GEOLOŠKI ANALI BALKANSKOGA POLUOSTRVA
Volume 80 (1), July 2019, 29–43
–
DOI: 10.2298/GABP1901029J

Middle Miocene shark teeth from the southern margin of the Pannonian Basin System (Serbia, Central Paratethys)

Gordana Jovanović[1], Nicolae Trif[2],
Vlad Codrea[3] & Dragana Đurić[1]

Abstract. This paper describes Middle Miocene (Badenian) shark teeth from Serbia and discusses their geographical distribution at other localities of the Central Paratethys. The shark teeth originate from Višnjica (near Belgrade), from Višnjica Clay, or the 'Pleurotoma Clay'. The variety of sharks is very low, but according to these fossils Višnjica is the richest among Serbian localities. The sharks teeth reported in the paper belong to the following taxa: *Otodus* (*Megaselachus*) *megalodon* (Agassiz, 1835), *Hemipristis serra* Agassiz, 1835 and Odontaspididae indet. The high diversity of invertebrates (molluscs, echinoids, corals etc.) and other coeval fossil assemblages indicate a warm period (the Middle Miocene Climatic Optimum), which preceded the Middle Miocene Climatic Transition.

Key words:
Middle Miocene, Badenian, sharks, Paratethys Sea, Serbia.

Апстракт. У овом чланку се описују средњомиоценски (баденски) зуби ајкула из Србије и дискутује о њиховој географској дистрибуцији на другим локалитетима Централног Паратетиса. Зуби ајкула потичу из Вишњице (недалеко од Београда), из Вишњичких глина или "Плеуротомских глина". Разноврсност ајкула је врло ниска, али је по овим фосилима Вишњица најбогатија међу српским локалитетима. Описани зуби ајкула припадају следећим таксономима: *Otodus* (*Megaselachus*) *megalodon* (Agassiz, 1835), *Hemipristis serra* Agassiz, 1835, и Odontaspididae indet. Висока разноврсност бескичмењака (мекушаца, ехиноида, корала) као и других фосилних заједница указују на топли период (средњомиоценски климатски оптимум), који је претходио средњомиоценској климатској транзицији.

Кључне речи:
Средњи миоцен, баден, ајкуле, море Паратетис, Србија.

[1] Natural History Museum, Njegoševa 51, 11000 Belgrade, Serbia. E-mails: gordana.j@nhmbeo.rs;dragana.djuric@nhmbeo.rs

[2] Brukenthal National Museum, Natural History Museum, Sibiu, Romania, Cetății Street 1, Sibiu, RO-550160, Romania. E-mail: nicolae.trif@gmail.com

[3] Babeș-Bolyai University, Faculty of Biology-Geology, Department of Geology 1, Kogălniceanu Str., Cluj-Napoca, RO-400084, Romania. E-mail: vlad.codrea@ubbcluj.ro

Introduction

Miocene shark teeth from Paratethys are mentioned in the literature since the 19th century with numerous described extinct species (e.g., Agassiz, 1843; Probst, 1878; Koch, 1903; Schultz, 1971, 1979, 2013). Recent research allows the evaluation of their diversity, as well as the areal and the stratigraphic distribution of these fossils. Many references deal with the taxonomy and the reassessment of these sharks (e.g. Capetta, 2012; Mikuž & Šoster, 2013; Mikuž et al., 2014, 2015, 2017; Szabó & Kocsis, 2016; Trif et al., 2016; Trif & Codrea, 2017). The present analysis points out that the shark teeth are relatively rare in the palaeontological record of the Serbian Miocene localities; but it also reflects a broad geographic distribution in the Central Paratethys Sea.

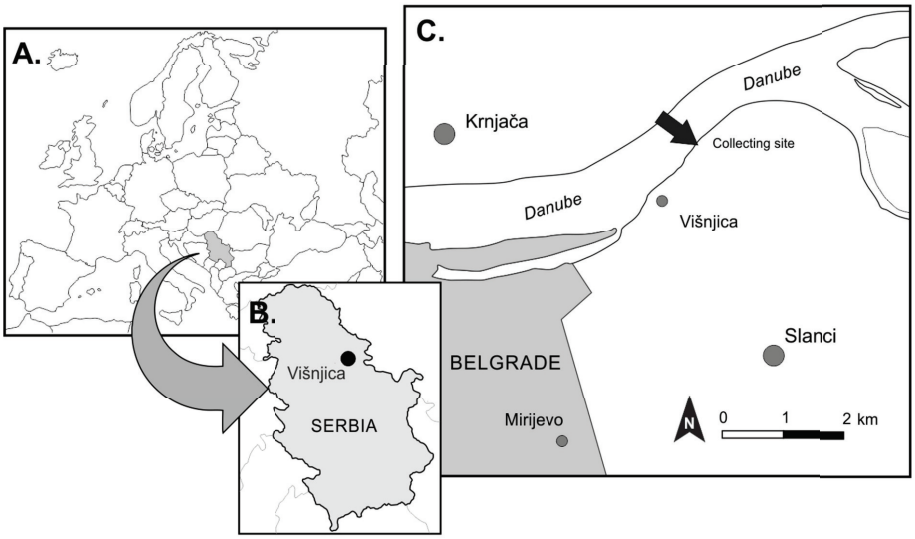


Fig. 1. *Location of Višnjica locality in:* ***A.*** *Europe;* ***B.*** *Serbia;* ***C.*** *Belgrade area.*

The fossil shark teeth from Serbia have been poorly studied in comparison with other fossils (e.g. Đurić et al., 2017: Radović & Bradić-Milinković, 2018). The Middle Miocene (Badenian) sediments from Serbia are exposed in various regions of the country. These sediments are rich in fossils, mainly invertebrate fossils. Shark teeth are mentioned only in a small number of localities, such as Višnjica and Rakovica, from the vicinity of Belgrade, and in eastern Serbia (Golubac), according to Mikinčić (1932), Grubić (1958), Anđelković et al. (1989) and Jovanović & Tomić (1997). In the past decades, only a few new data have been added to this topic.

This paper refers to the Badenian shark fauna from Višnjica (Belgrade, Serbia) (Fig. 1A, B, C). The aim of this study is to increase the knowledge about the shark diversity and its distribution along the southern margin of the Central Paratethys during the Middle Miocene. This study of the shark teeth fills a gap within this region, allowing correlations between Serbian fauna and the coeval well-documented similar faunas reported from the various other areas of the Paratethys. By analysis of the Middle Miocene Serbian localities, the Višnjica fauna appears to be the most diverse. In addition to the taxa previously reported herein, Grubić (1958) mentioned the following species: *Carcharodon megalodon* Agassiz, *Lamna cuspidata* Agassiz and *Lamna* (*Otodus*) *appendiculata* Agassiz. The last species is one of the most frequently reported nominal shark species from the Cretaceous and Paleocene according to Siversson et al. (2015) and Cappetta (2012), but not from the Miocene. Therefore, it is likely to be a misidentified taxon. The Miocene shark teeth from other Serbian localities, like Rakovica and Golubac, have generally been assigned to *Lamna*, or just to 'fish teeth' (Mikinčić, 1932; Jovanović & Tomić, 1997). With the exception of a single specimen of Odontaspididae from Rakovica, no other shark teeth could be found in the collections of the Belgrade Museum.

Geological setting

In the Paleogene, the collision between the African and the European plates has resulted in division of the Tethyan Realm into two different paleogeographical realms - the circum-Mediterranean in

the south and the Paratethys in the north (Laskarev, 1924; Rögl & Steininger, 1984; Rögl, 1998; Popov et al., 2004). On its turn, the Paratethys can be divided into three distinct regions: Western, Central, and Eastern Paratethys (Piller et al., 2007). Each region had specific developments in terms of facies and distribution. The former Central Paratethys region is congruent with the area of nowadays Austria, Slovenia, Poland, Hungary, Croatia, Serbia, Bosnia and Herzegovina, Ukraine and Romania. Several Middle Miocene sedimentary basins from Serbia have been closely connected to this area, which allowed faunal exchanges**.** In the Middle Miocene, in the vicinity of Belgrade, the Paratethys Sea flooded different types of basement and a normal marine regime occurred in the area. The related sedimentary deposits are very rich in fossils. The first geological studies in the area enabled a large number of typical marine taxa to be reported. In the Višnjica site, the largest group of taxa is represented by Badenian gastropods from the so-called '*Pleurotoma* Clay', or 'Višnjica Clay' (Luković, 1922; Stevanović, 1977; Anđelković et al., 1989) assigned to the Višnjica Clay Formation (abbreviated VCF).

