Bull. Soc. géol. France, 2012, t. 183, n° 4, pp. 273-286

Revised Middle and Late Triassic radiolarian ages for ophiolite mélanges: implications for the geodynamic evolution of the northern part of the early Mesozoic Neotethyan subbasins

PÉTER OZSVÁRT[1] and SÁNDOR KOVÁCS[2]

Key-words. – Triassic, Darnó and Szarvaskő Complex, Radiolarians, Ophiolite mélange, Western Neotethys

Abstract. – The study is based on the radiolarian assemblages of five radiolarite outcrops and two boreholes from the Darnó and Szarvaskő Complex, Hungary, and three radiolarite sections from the western Vardar Ophiolitic Unit in Serbia. These investigated sections belong to a Mesozoic volcano-sedimentary mélange belt that can be followed from the Hellenides, through the Dinarides to the western Carpathians. Samples from radiolarite localities in the Darnó and Szarvaskő Complex contain a mixture of Middle Triassic (Illyrian to Longobardian) and Upper Triassic (Carnian) fairly poorly preserved radiolarian assemblages. Radiolarite samples from the western Vardar Ophiolitic Unit (Gostilje, Krš Gradac and Bukovi) yielded poorly preserved Upper Triassic (Carnian-?Norian) radiolarians. Co-occurrences of Middle and Upper Triassic radiolarian specimens in Darnó and Szarvaskő Complex suggest resedimentation during the Carnian or later. One new radiolarian species (*Baumgartneria szarvaskoensis* n. sp.) is described herein from the Darnó and Szarvaskő Complex.

Révision des âges des radiolaires des mélanges ophiolitiques du Trias moyen et supérieur : implications pour l'évolution géodynamique de la partie nord des sub-bassins téthysiens du Mésozoïque inférieur

Mots-clés. – Trias, Complexe de Darnó et de Szarvaskő, Radiolaires, Mélange ophiolitique, Néotéthys de l'Ouest.

Résumé. – Cette étude est basée sur des assemblages de radiolaires de cinq affleurements de radiolarites et de deux forages dans le complexe de Darnó et de Szarvaskő (Hongrie), ainsi que de trois sections de radiolarites de l'unité ophiolitique de l'Ouest Vardar en Serbie. Les sections étudiées appartiennent à une ceinture de mélanges volcano-sédimentaires du Mésozoïque qui peut être suivie depuis les Hellénides jusqu'à l'Ouest des Carpathes, en passant par les Dinarides. Les échantillons de radiolarites dans les localités du complexe de Darnó et de Szarvaskő contiennent un mélange de radiolaires du Trias moyen (Illyrien à Longobardien) et supérieur (Carnien) qui sont relativement mal préservés. Les échantillons de radiolarites qui proviennent de l'unité ophiolitique de l'Ouest Vardar (Gostilje, Krš Gradac et Bukovi) ont livrés des radiolaires mal préservés du Trias supérieur (Carnien-?Norien). L'occurrence simultanée de radiolaires du Trias moyen et supérieur dans le complexe de Darnó et de Szarvaskő suggère une resédimentation au cours du Carnien ou plus tard. Une nouvelle espèce de radiolaire (*Baumgartneria szarvaskoensis* n. sp.) provenant du complexe de Darnó et de Szarvaskő est décrite ici.

INTRODUCTION

The ophiolite belt of the Balkan Peninsula (previously called "Diabase-Chert Formation" and "Porphyrite-Chert Formation" in former Yugoslavia; see details in Obradović and Goričan [1988]) provides one of the most important clues for the reconstruction of the geodynamic evolution of the Mesozoic Neotethys. This geological unit can be followed through eight different countries (Greece, Albania, former Yugoslav Republic of Macedonia, Bosnia, Serbia, Croatia, Hungary and Slovakia). Hence, it has been described under various names in different countries as follows: Central Dinaridic Ophiolite belt [Lugović *et al.*, 1991] or Dinaride Ophiolite belt (DOB) after Pamić *et al.* [2002], or western Vardar Ophiolitic unit [Schmid *et al.* 2008] in Serbia, former Yugoslav Republic of Macedonia, and Bosnia; Repno Complex [Babić and Zupanić, 1978] in Zagorje region, NW Croatia; Mirdita Zone in Albania [e. g. Bortolotti *et al.,* 2006; Gawlick *et al.,* 2008], western Greek Ophiolite belt of the Inner Hellenides, northern Greece (Avdella Mélange in northern Pindos mountains and its equivalent formation in the Loggitsion Unit in Othris mountains, also known as "Maliak" unit [e.g. Jones and Robertson, 1991]) and the Pagondas mélange of Euboia Island [Danelian and

1. Hungarian Academy of Sciences – Hungarian Natural History Museum – Eötvös Loránd University, Research Group for Paleontology, H-1083 Budapest, Ludovika tér 2, ozsi@nhmus.hu; Present address: 8 rue Paul Noesen, L-2228, Luxembourg
2 Deceased, Hungarian Academy of Sciences – Eötvös Loránd University, Geological, Geophysical and Space Science Research Group, Pázmány P. sétány 1/C, H-1117 Budapest, Hungary
Manuscript deposited on May 12, 2011; accepted on March 20, 2012.

Robertson, 2001]. In addition, several displaced fragments of this belt appear in SE Slovakia (Meliata: Mello *et al.* [1995]) and in NE Hungary (Darnó and Szarvaskő Complex (fig. 1A) Balla *et al*. [1981]; Kozur and Réti [1986]; Kozur [1991]; Dosztály and Józsa [1992]; Józsa *et al*. [1996]). In addition, comparable units (although in several dissimilar aspects) are exposed in the Internal Western Vardar Ophiolite belt [Schmid *et al*., 2008] which were referred to under a variety of names in the former literature such the Vardar Zone western belt [Karamata 2006; Robertson *et al*., 2009] or Inner Dinaridic ophiolite belt [Lugović *et al.*, 1991]; External Vardar Subzone [Dimitrijević 1997, 2001] or Vardar Zone [Pamić *et al.,* 2002]. The difficulty is that this belt is connected to the external western Vardar Ophiolite belt (Dinaride Ophiolite belt after Pamić *et al.* [2002]) geographically, while it preferably relates in the lithology, in the age of metamorphic sole, in the geochemical composition and several other aspects [e. g. Karamata *et al*., 2000; Robertson *et al*., 2009] to the eastern Vardar Ophiolitic unit (or Main Vardar Zone after Karamata 2006; or Central Vardar Subzone after Dimitrijević [1997]). The presence of the isolated Jadar – Drina-Ivanjica – Korabi-Pelagonian zone within the Internal Western Vardar Ophiolite belt spawned two significantly different geodynamic models: a single Mesozoic Tethyan ocean vs. multiple oceanic basins with microcontinents (for a detailed discussion see e. g. Schmid *et al*. [2008]; Robertson *et al*. [2009]).

The ophiolite belt is composed of two distinct allochthonous units: the mélange consists of various sized dismembered thrust sheets and olistoliths (olistotrimma, olistoplacca) and the mafic-ultramafic bodies (e.g. Dimitrijević [1997]; Robertson *et al*. [2009]). Several oceanic remnants are trapped in the ophiolite belt. The various sized pre-Jurassic remnants are exclusively preserved in mélange blocks. Anisian (probably Illyrian) to Norian ages of radiolarites interbedded with basalts suggest a Triassic (Meliata-Maliak) oceanic crust (from early-rift related through rift/ocean transition to MOR-type) from Meliata to Euboia Island. A single radiometric age in gabbro from

