидних кречњака у Михајловићима доказана је горњоплинзбашка до доњотоарска старост овог кондензованог хоризонта. У оквиру средњотоарског хоризонта прона-

[1] Geological Survey of Montenegro, Naselje Kruševac bb, 81000 Podgorica, Montenegro. E-mail: comanski@gmail.com
[2] Montanuniversität Leoben, Department Applied Geoscience and Geophysics, Leoben, Austria. E-mail: gawlick@unileoben.ac.at
[3] Serbian Academy of Sciences and Arts, Kneza Mihaila 35, 11000 Belgrade, Serbia. E-mail: milan.sudar1946@gmail.com

ђене су врсте које нису констатоване ранијим истраживањима: *Calliphylloceras capitanii* (Catullo), *Harpoceras subplanatum* (Oppel) и *Furloceras* aff. *chelussii* (Parisch & Viale), а које су такође описане у овом раду. Нови подаци доказују постепено продубљивање током ране и средње јуре које је детаљно документовано у следећа четири седиментна члана: 1) плитководни субтајдални микроонкоидни кречњаци отвореног мора ?касног хетанжа до синемура/?најранијег плинзбашког доба; 2) кондензовани кречњаци отвореног мора са ријетким микроонкоидима и већим утицајем отвореног мора него у претходном члану, ?раног до касног плинзбашког доба; 3) кондензовани кречњаци са хардграундима отвореног мора тоарске старости; и 4) кондензовани црвени нодуларни *Bositra* кречњаци. Ова четири члана су одвојена хардграундима који представљају стратиграфске прекиде у депозицији. Постепено продубљивање током ране-средње јуре прати општи тренд депозиције какав је познат у читавом западном Тетису изнад каснотријаске дахштајнске карбонатне платформе.

Кључне речи:
Западни Тетис, Динариди, плинзбашки кат, амоноиди, биостратиграфија, СИ Црна Гора

Introduction

The Early-Middle Jurassic depositional history in the Inner Dinarides is poorly known due to the lack of available outcrops, and modern microfacies analysis in combination with exact biostratigraphic data are very rare (Gawlick et al., 2017, 2020 and references therein; Haas et al., 2019). In contrast to the Early–Middle Jurassic well known depositional history in the Outer Dinarides, i.e. the Adriatic Carbonate Platform Basement and the Adriatic Carbonate Platform evolution (Vlahović et al., 2005 and references therein), the transitional zone between the Early–Middle Jurassic shallow-water depositional realm of the Outer Dinarides and the open shelf environment (Inner Dinarides) near to the Neo-Tethys Ocean to the east (Gawlick et al., 2016; West Vardar Ocean in the nomenclature of Schmid et al., 2008, 2020) is poorly known. Early–Middle Jurassic sedimentary rocks from the outer shelf environment are practically unknown, since they were in parts removed/eroded or overthrust in the course of Middle to Late Jurassic west-directed ophiolite obduction (Gawlick et al., 2016, 2020; Gawlick & Missoni, 2019 and references therein). Only few remains of this facies belt are known preserved either as small components in the late Middle to early Late Jurassic trench-like foreland basin fills (Gawlick et al., 2017) or are preserved as metamorphosed successions (e.g., in the Kopoanik area: Schefer et al., 2010). In addition, due to intense erosion after mountain uplift from the Kimmeridgian/Tithonian boundary onwards (Gawlick et al., 2017, 2020) most of the Jurassic outer shelf successions were eroded. Especially in the areas of the Late Triassic open lagoonal facies belt (open lagoonal Dachstein Limestone: Gawlick et al., 2017, 2020) transitional to the Late Triassic reef belt, where the presence of Early–Middle Jurassic condensed red nodular limestone successions could so far only be reconstructed from pebble anaylsis (Gawlick et al., 2017) Early–Middle Jurassic sequences are preserved only in rare cases. The detailed deepening history of this red nodular Early–Middle Jurassic limestones (Ammonitico Rosso), with its well-known and in detail described facies characteristics (Flügel, 2004 and references therein) and the adjacent facies belts transitional to the Adriatic Carbonate Platform Basement, can in the Inner Dinarides only be reconstructed indirectly.

In addition, sedimentary sections transitional from shallow-water areas to this red nodular limestone open shelf environment are not preserved in most areas of the eastern Mediterranean mountain ranges, i.e. the Eastern Alps, Western Carpathians. Here, red nodular limestones, i.e. the open-marine condensed environment, were formed directly on top of the shallow-water limestones of the Dachstein Carbonate Platform. Early–Middle Jurassic sedimentary succession with shallow-water limestones in the earliest Jurassic followed by middle–

late Early Jurassic and Middle Jurassic deeper-water red nodular limestones are well described only in the eastern Southern Alps (for Italy: Masetti et al., 2012 and references therein; for Slovenia: Buser & Dozet, 2009 and references therein) or the Transdanubuian Range (Haas, 2012; Császar et al., 2018 and references therein). Nevertheless, they may differ from the sedimentary evolution in the Dinarides. In the Eastern Alps or Western Carpathians mainly Early–Middle Jurassic deep-water limestones, often in red nodular condensed facies are known (Haas et al., 2011 and references therein). However, all these areas are affected by the opening history of the Alpine Atlantic (Ligurian, Piemont, Penninic, Vah oceans in other nomenclature: Missoni & Gawlick, 2011) from Hettangian times onwards. There, the Early–Middle Jurassic sedimentary successions may reflect in their depositional history tectonostratigraphic events, i.e. the opening history of the Alpine Atlantic rather more as similar successions in the Dinarides, which are more or less shielded by the Adriatic Carbonate Platform (and its basement) towards the opening history of the Alpine Atlantic. Therefore, it is hard to decide if events in the sedimentary record in these successions reflect regional, over-regional or global events, or a mixture. Successions in the Inner Dinarides may provide a possibility to filter global and over-regional events and their importance.

Furthermore, a detailed knowledge about the sedimentary history of this transitional facies belt between the Adriatic Carbonate Platform and its basement and the open shelf environment, which is preserved in rare outcrops in the Inner Dinarides along a cross-section from southwest Serbia to northeast Montenegro, also provide the possibilty to fill the gap in understanding the Early–Middle Jurassic depositional history in the Inner Dinarides.

New ammonoid findings from Early Jurassic hardgrounds in northeastern Montenegro (Mihajlovići section: Fig. 1) enable a good chance to fill the gap in knowledge about the depositional history in Early–Middle Jurassic times, i.e. the stepwise deepening of the depositional realm throughout the Early–Middle Jurassic.

The ammonoid fauna from the Middle Toarcian Bifrons Zone of the Mihajlovići section is well known also from several other localities in Montenegro (e.g., in Vojnik Mt.: Bešić, 1948; Radoičić-Brstina, 1956; Mirković, 1965), but frequently without clear determination of the biostratigraphic zone.

The Jurassic section in Mihajlovići, located approximately 10 km east of the town Pljevlja on the road from Pljevlja to Prijepolje (Fig. 1B), has been studied in detail for almost a century, with special attention drawn to the Early Jurassic ammonoid fauna discovered in red nodular limestones. The section was first described by Živković & Milojević (1934) and an assigned Carnian age based on a scarce ammonoid association. After this, the section was studied in detail by Radoičić-Brstina (1956), Nöth (1956), Mirković (1970), Rampnoux (1974), Rabrenović et al. (2012), Metodiev et al. (2013), Ostojić & Milić (2014) and Gawlick et al. (2020). Most of the aforementioned authors agree that the ammonoid assemblage determined from red nodular limestones of this locality is Toarcian in age, while Rabrenović et al. (2012) and Metodiev et al. (2013) are designating it for the first time as Bifrons Zone fauna. However, the age of the underlying yellow-grey limestones is interpreted differently. Rabrenović et al. (2012) assigned these limestones to the ?Late Hettangian–Simemurian (see discussion in Gawlick et al. 2017, 2020).

According to Rampnoux (1974) the red nodular limestones from Mihajlovići contain ammonoids of Early Toarcian age, mixed faunas of Middle to Late Toarcian age, and an indeterminable fauna of uppermost Early Jurassic to early Middle Jurassic. The underlying pink and yellow limestones contain a microfauna indicating that its higher parts are of Early Jurassic age. In the most recent paper on the biostratigraphy of this section (e.g., Rabrenović et al., 2012), the age of the yellow-grey limestones underlying the red ammonoid-bearing horizon is determined as Sinemurian, based on foraminifera assemblages.

A new collection of ammonoids allows now a more precise age determination of the micro-oncoidal limestones below the Toarcian condensed red nodular limestones and to date exactly the stepwise deepening history in this transitional facies belt from the shallow-marine Adriatic Carbonate Platform Basement (sensu Vlahović et al., 2005) to the west and the open shelf environment to the east, i.e.

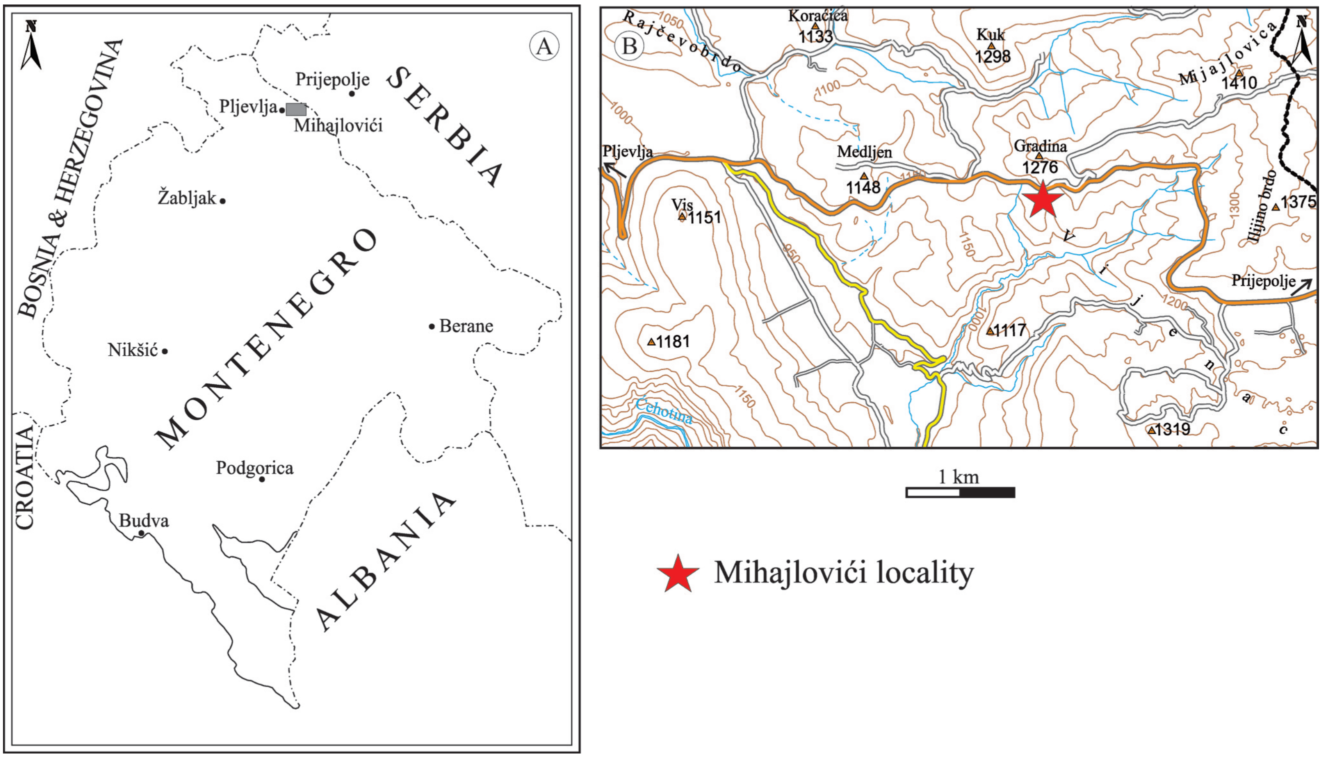

***Fig. 1. A.** Position of the Mihajlovići locality in NE Montenegro; **B.** Topographic map of the investigated area, arrows indicate directions to Pljevlja or Prijepolje.*

the western passive continental margin of the Neo-Tethys Ocean. In addition, a detailed study of the microfacies of the different members shows a change in the depositional environment during Early–Middle Jurassic times. In general a deeping trend can be observed and the different parts of the successions are divided by the formation of condensed limestones or hardgrounds, i.e. times of stratigraphic condensation (e.g., Jenkyns, 1971; Fürsich, 1971; Martire, 1992; Gomez & Fernandez-Lopez, 1994; Wendt, 2017).

Geological setting of Mihajlovići section

The studied Mihajlovići section is located in northeastern Montenegro and belongs to the underlying Triassic–Jurassic parautochthonous sequences of the East Bosnian–Durmitor Megaunit in sense of Gawlick et al. (2017, 2020; compare Schmid et al. 2008, 2020). This area is mostly built by Late Triassic shallow-water limestones, with rare occurrences of Early to Middle Jurassic limestones and Middle to Late Jurassic radiolarites. Geological relations are described by Mirković (1970) and Rampnoux (1974), and more detailed descriptions of the Mihajlovići locality are given by Rabrenović et al. (2012), Metodiev et al. (2013), and Gawlick et al. (2020).