The Badenian age of the deposits near Belgrade is based on the study of foraminiferal assemblages. It comprises three units: the Early Badenian (the Lagenidae Zone), the Middle Badenian (the *Spirorutilus carinatus* Zone) and the Late Badenian (*Elphidium crispum* and *Ammonia beccarii* Zone) (Petrović, 1970; 1985). The VCF exposures have been reported in the Ramadan stream, at its confluence with the Danube. The outcrops from the banks of the Danube studied in the 19th and 20th centuries allowed the collection of these fossils. However, after the construction of the dam at hydroelectric power plant "Đerdap" (Iron Gates), the Danube level rose and these outcrops are currently flooded.

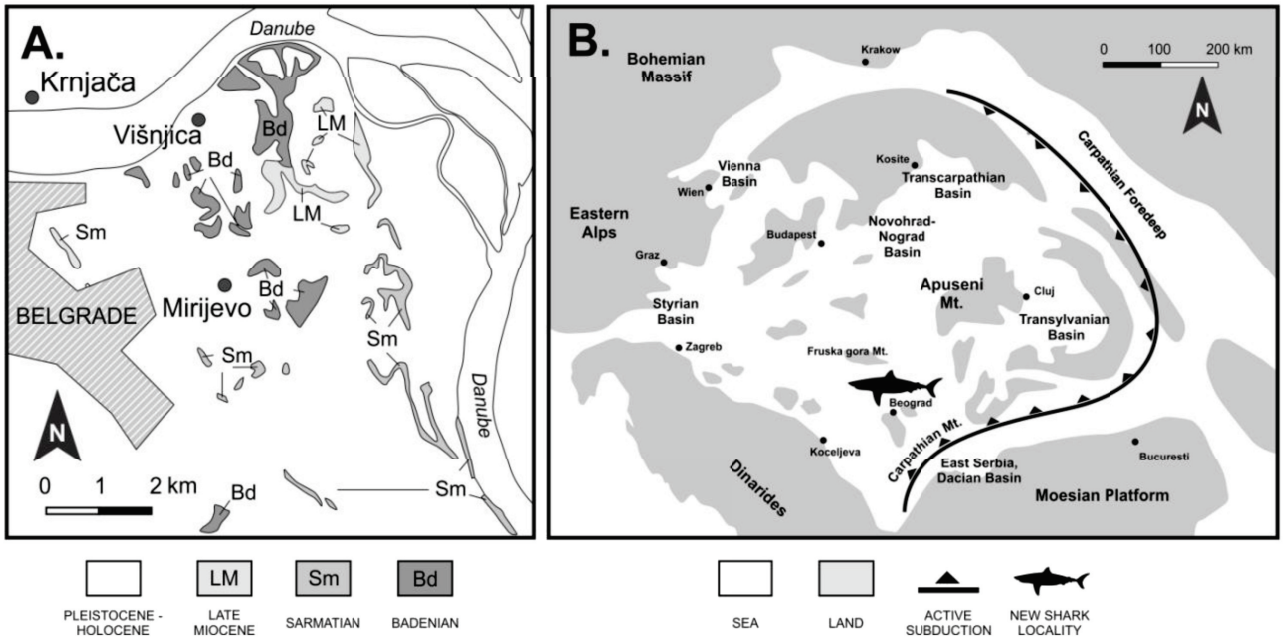


Fig. 2. A*. Geological map of the Višnjica area (after the map 1:100.000 of Serbia, sheet Pančevo, according to Ivković et al. 1966, modified);* ***B****. The map of Central Paratethys (after Rögl & Steininger, 1984, modified).*

Material and methods

This study is based on the review of fifteen fossil shark teeth collected during several past field works. The studied shark teeth originate from three distinct collections, all obtained from the same Badenian deposits. The collectors were: Petar Pavlović, at the end of the 19th century, Petar Stevanović, in 1959, and Ve-

limir Milošević, around the mid-20th century. Morphological features have been used to provide detailed taxonomic data. We considered the shape and size of the main cusp and the serration, where available. The photos of the specimens have been taken with an OLYMPUS Z4001 camera and a PANASONIC DMC-FZ50 camera, respectively, attached to a BIOOPTICA 100 stereomicroscope.

The shark teeth found in the VCF range in size from less than 8 mm to over 80 mm. These have been collected directly by hand, without sieving the sediment. The fossils are housed at the Natural History Museum in Belgrade, Serbia (abbreviated as NHMB; collection numbers: K 7050; PS 23-26; KV-P 282-291). Some of the shark teeth are poorly preserved and eroded with exposed enamel cracks. The roots are damaged too. This state of preservation suggests that some teeth have been exposed to wave action, which led to fragmentations, abrasion and polishing. Most of the teeth are black and dark grey, while others are brownish or even white.

Systematic paleontology

Superorder Galeomorphii Compagno, 1973
Order Lamniformes Berg, 1958
Family Otodontidae Glickman, 1964
Genus *Otodus* Agassiz 1843 (*sensu* Cappetta, 2012).

Otodus (*Megaselachus*) *megalodon* Agassiz, 1835

Material: Three teeth (Figs. 3.a-d; e-g and h-j); NHMB: PS 23, K 7050, PS 24.

The tooth illustrated in Fig. 3.a-d is the biggest and the most complete tooth ever found in this locality. It has a height of 82 mm and a width of 57 mm. Its general shape is triangular with a strong root and a well defined neck. The lingual side is convex (Fig. 3a), while the labial one is flat (Fig. 3b). The cutting edge is well preserved and has a fine and regular serration (Fig. 1c). No cusplets are present at the base of the crown. Based on the general shape of the tooth, it most likely had an anterior position.

The tooth in the Figs. 3e-g is smaller, measuring only 48 mm in height and 37 mm in width. Most of its root and the apex are missing. The serration is well preserved, fine and regular. The neck is fragmented, but it can be noticed in the central part, on the lingual side of the tooth. The lingual side is moderately convex, while the labial one is flat. The shape of the crown suggests an antero-lateral position of this tooth.

The tooth in the Figs. 3h-j is also of a rather modest size, with a height of 61 mm and a preserved width of 48 mm. The general shape is similar to the other two teeth already described. The cutting edge is strongly worn-out and the serration is only preserved in a small portion. It is interesting to note the bio-erosion marks on the enamel of this tooth. Both sides of the crown bear hundreds of indentations caused by an unknown organism. Based on the general shape, it is likely that this tooth had an upper anterior position.

Discussions. The taxonomy of the Otodontidae family has been debated for a long time, particularly over the last decade (Jordan & Hannibal, 1923; Glickman, 1964; Schultz, 1971; Pimiento et al., 2010; Cappetta, 2012 etc.). Based on the presence, absence or size of the serrations and cusplets, as well as on the differences in the root morphology, Cappetta (2012) revised and divided the *Otodus* genus into three subgenera. The described morphology allows us to confidently assign the specimens to the *Otodus* (*Megaselachus*) *megalodon* species (Cappetta, 2012).

Although this species has a cosmopolitan distribution and it is by far better known from the Mio-Pliocene formations of the North, Central and South America (Fowler & Kummel, 1911; de Muizon & Devries, 1985; Pimiento et al., 2013; Carrillo-Briceno et al., 2015), it is also ubiquitous in the Central Paratethys Sea. *Otodus* (*M.*) *megalodon* has been found in the Badenian deposits from over 50 outcrops in: Austria (Zapfe, 1954; Flügel & Kollmann, 1964; Kollmann, 1969; Schultz, 1971; Hiden, 1995; Rögl et al., 2008; Schultz, 2013), the Czech Republic (Schultz et al., 2010), Hungary (Szabó & Kocsis, 2016), Slovenia (Mikuž, 2000; Mikuž & Šoster, 2013; Mikuž et al., 2014, 2015), Croatia (Paunović, 1987), Poland (Pawlowska, 1960; Radwanski, 1965; Schufltz, 1977, 1979), Slovakia (Holec & Sabol, 1996; Holec, 2001) and Romania (Trif et al., 2016; Trif & Codrea, 2017). Sometimes, associated teeth can also be found (see Mikuz & Šoster, 2013). It is interesting to note that *O.*

(*M*) *megalodon* is part of the fauna listed in the Badenian type-section of Baden-Sooss in Lower Austria (Rögl et al., 2008).

Order Carchariniformes Compagno, 1973
Family Hemigaleidae Hasse, 1879
Genus *Hemipristis* Agassiz, 1843.