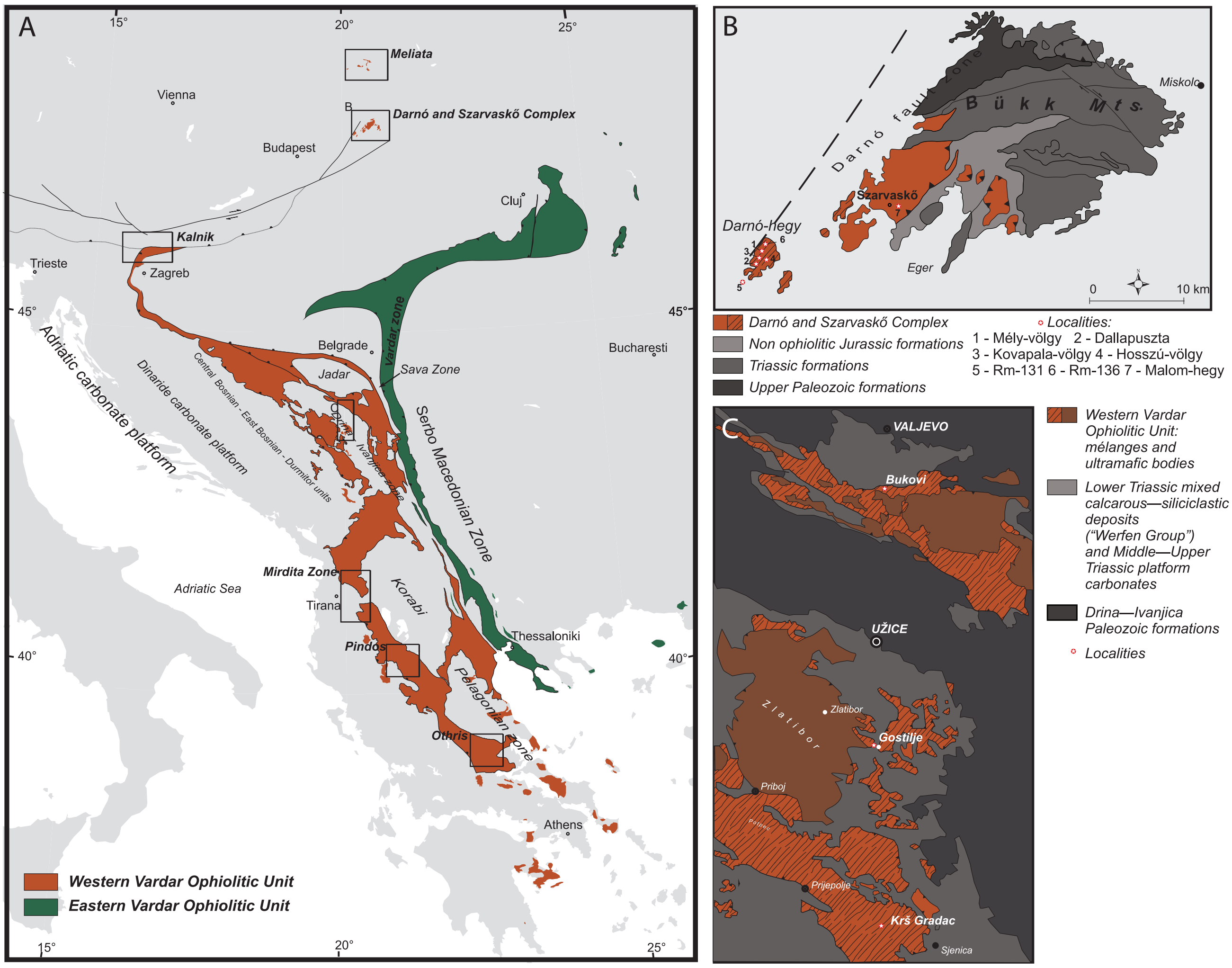


FIG. 1. – A. Neotethyan ophiolite belts in the Carpathians, Dinarides and Hellenides, and their dismembered fragments (=small-sized “disrupted terranes” of Neotethyan oceanic origin) in the Circum-Pannonian region. Base map simplified after Schmid *et al*. [2008]. B. Geological sketch map of the Darnó and Szarvaskő Complex. C. Simplified geological map of the Zlatibor - northern Zlatar area, SW Serbia with locations of the studied outcrops.
FIG. 1. – A. *Ceintures ophiolitiques néotéthysiennes dans les Carpathes, dans les Dinarides et dans les Hellénides, ainsi que leurs fragments démantelés (= « disrupted terranes » de petite taille et d'origine océanique provenant de la Néotéthys) de la région circum-pannonienne. Carte de base simplifiée d'après Schmid* et al. *[2008].* B. *Aperçu de la carte géologique du complexe de Darnó et de Szarvaskő.* C. *Carte géologique simplifiée de Zlatibor et de la partie nord de Zlatar, Sud-Ouest de la Serbie, avec la localisation des affleurements étudiés.*

Kerassies-Milia, Greece indicates 210.0 Ma (Norian?) [Pe-Piper, 1998]. In addition, Upper Triassic (Carnian-Norian) radiolarites stratigraphically overly gabbros of the Agelona ophiolite complex in S. Peloponnese (Greece) [Danelian *et al.*, 2000]. The Jurassic Neotethyan oceanic remnants consist of variably dismembered, mainly ultramafic bodies and predominant Middle-Late Jurassic radiolarites. Significantly less late Early Jurassic and Early Cretaceous radiolarites are known so far. These units are preserved within the obducted ophiolites [Schmid *et al.*, 2008]. Recently, several radiometric ages ranging from 189-152 Ma (Pliensbachian-Kimmeridgian) were published from NE Hungary [Dosztály and Józsa, 1992], from Kalnik Mts., Croatia [Pamić, 1997] and from the Mirdita Zone, Albania [Dimo-Lahitte *et al.*, 2001]. These data indicate that oceanic crust was forming continuously during the Early to Late Jurassic. In addition, numerous radiometric ages (179-150 Ma) from metamorphic soles are available from the Dinarides and Hellenides (e. g. Spray *et al.* [1984]) that were associated with the obduction of the Jurassic Neotethyan oceanic crust.

The ophiolite belt plays a key role in the geodynamic reconstruction of the Mesozoic Neotethys. Commonly, these slices contain ribbon radiolarian chert, which is locally associated with pillow basalts. Stratigraphic dating of these basaltic rocks is especially difficult due to the absence of macrofauna. However, radiolarian micropaleontologic investigations have proven that this group is particularly useful for biostratigraphic dating in such sequences where the deep-sea sedimentary units (e. g. radiolarian cherts, cherty limestones, etc.) are connected with volcanics (e.g. Jones *et al.* [1992]; Chiari *et al.* [1996, 1997]). Therefore it provides ages for the time of basalt eruption related to initial opening of Neotethys [Danelian and Robertson, 2001; Bortolotti *et al.*, 2008; Ozsvárt *et al.*, 2012]. In most geodynamic reconstructions, the onset of seafloor spreading is suggested for Middle to Late Triassic times (e.g. Jones and Robertson [1991]; Jones *et al.* [1992]; Danelian and Robertson [2001]; Bortolotti *et al.* [2006]; Ozsvárt *et al.* [2012]). The aim of this study is to present new radiolarian biostratigraphical data from several localities of the Western Vardar Ophiolitic unit [Schmid *et al.* 2008]) from Serbia (Krš; Gostilje, Bukovi), and its equivalent, but dismembered unit from Hungary (Darnó and Szarvaskő Complex). In all of the investigated areas, radiolarites are connected to and directly overlain by or intercalated with ocean-ridge related basalts.

GEOLOGICAL SETTING OF THE BÜKK MOUNTAINS

The Darnó and Szarvaskő complexes are situated in the western and southwestern foreland of Bükk mountains, NE Hungary (fig. 1B). The Bükk Mts. consist of three dissimilar units.

1. Paleozoic-Jurassic marine succession with distal flysch-type, dominantly siliciclastic series (Paleozoic) and platform carbonates, intraplatform sediments (Early to Late Triassic) with calc-alcaline volcanic series (Middle Triassic) and deep-water Jurassic radiolarite (Early Bajocian-Kimmeridgian) with thick distal turbiditic shale without any exact age data. This Paleozoic-Jurassic series is called the *Bükk Parautochthonous Unit* (e. g. Csontos [1999]), which is generally similar in lithologies and stratigraphy to the Jadar unit in Serbia and the Sana-Una unit in Bosnia (e. g. Csontos [1999]; Karamata *et al.* [2000]; Protić *et al.* [2000]; Pelikán *et al.* [2006]).

2. Middle and Upper Jurassic turbiditic series with various sized olistoliths (olistostromes) of different ages and lithologies set in a sheared, fine-grained, dominantly siliciclastic matrix. Triassic and Jurassic ages were identified from the blocks. This series is called the *Mónosbél Unit* (e. g. Balla [1987]; Csontos [1999]). It is accumulated in the foreland basin of the nappe thrust belt via tectonically controlled sedimentary processes [Haas, 2006]. Stratigraphically and lithologically the Mónosbél Unit is generally similar to the lower part of the Bosnian flysch [Pamić *et al.*, 2002].

3. Atypical ophiolitic series called the *Szarvaskő Unit* consisting of intrusive and effusive rocks and olistostromes. An equivalent incomplete ophiolitic sequence with associated deep-water sediments (chiefly Triassic radiolarites and Jurassic shales and sandstones) is exposed at the surface and subsurface in Darnó Hill. This is called the *Darnó Unit.* Based on radiometric (K-Ar) measurements, the age of the magmatic rocks is Middle Jurassic (168±8 Ma, Árva-Sós *et al.* [1987]; 175±10 Ma on Darnó Hill, Dosztály and Józsa [1992]).

Presumably, these dissimilar subunits are in a nappe system in the Bükk Mts. (e. g. Balla [1987]; Csontos [1988]), although there is no direct evidence for their boundaries. Nevertheless, these nappes have been interpreted as an accretionary complex in close genetic relationship with the ophiolite mélange complex of the Dinarides [Pamić, 1997, 2003; Haas and Kovács, 2001; Dimitrijević *et al.,* 2003]; they are considered to have reached their present-day position by major dextral strike-slip displacements during the Tertiary [Csontos *et al.,* 1992; Haas and Kovács, 2001].