Material

Except for a few fragments mentioned by Nöth (1956, p. 181), ammonoids haven't been discovered in the yellow-grey limestones of the member 2 (Fig. 2) of the Mihajlovići section. During recent investigations, three specimens belonging to *Fuciniceras lavinianum* (Fucini), *Lytoceras ovimontanum* Geyer and Arieticeratinae gen. indet. were found in the horizon just below red nodular limestone of Middle Toarcian age. These species indicate an early Late Pliensbachian age, at least for the upper part of yellow-grey limestones, which is very different than the age assigned to these rocks by Rabrenović et al. (2012).

Also a new ammonoid fauna from the *Hildoceras bifrons* horizon has been collected and the following species were determined: *Calliphylloceras capitanii* (Catullo), *Calliphylloceras* cf. *nilssoni* (Hebert), *Calliphylloceras* sp., *Phylloceras heterophyllum* (Sowerby), *Lytoceras francisci* (Oppel), *Lytoceras* sp., *Hildoceras lusitanicum* Meister, *Hildoceras bifrons* (Bruguiere), *Hildoceras* sp., *Harpoceras subplanatum* (Oppel), *Harpoceras* sp. and *Furloceras* aff. *chelussii* (Parisch & Viale). In the present paper, several specimens of *Calliphylloceras capitanii* (Catullo), *Harpoceras subplanatum* (Oppel) and *Furloceras* aff. *chelussii* (Parisch & Viale) are described, since they represent first findings of these species in the Middle Toarcian Bifrons Zone from this locality.

Results

The most detailed sedimentological columns and descriptions of the Mihajlovići section are given by Rabrenović et al. (2012) and Gawlick et al. (2020), and readers are refered to these publications. However, the new ammonoid data require a revision of that part of the section assigned to the Sinemurian by Rabrenović et al. (2012). The new ammonoid dating clearly improves a stepwise deepening throughout the whole Early–Middle Jurassic and the stratigraphic gaps in the Early Jurassic are shorter in duration as interpreted before.

The Early Jurassic can now be subdivided based on ammonoid data combined with microfacies analysis in following three members with the different ages:

1. Middle/Late Hettangian to Sinemurian,
2. Early to Late Pliensbachian, and
3. Toarcian,

followed in the Middle Jurassic by *Bositra* Limestone.

The three Early Jurassic members and the Middle Jurassic *Bositra* Limestone, as a fourth member, belong to the Krš Gradac Formation as described by Gawlick et al. (2017, 2020).

?Middle/Late Hettangian to Sinemurian

The lowermost part of the Early Jurassic succession consists of shallow-subtidal micro-oncoidal limestones, mainly grain- and packstones (Fig. 3) with abundand benthic foraminifers, crinoids and only few open-marine organisms. According to Rabrenović et al. (2012) the age of this part of the successions is exclusively Sinemurian, but the biostratigraphic age is based only on the occurrence of benthic foraminifers assemblages from the upper 8 meters of the succession (see Fig. 2). As marker foraminifers for the Sinemurian age Rabrenović et al. (2012) particularly consider *Ophthalmidium liasicum* (Küebler & Zwingli), *Ophthalmidium leischneri* (Kristan-Tollmann), *Lingulina* gr. *tenera* Bornemann, and *Reinholdella planiconvexa* (Fuchs). While all of the mentioned species can be found in Sinemurian sedimentary rocks, they actually have a much longer biostratigraphic age range, which is for specific taxa already published by Copestake & Johnson (1989), Trifonova (1993), Tudoran (1997), Hylton (2000), Mancinelli et al. (2004), Canales & Henriques (2008) amongst others.

The lower part of the micro-oncoidal limestone succession can not be dated exactly, but contains similar benthic foraminifers as documented from the higher part of the succession. These foraminifers are also known from Early Jurassic successions in the Eastern Alps from the Hettangian reaching the Sinemurian (Böhm, 1992; Ebli, 1997; Blau, 1987a, b; Blau & Grün, 1994, 1997; Gawlick et al., 2009a).

Micro-oncoidal framework is the only microfacies in this sedimentary member. Whereas in the lower part of this sedimentary member relatively large micro-oncoids with several layers are common the number of layers/laminae decreases upsection (Fig. 3). In addition, the variability of the benthic foraminifers and the amount of crinoid fragments increases throughout this sedimentary member, clearly indicating a slight deepening trend during the ?Middle/Late Hettangian-Sinemurian. According to Flügel (2004 and references therein) such micro-oncoidal framework was formed in a shallow-subtidal environment. Missing shallow-water reefal or lagoonal components or organisms show that the depositional environment of these micro-oncoidal limestones was relatively far away from the Adriatic Carbonate Platform Basement (according to Vlahović et al., 2005) with its abundant calcareous algae and different foraminifers assemblages (e.g., Velić,

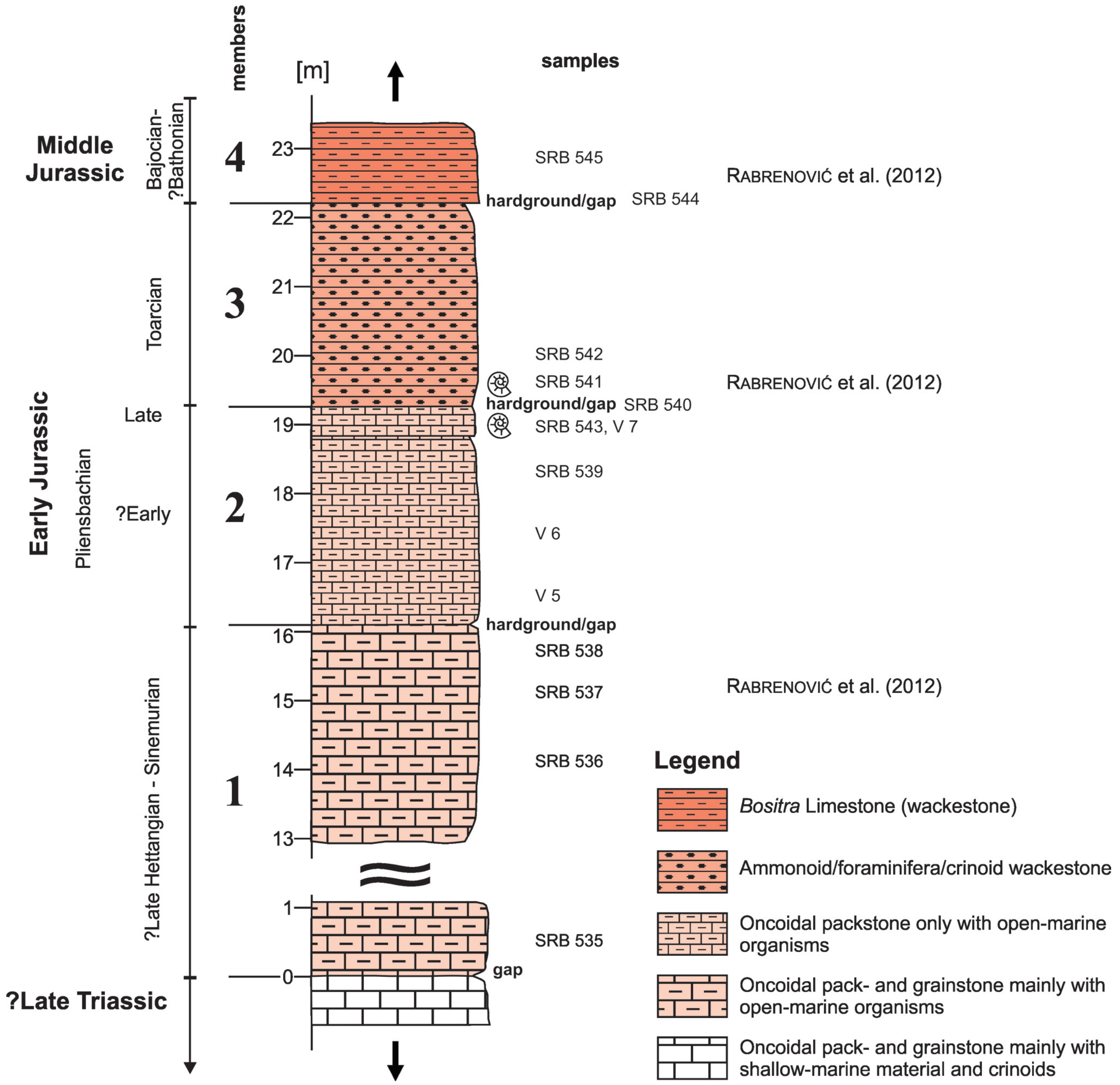

Fig. 2. *Early and Middle Jurassic parts of the Krš Gradac Formation in the Mihajlovići section, with sedimentary characteristics, ammonoid layers, and sample positions. Thickness of the succession according to* RABRENOVIĆ *et al. (2012). For a detailed description of the whole Late Triassic to Late Jurassic succession see* GAWLICK *et al. (2020) and references therein.*

2007), beside other organisms. We interpret therefore the depositional environment and setting as a tidally influenced marginal marine setting between the Adriatic Carbonate Platform Basement to the west and the open-marine shelf of the Neo-Tethys Ocean to the east.

? Early to Late Pliensbachian

RABRENOVIĆ et al. (2012) assigned the lowermost part of our sedimentary member 2 (Pliensbachian) also to the Sinemurian, based on biostratigraphic ages of foraminifers, which were found roughly one meter above the first hardground (section meter 16:

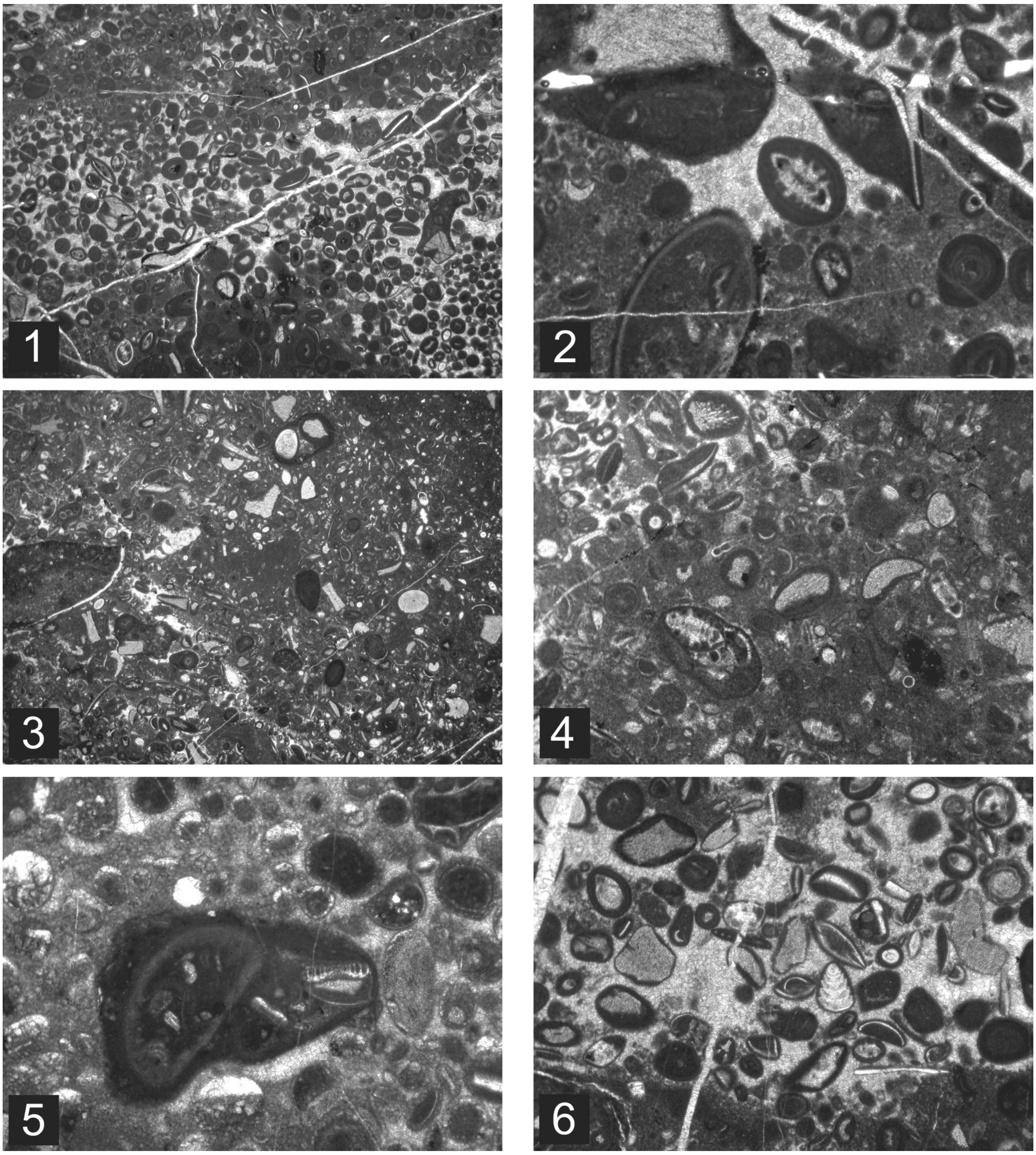

Fig. 3. *Microfacies characteristics of the lowermost Early Jurassic sedimentary member of the Mihajlovići section. For sample position see Fig. 2.* ***1****. Layered and well-sorted micro-oncoidal pack- to grainstone from the basal part of the Jurassic. The nucleus of the micro-oncoids are predominantly shell fragments, foraminifers, and crinoids. Aggregate grains occur rarely. The foraminifers fauna is not very diverse, involutinids and trocholinids are dominating. Sample SRB 535. Width of the photo: 1.25 cm.* ***2****. Enlargement of 1. Showing micro-oncoids with various nuclei and microbial induced cement between the micro-oncoids. The micro-oncoid in the centre of the photograph shows Involutina liassica (Jones) as nucleus. Width of the photo: 0.25 cm.* ***3****. Micro-oncoidal packstones were also formed, beside the micro-oncoidal grainstones. These packstone microfacies contain less micro-oncoids, and most organism fragments – predominantly crinoids, shell fragments, benthic foraminifers – have only one microbial layer. Missing layering indicates bioturbation. Sample SRB 536. Width of the photo: 1.25 cm.* ***4****. Enlargement of 3, different part. Benthic foraminifers, i.e. Involutina liassica (Jones), and crinoids are the most common nuclei of the micro-oncoids. Width of the photo: 0.25 cm.* ***5****. Slightly recrystallized well-sorted micro-oncoidal pack- to grainstone from the upper part of the lowermost Early Jurassic member. Several micro-oncoids were solved during early diagenetic processes and replaced by sparry calcite. Important to note, that this diagenetic feature appears only in this part of the successions, other layers are not affected by such strong recrystallization. Sample SRB 537. Width of the photo: 1.25 cm.* ***6****. Well-sorted micro-oncoidal grainstone with predominantly crinoid fragments as nuclei. The foraminifers occurring in the nuclei are much more diversed as in the lower part of this sedimentary member. Sample SRB 538. Width of the photo: 1.25 cm.*

Fig. 2). A similar foraminifers assemblage as in the member below was determined. The age ranges of the used foraminifers are not exclusively indicative for the Sinemurian, i.e. they are longer, at least to the Pliensbachian. In contrast, there is an abrupt microfacies change at this hardground. Whereas in the lowermost sedimentary member micro-oncoidal framework is the characteristic microfacies, this type of microfacies is practically missing in the sedimentary member 2 (Fig. 4).