***Hemipristis serra* Agassiz, 1835**

Material: One tooth (Figs. 3k-n); NHMB: PS 25

The illustrated tooth is an upper anterior. The crown is bent distally, flat, with a small basal fold on the labial side and convex on the lingual side. The cutting edges are typical for *H. serra* with larger, rarer serrations on the distal side, and smaller and more numerous serrations on the mesial side. The apex is devoid of any kind of serration. The root is only partly preserved, while the mesial lobe is missing.

Discussions: *Hemipristis serra* is a common Miocene species, especially in the Badenian, where it has been found in a large number of outcrops across the Central Paratethys (Schultz, 1977; Brzobohatý & Schultz, 1978; Schultz, 2013; Szabó & Kocsis, 2016; Trif & Codrea, 2017) and around the world (Müller, 1999; Purdy et al., 2001; Cappetta, 2012). Basically, it occurs in the same areas mentioned above for *O.* (*M*) *megalodon,* and it is particularly common in the Vienna and Styrian basins.

Family Odontaspididae Müller and Henle, 1839

Odontaspididae indet.

Material: Seven teeth (one illustrated in Figs. 3o-r); NHMB: KV-P 282

A small number of other shark teeth have been found in addition to the above described specimens. They are all poorly preserved. The teeth are heavily worn, most probably due to continuous wave action. The cutting edges and the apex are rounded and the lateral cusplets are reduced to just a few small bumps; the root is mostly fragmented, or totally missing, and in some cases polished to a smooth surface. However, the sigmoid profile and the slender crowns that are characteristic for a tearing type of dentition indicate that these teeth belong to the Odontaspididae family. These sharks had a wider distribution during the Cenozoic than nowadays. As a family of relatively large sharks, the Odontaspididae are known since the Aptian (early Cretaceous), according to Cione et al. (2007).

Discussion

Although the shark teeth from the Višnjica locality have been previously reported (Grubić, 1958), their value has not been precisely considered in the stratigraphic context. The stratigraphy of the VCF is still debated, but all the available data indicate a Middle Miocene (Badenian, calcareous nannoplankton NN5 Zone) age (Fig. 3). The sediments with shark teeth in Serbia were deposited during the Early Middle Miocene (Badenian) transgression. The Paratethys Sea flooded different terrains in Serbia, terrains which had either previously completely emerged, or had borne lacustrine sediments. It was a continuous expanding transition from freshwater lake environments to marine ones, on the whole southern sector of the Pannonian basin (Ćorić et al., 2009; Krstić et al., 2012). Therefore, the diversity of the marine fauna from Višnjica as well as other Badenian localities originated mainly from migration events from the Mediterranean basin through the Slovenian corridor. Connections are recorded also between the Pannonian basin and the Transylvanian one, through Mureș passageway (Chira & Mărunteanu, 1999).

In the Belgrade region, several Badenian lithological units have been established such as the Rakovica Sand, Višnjica Clay, Tašmajdan, Kalemegdan and Višnjica biogenic limestones (Leitha-type Limestone). Primary analyses were based on the foraminiferal and molluscan fauna. The foraminiferal fauna in Višnjica was studied by Pavlović (1897) who pointed out its strong similarity to the one of the 'Baden Tegel' (Vienna basin, Austria). Based on this rich fossil record, the Middle Miocene (Badenian) age was confirmed in the vicinity of Belgrade (Pavlović, 1922; Luković, 1922; Grubić, 1958). Later, foraminifera and calcareous nannofossils were studied by Petrović (1970), Stevanović (1977), Mihajlović & Knežević (1989). Grujičić (2010) pointed out the existence of the zone with *Spirorutilus carinatus* (D'Or-

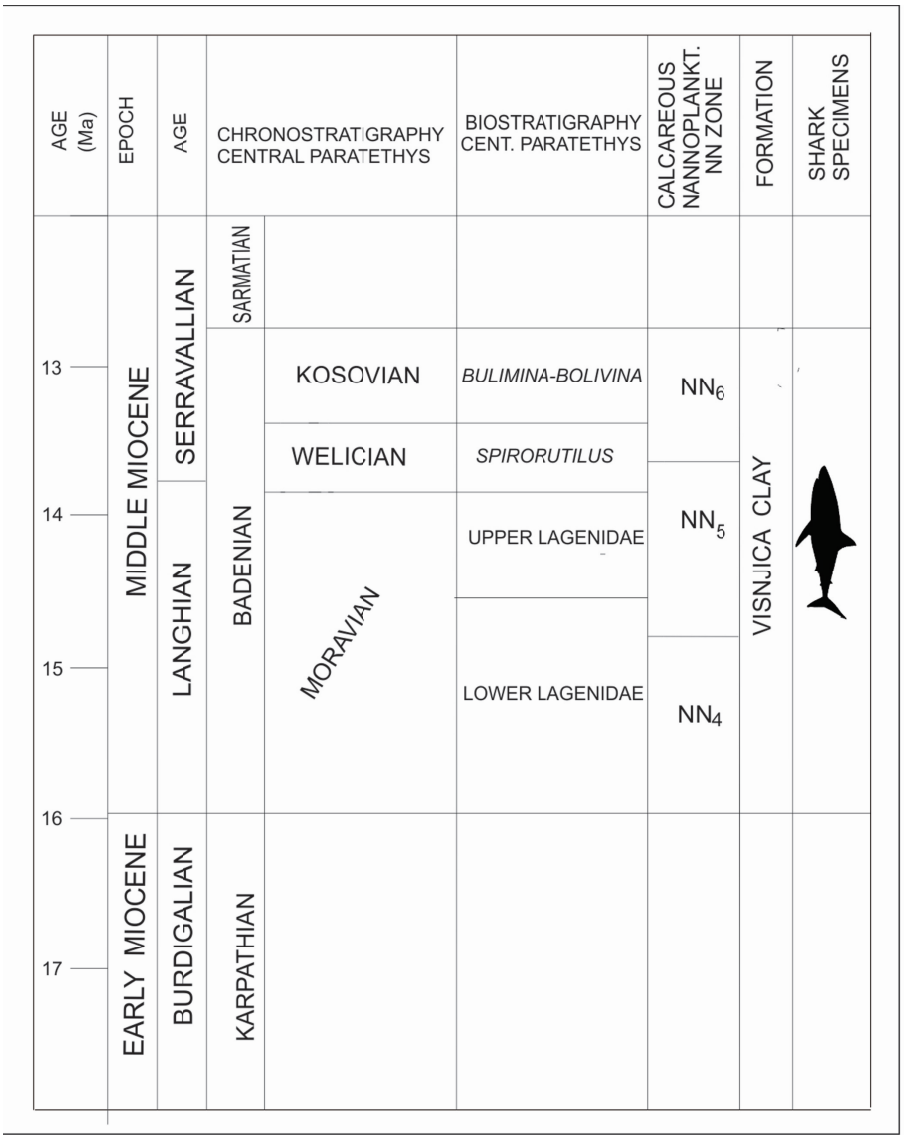


***Fig. 3**. Stratigraphic distribution of selachian occurrences across the southern margin of the Pannonian Basin Systems. Stratigraphic correlation table and position of the studied interval. Global chronostratigraphy after Hilgen et al. (2009), magnetostratigraphy and calcareous nannoplankton zones from Lourens et al. (2004a, b), Piller et al. (2007), Hohenegger et al.(2009), Pezelj et al. (2013), Sant et al. (2017). The position of calcareous nannoplankton in the study area after Krstić (1978), Mihajlović & Knežević (1989), Jovanović (2018), modified.*

bigny, 1846). However, the benthic foraminifera *Frondicularia sculpta* (Karrer, 1862) and *Annulofrondicularia annularis* (D'Orbigny, 1846) from 'Višnjica Clay' (Grujičić, 2010), Austria (Flügel, 1960) and Romania (Popescu & Crihan, 2004) are indicative for Early Badenian (Lagenidae Zone). Based on nannofossil assemblages, the first marine transgression in the Papuk Mt. (northern Croatia) according to Ćorić et al., (2009) corresponds to the NN5 Zone. Recently, Jovanović & Bošnjak (2016) based on the presence of some clams and scaphopods, assumed a late Early Badenian age. A main problem is related to the different interpretations of the Badenian stage subdivisions, as well as to the timing of Badenian marine transgressions in Paratethys (Piller et al., 2007; Kovač et al., 2007; Pezelj et al., 2013; Hohenegger et al., 2014; Sant et al., 2017). The different taphonomic conditions of the teeth suggest the origin from different stratigraphic levels. Additionally, a biostratigraphic revision is required for some Badenian localities (Jovanović et al., 2018). The sediments with shark teeth in Serbia were deposited during the early Middle Miocene (Badenian) transgression. The Paratethys Sea flooded different terrains in Serbia that were completely emerged or covered with lacustrine deposits during early Miocene.