DESCRIPTION OF LOCALITIES AND PREVIOUSLY REPORTED RADIOLARIAN AGES

The Darnó Unit, NE Hungary

The Darnó Unit in northern Hungary represents an ophiolite mélange complex similar to those present in the Dinarides. The ophiolite suite is closely associated with radiolarites and ophiolitic mélanges containing blocks of up to one kilometer in size. The components consist of radiolarites, pelagic Hallstatt-type limestones, and a complete suite of a Triassic-Jurassic ocean floor. The mélange contains a turbiditic, radiolarite-rich matrix, dated as Middle Jurassic by earlier preliminary investigations [Gawlick *et al.*, 2012]. The Darnó Hill area is underlain by a Jurassic mélange complex, according to drill-core documentation [Kovács *et al.,* 2005, 2008]. The Darnó Unit consists predominantly of pillow and massive basalts and subordinately of abyssal sediments: radiolarites and mudstones, and blue-grey, locally dark grey to black siliceous mudstones. Red radiolarite blocks yielded Triassic (Ladinian-Carnian) and Jurassic (Bajocian-Callovian) radiolarians [Balogh *et al.*, 1984; De Wever, 1984; Kozur, 1991; Dosztály and Józsa, 1992] in the different horizons, whereas in blue-grey cherty sediments only Jurassic (Callovian) radiolarians were found [Gawlick *et al*., 2012]. Geochemically, magmatic rocks are of MORB-type, with high Ti-content [Józsa, 1999]. Triassic ages within a magmatic block (where pillow basalts are intercalated with radiolarites) have been determined [Gawlick *et al*., 2012]. Peperitic basalts, rich in pink and white calcite amygdales and containing pink and reddish lime-mud inclusions and inter-pillow void fillings are common in the Darnó Unit. They are also widespread in the Dinaridic-Hellenic realm [Palinkaš *et al.,* 2008; Kovács *et al*., 2010]. According to some new observations [Kovács *et al*., 2010; Gawlick *et al*., 2012], in some exposures (e.g. Mély-völgy (völgy=valley) quarry), there are basalt blocks of different size intercalated with radiolarites. The age of Jurassic basalts is constrained by a single Bathonian radiolarian occurrence from a black siliceous shale inclusion in doleritic basalt [Józsa *et al*., 1996]. Ultramafic rocks which are common in the Inner Dinarides and Inner Hellenides are not preserved directly, but the former presence of a higher, ultramafic sheet is indicated by serpentinite pebbles in the Miocene Darnó Conglomerate [Sztanó and Józsa, 1996].

Radiolarite outcrops in Darnó Unit

Mély-völgy quarry (N 47º 56.961' E 20º 09.820')

The Mély-völgy quarry is situated in the northeasternmost part of the Darnó Hill (fig. 1B). In the section a typical mélange succession with blocks of peperitic basalt and intercalated radiolarites in a reddish grey to dark grey (plate I, figs. 1-2), sometimes black siliceous shale matrix, is exposed [Kovács *et al*., 2010]. The turbiditic siliceous shale matrix was dated as Bathonian-Callovian on the basis of well-preserved radiolarian faunas [Gawlick *et al.,* 2012]. The middle part of the section is a reddish radiolarite block, which is surrounded by radiolarian-rich late Middle Jurassic matrix [Gawlick *et al*., 2012]. The radiolarite insertion in the basalt block contains a radiolarian association of latest Anisian (Illyrian) to Late Ladinian (Longobardian) by former preliminary investigation [Gawlick *et al*., 2012], which is slightly older than those reported from Triassic radiolarites in the Darnó Unit [De Wever, 1984; Balogh *et al.,* 1984; Kozur and Krahl, 1984; Kozur, 1988a, b; Kozur, 1991; Dosztály and Józsa, 1992; Kozur and Mostler, 1994].

Dallapuszta (N 47º 55.648' E 20º 08.651')

Well-bedded, red radiolarite is exposed as an isolated olistolith in the southern foreland of the Darnó Hill (fig. 1B). The radiolarite is stratified in beds varying between 5 to 7 cm in thickness separated by thin mud layers [Dosztály, 1989]. The texture of the rock is carbonate-free radiolarian biomicrite with no traces of carbonate skeletal elements. This indicates a sedimentary environment below the carbonate compensation level [Dosztály and Józsa, 1992]. Previous investigations reported a relatively well-preserved and rich radiolarian fauna [De Wever, 1984; Kozur and Krahl, 1984; Balogh *et al.,* 1984; Kozur, 1988a, b; Dosztály, 1989; Kozur, 1991; Dosztály and Józsa, 1992; Kozur and Mostler, 1994] indicating a Ladinian (Middle to Upper Longobardian) age [De Wever, 1984; Dosztály, 1989; Dosztály and Józsa, 1992] or a Lower Carnian (Cordevolian (Julian)) age [Kozur and Mostler, 1994].

Kovapala-völgy (N 47º 56.181' E 20º 08.539')

A well-stratified, brownish-red to yellowish-brown radiolarite sequence crops out in a block north of the Dallapuszta

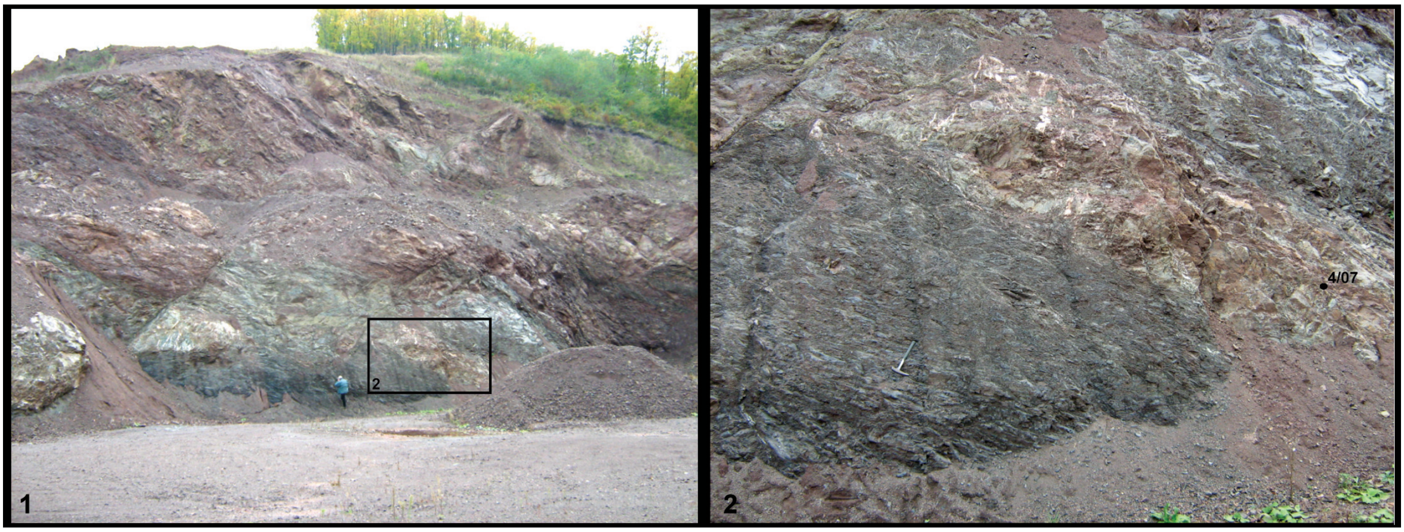


PLATE I.
1. Olistostrome/melange with reddish grey to dark grey, sometimes black siliceous shale matrix and with blocks of peperitic basalt. The latter are intersected by calcitic veins, oriented appr. perpendiculary to the schistosity of matrix. Mély-völgy quarry. (Photo by HJ Gawlick)
2. Peperitic basalt block (likely of Triassic age) with calcite veins and a red radiolarite- claystone intercalation (on its right side) in Jurassic (?) dark grey to black siliceous shale matrix. The S.04/07 showing the sample position.

Pl. I.
1. *Oloistostrome/mélange avec une matrice d'argiles siliceuses gris-rougeâtre à gris foncé, parfois noires contenant des blocs de basalte pépéritique. Ces derniers sont recoupés par des veines de calcite orientées approximativement perpendiculairement à la schistosité de la matrice. Carrière de Mély-völgy (Photo de HJ Gawlick).*
2. *Bloc de basalte pépéritique (probablement d'âge triasique) avec des veines de calcite et des intercalations de radiolarites rouges et d'argiles (sur la partie droite) dans une matrice d'argiles siliceuses gris foncé à noire du Jurassique (?). Le S.04/07 indique la position de l'échantillon.*