New ammonoid specimens are found in the uppermost 40 centimeters of member 2 (Fig. 2), below the upper hard-ground surface with the Middle Toarcian ammonoids. The age of this level based on an ammonoid fauna with *Fuciniceras lavinianum* (Fucini), indicates clearly an early Late Pliensbachian, establishing the Lavinianum Zone in this locality.

According to these new early Upper Pliensbachian ammonoids we assign the age of the sedimentary member 2 as ?Early Pliensbachian to early Late Pliensbachian. The hardground at the base of member 2 may represent therefore a gap of the uppermost Sinemurian to the Early Pliensbachian, which would be in accordance with sections known in the Southern Alps (Masetti et al., 2017). The hardground above the early Upper Pliensbachian ammonoids would therefore represent a longer gap in the depositional history, i.e. the rest of the Pliensbachian and the lowermost Toarcian is not documented by the deposition of sedimentary rocks, and subsolution during this time span was forming the hardground on top of the early Upper Pliensbachian ammonoid-bearing horizon (Fig. 4).

The microfacies characteristics of the Pliensbachian reddish limestones differs significantly from the ?Late Hettangian-Sinemurian micro-oncoidal limestones. Micro-oncoids are practically missing in most parts of this member. Only in few levels some few micro-oncoids appear, mainly with foraminifers as core. Wackestones with thick shells (brachiopods, ?bivalves), crinoids, some foraminifers and ammonoid shells are dominant (Fig. 4). Around the level with the early Upper Pliensbachian ammonoids the limestones are more condensed, as visible in the densely packed ammonid-crinoid-foraminifers packstones. Such microfacies types point to deposition in a relative low-energetic deeper-water environment. Missing shallow-water organisms clearly indicate a depositional realm far from a shallow-water carbonate production area, i. e. the Adriatic Carbonate Platform Basement, where contemporaneously the *Lithiotis* carbonate platform was formed (Vlahović et al., 2005; Gawlick & Schlagintweit, 2019). The condensend early Upper Pliensbachian level may correlate with the slight deepening event in the *Lithiotis* platform evolution, where siliceous deeper-water layers were deposited above massive lithiotid build-ups (*Litiosepta compressa* range zone, Gawlick & Schlagintweit, 2019). The change in the microfacies from the micro-oncoidal facies in the ?Late Hettangian-Sinemurian to the Pliensbachian deeper-water environment clearly indicates ongoing deepening.

Toarcian

The Toarcian part of the Early Jurassic succession in Mihajlovići is represented by deeper open-marine nodular and condensed limestones. The lowermost layer contains a rich Middle Toarcian ammonoid fauna (Rabrenović et al., 2012; Metodiev et al., 2013; this paper). The hardground itself consists of a Fe/Mn-crust indicating a lithified sea floor and a time of non-deposition, i.e. a gap. Ammonoids appear slightly above this hardground again in a micro-oncoidal facies and in crinoid-foraminifers-ammonoid limestones (Fig. 5). Here in the (Middle) Toarcian (Bifrons Zone according to Rabrenović et al., 2012) these micro-oncoids are much smaller, not as common as in the ?Late Hettangian-Sinemurian and have mainly only one or two rims (Fig. 5). Wacke- to packstones with common ammonoid fragments, foraminifers and crinoids are the dominant microfacies throughout the Toarcian part of the section, often with indication of ongoing hardground formation (Fig. 5) as indicated by the common lithoclasts with in cases Fe/Mn-crusts, shells with indications of boring organisms and layered hardgrounds. Gastropods and benthic foraminifers are also common. This microfacies indicates deposition in a low-energy relative deep-water environment (open shelf environment).

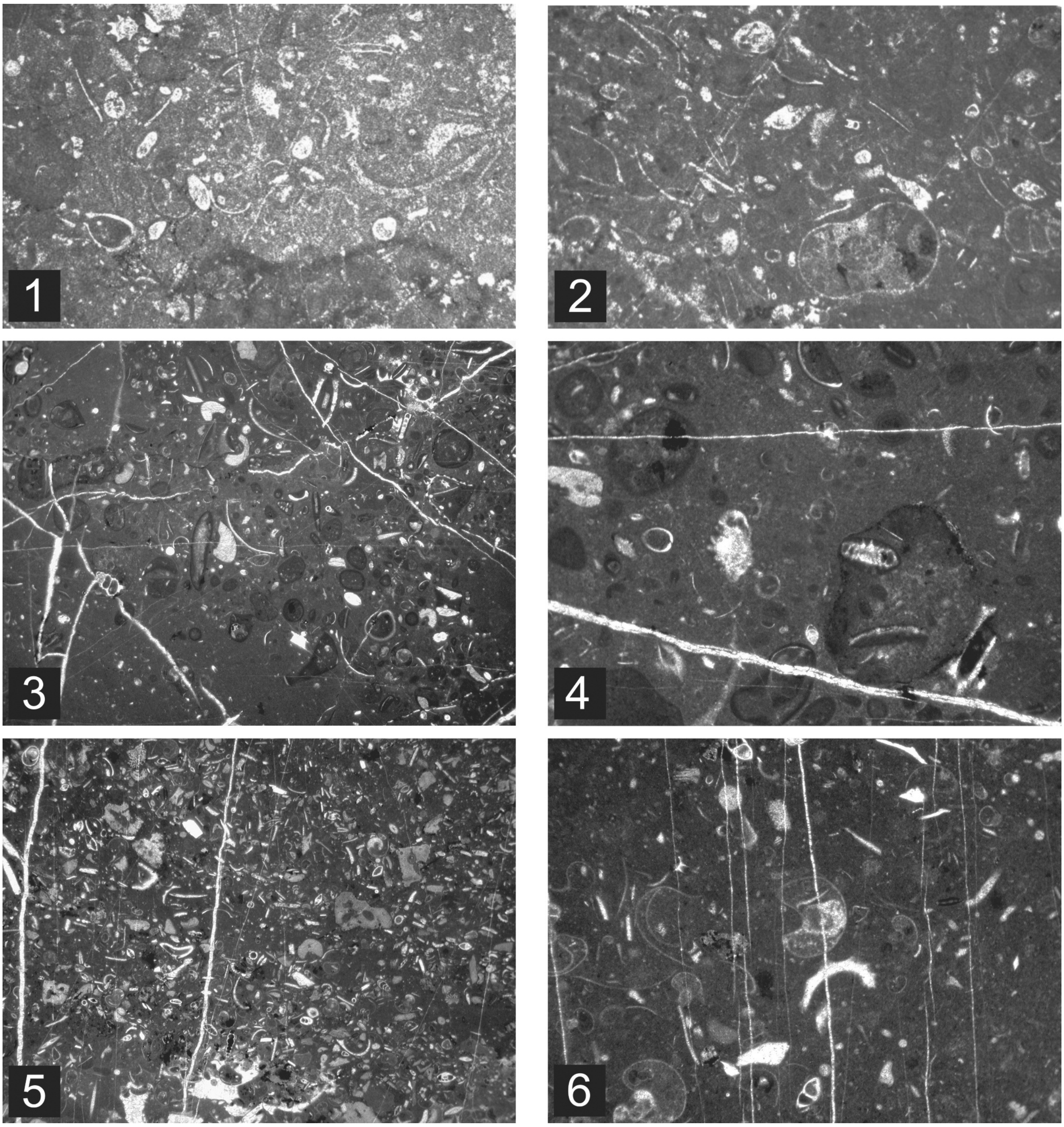

***Fig. 4.** Microfacies of the Pliensbachian reddish deeper-water limestones of the Mihajlovići section. For sample position see Fig. 2. **1.** Shell-rich packstone with same rare foraminifers. Lowermost part of member 2. Sample V5. Width of the photo: 0.35 cm. **2.** Wackestone with juvenile ammonoids, gastropods and some few foraminifers. Sample V6. Width of the photo: 0.35 cm. **3.** Crinoidal-rich wackestone with gastropods, foraminifers and few oncoidal grains. Sample SRB 539. Width of the photo: 1.25 cm. **4.** Enlargement of 3., other view. Crinoid-foraminifers wackestone with few small oncoidal grains. In the central part of the photo two specimen of Involutina liassica (Jones) are visible. Width of the photo: 0.25 cm. **5.** Condensed ammonid-crinoid-foraminifers packstone. Sample SRB 543. Width of the photo: 1.25 cm. **6.** Enlargement of 5., other view. Wackestone rich in juvenile ammonoids. Width of the photo: 0.25 cm.*

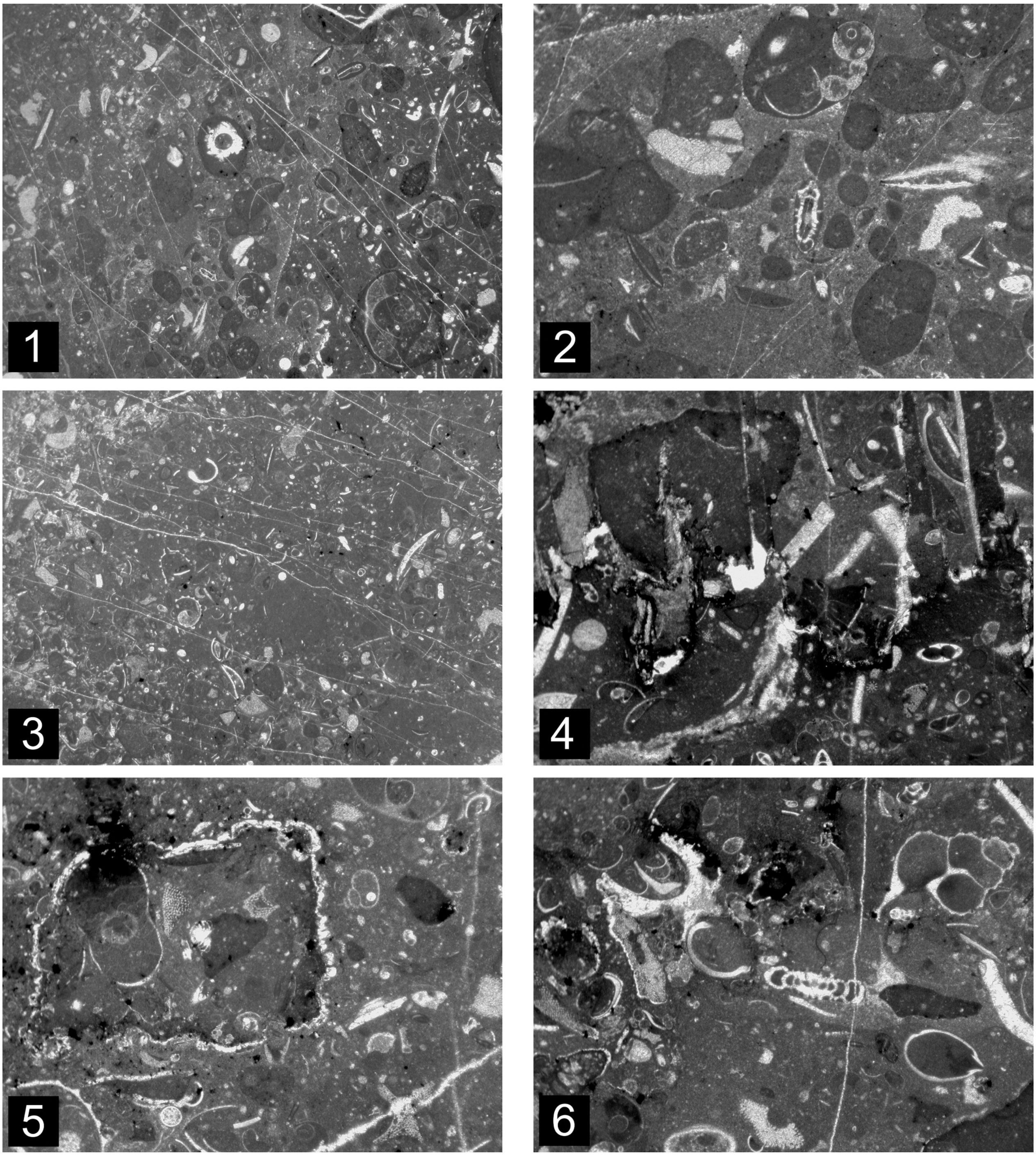

Fig. 5. *Microfacies of the Toarcian reddish deeper-water limestones of the Mihajlovići section. For sample position see Fig. 2.* ***1.*** *Micro-oncoidal packstone with ammonoids, crinoids, ostracods, and some foraminifers. Sample SRB 540. Width of the photo: 1.25 cm.* ***2.*** *Micro-oncoidal components with juvenile ammonoids, shell fragments or foraminifers (Involutina sp.) as cores beside crinoid fragments. Sample SRB 540, other view. Width of the photo: 0.5 cm.* ***3.*** *Crinoid-ammonoid wacke- to packstone with some micro-oncoids. Sample SRB 541. Width of the photo: 1.25 cm.* ***4.*** *Hardground on top of a crinoid-foraminifers-ammonoid wackestone and overlying shell-rich packstone with lithoclasts, shell fragments and ammonoids. Sample SRB 542. Width of the photo: 0.5 cm.* ***5.*** *Condensed crinoid-ammonoid wacke- to packstone with foraminifers and indication of hardground formation. Sample SRB 542. Width of the photo: 0.5 cm.* ***6.*** *Condensed crinoid-framinifers-gastropod wacke- to packstone with juvenile ammonoids, a foraminifer Involutina cf. liassica (Jones) and ostracod shells, lithoclasts and hardgrounds. Sample SRB 542. Width of the photo: 0.25 cm.*