Consistent to other geographically close-by localities (Schultz, 2013; Szabó & Kocsis, 2016; Trif et al., 2016; Trif & Codrea, 2017), the observed sharks appeared to be common in the Badenian deposits all around the Central Paratethys (Szabó & Kocsis, 2016) (Fig.4). In comparison with other localities in Croatia, Bosnia and Serbia (southern margin of Pannonian Basin Systems of Central Paratethys), Višnjica is richer in shark remains. In addition to the

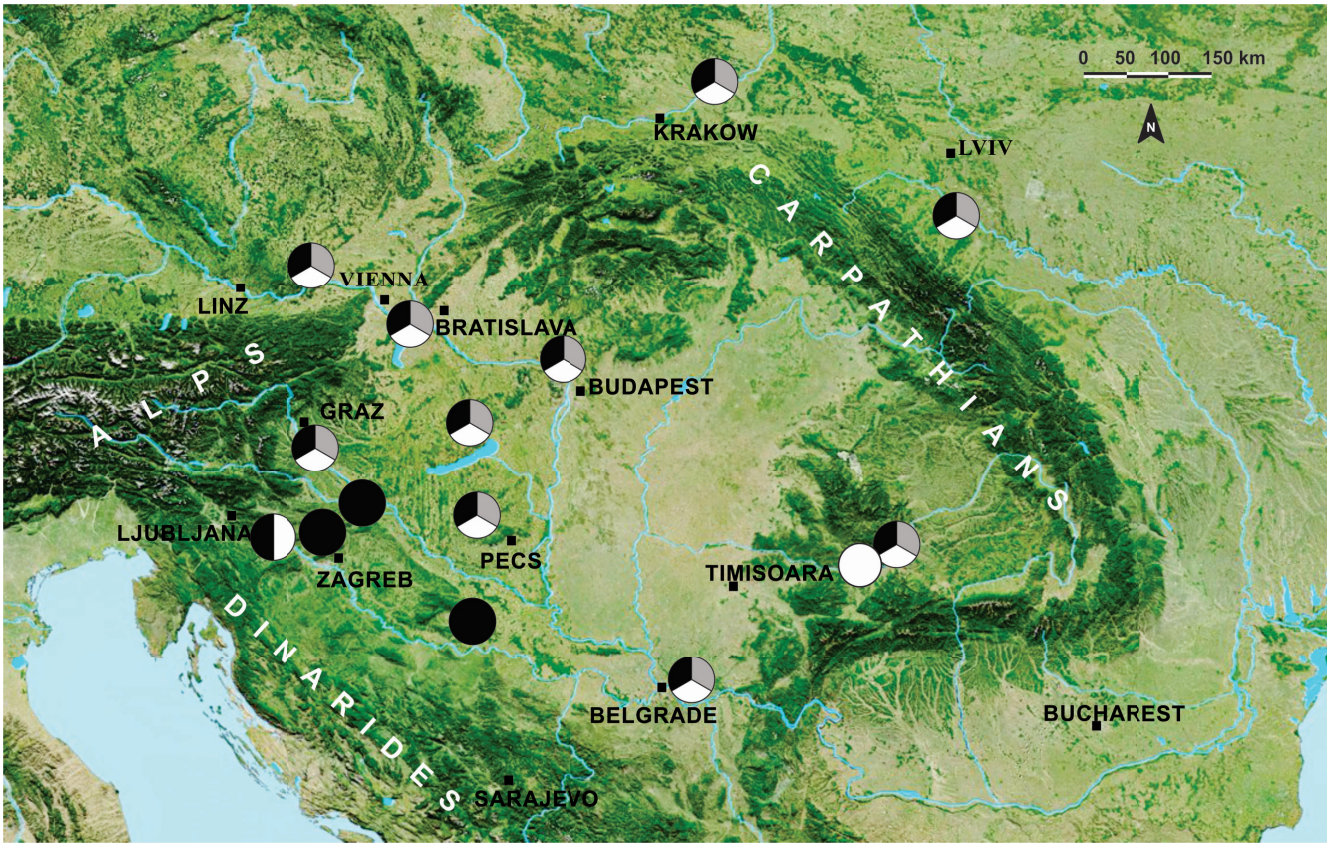


***Fig. 4**. Regional distribution of shark fauna; Otodus (Megaselachus) megalodon Agassiz, 1835 (white circles), Hemipristis serra Agassiz, 1835 (gray circles), and Odontaspididae Müller and Henle, 1839 (black circles) in Middle Miocene (Badenian), sensu Szabó & Kocsis (2016) in the Central Paratethys, modified.*

taxa herein reported, Grubić (1958) mentioned from Višnjica *Carcharodon megalodon*, *Lamna cuspidata* and *Lamna (Otodus) appendiculata*. In northern Croatia sharks are found in Papuk Mountain, but probably reworked in Sarmatian sediments (Vrsaljko et al., 2010). The dominant shark family from Višnjica is the Odontaspididae documented by seven teeth which could be identified only at a family level. The rarity of shark teeth in the Badenian of Serbia could be linked either to the lack of collecting or to the absence of equivalent ecological niches.

The Višnjica Clay, besides foraminifera, gastropods and bivalves, also bears shells of scaphopods, carbonated fossil wood, three-dimensional preserved *Pinus* cones and pyritized shells of *Aturia aturi* (Basterot, 1825). The fossil molluscan assemblages indicate a relatively global warm period (Middle Miocene Climatic Optimum), before the Middle Miocene Climatic Transition. The preserved *Pinus* cones and carbonated fossil wood fragments, as well as the analysis of the molluscan fauna indicate subtropical marine waters, with depths exceeding sometimes 100 m. The Badenian VCF was deposited in a neritic environment and the *Aturia* shell accumulations at Višnjica were interpreted by Stevanović (1970) as post mortal processes, the shells having drifted into shallower marine environments. Unlike Višnjica, some areas were covered by the sea only at the end of the Badenian, or in the Sarmatian. Several outcrops have shown that the transgression had occurred in Early Badenian on the basis of the flooding areas located more than 200 km southern of Belgrade (Koceljeva, Aranđelovac) (Anđelković et al., 1989). However, in such areas, the sea was mostly very shallow. Tectonic movements separated these rocks into distinct blocks, lifted or plunged, during the Neoalpine tectonic events

(Marović et al., 2007, Toljić et al., 2014). For this reason Badenian sediments are rarely exposed at the surface. The common presence of some large, oceanic sharks (e.g., *Otodus*, *Cosmopolitodus*) in the Central Paratethys during Middle Miocene could be explained by the abundance of their potential prey, represented by diverse marine mammals such as whales and dolphins (Szabó & Kocsis, 2016). Some remains of *Cetotherium* cf. *rathkii* Brandt, 1843 were also found in the Badenian deposits of northern Bosnia (Stefanović, 2010). Compared to the recent similar top predator *Carcharodon carcharias,* habitat of *O.* (*M.*) *megalodon* was probably similar. This shark hunted both on coastal environments but also offshore, on the continental and island shelves, over hundreds of meters (Weng et al., 2007).

While *O.* (*M.*) *megalodon* was clearly the top predator in these environments, we consider *H. serra,* with a length of 4 to 5 m (Kent, 1994) to be similar in its trophic level. The actual representative of the genus, *H. elongata* Klunzinger 1871, has a very similar dentition, but the smaller teeth length. Following Compagno (1984), the recent *H. elongata* feeds with a variety of fish prey, including smaller sharks and rays. Presumably, the fossil *H. serra* had a similar diet. The recent *Hemipristis elongata* lives in depths of up to 132 m (Stevens & Mc Loughlin, 1991).

Many Badenian localities have yielded a high diversity and excellent preservation of fossils, mostly invertebrates. The shark teeth from Višnjica however display different colors and marks of damage that could be explained by their specific taphonomy. All the shark teeth are considered autochthonous. As the Badenian transgression overlies continental and fluvio-lacustrine older deposits, reworking was not possible. Nowadays, the Višnjica exposure is inaccessible any more. A single tooth of *Otodus* (*M.*) *megalodon* is white in color. This specific color leads us to think that it originated from a different, distinct layer, possibly the white Leitha-type sandstone (once, exposed at Bela Stena, near Višnjica). The enamel and roots of the Odontaspididae teeth is heavily worn, most probably due to the wave action. Small transport could damage the root of the teeth. Even moderate abrasion/corrosion will result in reshaping of the edges of the root and a rounding of the lingual protuberance in basal and profile views (Siversson et al., 2015).