Radiolarian species	Darnó									SZ	WVOU		
	Mély-völgy S. 04/07	Dallapuszta	Kovapala-völgy	Hosszú-völgy	Rm-131: 594,8 m	Rm-131: 767,2 m	Rm-131: 781,4 m	Rm-136: 124,8 m	Rm-136: 324,0 m	Malom-hegy M 03	Gostilje G-97/3	Krš Gradac 2/6e	Bukovi B02/01
Annulotriassocampe cf. *sulovensis* (Kozur & Mock)		+								+			
Archaeocenosphaera sp.		+			+	+		+		+		+	
Astrocentrus sp.		+					+						
Baumgartneria bifurcata Dumitrica		+											
Baumgartneria curvispina Dumitrica		+											
Baumgartneria retrospina Dumitrica			+										
Baumgartneria cf. *retrospina* Dumitrica	+	+		+			+			+			
Baumgartneria stellata Dumitrica		+											
Baumgartneria szarvaskoensis n. sp.										+			
Baumgartneria spp.										+			
Canesium lentum Blome													+
Canoptum sp.		+								+	+		+
Capnodoce anapetes De Wever										+			
Capnodoce longibrachium Tekin													+
Capnodoce cf. *anapetes* De Wever										+			
Capnodoce cf. *primaria* Pessagno										+			
Capnodoce sp.										+	+		
?*Capnodoce* sp.											+		+
Capnuchosphaera gracilispinosa KMO										+			
Capnuchosphaera theloides De Wever													+
Capnuchosphaera triassica De Wever										+	+		
Capnuchosphaera cf. *lea* De Wever				+								+	
Capnuchosphaera cf. *okayi* Tekin										+			
Capnuchosphaera cf. *tricornis* De Wever										+			
Capnuchosphaera spp.		+			+			+			+	+	
?*Capnuchosphaera* sp. A De Wever		+											
Cryptostephanidium sp.			+				+						
?*Cryptostephanidium* sp.										+			
Dumitricasphaera sp.		+	+										
?*Entactinosphaera* cf. *triassica* Kozur & Mostler	+												
Eptingium manfredi Dumitrica		+								+			
Eptingium nakasekoi Kozur & Mostler										+			
Eptingium cf. *nakasekoi* Kozur & Mostler	+									+			
Eptingium sp.	+		+										
Falcispongus calcaneum Dumitrica										+			
Falcispongus falciformis Dumitrica		+	+										
Falcispongus hamatus Dumitrica		+											
Falcispongus rostratus Dumitrica		+											
Hagiastrum sp.										+			
Hungarosaturnalis multispinosa Kozur & Mostler		+											
Hungarosaturnalis sp.		+											
Kahlerosphaera sp.										+			
Karnospongella bispinosa Kozur & Mostler,		+											
Loffa sp.										+			
Muelleritortis cochleata (Nakaseko & Nishimura)		+	+	+		+							
Nakasekoellus sp.		+											
Oertlispongus inaequispinosus DKM		+					+			+			
Oertlispongus longirecurvatus Kozur & Mostler										+			
Oertlispongus spp.	+	+	+						+	+			
Paleosaturnalis cf. *triassicus* (Kozur & Mostler)										+			
Paleosaturnalis sp.										+			
?*Parasepsagon* sp.	+												
Paroertlispongus sp							+						
Paronaella trammeri (Kozur & Mostler)										+			
Paronaella cf. *simoni* (Kozur & Mostler)										+			
Paurinella cf. *curvata* Kozur & Mostler		+											
? *Pentaspongodiscus ruesti* Kozur & Mostler				+									
Pentaspongodiscus dercourti De Wever													
Pentaspongodiscus hexaspina (DKM)				+									
Pentaspongodiscus sp.		+											
Plafkerium abbotti Pessagno		+											
Poulpus piabyx De Wever		+											
Poulpus sp.		+											
Pseudostylosphaera coccostyla coccostyla (Rüst)		+	+	+			+			+			
Pseudostylosphaera helicatum (Nakaseko & Nishimura)		+											
Pseudostylosphaera longispinosa Kozur & Mostler	+		+										
Pseudosylosphaera goestlingensis (Kozur & Mostler)					+								
Pseudostylosphaera tenuis (Nakaseko & Nishimura)		+											
Pseudostylosphaera cf. *hellenica* (De Wever)													
Pseudostylosphaera spp.		+				+	+	+					
Sanfilippoella sp.		+											
Sarla kretaensis kretaensis (Kozur & Krahl)		+											
Sarla kretaensis robusta Dosztály		+											
Sarla sp.	+	+		+	+					+			
Sepsagon longispinosum (Kozur & Mostler)		+		+									
Sepsagon sp.			+										
?*Sepsagon* sp.	+												
Silicarmiger costatus Dumitrica, Kozur & Mostler	+												
Spongopallium contortum Dumitrica, Kozur & Mostler		+											
Spongopallium sp.	+												
Spongoserrula rarauana Dumitrica		+											
Spongostylus tortilis (Kozur & Mostler)		+											
Steigerispongus sp.										+			
Triassocampe deweveri (Nakaseko & Nishimura)		+	+	+									
Triassocampe cf. *deweveri* (Nakaseko & Nishimura)	+												
Triassocampe scalaris Dumitrica, Kozur & Mostler			+										
Triassocampe cf. *scalaris* Dumitrica, Kozur & Mostler						+							
Triassocampe sp. A in Gorican and Buser	+						+						
Triassocampe spp.		+	+				+						
Tripocyclia sp.		+											
Tritortis cf. *balatonica* Kozur		+											
? *Tritrabs* sp.								+					
Veghycyla sp.		+											
Yeharia sp.		+											
Zhamojdasphaera sp.		+											

TABLE I. – Middle and Upper Triassic radiolarian occurrences of the studied outcrops.
TABL. I. – *Occurrences des radiolaires du Trias moyen et supérieur dans les affleurements étudiés.*

olistolith, in the southwestern part of the Darnó Hill (fig. 1B). The bed thickness varies between 5 and 15 cm. This block contains mainly Illyrian to Longobardian radiolarians [Dosztály and Józsa, 1992], but Kozur [1991] published Tuvalian radiolarians and conodonts from the uppermost part of the section.

Hosszú-völgy (N 47º 55.760' E 20º 10.341')

The outcrop is located approximately 1.5 km N of the highway between Recsk and Sirok (fig. 1B), along a forestry road. The section contains a large block of albitized and silicified intersertal basalt overlain by radiolarites and clayey siltstone. De Wever [1984] published Fassanian radiolarians, but this outcrop was erroneously called Mély-völgy in his paper. Based on the revision of the works by De Wever [1984] and Kozur [1991], the age was determined to be Longobardian by Dosztály and Józsa [1992].

Boreholes around Darnó Hill

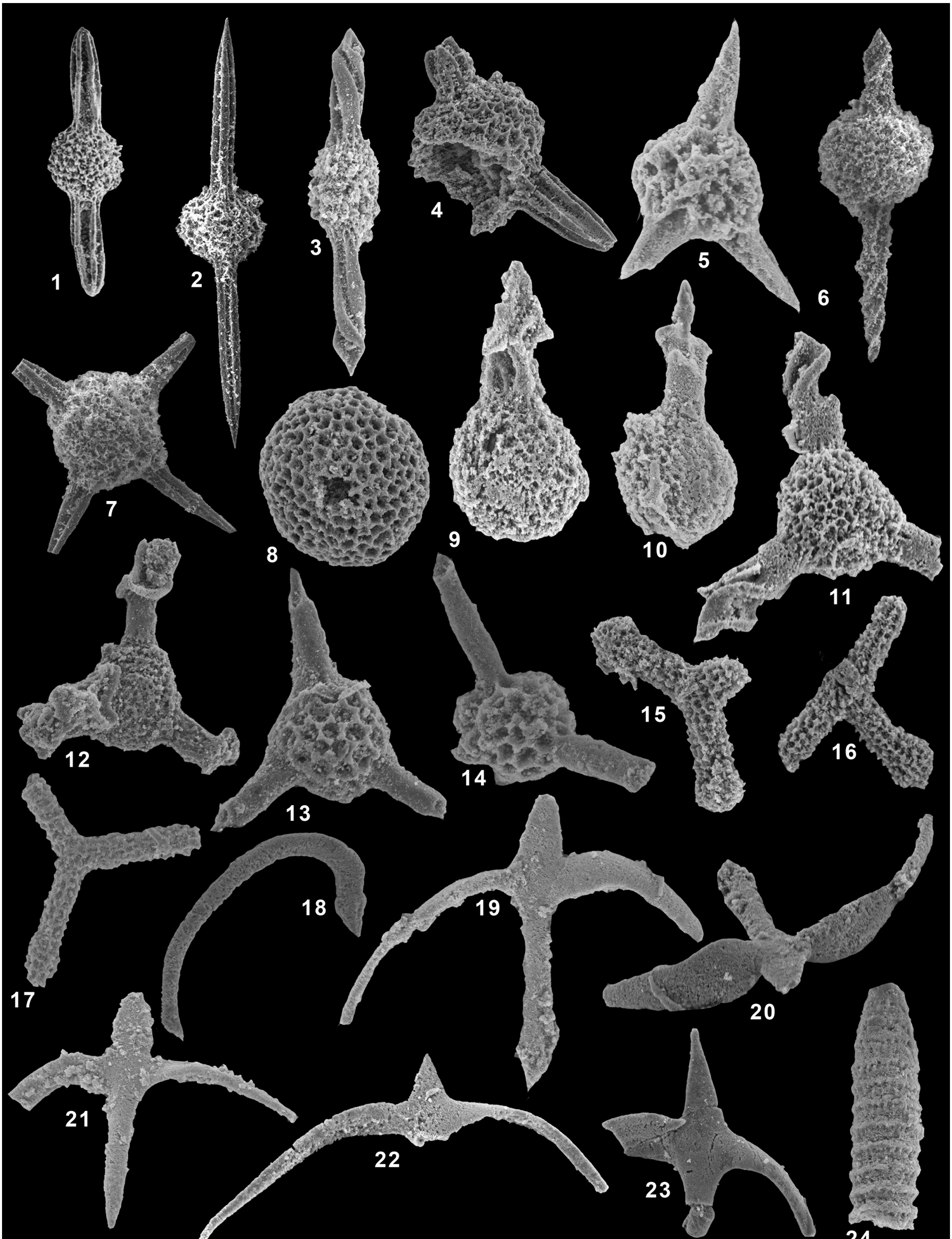
Beyond the outcrops from the vicinity of the Darnó Hill area (fig. 1B), a number of boreholes penetrated Triassic deep-water sediments of Bódvalenke-type (reddish-whitish siliceous limestones with red cherts) associated with reddish, amygdaloidal basalts that occur as slide blocks (olistotromma) within the Jurassic siliceous shale. The volcanic sequences consist predominantly of pillow and massive basalts and subordinately of abyssal sediments a few meters to tens of meters in thickness. Red radiolarites yielded Triassic (Ladinian or Carnian) and Jurassic (Bathonian to Callovian) radiolarians at different horizons [Dosztály and Józsa, 1992].