Middle Jurassic (Bajocian-?Bathonian)

After a long-lasting gap the Toarcian red nodular limestones are overlain by Middle Jurassic (Bajocian-?Bathonian) *Bositra* Limestone (Fig. 6). Above a hardground deposition of condensed red nodular limestones with juvenile ammonoids, crinoids and *Bositra* shells (filaments, *Posidonia* shells – compare Flügel, 2004) started. The microfacies with a lot of lithoclasts, Fe/Mn crusts and the extreme enrichment of shells indicate a very slow depositional rate, as typical for hemipelagic open marine settings with less carbonate production causing stratigraphic condensation. Important to note, that radiolarians, normally quite typical for the *Bositra* facies, are quite rare or practically missing. Deposition of such „Limestones with filaments“ (Flügel, 2004) started after the Toarcian Oceanic Anoxic Event in the Late Toarcian (Böhm, 1992) and prevail until the Kimmeridgian in cases. Mass occurrences of *Bositra* shells are normally quite common in Bajocian-Bathonian times, and they are rather rare in Late Toarcian to Aalenian times (Böhm, 1992, 2003; Ebli, 1997) and are also more rare in the Callovian. Furthermore, the onset of radiolarite deposition in this region started in the Bathonian (Gawlick et al., 2017, 2020). Therefore we assign the age of the *Bositra* Limestone to the Bajocian/?Bathonian. This age is also confirmed by the findings of *Globochaete alpina* Lombard, *Globuligerina oxfordiana* (Grigelis) and *Trochaminna globoconica* Tyszka &

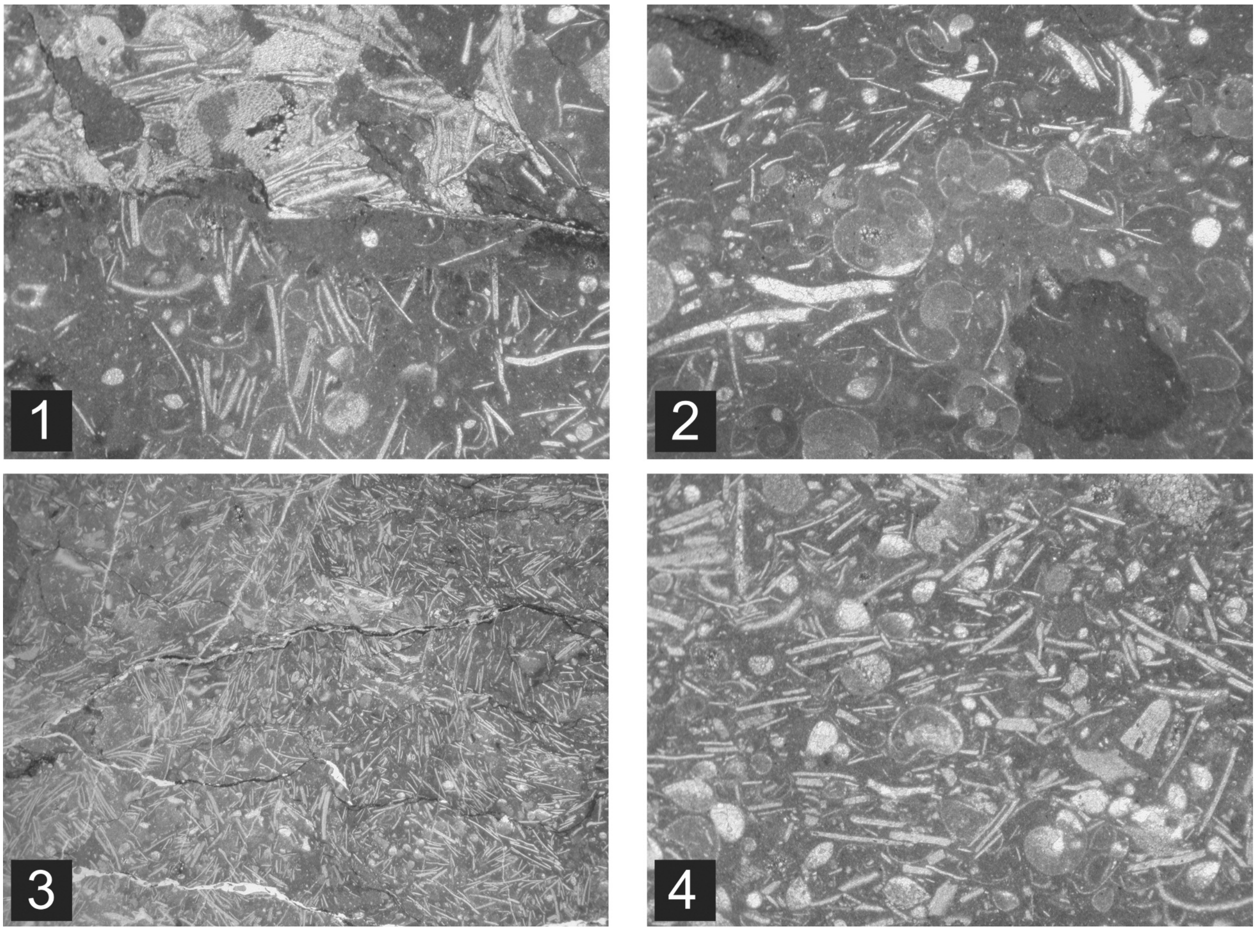

Fig. 6. *Microfacies of the Middle Jurassic reddish Bositra Limestone of the Mihajlovići section. For sample position see Fig. 2.* ***1****. Extremely condensed Bositra Limestone with crinoids and juvenile ammonoids. Hardground with a densely packed crinoidal limestone above a Bositra and ammonoids bearing wacke- to packstone. Sample SRB 544. Width of the photo: 0.5 cm.* ***2.*** *Layer of juvenile ammonoids with shell fragments, lithoclasts and Bositra shells. Sample SRB 544. Width of the photo: 0.5 cm.* ***3.*** *Densely packed Bositra Limestone with some crinoids. Sample SRB 545. Width of the photo: 1.25 cm.* ***4.*** *Packstone with juvenile ammonoids, crinoids and Bositra shells. Sample SRB 545. Width of the photo: 0.25 cm.*

Kaminski from the upper part of the *Bositra* Limestone by Rabrenović et al. (2012).

Systematic paleontology

Systematic descriptions follow the classification of Early Jurassic ammonoids given by Meister et al. (2017, and reference therein), where the authors summarize the work on this subject over the last 30 years. For all specimens wherever measurements were possible, dimensions of the diameter of the shell (D), whorl height (H), whorl width (W) and umbilical diameter (U) are given in milimeters and for H/D, W/D and U/D in percentages of D. The complete list of synonymy is not given, since all the references needed could not be aquired. Instead, special attention was given to the most recent references that could be found as well as the publications where the species were first described. However, new publications in which specimens are not figured were not placed in the synonymy.

The collection is stored in the Geological Survey of Montenegro, Podgorica. Each specimen has an inventory number, which consists of abbreviations for the locality (MIH – Mihajlovići), number of the specimen and the abbreviation for the year when the specimen was found (e.g., MIH-20/19).

Class CEPHALOPODA Cuvier, 1798
Subclass Ammonoidea Zittel, 1884
Order Phylloceratida Arkell, 1950
Superfamily Phylloceratoidea Zittel, 1884
Family Phylloceratidae Zittel, 1884
Genus *Calliphylloceras* Spath, 1927

Calliphylloceras capitanii (Catullo, 1847)
Fig. 7A

1853 *Ammonites capitanei* – Catullo: 222, pl. 4, fig. 4.
1867–1881 *Ammonites* (*Phylloceras*) *capitanei* –Meneghini: 94, pl. 18, figs. 4–6.
2011 *Calliphylloceras capitanii* (Catullo) – Kovács: 10, pl. 2, figs. 1–2, pl. 3, figs. 5–6, with synonymy.

Material. One internal mold (inventory number MIH-1/19).

Description. Specimen of medium size, involute, compressed, elliptical in shape. The whorl section is high oval, elliptical, with maximum thickness above the umbilicus. The venter is rounded, with gradual transition towards the flanks, which are slightly convex. The umbilicus is small, rounded and covered by sediment. The ornamentation consists of prorsiradiate, concave constrictions, that become weaker towards the venter, but pass over it. The specimen bears 7 constrictions that are partly damaged. The suture line is partly worn down, but with long symetric lobes, triphyllic first latteral saddle and diphyllic other saddles.

Dimensions.

	D	H	W	U	H/D	W/D	U/D
MIH 1/19	59	28.9	–	7.4	48.89	–	12.54

Remarks. The species is very similar to *Calliphylloceras nilssoni* (Hébert) with the number and shape of constrictions being the main difference between the two, as indicated by Kovács (2011).

Occurence. *Calliphylloceras capitanii* is known from Early to Middle Toarcian of Italy, Greece, Austria, Albania, Algeria, Hungary and probably Turkey (Kovács, 2011).

The discovery in Mihajlovići section represents the first finding of this species in the Middle Toarcian Bifrons Zone of Montenegro, as well as in the whole Inner Dinarides.

Order Psiloceratida Houša, 1965
Superfamily Lytoceratoidea Neumayr, 1875
Family Lytoceratidae Neumayr, 1875
Genus *Lytoceras* Suess, 1865

Lytoceras ovimontanum Geyer, 1893
Fig. 7G-I

1893 *Lytoceras ovimontanum* nov. sp., Geyer: 55, pl. 8, fig. 1.
1900 *Lytoceras ovimontanum* Geyer – Bettoni: 36, pl. 2, fig. 4.
1980 *Lytoceras ovimontanum* Geyer – Castelli: 50, pl. 3, fig. 1.
1980 *Lytoceras nothum* Meneghini – Castelli: 49, pl. 2, figs. 5-6.
1998 *Lytoceras ovimontanum* Geyer – Géczy & Meister: 98, pl. 5, figs. 1, 6 and 7.

2003 *Lytoceras ovimontanum* Geyer – Meister & Friebe: 28, pl. 3, fig. 14, pl. 4, fig. 1.

2017 *Lytoceras ovimontanum* Geyer – Meister et al.: 100, pl. 4, figs. 1 and 4, pl. 5, figs. 1 and 5, with synonymy.

Material. One partially preserved internal mold (MIH-21/19).

Description. Specimen of medium size, evolute. The whorl section is suboval, with maximum thickness above the umbilicus. The venter is rounded, with very slightly pronounced transition towards the flanks, which are straight. The umbilicus is wide, taking approximately half of the specimen, deep and with overhanging transition towards the flanks. The ornamentation is not preserved. The suture line is only partially visible, with complex first lateral lobe and a complex first lateral saddle. Due to bad preservation of the specimen, the dimensions could not be measured.

Remarks. Even though the ornamentation or a complete suture line is not preserved, Geyer (1893) described the overhanging transition from the umbilicus towards the flanks as to be one of the most important characteristics of the species, which is very well pronounced on the specimen from Mihajlovići. Likewise, suboval whorl section represents also as important characteristic, as indicated by Meister & Friebe (2003).

Occurence. The species is known from Late Pliensbachian of Italy, Austria, Hungary, Morocco, Algeria and France (Meister et al. 2017).

The discovery in Mihajlovići locality represents the first finding of this species in the early Late Pliensbachian Lavinianum Zone of Montenegro, as well as in the whole Inner Dinarides.

Superfamily Hildoceratoidea Hyatt, 1867
Family Hildoceratidae Hyatt, 1867
Subfamily Harpoceratinae Neumayr, 1875
Genus *Fuciniceras* Haas, 1913

Fuciniceras lavinianum (Fucini, 1900)
Fig. 7B–C

1900 *Hildoceras Lavinianum* Meneghini in Fucini: 52, pl. 11, figs. 6–7.

1900 *Hildoceras Lavinianum* Meneghini var. *coniungens* Fucini: 54, pl. 12, figs. 2–3.

1991 *Fuciniceras* gr. *lavinianum* (Fucini) – Blau & Meister: 182, pl. 5, fig. 23, pl. 6, figs. 5–11.