Conclusion

The shark teeth from VCF document three different families: Otodontidae, Hemigaleidae and Odontaspididae, described for the first time from the Badenian of Serbia. The first two families are documented by a single species, i.e. *Otodus* (*Megaselachus*) *megalodon* Agassiz and *Hemipristis serra* Agassiz. The shark assemblage includes well known and widespreaded Middle Miocene (Badenian) taxa, reported also from the other Paratethyan localities. Therefore, the Middle Miocene of Serbia is dominated by the cosmopolitan sharks. We conclude that the shark findings are consistent with a connection between the southern margin of the Pannonian Basin Systems and the other basins and sub-basins within the Central Paratethys in the Badenian. Višnjica represents the richest Badenian shark teeth locality in Serbia. The lack of small shark teeth is most probably related to the sampling due to the fact that all the shark teeth were obtained by picking from the exposed sediment surface without sieving.

Acknowledgments

We thank both reviewers, for their suggestions and comments on our manuscript: Werner Schwarzhans (Natural History Museum of Denmark, Zoological Museum, Denmark) and Vasja Mikuž (University of Ljubljana, Department of Geology, Slovenia). Also, the authors thank Oleg Mandić (Natural History Museum, Vienna) for his observations and suggestions for the stratigraphic interpretation. One of the authors (VC) would also like to acknowledge the support received from the Babeș-Bolyai University, Cluj-Napoca, grants AGC: 30852, 30851, 30850, 31509.

References

Agassiz, L. 1833-1843. *Recherches sur les poissons fossiles, (Contenant l'Histoire des Cycloides)*. Imprimerie de Petitpierre, Neuchatel. Suise, 390 pp.

Anđelković, M., Pavlović, M., Eremija, M. & Anđelković, J. 1989. Paleogeografija. In: Anđelković, M., (Ed.). *Geologija šire okoline Beograda,* [Geology of the surroundings of Belgrade - in Serbian], IV, University of Belgrade, 282 pp.

Berg, L.S. 1958. *System der Rezenten und Fossilen Fischartigen und Fische*. Hochschulbücher für Biologie, Berlin, 310 pp.

Brandt, J.F. 1843. De Cetotherio, novo balaenarum familiae genere, in Rossia meridionali anti aliquot annos eff oso. *Bulletin de l'Academie imperiale des Sciences de St. Petersbourg*, (2) 1: 145–148.

Brzobohatý, R. & Schultz, O. 1978. Die Fischfauna des Badeniens. In: Papp, A., Cicha, I., Senes, J. & Steininger, F., (Eds.). *M4 Badenien (Moravien, Wielicien, Kosovien). Chronostratigraphie und Neostratotypen*, Miozän der Zentralen Paratethys, 6: 441–465.

Cappetta, H. 2012. *Handbook of Paleoichthyology. Vol. 3E: Chondrichthyes. Mesozoic and Cenozoic Elasmobranchii: Teeth*. Verlag Dr. Friedrich Pfeil. München, 512 pp.

Carrillo-Briceno, J.D., De Gracia, C., Pimiento, C., Aguilera, O.A.,Kindlimann, R., Santamarina, P. & Jaramillo, C. 2015. A new Late Miocene Chondrichthyan assemblage from the Chagres Formation, Panama. *Journal of South American Earth Sciences*, 60: 56–70.

Chira, C. & Mărunţeanu, M. 1999. Middle Miocene (Lower Badenian) calcareous nannofossils from the Mureş passage way and Făget basin, Romania. *Acta Palaeontologica Romaniae*, 2: 73–82.

Cione, A.L., Mennucci, J., Santalucita, F. & Acosta Hospitaleche, C. 2007. Local extinction of genus *Carcharias* (Elasmobranchii, Odontaspididae) in the eastern Pacific Ocean. *Revista Geológica de Chile*, 34: 139–145.

Compagno, L.J.V., 1973. Interrelationships of living elasmobranchs. *Zoological Journal of the Linnean Society*, 53 (Supplement 1): 15–61.

Compagno, L.J.V. 1984. An annotated and illustrated catalogue of shark species known to date (Carcharini-formes). FAO Species Catalogue for Fishery Purposes. *Food and agriculture organization of the United Nations*, 4 (2): 251–655.

Ćorić, S., Pavelić, D., Rögl, F., Mandic, O., Vrabac, S., Avanić, R., Jerković, L., Vranjković, A. 2009. Revised Middle Miocene datum for the initial marine flooding of North Croatian basin (Pannonian Basin System, Central Paratethys). *Geologica Croatica*, 62 (1): 31–43.

De Muizon, C. &De Vries, T.H. 1985. Geology and paleontology of late Cenozoic marine deposits in the Sacaco area (Peru). *Geologische Rundschau*, 74 (3): 547–563.

Domning, D.P. &Pervesler, P. 2012. The sirenian *Metaxytherium* (Mammalia: Dugongidae) in the Badenian (Middle Miocene) of Central Europe. *Austrian Journal of Earth Sciences*, 105 (3): 125–160.

Đurić, D., Bogićević, K., Petrović, D. & Nenadić, D. 2017. Late Pleistocene Squamate Reptiles from the Baranica Cave near Knjaževac (Eastern Serbia). *Geološki anali Balkanskoga poluostrva*, 78: 23–35.

Flügel, E. 1960. Typen-Katalog. Verzeichnis der in der Geologisch-Paläontologischen bteilung des Naturhistorischen Museums in Wien aufbewahrten Typen sowie der bbildungsoriginale I. Invertebrata: 1. Protozoa. 2. Coelenterata. Geologie und Paläontologie. *Annalen des Naturhistorischen Museums in Wien*, 64: 65–104.

Flügel, E. & Kollmann, H. 1964. Verzeichnis der wichtigsten Objekte der Geologisch-Paläontologischen Sammlung (Rotpunkt-Verzeichnis). Alphabetische Zusammenstellung wichtiger Schauobjekte mit Erläuterungen. *Veröffentlichungen aus dem Naturhistorischen Museum Wien*, 5: 148–156.

Fowler, H.W. & Kummel, H.B. 1911. A Description of the Fossil Fish Remains of the Cretaceous, Eocene and Miocene Formations of New Jersey. *Bulletin of New Jersey Geological Survey*, 4: 1–192.

Glickman, L .S. 1964. *Sharks of Paleogene and their stratigraphic significance*. Nauka Press Moscow, 228 pp.

Grubić, D. 1958. Prilog poznavanju Višnjičkih plavih glina [Contributtion to knowledge of Višnjica blue clays – in Serbian]. *Vesnik Zavoda za geološka i geofizička istraživanja N.R. Srbije*, 15: 11–121.

Grujičić, Lj. 2010. Foraminifere roda *Frondicularia* iz Beogradskog dunavskog ključa [Foraminifers of the Genus *Frondicularia* from Belgrade area Danubian Meander]. In: Banjac, N. (Ed.),. Proceedings of the 15th Congress of the Geologists of Serbia with international participation, Belgrade, 69–73.

Hasse, J.C.F. 1879-1885. Das Natürliche System der Elasmobranchier auf Grundlage des Baues und der Entwicklung ihrer Wirbelsäule. Eine Morphologische und Paläontologische Studie. Gustav Fischer Verlag, Jena. Allgemeiner Theil: i-vi, 1–76, 1879; Besonderer Theil, (1): 1-94, pls. 1–12: 1882; (2): 97-109, pls. 13-23: 1882; (3): i-vi, 183–285, pls. 24–40: 1882; Ergänzungsheft, pp: 1–27.

Hiden, H.R., 1995. Elasmobranchier (Pisces, Chondrichthyes) aus dem Badenium (Mittleres Miozän) des Steirischen Beckens (Österreich). *Mitteilungen der Abteilung für Geologie und Paläontologie am Landesmuseum Joanneum,* 52/53: 41–110.

Hilgen, F.J., Abels, H.A., Iaccarino, S., Krijgsman, W., Raffi, I., Sprovieri, R., Turco, E. & Zachariasse, W.J. 2009. The Global Stratotype Section and Point (GSSP) of the Ser-

ravallian Stage (Middle Miocene). *Episodes*, 32: 152–166.