Rm-131

Borehole Rm-131 contains Paleozoic crystalline limestone between 1200 and 998 m, which is overlain (between 998 and 723 m) by a mélange sequence consisting of marly limestone, turbiditic shale, cherty limestone, radiolarite, tuff and basalts (see fig. 8 in Kovács *et al*. [2008]). Due to poor fossil content, its age is not known precisely for the whole sequence, although several cherty limestone or radiolarite blocks (ranging up to tens of meters in size) contain Triassic (Ladinian to Carnian) radiolarians and the black siliceous shales contain Jurassic (Bathonian to Callovian) radiolarians [Dosztály and Józsa, 1992]. Between 723 and 95 m, turbidite shales, basalts (amygdaloidal pillow basalt containing pink and reddish lime mud inclusions) and massive gabbro (ranging up hundreds of meters in thickness), alternate. At 95 m depth the mafic magmatic body is unconformably overlain by Miocene sandstone.

Rm-136

This sequence is almost equivalent to that of borehole Rm-131: the lower part (between 1200 and 870 m) contains Paleozoic crystalline limestones overlain by a mélange consisting of limestones, siltstones, sandstones, and turbiditic shales up to 380 m (see fig. 9 in Kovács *et al*. [2008]). The interval between 380 and 17 m consists of thick, black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turbiditic shales intercalated with massive magmatic bodies [Dosztály and Józsa, 1992].

Szarvaskő Complex

Malom-hegy (N47º 59.451' E20º 20.372')

This isolated, relatively small radiolarite block is situated on the southwestern ridge of Malom-hegy (fig. 1B). It is an olistolith on top of a massive magmatic body. Dosztály and Józsa [1992] reported a radiolarite block with an uncertain spatial, tectonic and stratigraphic position on the western slope of Malom-hegy. They reported Lower Ladinian and Carnian radiolarians from that block.

Ophiolitic mélanges in Serbia

Ophiolitic mélanges in Serbia (="Diabase-Chert Formation" and "Porphyrite-Chert Formation" in the former literature) occur in two tectonic positions: In the Western Vardar Ophiolitic Unit in the west, and in the Eastern Vardar Ophiolitic Unit in the east (sensu Schmid *et al.* [2008]).

The dissimilarities of the ophiolitic mélange in the different zones are in the lithologies of sedimentary and mafic units, age of the olistoliths and matrix, tectonic movements etc. (see details in Dimitrijević [1997]; Dimitrijević *et al.* [2003]; Schmid *et al.* [2008]; Robertson *et al.* [2009]). The Western Vardar Ophiolitic Unit and the Eastern Vardar Ophiolitic Unit are separated from each other by the Sava Zone [Schmid *et al.*, 2008].

Zlatibor Mountains, SW Serbia

Zlatibor Mts. (fig. 1C) is the best studied area of ultramafic bodies in the Western Vardar Ophiolitic Unit. These ophiolite bodies are directly overlain by the mélange and the Middle and Upper Triassic carbonates, which represent different depositional environments from platform carbonates through patch-reefs to peritidal-lagoonal facies [Hips *et al.*, 2011]. The contacts between the ultramafics (primarily lherzolites and amphibolites) and the mélanges and carbonates are tectonic, with a metamorphic sole in some places [Robertson *et al.*, 2009]. In the mélange, Jurassic clastic sedimentary matrix contains the investigated radiolarite blocks. Two occurrences (Gostilje and Krš Gradac) were involved in our comparative studies.

Gostilje

Along the road from Gostilje (fig. 1C) to Sirogojno running down to Katusnica stream, in the road curve before the stream, greenish pillow basalts are exposed. They are intercalated with reddish limestones and red cherts [Vishnevskaya *et al.*, 2009].

Krš Gradac

Liassic grey limestone blocks in the lower part and Middle and Upper Jurassic (Bathonian to Thitonian) red to green clayey chert, cherty limestone, and dark-green radiolarites in the upper part [Vishnevskaya *et al.*, 2009; Vishnevskaya and Djerić, 2009] are exposed in an outcrop that is situated in a creek about 8 km northwest of Sjenica (fig. 1C). On top of this Jurassic block an Upper Triassic olistostrome with sandstone and radiolarite is exposed that is set in a mélange block [Karamata *et al.*, 2006].

Maljen Ophiolite Massif

The Maljen Ophiolite Massif belongs to the N-S trending, Internal Western Vardar Ophiolitic Unit (=Vardar Zone Western Belt after Karamata [2006]; Robertson *et al.* [2009]). This ophiolite and mélange belt is located between the Drina-Ivanjica unit and the Kopaonik Block. Several authors [Karamata, 2006; Robertson *et al.*, 2009] proposed that this unit existed between the Drina-Ivanjica unit and the Kopaonik block from the Late Triassic to the Late Cretaceous, while others [Schmid *et al.*, 2008; Schefer *et al.*, 2010] regard all these units as thrust sheets and assume a westward thrusting (over the Jadar-Kopaonik thrust sheet) during Tertiary. The Maljen Ophiolitic Massif is mainly composed of serpentinites and serpentinized peridotites and a mélange consisting of a siliciclastic matrix (from argillites to conglomerates and breccias) and carbonate olistoliths and mafic to ultramafic bodies. The mélange is overlain by Late Cretaceous transgressive conglomerates and turbidites [Principi *et al.*, 2008].

◄

PLATE 2. – Illustration of selected radiolarian taxa from the Darnó and Szarvaskő Complex and from the Bukovi locality.
Pl. 2. – *Illustration des taxons sélectionnés (radiolaires) provenant du complexe de Darnó et de Szarvaskő, et de la localité de Bukovi.*
1. *Pseudostylosphaera coccostyla coccostyla* (RÜST), Borehole Rm-131: 781,4 m
2. *Pseudostylosphaera longispinosa* KOZUR and MOSTLER, Mély-völgy: S.04/07
3. *Pseudostylosphaera* cf. *hellenica* (DE WEVER), Borehole Rm-131: 594 m
4. *Eptingium* cf. *manfredi* DUMITRICA, Szarvaskő, southwestern ridge of Malom-hegy
5. *Cryptostephanidium* sp., Szarvaskő, southwestern ridge of Malom-hegy
6. *Spongopallium* sp., Mély-völgy: S.04/07
7. *?Parasepsagon* sp., Mély-völgy: S.04/07
8. *Archaeocenosphaera* sp., Szarvaskő, southwestern ridge of Malom-hegy
9. *Kahlerosphaera* sp., Szarvaskő, southwestern ridge of Malom-hegy
10. *Capnuchosphaera* cf. *okayi* TEKIN, Szarvaskő, southwestern ridge of Malom-hegy
11. *Capnuchosphaera gracilispinosa* KOZUR, MOIX and OZSVÁRT, Szarvaskő, southwestern ridge of Malom-hegy
12. *Capnuchosphaera* sp., Bukovi
13. *Capnodoce* sp., Bukovi
14. *Capnodoce* cf. *primaria* PESSAGNO, Szarvaskő, southwestern ridge of Malom-hegy
15. *Paronaella* cf. *simoni* (KOZUR and MOSTLER), Szarvaskő, southwestern ridge of Malom-hegy
16. *Hagiastrum* sp., Szarvaskő, southwestern ridge of Malom-hegy
17. *Paronaella trammeri* (KOZUR & MOSTLER), Szarvaskő, southwestern ridge of Malom-hegy
18. *Oertlispongus inaequispinosus* DUMITRICA, KOZUR and MOSTLER, Szarvaskő, southwestern ridge of Malom-hegy
19-20. *Baumgartneria szarvaskoensis* n. sp., Holotype, Szarvaskő, southwestern ridge of Malom-hegy. (19: lateral view; 20: axial view)
21-22. *Baumgartneria szarvaskoensis* n. sp., Paratype, Szarvaskő, southwestern ridge of Malom-hegy
23. *Baumgartneria szarvaskoensis* n. sp., Szarvaskő, southwestern ridge of Malom-hegy
24. *Annulotriassocampe* cf. *sulovensis* (KOZUR and MOCK), Szarvaskő, southwesternridge of Malom-hegy

Bukovi

This olistolith block crops out south of Valjevo (fig. 1C) along the national road to Bukovi. The section contains red cherts and basalt intercalations within reddish shales.