1998 *Fuciniceras* gr. *lavinianum* (Fucini)–*portisi* (Fucini) – Géczy & Meister: 111, pl. 7, fig. 7, pl. 8, figs. 1–11, pl. 9, figs. 1–3 and 5.

2003 *Fuciniceras lavinianum* (Meneghini in Fucini) – Macchioni & Meister: 388, pl. 4, figs. 10–16 and 18.

2007 *Fuciniceras* (*F.*) gr. *lavinianum* (Meneghini) – Fauré et al.: 489, fig. 6F–H.

2011 *Fuciniceras* gr. *lavinianum* (Fucini)–*portisi* (Fucini) – Meister et al.: 117.e38, figs. 21 (1–14) and 22 (1–7).

2014 *Fuciniceras* gr. *portisi* (Fucini)–*lavinianum* (Fucini) – Meister & Blau: 262, figs. 4n–v and 5a–u, with synonymy.

Material. One partially preserved specimen (MIH-20/19).

Description. All of the species characteristics could not be observed, as it is only partially and poorly preserved. The whorl section is subrectangular, with maximum thickness in the middle of the section. The venter is very characteristic, tricarinate-bisulcate, with the keel in the middle being slightly more pronounced and sulci not very deep. The flanks are straight, with sharp transition towards the venter. The umbilicus is covered with sediment, not visible. The ornamentation consists of angustirursiradiate ribs that are very fainthe near the umbilical edge and become stronger on midflank, reach ventro-lateral edge where they dissappear. The suture line is not preserved.

Dimensions.

	D	H	W	U
MIH 20/19	–	12.0	8.9	–

Remarks. As already noted by Macchioni & Meister (2003) clear distinction between *Fuciniceras lavinianum* and *Fuciniceras portisi* is not easy to establish, which is the reason why these close forms are usually described in recent literature as *Fuciniceras* gr. *lavinianum* (Fucini)–*portisi* (Fucini). The specimen from Mihajlovići shows most resemblence to the species *Hildoceras Lavinianum* described by Fucini (1900), especially the ones that the author determined as *Hildoceras Lavinianum* var. *coniungens*. Macchioni & Meister (2003) consider these later forms to be closer to *Fuciniceras portisi*, which they include into *Fuciniceras ambiguum*, neglecting however differences in the shape of whorl section or venter between these and specimens described by Fucini (1900) as *Grammoceras Portisi*. Additional difference between *F. lavinianum* and *F. portisi* can also be observed in their ornamentation, where it seems that the later has more robust ribbing. However, all of this can be intraspecific variations within one very variable species. In any case, thorough revision of the genus is needed, so valid and well defined species can be established. Solution for this can perhaps be found in the criteria published by Bardin et al. (2017) for the family Hildoceratidae in a detailed study of the phylogeny of this group.

Occurence. The species is known from Italy, Hungary, Spain and Morocco and is considered a zonal species for Lavinianum Zone (Macchioni & Meister, 2003). Blau & Meister (1991) reported it from Late Pliensbachian of Austria and Fauré et al. (2007) describe it also from Tunisia.

The discovery in Mihajlovići section makes it possible to establish this zone in the early Late Pliensbachian of Montenegro, as well as in the whole Inner Dinarides.

Genus *Harpoceras* Waagen, 1869

Harpoceras subplanatum (Oppel, 1856)
Fig. 7E

1846 *Ammonites complanatus* Bruguieré – D'Orbigny: 353, pl. 114, figs. 1–2 and 4 (non. fig. 3).

1856 *Ammonites subplanatus* Oppel: 244.

1967 *Polyplectus subplanatus* (Oppel) – Géczy: 123, pl. 2, fig. 4.

1972 *Harpoceras subplanatum* (Oppel) –Guex: 638, pl. 5, fig. 8.

1986 *Polyplectus subplanatus* (Oppel) – Gaković: 115, pl. 19, fig. 2.

1992 *Harpoceras subplanatum* (Oppel) – Howarth: 136, text-fig. 18H and 35, pl. 22, figs. 4–7, pl. 23, figs. 1–3, with synonymy.

2011 *Harpoceras* (*Harpoceras*) *subplanatum* (Oppel) – Kovács: 32, pl. 8, figs. 3–4, pl. 11, fig. 3, with synonymy.

Material. One partially preserved internal mold (MIH-14/19).

Description. Specimen of small size, involute, compressed, elliptical in shape. The whorl section is lanceolate, with maximum thickness in the middle of the section. The venter is carinate, with a poorly preserved (eroded) keel; the flanks are slightly convex. The umbilicus is only partially preserved, shallow. The ornamentation consists of dense, falcate ribs, that start near the umbilical edge and reach the transition towards the venter. The suture line is only partially preserved, with first and second lateral lobe and second and third lateral saddle being visible, which are damaged by erosion, but still very similar to the one figured by Howarth (1992, text-fig. 18H). Due to bad preservation of the specimen, the dimensions could not be measured.

Remarks. Even though the specimen from Mihajlovići is poorly preserved and all the characteristics could not be observed, the shape of the whorl section, ornamentation and parts of suture line have enough resemblance to specimens shown by Howarth (1992) and Kovács (2011) to assign it to the species *Harpoceras subplanatum*.

Occurence. The species is known from Middle Toarcian sediments world-wide (Kovács, 2011).

The discovery in Mihajlovići locality represents the first finding of this species in the Middle Toarcian Bifrons Zone of Montenegro, as well as in the whole Inner Dinarides.

Subfamily Arieticeratinae Howarth, 1955

Arieticeratinae gen. indet.
Fig. 7F

Material. One very small fragment of an internal mold (MIH-22/19).

Description. The specimen has a sub-octagonal whorls section, with maximum thickness in the middle of the section. The venter is tricarinate-bisulcate; the flanks are convex. Simple ribs are visible on this internal mold; even though they are eroded, it can be concluded that they were robust, since they have still stayed preserved. The suture line is not preserved. Due to bad preservation of the specimen, the dimensions could not be measured.

Remarks. Because of poor preservation, this fragment could only be determined as Arieticeratinae gen. indet., showing most resemblance with genera *Fontanelliceras* or *Tauromeniceras*. However, as this is an only partially preserved specimen, which is worn down by erosion, the assignment to a specific genus is not possible.

Subfamily Phymatoceratinae Hyatt, 1867
Genus *Furloceras* Elmi & Rulleau, 1995

Furloceras* aff. *chelussii (Parisch & Viale, 1906)
Fig. 7D

1906 *Hildoceras* (*Lillia*) *Chelussii* n. f., Parisch & Viale: 156, pl. 11, figs. 10–11.
1967 *Phymatoceras narbonense aequale* n. subsp., Géczy: 142, pl. 7, fig. 1.
2006 *Phymatoceras aequale* Géczy – Géczy & Szente: pl. 5, fig. 1.
p 2013 *Phymatoceras* gr. *narbonense* Buckman – Metodiev et al.: 75, fig. 4e–f (non fig. 5a).
2014 *Furloceras chelussii* (Parisch & Viale) – Kovács: 19, pl. 2, figs. 1 and 5.
2014 *Furloceras pulcher* (Merla) – Kovács: 20, pl. 2, fig. 2.
2014 *Furloceras venustulum* (Merla) – Kovács: 20, pl. 1, figs. 6-7, pl. 4, fig. 1.
2015 *Furloceras* gr. *chelussii* (Parisch & Viale) – Rulleau et al.: 126, pl. 82, figs. 6–7, pl. 83, pl. 84, figs. 1–3 and 7, pl. 85, fig. 5, pl. 86, fig. 1, pl. 87, figs. 1 and 3, pl. 90, figs. 1, 3 and 5, with synonymy.

Material. One partialy preserved specimen (MIH-10/19).

Description. Large specimen, evolute, elliptical in shape. The whorl section is subtriangular in shape, with maximum thickness near the umbilical edge. The venter is carinate, with a poorly preserved (eroded) keel, without sulci, with gradual transition towards the flanks that are slightly convex. The umbilicus is wide and shallow, with rounded umbilical edge. The ornamentation is not well preserved, consisting of sigmoid ribs and barely visible, eroded umbilical nodes.

Dimensions.

	D	H	W	U
MIH 10/19	–	32.5	22.9	48.3 ?

Remarks. The species *Furloceras chelussii* is very similar to *Phymatoceras narbonense* (Buckman) and not easy to distinguish from it. Rulleau et al. (2015) give an extensive list of synonymy in their revision of the subfamily Phymatoceratinae, where most of Mediterranean examples of *Phymatoceras* have been included in this species. This opinion has been adopted also in the present paper, with the specimen from Mihajlovići being determined as *Furloceras* aff. *chelussii*. Described specimen shows greatest resemblance to forms described from Hungary by Géczy & Szente (2006, therein described as *Phymatoceras aequale*) and Kovács (2014, therein described as *Furloceras venustulum*).

Part of the material described by Metodiev et al. (2013) as *Phymatoceras* gr. *narbonense* should also be included with *Furloceras* aff. *chelussii*, based on morphological features convex flanks and ribs arising from small umbilical tubercules.

Occurence. According to Rulleau et al. (2015) the species *Furloceras chelussii* is known from Mediterranean Domain, ranging from Bifrons to Gradata Zone.

The discoveries in Mihajlovići (Metodiev et al., 2013; present paper) represent the first findings of this species in the Middle Toarcian Bifrons Zone of Montenegro, as well as in the whole Inner Dinarides.

Discussion

Comparison with Krš Gradac and similar sections

A comparison of the Mihajlovići sedimentological evolution during Early–Middle Jurassic times with other sections in the wider area, i.e. the western part of the Inner Dinarides is practically impossible due to the missing descriptions and modern biostratigraphic age datings in combination with detailed microfacies analysis. Only the Krš Gradac section in southwestern Serbia was studied in detail (Radoičić et al., 2009; Gawlick et al., 2009b, 2017, 2020). This section, as well as the Mihajlovići section, has also been described for a very long time and has been dated with brachiopods (Albrecht, 1925), ammonoids (Petković, 1934; Ledebur, 1941; Ćirić, 1954; Rampnoux, 1974) and microfossil associations (Radoičić,

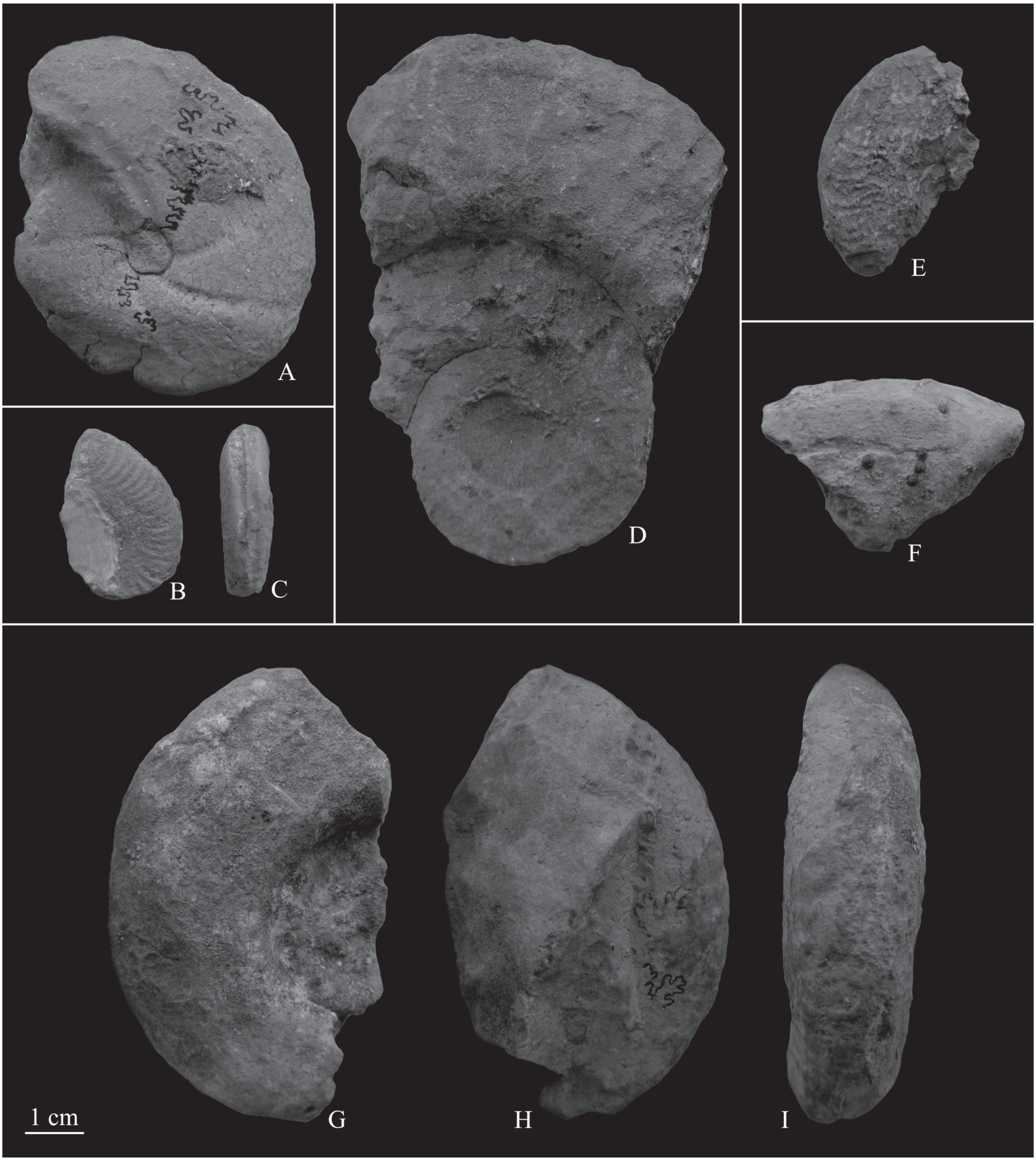

Fig. 7. *Early Jurassic ammonoids from Mihajlovići section.* ***A.*** *Calliphylloceras capitanii (Catullo), MIH-1/19;* ***B-C.*** *Fuciniceras lavinianum (Fucini), MIH-20/19;* ***D.*** *Furloceras aff. chelussii (Parisch & Viale), MIH-10/19;* ***E.*** *Harpoceras sublpanatum (Oppel), MIH-14/19;* ***F.*** *Arieticeratinae gen. indet., MIH-22/19;* ***G-I.*** *Lytoceras ovimontanum Geyer, MIH-21/19. Figs. B-C, F and G-I are from member 2 – early Late Pliensbachian, Lavianum Zone (samples SRB 543, V 7); figs. A, D and E are from member 3 – Middle Toarcian, Bifrons Zone (sample SRB 541). For sample positions see Fig. 2.*