Hohenegger, J., Rögl, F., Ćorić, S., Pervesler, P., Lirer, F., Roetzel, R., Scholger, R. & Stingl, K. 2009. The Styrian Basin: A key to the Middle Miocene (Badenian/Langhian) Central Paratethys transgressions. *Austrian Journal of Earth Science*, 102: 102–132.

Hohenegger, J., Ćorić, S. & Wagreich, M. 2014. Timing of the Middle Miocene Badenian Stage of the Central Paratethys. *Geologica Carpatica*, 65 (1): 55–66.

Holec, P. & Sabol, M., 1996. The Tertiary Vertebrates from Devínska Kobyla. *Mineralia Slovaca*, 28: 519–522.

Holec, P. 2001. Chondrichthyes and Osteichthyes (Vertebrata) from Miocene of Vienna Basin near Bratislava (Slovakia). *Mineralia Slovaca*, 33 (2): 111–134.

Ivković, A, Vuković, A, Nikolić J, Kovačević, D, Palavestrić, LJ., Petrović, LJ., Jovanović, O., Trifunović, I. & Sebinović, LJ. 1966. Osnovna Geološka karta Jugoslavije 1:100,000, list Pančevo [Basic Geologic Map of Former Yugoslavia 1:100,000, Sheet Pančevo]. Savezni geološki zavod, Beograd.

Jordan, D.S. & Hannibal, H. 1923. Fossil sharks and rays of the Pacific Slope of North America. *Bulletin of the Southern California Academy of Sciences*, 22: 27–63.

Jovanović, G. 2018. Badenske školjke jugoistočnog oboda panonskog basena [Badenian bivalves of the southeastern margin of Panonian Basin Systems (Central Paratethys) – in Serbian]. *Bulletin of Natural History Museum*, Special editions 44: 1–136.

Jovanović, G. & Bošnjak, M. 2016. *Fissidentalium badense* (Partsch in Hörnes, 1856) from the Badenian deposits of the south and southwestern margin of the Pannonian Basin System (Central Paratethys). *Geologica Croatica*, 69 (2): 195–200.

Jovanović, G. & Tomić, Z. 1997. Paleoekološke i mineraloške metode pri rekonstrukcijama životnih uslova u badenskom veku Golupca [Paleoecological and mineralogical methods in living conditions reconstruction in Badenian age at Golubac (Eastern Serbia) – in Serbian]. *Geološki anali Balkanskoga poluostrva*, 61 (2): 371–392.

Jovanović, G., Ćorić, S. & Vrabac, S. 2018. Prvi dokazi donjobadenske morske transgresije kod Koceljeve [The First evidence of marine Badenian transgression near Koceljeva (western Serbia) – in Serbian]. *Abstract Proceedings of 17th Serbian Geological Congress, May 17th-20th, Vrnjačka Banja, Serbia*, volume 1, 139–143.

Kent, B.W., 1994. *Fossil Sharks of the Chesapeake Bay Region*. Egan Rees and Boyer, Columbia, 146 pp.

Klunzinger, C.B. 1871. Synopsis der Fische des Rothen Meeres II. Theil. *Verhandlungen der Königlischen Zoologischen–Botanischen Gesellschaft in Wien,* 21: 441–688.

Koch, A. 1903. Tarnócz, in Nógrád County, as new and rich locality for fossil shark teeth. *Földtani Közlöny*, 33: 22–44.

Kollmann, H. 1969. Verzeichnis der wichtigsten Objekte der Geologisch-Paläontologischen Sammlung (Rotpunkt-Verzeichnis). Alphabetische Zusammenstellung wichtiger Schauobjekte mit Erläuterungen. *Veröffentlichungen aus dem Naturhistorischen Museum Wien*, 5 (2): 167–177.

Kováč, M., Andreyeva-Grigorovich, A., Bajraktarević, Z., Brzobohatý, R., Filipescu, S., Fodor, L., Harzhauser, M., Nagymarosy, A., Oszczypko, N., Pavelić, D., Rögl, F., Saftić, B., Sliva, L. & Studencka, B. 2007. Badenian evolution of the Central Paratethys Sea: paleogeography, climate and eustatic sea-level changes. *Geologica Carpathica*, 58 (6): 579–606.

Krstić, N. 1978. Miocenski ostrakodi iz Dunavskog ključa kod Beograda [Miocene ostracods from Belgrade area Danubian Meander – in Serbian]. *Proceedings of the 9th Congress of the Geologists of Yugoslavia, Sarajevo*, 117–125.

Krstić, N., Savić, Lj. & Jovanović, G. 2012. The Neogene Lakes on the Balkan Land. *Geološki anali Balkanskoga poluostrva*, 73: 37–60.

Laskarev, V. 1924. Sur les equivalents du Sarmatien supérieur en Serbie. In: Vujević, P. (Ed.): *Receuil de traveaux offert à M. Jovan Cvijic par ses amis et collaborateurs*. Državna Štamparija, Beograd, 73–85.

Lourens, L.J., Hilgen F.J., Laskar, J., Shackleton, N.J. & Wilson, D. 2004a. *The Neogene period.* In: Gradstein, F.M., Ogg, J.G. & Smith, A.G. (Eds.). *A geologic time scale 2004.* Cambridge University Press, 409–440.

Lourens, L., Hilgen, F., Shackleton, N.J., Laskar, J. & Wilson, D. 2004b. Orbital tuning calibrations and conversions for the Neogene Period. In: Gradstein, F.M., Ogg, J.G. & Smith, A.G., (Eds.). *A Geologic Time Scale 2004*. Cambridge University Press, Cambridge, 469–484.

Luković, M. 1922. Drugomediternakse facije iz okoline Beograda [Second Mediterranean facies from Belgrade surroundings – in Serbian].*Geološki anali Balkanskoga poluostrva*, 7 (1): 22–41.

Marović, M., Toljić, M., Rundić, Lj. & Milivojević, J., 2007. *Neoalpine tectonics of Serbia*. Serbian Geological Society, Belgrade, 87 pp.

Mihajlović, Đ. & Knežević, S. 1989. Krečnjački nanoplankton iz badenskih i sarmatskih sedimenata Višnjice i Karaburme kod Beograda [Calcareous nannoplankton from Badenian and Sarmatian deposits at Višnjica and Karaburma in Belgrade – in Serban]. *Geološki anali Balkanskoga poluostrva*, 53: 342–366.

Mikuž, V. 2000. The great-teeth shark *Carcharocles megalodon* (Agassiz) also from Middle Miocene-Badenian beds above Trbovlje, Slovenia. *Geologija*, 42: 141–150.

Mikuž, V. & Šoster, A. 2013. A Mackerel Shark (*Megaselachus megalodon*) find in Orehovica, Dolenjska, Slovenia. *Folia Biologica et Geologica*, 54 (1): 109–119.

Mikuž, V., Šoster, A. & Ulaga, S. 2014. *Megaselahus* in the Miocene beds of Retje – Plesko Quarries above Trbovlje, Slovenia. *Folia Biologica et Geologi*ca, 55 (1): 73–88.

Mikuž, V., Šoster, A., Stare, F. & Sukič-Prekmurski, M. 2015. *Megalodon* teeth from Miocene marlstone at Virštanj, Slovenia. *Folia Biologica et Geologica*, 56 (2): 77–107.

Mikuž, V., Šoster, A. & Ulaga, Š. 2017. Fossil fish teeth from sites between Trbovlje and Laško, Slovenia. *Folia Biologica et Geologica*, 58 (1): 59–75.

Mikinčić, V. 1932. Kenozojski sedimenti između Golupca, Vukotića i V. Gradišta [Cenozoic deposits between Golubac, Vukotić and V. Gradište – in Serbian]. *Bulletin of the Yugoslavian Royal Geological Institute*, 1 (1): 89–104.

Müller, J. & Henle, F.G.J. 1838. On the generic characters of cartilaginous fishes, with descriptions of new genera. *Magazine of natural history and journal of zoology, botany, mineralogy, geology and meteorology*, 2: 33-37, 88–91.

Müller, A. 1999. *Ichthyofaunen aus dem atlantischen Tertiär der USA*. Leipziger Geowissenschaften, 9/10: 1–360.

Paunović, M. 1987. Ein Beitrag zur Kenntnis der obermiozänen Knorpelfische Kroatiens. *Jugoslavenske akademije znanosti i umjetnosti*, 431: 131–140.