RADIOLARIAN FAUNA AND BIOSTRATIGRAPHY

Radiolarians were extracted from the cherts and radiolarites using hydrofluoric acid and standard laboratory techniques [De Wever *et al.,* 2001]. Preservation is generally poor, sometimes very poor, but a few identifiable taxa have been found suitable for biostratigraphic dating. Table I summarises the taxa identified in samples from the sections.

In the Mély-völgy quarry, we found a poorly preserved but unambiguously Middle Triassic radiolarian assemblage in a dark, reddish radiolarite horizon within a meter-sized green basalt block (plate I, figs. 1-2.). The sample 4/07 yielded numerous unidentifiable sponge spicules and some poorly preserved radiolarian species: ?*Entactinosphaera* cf. *triassica* KOZUR and MOSTLER, *Pseudostylosphaera longispinosa* KOZUR and MOSTLER, *Spongopallium* sp., *Parasepsagon* sp. As a consequence of the poor preservation, an unambiguous age cannot be assigned. The occurrence of *Pseudostylosphaera longispinosa* KOZUR and MOSTLER in the Buchenstein Limestone of Recoaro (Vicentinian Alps,

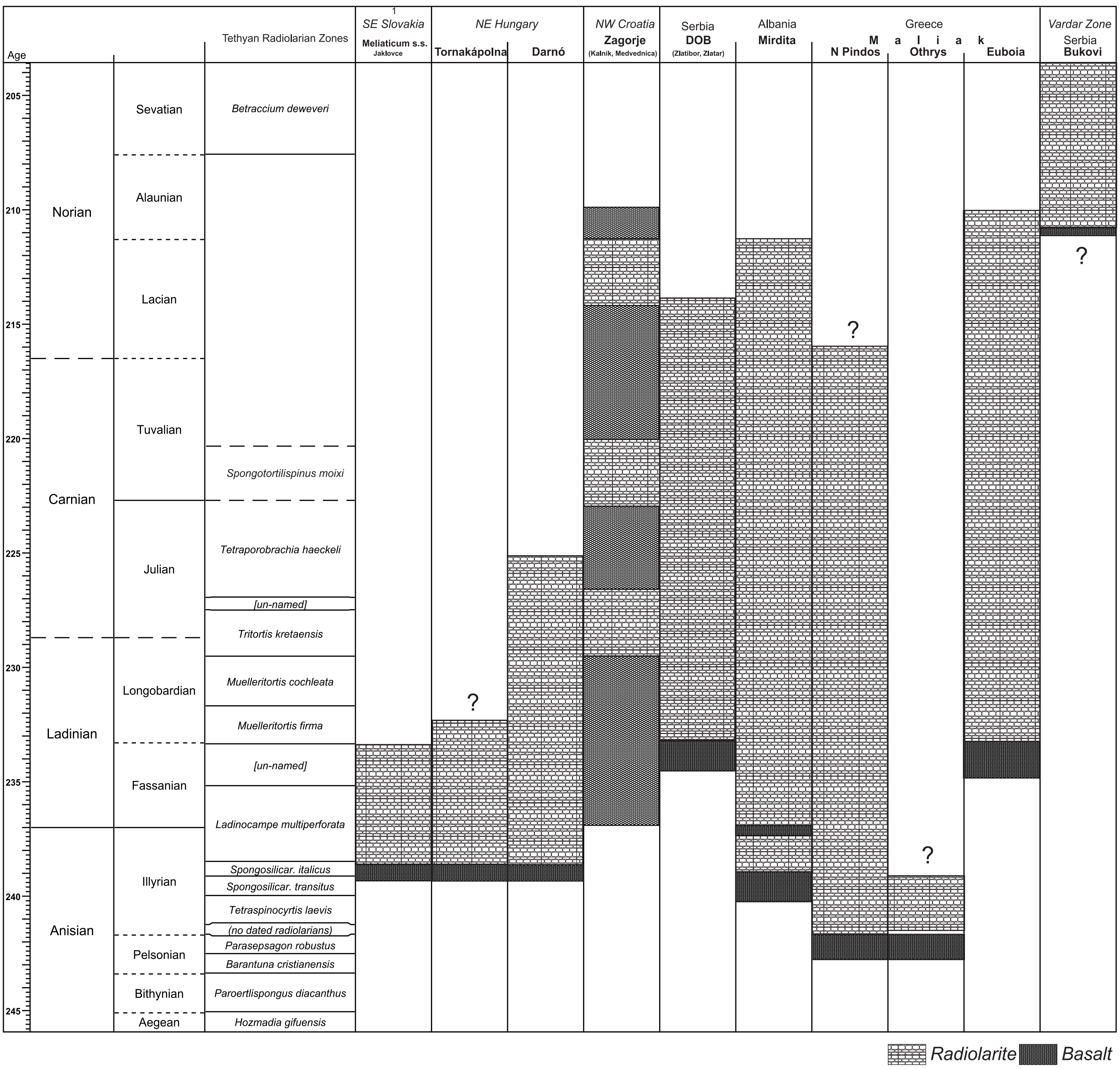


FIG. 2. – Published age ranges of radiolarites with associated pillow basalts in the western part of Mesozoic Neotethys [after Ozsvárt *et al*., 2012]. See text for references. The Tethyan Radiolarian Zones come from Kozur [2003] and Moix *et al*. [2007].

FIG. 2. – *Compilation des âges publiés de radiolarites associées avec des laves en coussins dans la partie ouest de la Néotéthys mésozoïque [d'après Ozsvárt* et al., *2012]. Voir le texte pour les références. Les zones à radiolaires de la Téthys proviennent de Kozur [2003] et de Moix* et al. *[2007].*

northern Italy) is Upper Illyrian to Lower Fassanian [Kozur and Mostler, 1981]. In addition, Goričan and Buser [1990] mentioned it from Upper Illyrian to Upper Fassanian (?) – Longobardian from the Julian Alps (Vršič section, Slovenia). Consequently, this sample could be assigned to the Middle Triassic (Upper Illyrian to Longobardian), which constrains the beginning of the basaltic volcanism in the Darnó Unit, as Middle Triassic. The former detailed investigations from the outcrop at Dallapuszta revealed different age data: De Wever [1984], Dosztály [1989] and Dosztály and Józsa [1992] found Middle Triassic (Upper Ladinian, Longobardian) radiolarians, while Kozur and Mostler [1994] reported Upper Triassic (Upper Carnian, Tuvalian) ages based on the radiolarian and conodont assemblages. The main problem is the co-occurrence of typical Upper Anisian forms (e. g. *Oertlispongus inaequispinosus* DUMITRICA, KOZUR and MOSTLER or *Falcispongus falciformis* DUMITRICA) with Lower and Upper Ladinian (*Baumgartneria curvispina* DUMITRICA, *Falcispongus hamatus* DUMITRICA, *Spongoserrula rarauana* DUMITRICA) and Carnian forms (*Capnuchosphaera* sp.) in the same layer. This indicates that the succession contains re-deposited radiolarian assemblages.

Poorly preserved radiolarian assemblages from Kovapala-völgy present a similar problem as Dosztály and Józsa [1992] reported a Middle Triassic (Illyrian to Longobardian) age, while Kozur [1991] reported Upper Triassic (Tuvalian) radiolarians and conodonts from the same section. This may be explained by the presence of reworked radiolarian assemblages in the Kovapala-völgy succession.

In the section at Hosszú-völgy, the co-occurrence of the Late Triassic *Capnuchosphaera* cf. *lea* (DE WEVER) with the Middle Triassic ?*Pentaspongodiscus ruesti* (KOZUR and MOSTLER) introduces ambiguity in the age assignment, as noted by De Wever [1984].

Borehole Rm-131 contains three bigger Triassic blocks in a Jurassic siliceous matrix. The oldest block (at depth 780 m) contains unambiguously Illyrian radiolarians, although Dosztály and Józsa [1992] assigned this block to the Ladinian in accordance with the former Anisian-Ladinian stage boundary, which placed the base of the Ladinian at the base of the *Reitzi* Ammonoid Zone, but in contrary to the recently accepted GSSP (Global Boundary Stratotype Section and Point) that places the base of the Ladinian at the base of the *Curionii* Ammonoid Zone [Brack *et al.,* 2003; 2005]. The block at depth 767 m contains certainly Longobardian (Middle Triassic) radiolarians (*Muelleritortis cochleata* (NAKASEKO and NISHIMURA)), while the block at 595 m contains Middle and Upper Triassic radiolarians.

In borehole Rm-136 there are two unambiguously Triassic olistoliths in a dark, siliceous matrix. At depth 324 m, a Middle Triassic (probably Illyrian) age is proposed based on the presence of poorly preserved Oertlispongidae. Based on the presence of some poorly preserved Capnuchosphaeridae, an Upper Triassic age (probably Carnian to Norian) is assumed for the upper block (at depth 124 m).

Poorly preserved, but relatively rich radiolarian assemblages were extracted from the small, red radiolarite block on the southwestern ridge of Malom-hegy. This olistostrome yielded numerous unambiguously Middle Triassic *Baumgartneria* spp. including *Baumgartneria szarvaskoensis* n. sp., *Eptingium* spp., *Oertlispongidae*, and numerous unambiguously Late Triassic (e. g. *Capnodoce* spp. and *Capnuchosphaera* spp.) radiolarians. Our new investigations, in agreement with Dosztály and Józsa [1992], show that two significantly different ages can be assigned for this olistostrome: Upper Anisian (Illyrian) and Carnian-?Norian.