1962; Ljubović-Obradović et al., 1998; Radoičić et al., 2009; Gawlick et al., 2017, 2020). A Late Sinemurian brachiopod fauna was described by Albrecht (1924) whereas microfossil associations were assigned to the Early Jurassic (Radoičić, 1962; Ljubović-Obradović et al., 1998) and to the Bajocian–Bathonian (Radoičić et al., 2009; Gawlick et al., 2020). Unfortunatelly, a new ammonoid fauna is not known from this localiy, but some assumtions can be made according to species cited in published literature. Except for Petković (1934) who thought that the ammonoids from the red nodular limestones were Middle Triassic in age, all other authors mention or describe Early Jurassic species. Ledebur (1941) describes from this section *Lytoceras fimbriatum* and *Calliphylloceras* cf. *nilssoni* (therein described as *Phylloceras* cf. *nilssoni*), Ćirić (1954) cited *Calliphylloceras nilssoni* (therein as *Phylloceras nilssoni*) and Rampnoux (1974) mentions *Lytoceras sepositum*, *Calliphylloceras capitanii* and *Harpoceras strangewaysi* (therein as *Harpoceratoides strangewaysi*), all found in the red nodular limestones above the micro-oncoidal facies. One of these species (*Lytoceras fimbriatum*) can only be found in Pliensbachian sedimentary rocks, another (*Harpoceras strangewaysi*) is known only from Early Toarcian, whereas the third (*Lytoceras sepositum*) is characteristic for Middle Toarcian. *Calliphylloceras nilssoni* can be found in Early and Middle Toarcian sedimentary rocks. The red limestone member in the Krš Gradac section (middle member in Gawlick et al., 2020) has the thickness of approximately one meter and represents a very condensed facies. As the sampling positions of determined ammonoid species are not known, it cannot be decided if these levels are of different ages or the specimens were collected from one level with mixed faunas. However, at least a ?Late Pliensbachian and Early Toarcian age of one part of this section has to be assumed, until new ammonoid data will be available from the Krš Gradac section.

West of the town Sjenica and north of the village Uvac Ledebur (1941) described the Maljevine locality where on top of Late Triassic limestones, in brecciated red limestones a “middle Liassic“ ammonoid fauna: *Harpoceras* (*Lioceras*), *Phylloceras lipoldi*, *Rhacophyllites stella* and *Lytoceras* sp. were found. Figured specimen determined as *Harpoceras* (*Lioceras*) resembles mostly the species *Eleganticeras elegantulum*, whereas the one determined as *Rhacophyllites stella* shows most resemblence to *Juraphyllites libertus*, especially in the shape of the suture line. Other species from this locality are described, but not figured by Ledebur (1941). The re-determinations would indicate early Toarcian age of the Jurassic part of this section.

Similar Middle Toarcian red nodular limestones in Montenegro can be found on the southern side of Vojnik Mountain. Bifrons Zone is well known and described from this region for more than half a century (Bešić, 1948; Radoičić-Brstina, 1956; Mirković, 1965). However, as the emphasis in these publications was given to the paleontological descriptions of the collected fauna, the outcrops were only described in general, with the work of Bešić (1948) being the most detailed one. Without new investigations in this area of Montenegro, it is for now only possible to conclude that Middle Toarcian sedimentary rocks and their faunas are very similar with the Mihajlovići succession, but a convincing comparison of the underlying or overlying strata is not possible yet.

Biostratigraphic and paleogeographic discussions

Meister (2010) and Meister & Blau (2014 and reference therein) have summarized the Pliensbachian ammonoid zonation for Pacific, Euroboreal and Western Tethys Domains, placing Lavinianum Zone in the lower part of the early Late Pliensbachian of the Western Tethys Realm, which is age equivalent of Stokesi and Subnodosus Subzones of Margaritatus Zone within Euroboreal Domain. However, the authors place the species (as gr. *lavinianum* or *lavinianum-portisi*) within the lowermost horizon of this zone, calling it Lavinianum-Portisi Subzone and Horizon. The 3.1 m thick bioclastic crinoidal limestones of Mihajlovići may most probably represent only this horizon, in the present paper it is defined as Lavinianum Zone, as only three specimens of ammonoids were collected from its topmost part. This implies that the layers below the ammonoid bearing horizon are most probably older, i.e. Early Pliensbachian in age. This is also supported by the microfacies evolution throughout this member. The hardground with the ammonoids imply that the break in sedimentation already started in the early Late Pliensbachian, lasting at least until the end of Early Toarcian.

Correlation within the Dinarides is currently possible only with the area of Zalomka in Bosnia and Herzegovina, where Gaković (1986) distinguished ammonoid zones for almost the complete Upper Pliensbachian substage. The author described ammonoids from the lowermost Upper Pliensbachian, dominated by the representatives of the genus *Protogrammoceras*, placing them within *Fuciniceras* (*Fuciniceras*) *boscense* Zone, which would be the age equivalent of Lavinianum Zone in Mihajlovići. However, regarding the facies, Late Pliensbachian carbonates in Zalomka are dominated by yellow and gray often silicified micrites and biomicrites with a thickness of approximately 20 meters.

The Mediterranean character of the Middle Toarcian ammonoid fauna of Mihajlovići section is already emphasized by Rabrenović et al. (2012) and Metodiev et al. (2013), comprising of cosmopolitan species as well as the ones characteristic for the Western Tethys Realm, which is confirmed also by our new results. Although only three specimens have been collected from the early Late Pliensbachian part of the section, *Fuciniceras lavinianum* is only known from the Mediterranean Domain, whereas *Lytoceras ovimontanum* was also reported from the Euroboreal Domain by Meister et al. (2017), but only from its southern part. It is therefore most likely that the early Upper Pliensbachian ammonoid fauna from Mihajlovići also has a Mediteranean character, and represent in moment the easternmost occurence of both mentioned species.

Conclusion

New investigations on the Early–Middle Jurassic Mihajlovići section in northeastern Montenegro resulted in the reconstruction of a stepwise Early Jurassic deepening based on recent biostratigraphic results. The new ammonoid fauna proves for the first time in this section, as well as in whole of Montenegro and the whole Inner Dinarides, the early Late Pliensbachian Lavinianum Zone below the Toarcian Bifrons Zone and, therefore, an important gap between them. Several ammonoid species that are new for the Middle Toarcian condensed horizon of this section have also been described.

The ages of previously published gaps in deposition have been emended, with the first gap during the ?Late Sinemurian–Early Pliensbachian timespan, and the second gap lasting from the early Late Pliensbachian until the end of Early Toarcian. The Mediteranean character of the fauna is confirmed for the ammonoids of the Bifrons Zone and the same is proposed with some restrictions for the ammonoids from Lavinianum Zone.

The sedimentary evolution during the Early and Middle Jurassic clearly indicates a stepwise deepening of the depositional realm. Above the ?Late Hettangian-Sinemurian shallow-subtidal micro-oncoidal limestones follow above a gap deeper-marine ?Early to early Late Pliensbachian limestones with micro-oncoids only in few levels. The deepening trend can be manifested by the occurrence of smaller micro-oncoids with only few rims and an increase in the variability of the benthic foraminifers associations as well as the increasing number of crinoid fragments and ammonids. In the upper part of the Early Pliensbachian and the early Late Pliensbachian more condensed ammonid-crinoid-foraminifers packstones, without micro-oncoids were deposited in a relative low-energetic deeper-water environment. After the next hiatus marked by a Fe/Mn-crust, wacke- to packstones with ammonoid fragments, foraminifers and crinoids, and ongoing hardground formation were formed in the late Early Toarcian to Late Toarcian. After a long-lasting gap in deposition, from the Late Toarcian onwards, Bajocian-?Bathonian condensed *Bositra* Limestone was deposited indicating a very slow depositional rate in a hemipelagic open marine setting.

The depositional history with its stepwise deepening in this transitional depositional realm between the Adriatic Carbonate Platform and its Basement to the west and the open-marine outer shelf with its Early-Middle Jurassic condensed red nodular limestones facies reflects more or less time equivalent deepening events as known from the whole Western Tethyan Realm, as described in Sicily (Di Stefano et al., 2002), the Southern Apennines (Iannace et al., 2005), and the Southern Alps (Martire et al., 2006; Buser & Dozet, 2009; Masetti et al., 2017). The reconstruction of the Early–Middle Jurassic depositional history in the East Bosnian–Durmitor Megaunit closes an important gap in the understanding of the Jurassic evolution in the Dinarides.

Acknowledgements

This publication is a contribution to the IGCP-710 project "Western Tethys meets Eastern Tethys" (HJG) and to the bilateral project "Jurassic mélanges and Mesozoic geodynamic history of the Eastern Alps (Austria) and Dinarides (Montenegro): a comparison", between the Geological Survey of Montenegro and the Montanuniversität Leoben, Department of Applied Geoscience and Geophysics, Austria, project No. ME 03/2019. The research of Milan Sudar was supported by the Serbian Academy of Sciences and Arts (Project F-22). The authors would like to thank Ivan Danilović and Branko Vilotijević for their help in collecting the fossil material in the field. Finally, the authors would like to thank the reviewers Philippe Fauré and Roman Aubrecht for their usefull comments that helped improving the overall content of the manuscript. Philippe Fauré is especially thanked for giving advice on paleontological descriptions and systematic positions of collected ammonoid faunas.

References

Albrecht, I. 1924. Paläontologische und stratigraphische Ergebnisse der Forschungreise nach Westserbien 1918. *Denkschriften der kaiserlichen Akademie der Wissenschaften in Wien, Mathematish-Naturwissenschaftliche Klasse*, 99: 1–289.

Bardin, J., Rouget, I. & Cecca, F. 2017. The phylogeny of Hildoceratidae (Cephalopoda, Ammonitida) resolved by an integrated coding scheme of the conch. *Cladistics*, 33: 21–40.

Bešić, Z. 1948. Pojava sedimenata starije jure u okolini planine Vojnika (Crna Gora) [Les sédiments du jura ancien trouvés dans les environs de la montagne Vojnik (Monténégro)]. *Godišnjak Biološkog instituta u Sarajevu*, 1 (1): 5–22.

Bettoni, A. 1900. Fossili Domeriani della Provincia di Brescia. *Mémoires de la Société Paléontologique Suisse*, 28: 1–88.

Blau, J. 1987a. Neue Foraminiferen aus dem Lias der Lienzer Dolomiten. Teil I: Die Foraminiferenfauna einer roten Spaltenfüllung in Oberrhätkalken. *Jahrbuch der Geologischen Bundesanstalt*, 129 (3–4): 495–523.

Blau, J. 1987b. Neue Foraminiferen aus dem Lias der Lienzer Dolomiten. Teil II: Foraminiferen Involutinina, Spirillinina) aus der Lavanter Breccie (Lienzer Dolomiten) und den Nördlichen Kalkalpen. *Jahrbuch der Geologischen Bundesanstalt*, 130 (1): 5–23.

Blau, J. & Grün, B. 1994. Mikrofazies und Foraminiferenfaunen im unteren Lias (Kendlbachschichten, Enzesfelder Kalk) der Osterhorngruppe (Salzburg, Österreich). *Giessener Geologische Schriften*, 51: 63–83.

Blau, J. & Grün, B. 1997. Neue Involutinen (Foraminiferen) aus dem marmorea-Hartgrund (Hettangium/Sinemurian, Lias) von Adnet (Österreich). *Neues Jahrbuch Geologie-Paläontologie, Abhandlungen*, 204: 247–262.

Blau, J. & Meister, C. 1991. Liassic (Pliensbachian) Ammonites from the Lienz Dolomites (Eastern Tyrol, Austria). *Jahrbuch der Geologischen Bundesanstalt*, 134 (2): 171–204.

Böhm, F. 1992. Mikrofazies and Ablagerungsmilieu des Lias und Dogger der Nordöstlichen Kalkalpen. *Erlanger Geologische Abhandlungen*, 121: 55–217.

Böhm, F. 2003. Lithostratigraphy of the Adnet Group (Lower to Middle Jurassic, Salzburg, Austria). In: Piller, W.E. (Ed.). Stratigraphia Austriaca. *Österreichische Akademie der Wissenschaften), Schriftenreihe der Erdwissenschaflichen Kommissionen*, 16: 231–268.

Buser, S. & Dozet, S. 2009. Jura (Jurassic). In: Pleničar M., Ogorelec, B. & Novak, M. (Eds.). *Geologija Slovenije (The Geology of Slovenia)*, Geološki zavod Slovenije, Ljubljana: 215–254 (in Slovenian and English).