Pavlović, P. 1897. Prilog poznavanju foraminifera iz drugomediternskih slojeva u Srbiji [Contribution to the knowledge of foraminifera from the II Mediterranean layers in Serbia – in Serbian]. *Bulletin of Serbian Royal Academy*, 56: 114–140.

Pavlović, P. 1922. Geološki sastav Beogradskog Dunavskog ključa [Geological composition of the "Beogradski Dunavski ključ" – in Serbian]. *Geološki anali Balkanskoga poluostrva,* 7 (1): 1–21.

Pawlowska, K. 1960. The fish remains of the Miocene limestone of Pinczowa. *Acta Palaeontologica Polonica*, 5 (4): 421–432.

Petrović, M. 1970. Kredni i miocenski foraminiferi Beograda i njegove okoline [Cretaceous and Miocene foraminifera of Belgrade area – in Serbian]. *Geološki anali Balkanskoga poluostrva*, 35: 191–209.

Petrović, M. 1985. Foraminiferske zone i loze badenskog kata okoline Beograda [Foraminiferal zone and lineages of the Badenian stage of the surroundings of Belgrade - in Serbian]. *Geološki anali Balkanskoga poluostrva,* 49: 271– 291.

Piller, W.E., Harzhauser, M. & Mandic, O. 2007. Miocene Central Paratethys stratigraphy – current status and future directions. *Stratigraphy*, 4 (2/3): 151–168.

Pimiento, C., Ehret, D.J., MacFadden, B.J. & Hubbell, G. 2010. Ancient Nursery Area for the Extinct Giant Shark *Megalodon* from the Miocene of Panama. *PLoS ONE*, 5 (5): e10552.

Pimiento, C., Gonzalez-Barba, G., Ehret, D.J., Austin, J.W., MacFadden, B.J. & Jaramillo, C. 2013. Sharks and rays (Chondrichthyes, Elasmobranchii) from the late Miocene Gatun formation of Panama. *Journal of Paleontology*, 87 (5): 755–774.

Pezelj, D.J., Mandić, O. & Ćorić, S. 2013. Paleoenvironmental dynamics in the southern Pannonian Basin duing initial Middle Miocene marine flooding. *Geologica Carpathica*, 64 (1): 81–100.

Popescu, G. & Crihan, I.M. 2004. Contributions to the knowledge of Miocene foraminifera from Romania: Superfamily Nodosariacea (Fam. Nodosariidae and Vaginulinidae). *Acta Paleontologica Romaniae*, 4: 385–402.

Popov, S.V., Rögl, F., Rozanov, A.Y., Steininger, F. F., Shcherba, I.G. & Kovác, M. 2004. Lithological paleogeographic maps of Paratethys. 10 Maps Late Eocene to Pliocene. *Courier Forschungs Institut Senckenberg*, 50: 1–46.

Probst J. 1878. Beiträge zur Kenntniss der fossilen Fische aus der Molasse von Baltringen. Hayfische. *Jahreshefte des Vereins für vaterländische Naturkunde in Württemberg*, 34: 113–154.

Purdy, R. W., Schneider, V. P., Applegate, S. P., Mclellan, J. H., Meyer, R. L. & Slaughter, R. 2001. The Neogene sharks, rays, and bony fishes from Lee Creek Mine, Aurora, North Carolina. In: Ray, C. & Bohaska, D.(Eds.). *Geology*

and paleontology of the Lee Creek Mine, North Carolina, III, Smithsonian Contributions to Paleobiology, 90: 71–202.

Radović, P. & Bradić-Milinković, K., 2018. A new elephantoid dental specimen from the Miocene of Kruševac Basin in Central Serbia. *Geološki anali Balkanskoga poluostrva*, 79 (2): 1–10.

Radwanski, A. 1965. A contribution to the knowledge of Miocene Elasmobranchii from Pinczow (Poland). *Acta Palaeontologica Polonica*, 10 (2): 267–279.

Rögl, F. 1998. Palaeogeographic Considerations for Mediterranean and Paratethys Seaways (Oligocene to Miocene). *Annalen des Naturhistorischen Museums in Wien*, 99 (A): 279–310.

Rögl, F. & Steininger, F.F. 1984. Neogene Paratethys, Mediterranean and Indo-pacific Seaways. Implications for the paleobiogeography of marine and terrestrial biotas. In: Brenchley, P. (Ed.). *Fossils and Climate*. John Wiley and Sons, 171–201.

Rögl, F., Ćorić, S., Harzhauser, M., Jimenez-Moreno, G., Kroh, A., Schultz, O., Wessely, G. & Zorn, I. 2008. The Middle Miocene Badenian stratotype at Baden-Sooss (Lower Austria). *Geologica Carpatica*, 59: 367–374.

Sant, K., Palcu, D., Mandic, O. & Krijgsman, W. 2017. Changing seas in the Early–Middle Miocene of Central Europe: a Mediterranean approach to Paratethyan stratigraphy. *Terra Nova*, 29 (5): 273–281.

Schultz, O. 1971. Die Selachier-Fauna (Pisces, Elasmobranchii) desWiener Beckens und seiner Randgebiete im Badenien (Miozän). *Annalen des Naturhistorischen Museums in Wien*, 75: 311–341.

Schultz, O. 1977. Elasmobranch and teleost fish remains from the Korytnica Clays (Middle Miocene, Holy Cross Mountains, Poland). *Acta Geologica Polonica*, 27 (2): 201–209.

Schultz, O. 1979. Supplementary notes on elasmobranch and teleost fish remains from the Korytnica Clays (Middle Miocene; Holy Cross Mountains, Central Poland). *Acta Geologica Polonica*, 29 (3): 287–293.

Schultz, O. 2013. Pisces. Ein systematisches Verzeichnis aller aufösterreichischem Gebiet festgestellen Fossilien Band 1/Teil 3: Bivalvia neogenica (Solenoidea-Clavagelloidea). In: Piller, W. (Ed.). *Catalogus Fossilium Austriae*, Bd. 3, Verlag der Österreichischen Akademie der Wissenschaften, Wien, 576 pp.

Schultz, O., Brzobohatý, R. & Kroupa, O. 2010. Fish teeth from the Middle Miocene of Kienberg at Mikulov, Czech Republic, Vienna Basin. *Annalen des Naturhistorischen Museums in Wien*, 112 (A): 489–506.

Siversson, M., Lindgren, J., Newbrey, M.G., Cederström, P. & Cook, T.D. 2015. Cenomanian–Campanian (Late Cretaceous) mid-palaeolatitude sharks of Cretalamna appendiculata type. *Acta Palaeontologica Polonica*, 60 (2): 339–384.

Stefanović, I. 2010. Note on the first fossil remains of a whale from northern Bosnia. *Geološki anali Balkanskoga poluostrva*, 71: 127–137.

Stevanović, P. 1970. Paleogeografsko-ekološke prinove iz tortona okoline Beograda [Paleogeographic-ecological novelties from the Tortonian of Belgrade area– in Serbian]. *Bulletin of Serbian Academy of Science and Arts*, 278, *Department of Natural Science and Mathematics*, 33: 1–20.

Stevanović, P. 1977. Miocene of Belgrade. In: Petković, K. (Ed.). *Geology of Serbia*, 2-3, Stratigraphy of Cenozoic, 3-8. University of Belgrade, 107–171.

Stevens, J.D. & McLoughlin, K.J. 1991. Distribution, size and sex composition, reproductive biology and diet of sharks from northern Australia. *Australian Journal of Marine and Freshwater Research*, 42 (2): 151–199.

Szabó, M. & Kocsis, L. 2016. A new Middle Miocene selachian assemblage (Chondrichthyes, Elasmobranchii) from the Central Paratethys (Nyirád, Hungary): implications for temporal turnover and biogeography. *Geologica Carpathica*, 67 (6): 573–594.

Toljić, M., Nenadović, D., Stojadinović, U., Gaudényi, T. & Bogićević, K., 2014. Quaternary tectonic and depositional evolution of eastern Srem (northwest Serbia). *Geološki anali Balkanskoga poluostrva*, 75: 43–57.

Trif, N., Ciobanu, R. & Codrea, V. 2016. The first record of the giant shark *Otodus megalodon* (Agassiz, 1835) from Romania. *Brukenthal Acta Musei*, 11 (3): 507–526.

Trif, N. & Codrea, V. 2017. Some Badenian fish teeth from Western Transylvania (Romania). *Oltenia*. *Studii şi comunicări. Ştiinţele Naturii*, 33 (1): 7–17.