Samples from Gostilje and Krš Gradac in Zlatar and Zlatibor mountains, SW Serbia yielded a Late Triassic (Carnian) age based on the presence of moderately well preserved *Capnuchosphaeridae* radiolarians (see table I). A Late Triassic (Carnian) age could be assigned also for the Bukovi section.

Systematic paleontology

Family: Oertlispongidae Kozur and Mostler *in* Dumitrica *et al.*, 1980

Subfamily: Oertlisponginae Kozur and Mostler *in* Dumitrica *et al.*, 1980

Genus: *Baumgartneria* DUMITRICA, 1982

Type species: *Baumgartneria retrospina* DUMITRICA, 1982

Baumgartneria szarvaskoensis n. sp.
(plate II, figs.19-23)

1992. *Baumgartneria retrospina* DUMITRICA - DOSZTÁLY and JÓZSA, pl. I. fig. 6.

Derivatio nominis: In allusion to its occurrence at the locality of Szarvaskő, Hungary.

Holotype: The specimen on plate II, figs. 19-20.

Material: 22 specimens. The illustrated material is deposited in the Hungarian Natural History Museum, Budapest.

Type locality: Szarvaskő, isolated, relatively small radiolarite block situated on the southwestern ridge of Malom-hegy.

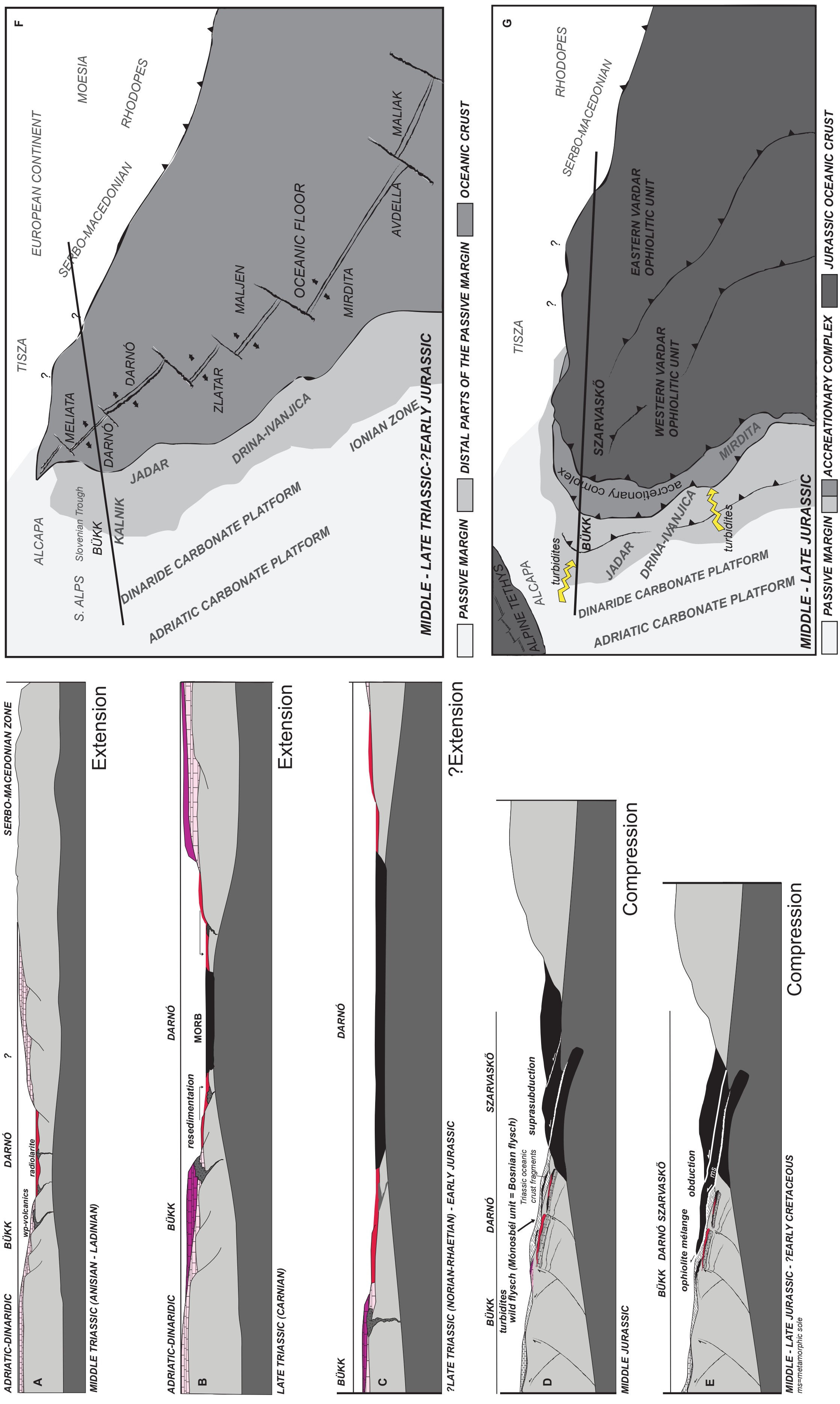
Age: ?Lower Ladinian.

Diagnosis: Test unknown, main polar spine cylindrical or slightly flattened with strongly flattened, triangular axial spine. Two long, recurved and strongly flattened lateral bifurcations; propeller-like in axial view, suddenly widening, and needle-like distally.

Remarks: Although the specimens are poorly preserved, *Baumgartneria szarvaskoensis* n. sp. is distinguished from all other species of *Baumgartneria* by having strongly flattened, propeller-like lateral branches.

DISCUSSION

Using radiolarians, we have dated two radiolarite outcrops and revised the age of six radiolarite and chert outcrops and two boreholes within tectono-stratigraphic mélanges of the Western Vardar Ophiolitic Unit from Serbia (localities Krš, Gostilje and Bukovi) and its equivalent dismembered unit from Hungary (Darnó and Szarvaskő Complex). In the Mély-völgy quarry (Darnó Unit) and in Gostilje (Zlatar and Zlatibor mountains) and Bukovi (Maljen Ophiolite massif) the radiolarites are intercalated with pillow basalts and therefore provide direct biostratigraphic constraints for the onset of rifting or seafloor spreading. Detailed geochemical analyses from Hungary [Dosztály and Józsa, 1992; Harangi *et al.*, 1996] and from Serbia [Vishnevskaya *et al.*, 2009]


F
EUROPEAN CONTINENT
MOESIA
RHODOPES
SERBO-MACEDONIAN
TISZA
MELIATA
DARNÓ
ZLATAR
MALJEN
OCEANIC FLOOR
MIRDITA
AVDELLA
MALIAK
ALCAPA
S. ALPS
Slovenian Trough
BÜKK
KALNIK
JADAR
DRINA-IVANJICA
IONIAN ZONE
DINARIDE CARBONATE PLATFORM
ADRIATIC CARBONATE PLATFORM
MIDDLE - LATE TRIASSIC-?EARLY JURASSIC
PASSIVE MARGIN
DISTAL PARTS OF THE PASSIVE MARGIN
OCEANIC CRUST
G
RHODOPES
SERBO-MACEDONIAN
EASTERN VARDAR OPHIOLITIC UNIT
TISZA
SZARVASKŐ
WESTERN VARDAR OPHIOLITIC UNIT
MIRDITA
accretionary complex
ALPINE TETHYS
ALCAPA
turbidites
BÜKK
JADAR
DRINA-IVANJICA
DINARIDE CARBONATE PLATFORM
ADRIATIC CARBONATE PLATFORM
MIDDLE - LATE JURASSIC
PASSIVE MARGIN
ACCREATIONARY COMPLEX
JURASSIC OCEANIC CRUST
ADRIATIC-DINARIDIC
BÜKK
DARNÓ
SERBO-MACEDONIAN ZONE
wp-volcanics
radiolarite
A
MIDDLE TRIASSIC (ANISIAN - LADINIAN)
Extension
B
resedimentation
MORB
LATE TRIASSIC (CARNIAN)
C
?LATE TRIASSIC (NORIAN-RHAETIAN) - EARLY JURASSIC
?Extension
D
turbidites
wild flysch (Mónosbél unit = Bosnian flysch)
Triassic oceanic crust fragments
suprasubduction
SZARVASKŐ
MIDDLE JURASSIC
Compression
E
ophiolite mélange
obduction
ms
MIDDLE - LATE JURASSIC - ?EARLY CRETACEOUS
ms=metamorphic sole

indicated MOR-type basalts (N-MORB-type and locally WPB-type), although Downes *et al*. [1990] and Kiss *et al*. [2008] interpreted them, based on some geochemical data and the development of the peperitic basalts, as non MORB-like magmatism for the Darnó Unit.

In the radiolarian samples from Dallapuszta, Kovapala-völgy, Hosszú-völgy, boreholes Rm-131, Rm-136, and Malom-hegy co-occur a mixture of Middle (Illyrian to Longobardian) and Late (Carnian) Triassic forms, suggesting that resedimentation took place during Carnian times or later. The age determination of this radiolaritic olistolith together with the already known Triassic radiolarites proves the existence of a Middle to Late Triassic oceanic realm in the provenance area of the blocks in the Darnó Unit.