Canales, M.L. & Henriques, M.H. 2008. Foraminifera from the Aalenian and the Bajocian GSSP (Middle Jurassic) of Murtinheira section (Cabo Mondego, West Portugal): Biostratigraphy and paleoenvironmental implications. *Marine Micropaleontology*, 67: 155–179.

Castelli, M. 1980. Ammoniti del Pliensbachiano della collezione paleontologica del Museo civico di storia naturale di Brescia. *Natura Bresciana, Annulario del Museo Civico di Storia Naturale di Brescia*, 17: 34–76.

Catullo, T.A. 1853. Intorno ad una nuova classificazione delle calcarie rosse ammonitiche delle Alpi Venete. *Memorie dell'Imperiale Regio Istituto Veneto di Scienze, Lettere ed Arti*, 5: 187–241.

Copestake, P. & Johnson, B. 1989. The Hettangian to Toarcian (Lower Jurassic). In: Jenkins, D.G. & Murray, J.W. (Eds.). *Stratigraphical Atlas of Fossil Foraminifera*, 2nd edition. *British Micropaleontological Society Series*, 129–188.

Császar G., Budai, T. & Fodor, L. 2018. Jurassic. In: Budai, T. (Ed.). *Geology of the Gerecse Mountains*. *Regional map series of Hungary (Explanatory Book to the Geological Map of the Gerecse Mountains (1:50 000)*, 23–39, Mining and Geolological Survey of Hungary, Budapest (in Hungarian and English).

Ćirić, B. 1954. Neka zapažanja o dijabaz-rožnačkoj formaciji Dinarida (Einege betrachtungen über die Diabas-Hornstein Formation der Dinariden). *Vesnik Zavoda za geološka i geofizička istraživanja NR Srbije*, 11: 31–88.

Di Stefano, P., Galacz, A., Mallarino, G., Mindszenty, A. & Vörös, A. 2002. Birth and early evolution of a Jurassic escarpment: Monte Kumeta, Western Sicily. *Facies*, 46: 273–298.

Ebli, O. 1997. Sedimentation und Biofazies and passive Kontinentalrändern: Lias und Dogger des Mittelabschnittes der Nördlichen Kalkalpen und des frühen Atlantik (DSDP site 547B, Marokko). *Münchner Geowissenschaftliche Abhandlungen, Reihe A*, 32:1–255.

Fauré, P., Alméras, Y., Sekatni, N. & Zargouni, F. 2007. Le Pliensbachien du Jebel Zaghouan (Tunisie). Nouvelles données fauniques. Implications biostratigraphiques et paléobiogéographiques. *Geodiversitas*, 29 (4): 473–506.

Flügel, E. 2004. *Microfacies of Carbonate Rocks. Analysis, Interpretation and Application*. 1–976, (Springer), Berlin Heidelberg.

Fucini, A. 1900. Ammoniti del Lias medio dell'Appenino centrale esistenti nel Museo di Pisa Parte 2. *Palaeontographia Italica*, 5: 145–185.

Fürsich, F.T. 1971. Hartgründe und Kondensation im Dogger von Calvados. *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen*, 138: 313–342.

Gaković, M.B. 1986. Stratigrafija lijasa Zalomke i Gacka u Hercegovini kao osnova biostratigrafske podele donje jure u Dinaridima (Stratigraphy of the Liassic of the Zalomka and Gacko in Herzegovina as a base of biostratigraphic division of the Lower Jurassic in the Dinarides). *Geološki glasnik Sarajevo*, special issue 21: 1–143.

Gawlick, H.-J. & Missoni, S. 2019. Middle-Late Jurassic sedimentary mélange formation related to ophiolite obduction in the Alpine-Carpathian-Dinaridic Mountain Range. *Gondwana Research,* 74: 144–172.

Gawlick, H.-J., Missoni, S., Schlagintweit, F., Suzuki, H., Frisch, W., Krystyn, L., Blau, J. & Lein, R. 2009a. Jurassic Tectonostratigraphy of the Austroalpine domain. *Journal of Alpine Geology*, 50: 1–152.

Gawlick, H.-J., Sudar, M., Suzuki, H., Djerić, N., Missoni, S., Lein, R. & Jovanović, D. 2009b. Upper Triassic and Middle Jurassic radiolarians from the ophiolite mélange of the Dinaridic Ophiolite Belt, SW Serbia. *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen,* 253 (2–3): 293–311.

Gawlick, H.-J., Missoni, S., Suzuki, H., Sudar, M., Lein, R. & Jovanović, D. 2016. Triassic radiolarite and carbonate components from the Jurassic ophiolitic mélange (Dinaridic Ophiolite Belt). *Swiss Journal of Geosciences*, 109 (3): 473–494.

Gawlick, H.-J. & Schlagintweit, F. 2019. Upper Triassic to Lower Jurassic shallow-water carbonates north of Lake Shkodra (NW Albania, Albanian Alps Zone): part of the Adriatic Carbonate Platform basement. *Acta Palaeontologica Romaniae*, 15: 3–12.

Gawlick, H.-J., Sudar, M.N., Missoni, S., Suzuki, H., Lein, R. & Jovanović, D. 2017. Triassic-Jurassic geodynamic history of the Dinaridic Ophiolite Belt (Inner Dinarides, SW Serbia). Field Trip Guide, 13th Workshop on Alpine Geological Studies (Zlatibor, Serbia 2017). *Journal of Alpine Geology*, 55: 1–167.

Gawlick, H.-J., Sudar, M.N., Missoni, S., Aubrecht, R., Schlagintweit, F., Jovanović, D. & Mikuš, T. 2020. Formation of a Late Jurassic carbonate platform on top of the obducted Dinaridic ophiolites deduced from the analysis of carbonate pebbles and ophiolitic detritus in southwestern Serbia. *International Journal of Earth Sciences*, 109: 2023–2048.

Géczy, B. 1967. Upper Liassic ammonites from Úrkút, Bakony Mountains, Transdanubia, Hungary. *Annales Universitatis Scientarium Budapestinensis de Rolando Eötvös nominatae*, *Sectio Geologica*, 10: 115-150.

Geczy B. & Meister, C. 1998. Les ammonites du Domérien de la montagne du Bakony (Hongrie). *Revue de Paléobiologie*, 17 (1): 69–161.

Géczy, B. & Szente, I. 2006. Middle Toarcian Ammonitina from the Gerecse Mts, Hungary. *Acta Geologica Hungarica*, 49 (3): 223–252.

Geyer, G. 1893. Die mittel-liasische Cephalopoden-Fauna des Hinter-Schafberges in Oberösterreich. *Abhandlungen der kaiserlich-königlichen geologischen Reichanstalt*, 15: 1–76.

Gomez, J.J. & Fernandez-Lopez, S. 1994. Condensation processes in shallow platforms. *Sedimentary Geology*, 92: 147–159.

Guex, J. 1972. Répartition biostratigraphique des ammonites du Toarcien moyen de la bordure sud des Causses (France) et révision des ammonites décrites et figurées par Monestier (1931). *Eclogae Geologicae Helvetiae*, 65 (3): 611–645.

Haas, J. 2012. *Geology of Hungary*. Springer. 1–244.

Haas, J., Kovács, S., Gawlick, H.-J., Gradinaru, E., Karamata, S., Sudar, M., Péró, Cs., Mello, J., Polák, M., Ogorelec, B. & Buser, S. 2011. Jurassic Evolution of the Tectonostratigraphic Units of the Circum-Pannonian Region. *Jahrbuch der Geologischen Bundesanstalt*, 151 (3–4): 281–354.

Haas, J., Jovanović, D., Görög, Á., Sudar, M.N., Józsa, J., Ozsvárt, P. & Pelikán, P. 2019. Late Triassic-Middle Jurassic resedimented toe-of-slope and hemipelagic basin deposits in the Dinaridic Ophiolite Belt, Zlatar Mountain, SW Serbia**.** *Facies,* 65 (2): 23.

Howarth, M.K. 1992. The Ammonite family Hildoceratidae in the Lower Jurassic of Britain. Part II. *Monograph of the Palaeontographical Society*, 107–200.

Hylton, M.D. 2000. *Microfaunal investigations of the Early Toarcian (Lower Jurassic) extinction event in N.W. Europe*. Unpublished PhD Thesis, Department of Geological Sciences, Faculty of Science, University of Plymouth, 287 pp.

Iannace, A., Parente, M. & Zamparelli, V. 2005. The Upper Triassic platform margin facies of Southern Apennines and their Jurassic fate: state of the art. *Bolletino della Societa Geologica Italiana*, 124: 203–214.

Jenkyns, H.C. 1971. The genesis of condensed sequences in the Tethyan Jurassic. *Lethaia*, 4: 327–352.

Kovács, Z. 2011. Lower Toarcian Ammonitida fauna and biostratigraphy of the Gerecse Mountains (Hungary). *Fragmenta Palaeontologica Hungarica*, 29: 1–48.

Kovács, Z. 2014. Phymatoceratidae (Ammonitina) fauna from the Lower Jurassic of the Gerecse Mts (Hungary). *Földtani Közlöny*, 144 (1): 123–143.

Ledebur, K.H. 1941. Stratigraphie und Tektonik Jugoslawiens zwischen Lim und Ibar. *Neues Jahrbuch für Mineralogie*, *Geologie und Paläontologie*, *Abhandlungen B*, 85: 463–506.

Ljubović-Obradović, D., Jovanović, D. & Radovanović, Z. 1998. Novi nalasci lijaskih krečnjaka na terenima jugozapadne Srbije (okolina Sjenice) [New findings of Liassic limestones in SW Serbia (surrounding of Sjenica)]. *13. Kongres geologa Jugoslavije*, *knj. 2*, *Regionalna geologija, stratigrafija i paleontologija*, 175–183.

Macchioni, F. & Meister, C. 2003. Ammonite biostratigraphy of some Mediterranean sections. 2: The succession of the Gola del F. Burano (Umbria-Machigiano Basin, Apennine), a reference section for Tethyan Domain. *Revue de Paléobiologie*, 22 (1): 363–420.

Mancinelli, A., Chiocchini, M., Chiocchini, R.A. & Romano, A. 2004. Biostratigraphy of the Upper Triassic-Lower Jurassic carbonate platform sediments of the Central-Southern Apennines (Italy). *Rivista Italiana di Paleontologia e Stratigrafia*, 111 (2): 271–283.

Martire, L. 1992. Sequence stratigraphy and condensed pelagic sediments. An example from the Rosso Ammonitico Veronese, northeastern Italy. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 94: 169–191.

Martire, L., Clari, P, Lozar, F. & Pavia, G. 2006. The Rosso Ammonitico Veronese (Middle-Upper Jurassic of the Trento Plateau): A proposal of lithostratigraphic ordering and formalization. *Rivista Italiana di Paleontologia e Stratigraphia*, 112 (2): 227–250.

Masetti, D., Fantoni, R., Romano, R., Sartorio, D. & Trevisani, E. 2012. Tectonostratigraphic evolution of the Jurassic extensional basins of the eastern Southern Alps and Adriatic foreland based on an integrated study of surface and subsurface data. *American Association of Petroleum Geologists Bulletin,* 96: 2065–2089.

Masetti, D., Figus, B., Jenkyns, H.C., Barattolo, F., Mattioli, E. & Posenato, R. 2017. Carbon-isotope anomalies and demis of carbonate platforms in the Sinemurian (Early Jurassic) of the Tethyan region: evidence from the Southern Alps (Northern Italy). *Geological Magazine*, 154 (3): 625–650.

Meister, C. 2010. Worldwide ammonite correlation at the Pliensbachian Stage and Substage Boundaries (Lower Jurassic). *Stratigraphy*, 7 (1): 83–101.

Meister, C. & Blau, J. 2014. Pliensbachian ammonites from the Central Apennines, Italy (Acquasparta section) - a revision of FISCHER's collection and new data. *Neues*

Jahrbuch für Geologie und Paläontologie Abhandlungen, 273 (3): 253–275.

Meister, C. & Friebe, J.B. 2003. Austroalpine Liassic Ammonites from Vorarlberg (Austria, Northern Calcareous Alps). *Beiträge zur Paläontologie*, 28: 9–99.

Meister, C., Dommergues, J. L., Dommergues, C., Lachkar, N. & El Hariri, K. 2011. Les ammonites du Pliensbachien du Jebel Bou Rharraf (Haut-Atlas oriental, Maroc). *Geobios*, 44: 117.e1–117.e60.

Meister, C., Schirolli, P. & Dommergues, J.-L. 2017. Early Jurassic (Sinemurian to basal Toarcian) ammonites of the Brescian Prealps (Southern Alps, Italy). *Rivista Italiana di Paleontologia e Stratigrafia*, 123 (1): 79–148.

Meneghini, J. 1867–1881. Mogographie des fossiles du calcaire rouge ammonitique (Lias supérieur) de Lombardie et de l'Apennin Central. *Paléontologie Lombarde*, 4: 1–242.

Metodiev, L.S., Rabrenović, D., Mojsić, I., Ivanova, D.K., Koleva-Rekalova, E.K. & Radulović, V. 2013. The ammonites of the Bifrons Zone (Toarcian, Lower Jurassic) from Mihailovići (Northern Montenegro). *Comptes rendus de l'Académie bulgare des Sciences*, 66 (1): 67–76.

Mirković, B. 1965. Gornjolijaska cefalopodska fauna iz sela Prage (Crna Gora) [Faune Cephalopode du Lias Superieur aux environs de village Praga (Monténégro)]. *Geološki glasnik*, 4: 245–253.