Vrsaljko, D., Japundžić, S., Kovačić, M., Grganić-Vrdoljak, Z. & Pleše, P. 2010: Vranić: The most important finding place of fossil whales in Northern Croatia. *4th Croatian Geological Congress*, Zagreb, 118.

Weng, K.C., Boustany, A.M., Pyle, P., Anderson, S.D., Brown, A. & Block, B.A. 2007. Migration and habitat of white sharks (*Carcharodon carcharias*) in the eastern Pacific Ocean. *Marine Biology,* 152 (4): 877–894.

Zapfe, H., 1954. Vorzeitliche Meere im Wiener Becken. Universum. *Natur und Technik*, 9 (15): 468–480.

Резиме

Средњомиоценски зуби ајкула из јужног обода Панонског басена (Србија, Централни Паратетис)

Миоценски зуби ајкула из Паратетиса су познати у геолошким радовима још од 19. века. Најновија истраживања су омогућила процену разноврсности, као и њихову географску и стратиграфску дистрибуцију (Szabó & Kocsis, 2016). На подручју јужног обода Панонског басена остаци миоценских зуба ајкула су релативно ретки и углавном су представљени врстама које на подручју Централног Паратетиса имају широко географско распрострањење. Описани таксони попуњавају празнину у познавању средњомиоценске фауне ајкула у овом региону и омогућавају корелације са сличним фаунама из других локалитета Централног Паратетиса.

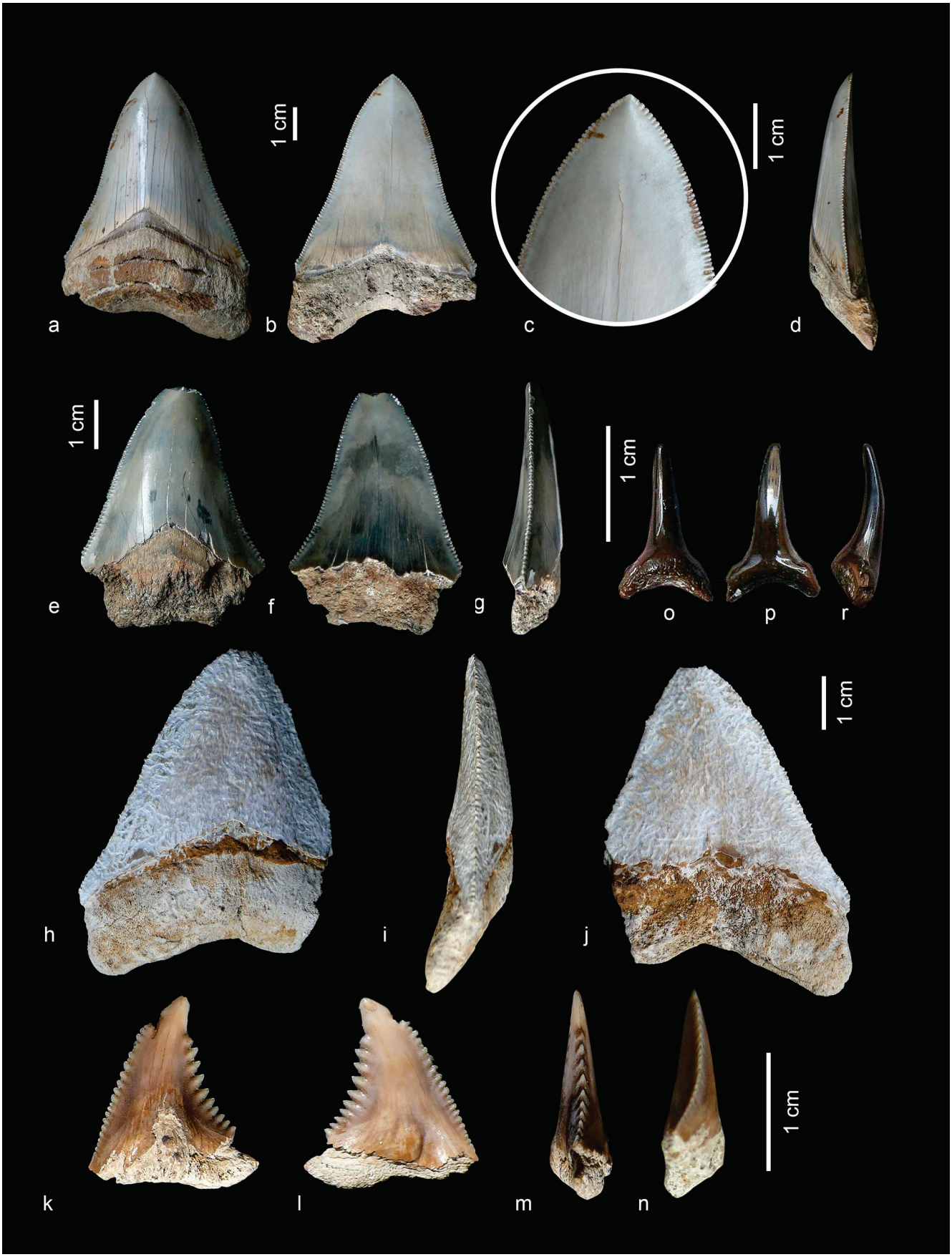
Стратиграфија Формације Вишњичких глина (VCF) је предмет расправа геолога, и сви расположиви подаци указују на средњомиоценску старост (баден, кречњачки нанопланктон NN5 зона). Чести налази остатака зуба прилично великих ајкула (нпр. *Otodus*, *Cosmopolitodus*) у средњем миоцену Централног Паратетиса могли би бити објашњени обиљем њиховог потенцијалног плена, представљеног разним сисарима као што су китови и делфини. Станиште предатора Otodus (*Megaselachus*) megalodon као и *Hemipristis serra* је била приобална морска средина са дубинама које су могле бити нешто веће од 100 м, на шта указују и заједнице других фосилних организама.

У овом раду су први пут описани зуби ајкула из баденских седимената VCF код Београда (Србија), који припадају трима различитим породицама: Otodontidae, Hemigaleidae и Odontaspididae. Прве две породице су представљене по једном врстом - *Otodus (Megaselachus) megalodon* Agassiz и Hemipristis serra Agassiz. Примерци Odontaspididae, због оштећења нису могли бити прецизније одређени. Иако је анализиран мали број фосилних остатака, очигледно је да су у средњомиоценским седиментима Србије биле заступљене космополитске врсте ајкула. Можемо закључити да су ови таксони доказ о везама јужног обода Панонског басена са другим басенима унутар Централног Паратетиса, током бадена. Разноврсност морске фауне из Вишњице, као и других баденских локалитета, указује на миграцију фауне из Медитеранског басена, преко Словеначког коридора у област јужног обода Панонског басена. Везе су констатоване и између Панонског и Трансилванијског басена, преко пролаза Муреш (Chira, C. & Mărunţeanu, 1999). Ова специфична палеогеографија омогућила је заједничке особине не само у фаунама мекушаца (Jovanović, 2018), већ и у заједницама морских кичмењака. Локалитет Вишњица је најбогатије налазиште зуба ајкула у Србији, иако је фосилна асоцијација малобројна. Зуби из Вишњице су различите боје, а запажена су и различита оштећења, што би могло бити објашњено специфичном тафономијом. Док су налази ситних Elasmobrachii у другим средњомиоценским налазиштима Паратетиса чести (Szabó & Kocsis, 2016), у српским локалитетима ови остаци нису пронађени, што не значи да нису били део баденских заједница, већ да се у досадашњим истраживањима највероватније није посветила пажња просејавању веће количине седимената, што би управо требало да буде циљ будућих теренских радова у Србији.

Manuscript recieved February 10, 2019
Revised manuscript accepted June 25, 2019

Plate 1.

Selachians from Višnjica, Badenian (NHMB): **a-d** - col. Petar Stevanović – PS 23; **e-g** - Petar Pavlović – K 7050); **h-j:** *Otodus (Megaselachus) megalodon* (col. Petar Stevanović – PS 24); **k-n:** *Hemipristis serra* (col. Petar Stevanović – PS 25); **o-r:** Odontaspididae indet; **a, e, h, k, o** (col. Velimir Milošević – KV-P 282); (lingual view; **b, f, j, l, p** - labial view; **g, h, n** - mesial view; **d, n** - distal view; **c** - detail of serration).


a
b
c
d
e
f
g
o
p
r
h
i
j
k
l
m
n
1 cm
1 cm
1 cm
1 cm
1 cm