Mirković, M. 1970. Stratigrafija trijasa i jure okoline Pljevalja (La stratigraphie du Trias et du Jura dans les environs de la ville de Pljevlja). *Geološki glasnik*, 6: 39–49.

Missoni, S. & Gawlick, H.-J. 2011. Jurassic mountain building and Mesozoic-Cenozoic geodynamic evolution of the Northern Calcareous Alps as proven in the Berchtesgaden Alps (Germany). *Facies*, 57: 137–186.

Nöth, L. 1956. Beiträge zur Geologie von Nordmontenegro. Oberlias in der Umgebung von Pljevlja. *Raimund von Klebelsberg-Festschrift der Geologischen Gesellschaft in Wien*, 48: 167–191.

Oppel, A, 1856. Die Juraformation Englands, Frankreich und des súdwestlichen Deutschlands. *Jahreshefte des Vereins für vaterländische Naturkunde in Württemberg*, 12: 1–438.

d'Orbigny, A. 1842-1851. *Paléontologie française, Terrains Jurassique I: Céphalopodes*. 1–642.

Ostojić, Z. & Milić, M. 2014. Lijaski krečnjaci Mihailovića kod Pljevalja [Liassic limestone from Mihailovića near Pljevlja]. *Zbornik radova XVI Kongres geologa Srbije, Donji Milanovac*, 103–106.

Parisch, C. & Viale, C. 1906. Contribuzione allo studio delle ammoniti del Lias superiore. *Rivista Italiana di Paleontologia*, 12: 141–168.

Petković, K.V. 1934. Profil Krša pod Gradcem nedaleko od Sjenice i njegov značaj za odredbu starosti serije rožnaca i peščara u oblasti Stare Raške. *Glas Srpske kraljevske akademije, CLXII, Prvi razred*, 79: 139–152.

Rabrenović, D., Metodiev, L.S., Ivanova, D.K., Koleva-Rekalova, E.K., Radulović, V. & Mojsić, I. 2012. The Lower and the Middle Jurassic facies and biostratigraphy (ammonites and foraminifers) of the Lim river area (Internal Dinarides), Montenegro. *Comptes rendus de l'Académie bulgare des Sciences*, 65 (12): 1705–1716.

Radoičić-Brstina, R. 1956. Nove lokalnosti starije jure u sjeverozapadnoj Crnoj Gori (Les localités nouvelles du jura ancien dans les Dinarides). *Geološki glasnik* (Cetinje), 1: 91–113.

Radoičić, R. 1962. Mikrofauna gornjolijaskih krečnjaka sjeverne Crne Gore, Stare Raške i Rožaja [Microfaune des calcaires du Lias supérieur du Monténégro du nord, de Stara Raška et de Rožaj]. *Vesnik Zavoda za geološka i geofizička istraživanja*, 20: 211–222.

Radoičić, R., Jovanović D. & Sudar, M. 2009. Stratigraphy of the Krš Gradac section (SW Serbia). *Geološki anali Balkanskoga poluostrva*, 70: 23–41.

Rampnoux, J.-P. 1974. Contribution à l'étude géologique des Dinarides: un secteur de la Serbie méridionale et du Monténégro oriental (Yougoslavie). *Mémoires de la Société Géologique de France*, 119: 1–100.

Rulleau, L., Lacroix, P. & Le Pichon, J.-P. 2015. *Révision des Phymatoceratinae (Hildoceratidae, Ammonitina) du Toarcien moyen et supérieur, en France et dans le monde*. Dédale Editions, 351 pp.

Schefer, S., Egli, D., Missoni, S., Bernoulli, D., Fügenschuh, B., Gawlick, H.-J., Jovanović, D., Krystyn, L., Lein, R., Schmid, S. & Sudar, M. 2010. Triassic metasediments in the Internal Dinarides (Kopaonik area, southern Serbia): stratigraphy, paleogeography and tectonic significance. *Geologica Carpathica*, 61: 89–109.

Schmid, S.M., Bernoulli, D., Fügenschuh, B., Matenco, L., Schefer, S., Schuster, R., Tischler, M. & Ustaszewski, K. 2008. The Alpine-Carpathian-Dinaride-orogenic system: correlation and evolution of tectonic units. *Swiss Journal of Geosciences*, 101: 139–183.

Schmid, S.M., Fügenschuh, B., Kounov, A., Matenco, L., Nievergelt, P., Oberhansli R., Pleuger, J., Schefer, S., Schuster, R., Tomljenović B., Ustaszewski, K. van Hinsbergen D.J.J. 2020. Tectonic units of the Alpine collision zone between Eastern Alps and western Turkey. *Gondwana Research*, 78: 308–374.

Trifonova, E. 1993. Taxonomy of Bulgarian Triassic foraminifera. II Families Endothyriidae to Ophthalmiidae. *Geologica Balcanica*, 23 (2): 19–66.

Tudoran, A. 1997. *Biostratigraphic and Paleoenvironmental Significance of Jurassic Microfossils from Romania*. Unpublished PhD Thesis, The Department of Geology and Geophysics, Graduate Faculty of the Louisiana State University, 211 pp.

Velić, I. 2007. Stratigraphy and Palaeobiogeography of Mesozoic Benthic Foraminifera of the Karst Dinarides (SE Europe), parts 1-3. *Geologia Croatica*, 60 (1): 1–113.

Vlahović, I., Tišljar, J., Velić, I. & Matičec, D. 2005. Evolution of the Adriatic Carbonate Platform: Palaeogeography, main events and depositional dynamics. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 220: 333–360.

Wendt J. 2017. A unique fossil record from neptunian sills: the world´s most extreme example of stratigraphic condensation (Jurassic, western Sicily). *Acta Geologica Polonica*, 67 (2): 163–199.

Živković, M.R. & Milojević, S.P. 1934. Karniski krečnjaci u Mihailovićima kod Pljevalja. Prilog geologiji Stare Raške [Calcaires du Carnien de Mihailovići près de Pljevlja (Serbie du sud)]. *Vesnik Geološkog instituta kraljevine Jugoslavije*, 3: 199–212.

Резиме

Рано-средњојурско постепено продубљивање у прелазном фацијалном појасу између Јадранске карбонатне платформе и отвореног шелфа Неотетиса у сјевероисточној Црној Гори доказано помоћу нових података о амонитима из доњег дијела касноплинзбашког доба (Lavinianum зона)

Депозициона историја током ране и средње јуре у Унутрашњим Динаридима је слабо позната због ријеткости доступних изданака, а модерна анализа микрофација у комбинацији са тачним биостратиграфским подацима је такође веома ријетка (Haas et al., 2019; Gawlick et al., 2017, 2020 са референцама). Супротно рано-средњојурској депозиционој историји која је добро проучена и дефинисана у Спољашњим Динаридима, прелазна зона између плитководних творевина Спољашњих Динарида и средине отвореног шелфа у близини океана Неотетиса на истоку током ране и средње јуре је слабо позната. Седиментне стијене ране и средње јуре које су стваране на отвореном шелфу су практично непознате, јер су еродоване или прекривене током средњо до каснојурске западно оријентисане обдукције офиолита (Gawlick et al., 2016, 2020; Gawlick & Missoni, 2019 са референцама). Детаљна историја продубљивања црвених рано-средњојурских нодуларних кречњака (Ammonitico Rosso) са добро познатим и детаљним описима карактеристика фација (Flügel, 2004 и цитиране референце) и сусједних фацијанлних појасева који представљају прелаз према подини Јадранске карбонатне платформе, може у Унутрашњим Динаридима бити реконструисана само индиректно.

Обимније познавање седиментне историје овог прелазног фацијалног појаса, очуваног на ријетким изданцима у Унутрашњим Динаридима у југозападној Србији и сјевероисточној Црној Гори, даје могућност да се попуни празнина у разумијевању депозиционе историје Унутрашњих Динарида током ране јуре.

Нови проналасци амонита у ранојурским хардграундима у Црној Гори (Михајловићи) управо дају добру могућност да се попуни ова празнина у познавању депозиционе историје ране јуре, тј. о постепеном продубљивању депозиционе области током ране и средње јуре, а такође дозвољавају и ревизију неких раније објављених података о старости старијих слојева. Током нових истраживања локалитета, три примјерка таксона *Fuciniceras lavinianum* (Fucini), *Lytoceras ovimontanum* Geyer и Arieticeratinae gen. indet. пронађена су у слоју одмах испод црвених нодуларних кречњака средњотоарске старости. Ове врсте указују на касноплинзбашку старост,

макар у горњем дијелу жуто-сивих кречњака члана 2, што се значајно разликује од старости коју су одредили Rabrenović et al. (2012).

У овом раду неколико примјерака *Calliphylloceras capitanii* (Catullo), *Harpoceras subplanatum* (Oppel) и *Furloceras* aff. *chelussii* (Parisch & Viale) је такође описано, пошто су то први проналасци наведених врста у средњотоарској Bifrons зони на локалитету Михајловићи.

Ново датирање на основу амонита унапређује модел постепеног продубљивања током ране-средње јуре, док је трајање стратиграфских празнина скраћено у односу на раније интерпретације. Рана јура на основу амонита у комбинацији са анализом микрофација може се подијелити у три члана различите старости:

1. средње/касно хетаншко до синемурско доба,
2. рано до касно плинзбашко доба, и
3. тоарско доба,

након којих су у средњој јури присутни *Bositra* кречњаци као четврти члан. Три ранојурска члана и *Bositra* кречњаци припадају формацији Крш Градац како су је описали Gawlick et al. (2017, 2020).

Поређење седиментолошке еволуције на локалитету Михајловићи током ране-средње јуре са другим изданцима у широј околини, односно у западном дијелу Унутрашњих Динарида је практично немогуће, због недостатка описа или модерних биостратиграфских података у комбинацији са детаљном анализом микрофација. Само локалитет Крш Градац у југозападној Србији је детаљно проучен (Radoičić et al., 2009; Gawlick et al., 2009b, 2017, 2020) тако да је са њим и урађено поређење. У одређеној мјери, на основу литературних података, Михајловићи су упоређени и са локалитетом Маљевине у околине Сјенице (југозападна Србија, Ledebur 1941), односно планином Војник у Црној Гори (Bešić, 1948; Radoičić-Brstina, 1956; Mirković, 1965). Корелација старости плинзбашких седимената на основу амонита је у Динаридима за сада могућа само са облашћу Заломке у Босни и Херцеговини, гдје је Gaković (1986) утврдио амонитске зоне за готово комплетан горњоплинзбашки поткат. Амоните најранијег горњоплинзбашког потката, у којима доминирају представници рода *Protogrammoceras*, аутор је смјестио у *Fuciniceras* (*Fuciniceras*) *boscense* зону, која би представљала еквивалент Lavinianum зоне у Михајловићима.

Нова истраживања ране и средње јуре Михајловића у сјевероисточној Црној Гори омогућила су реконструкцију постепеног продубљивања током ране јуре на основу нових биостратиграфских резултата. Нова амонитска фауна потврђује по први пут на овом профилу, као и у читавој Црној Гори, односно и у Унутрашњим Динаридима, Lavinianum зону касноплинзбашке старости испод Bifrons зоне тоарске старости и према томе значајан хијатус. Амонитске врсте које су нове за средњотоарски дио овог локалитета су такође описане.

Старост раније публикованих седиментних празнина је исправљена, тако да се први прекид у седиментацији догодио током ?касног синемурског до раног плинзбашког доба, а други је трајао од касног плинзбашког до краја раног тоарског доба. Медитерански карактер фауне је потврђен за амоните Bifrons зоне, а исто је предложено са одређеном резервом и за оне из Lavinianum зоне.

Седиментна еволуција током ране и средње јуре јасно указује на постепено продубљивање депозиционе области. Изнад плитководних микроонкоидних кречњака ?касног хетаншког до синемурског доба, након хијатуса, формирани су кречњаци са микроонкоидима у само неколико нивоа током ?раног до касног плинзбашког доба. Наставак продубљивања може се манифестовати појавом мањих микроонкоида са само неколико ламина и повећањем разноврсности асоцијација бентоских фораминифера, као и повећаним бројем криноидских фрагмената и амонита. У горњем дијелу плинзбашког ката кондензовани амонитско-криноидско-фораминиферски пекстони без микроонкоида таложени су у дубоководној средини са релативно слабом енергијом воде. Након следећег хијатуса обиљеженог Fe/Mn корама, векстони до пекстони са фрагментима амонита, фораминиферама и криноидима, и континуираног стварања хардграунда, формирани су током раног до касног тоарског доба. Након дужег прекида у депозицији од касног тоарског доба надаље, кондензовани *Bositra* кречњаци образовани су током бајеског-?батског доба, указујући на веома спору седиментацију у хемипелашким условима отвореног мора.

Депозициона историја са постепеним продубљивањем у прелазној области седиментације између Јадранске карбонатне платформе и њене подине на западу и спољашњег шелфа отвореног мора са рано до средњојурским кондензованим црвеним нодуларним кречњачким фацијама одражава у мањој или већој мјери временске еквиваленте догађаја познатих у читавом Западном Тетису, како је описано на Сицилији (Di Stefano et al., 2002), у Јужним Апенинима (Iannace et al., 2005), као и у Јужним Алпима (Martire et al., 2006; Buser & Dozet, 2009; Masetti et al., 2017). Приказана реконструкција рано до средњојурске депозиционе историје у Источнобосанско-дурмиторској мега јединици затвара важну празнину у разумијевању јурске еволуције у Динаридима.

Manuscript received December 30, 2020
Revised manuscript accepted April 21, 2021