In the comparison with other areas preserving remnants of western Neotethyan subbasins we note that upper Illyrian (Anisian) to late Ladinian radiolarians have been reported (partly from outcrops, where radiolarites are associated with basalts) from several localities in SE Slovakia [Mello *et al.,* 1995]. In addition, upper Ladinian to middle Norian radiolarian assemblages were dated from Kalnik Mountain in Croatia where radiolarites directly overlie basaltic volcanics [Halamić and Goričan 1995; Halamić *et al*., 2001; Goričan *et al.,* 2005]. Further localities were also reported from the Internal Western Vardar Ophiolite Belt (Ovčar-Kablar gorge, west of Čačak) and from the External Western Vardar Ophiolite Belt (Katusnica creek, near Gostilje, Zlatibor Mountains) where radiolarian-bearing rocks are associated with basalts, dated as Ladinian to Norian in age [Obradović and Goričan 1988; Vishnevskaya *et al*., 2009]. Further south, several localities in the Mirdita Zone in Albania have been proven to be of Anisian age (fig. 2). In that area alkaline basalts within the Middle Jurassic mélange are directly overlain by upper Anisian (Illyrian) to lower Carnian radiolarites [Chiari *et al.,* 1994; 1996; Kellici *et al.,* 1994; Marcucci *et al.,* 1994; Bortolotti *et al.,* 2006; Gawlick *et al.,* 2008]. The oldest radiolarian data were reported from the Pindos mountains [Ozsvárt *et al.,* 2012], where poorly preserved radiolarians indicate early Illyrian (Middle Triassic, latest Anisian) age.

PALEOGEOGRAPHIC-PALEOTECTONIC RECONSTRUCTION

The radiolarian biostratigraphic data confirm that Neotethyan rifting started in the Anisian (Illyrian) in the western ophiolite belt of the Balkan Peninsula (Western Vardar Ophiolitic Unit) and its dismembered units (Kalnik, Darnó, Szarvaskő and Meliata units). However, each of the remnants of the Triassic oceanic crust (from early-rift related through rift/ocean transition to MOR-type) are preserved in mélange blocks. They were presumably formed in a continuous belt from Greece to the dismembered Darnó-Szarvaskő Complex-Meliata units. Thus a single Triassic ocean between the Adriatic – Dinaridic (Jadar – Drina-Ivanjica – Korabi-Pelagonian zone) and Serbo-Macedonian composite unit existed since the Anisian. The Paleozoic and Triassic succession of the Bükk parautochthon shows strong similarities to the Jadar "block" [Filipović *et al*., 2003; Pelikán *et al*., 2006]. During this time it was part of the distal Adriatic-Dinaridic passive margin (fig. 3 F), somewhere between the southern Alps and the Dinaridic domain [Haas *et al*., 2010]. The Middle and Late Triassic period is characterized by the closure of the Paleotethys and the westward opening of the Neotethys (fig. 3 A, F) by rifting/initial spreading and the first radiolarite accumulation in the Illyrian (Anisian, Middle Triassic). The Middle Triassic Neotethys rifting (Illyrian to Longobardian) led to segmentation of the carbonate ramps on the passive margin; isolated platforms and grabens were then formed [Haas *et al*., 2010] while radiolarite deposition was associated with the formation of the MORB-type oceanic crust (oceanic fragments of Darnó Unit) in the deep, oceanic basins (fig. 3 B, F). Considering a mixture of Middle Triassic (Illyrian to Longobardian) and Upper Triassic (Carnian) radiolarian assemblages in Darnó and Szarvaskő Complex, intrabasinal resedimentation may have started in the Carnian. It cannot be excluded that radiolarite deposition (fig. 3 C) continued during the Late Triassic (late Norian-Rhaetian) to Middle Jurassic (Aalenian), although lithostratigraphic and unambiguous biostratigraphic evidence for this time interval is still lacking from the Western Vardar Ophiolitic Unit of the Balkan Peninsula, including the displaced units, as well.

◄

FIG. 3. – Simplified plate tectonic model of Darnó and Szarvaskő Complex and related units.
A. Neotethys rifting in the Middle Triassic. B. Formation of the MORB-type oceanic crust in the Late Triassic. C. Assumed radiolarite deposition during the Late Triassic (late Norian-Rhaetian) to Middle Jurassic (Aalenian). D. The tectono-sedimentary mélanges forming from the Middle Jurassic, which contain Pre-Jurassic oceanic crust fragments, platform carbonates, slope sediments, radiolarites and cherty limestones. In addition, they contain Middle and Upper Jurassic allodapic limestones with radiolarite intercalations included in a siliciclastic matrix (Mónosbél unit). In addition, ultramafics, gabbros, diabases, and basalts formed from the Middle Jurassic (probably Bajocian). This can be interpreted as a suprasubduction complex. E. The obduction of the Western Vardar Ophiolitic Unit may have begun in the Late Jurassic-?Early Cretaceous with strong deformation/metamorphism, attesting by syn-sedimentary thrusting of the ophiolite complex. F. Schematic paleogeography of the western Neotethyan region during the Middle - Late Triassic - ?Early Jurassic. G. Middle - Late Jurassic paleogeography in the western Neotethys.

FIG. 3. – *Modèle géodynamique simplifié du complexe de Darnó et de Szarvaskő et de ses unités associées.* A. *Rifting de la Néotéthys au Trias moyen.* B. *Formation de basaltes de croûte océanique au Trias supérieur.* C. *Déposition probable des radiolarites du Trias supérieur (Norien supérieur-Rhétien) au Jurassique moyen (Aalénien).* D. *Les mélanges tectono-sédimentaires qui se forment à partir du Jurassique moyen contiennent des fragments de croûte océanique pré-Jurassique, des carbonates de plateforme, des sédiments de pentes, des radiolarites et des calcaires à nodules de silice. En plus, ils contiennent des calcaires allodapiques du Jurassique moyen et supérieur avec des intercalations radiolaritiques comprises dans une matrice siliciclastique (Mónosbél unit). De plus, des roches ultra-mafiques, des gabbros, des diabases et des basaltes se sont formés depuis le Jurassique moyen (probablement à partir du Bajocien). Ceci peut être interprété comme un complexe de supra-subduction.* E. *L'obduction des unités ophiolitiques de l'Ouest Vardar pourrait avoir comencé au cours du Jurassique supérieur-?Crétacé inférieur avec de fortes déformations et un métamorphisme élevé, attestant le chevauchement syn-sédimentaire du complexe ophiolitique.* F. *Paléogéographie schématique de la région de l'Ouest Néotéthys pendant la période du Trias moyen-supérieur au ?Jurassique inférieur.* G. *Paléogéographie du Jurassique moyen-supérieur de l'Ouest Néotéthys.*

These missing units may have been completely subducted, except for the units preserved in the ophiolite mélange (fig. 3 D). Schmid *et al.* [2008] interpreted this ophiolitic mélange as an accretionary prism that may have formed during the obduction of ophiolites in the Middle-Late Jurassic (fig. 3 E). The exceptions are the Kopaonik Mts. (Studenica section) and the Slovenian trough, where the pelagic Late Triassic-Jurassic sedimentary sequences were completely preserved (i. e. Rožič *et al.* [2009]; Schefer *et al.* [2010]). The tectono-sedimentary mélanges including olistoliths formed from the Middle Jurassic time (fig. 3 E, D). They consist of Lower and Middle Jurassic fragments derived from the Adriatic-Dinaridic Carbonate Platform. The Middle Jurassic reconstruction (fig. 3 D), however, is based on the assumption that an accretionary prism was formed at the subduction zone. It contains fragments of pre-Jurassic oceanic crust, platform carbonates, slope sediments, radiolarites and cherty limestones. In addition, they contain Middle and Upper Jurassic allodapic limestones with radiolarite intercalations included in a siliciclastic matrix (Mónosbél unit), while ultramafics, gabbros, diabases, and basalts formed from the Middle Jurassic (probably Bajocian) in deep oceanic environment. This can be interpreted as a suprasubduction complex (fig. 3 D), similar to that of Medvednica and Kalnik mountains in Croatia [Goričan *et al.*, 2005], the Western Vardar Ophiolitic Unit in Serbia, the Mirdita mélange in Albania, or the Avdella Mélange in Greece [Robertson, 2002; Robertson *et al.*, 2009; Smith, 2006; Gawlick *et al.*, 2008]. Obduction of the Western Vardar Ophiolitic Unit may have begun in the Late Jurassic-?Early Cretaceous (fig. 3 E) with strong deformation and metamorphism [Csontos, 1988] reflected by syn-sedimentary thrusting of the ophiolite complex (Szarvaskő Complex) onto the continental fragment (Bükk Parautochthonous Unit), although there is no direct evidence for their boundary. The present-day position of the Darnó and Szarvaskő Complex evolved by strike-slip movements along the Mid-Hungarian Zone during the ?Cretaceous and Tertiary.

CONCLUSIONS

1. Samples from radiolarite localities in the Darnó and Szarvaskő Complex contain a mixture of Middle (Illyrian to Longobardian) and Upper (Carnian) Triassic fairly poorly preserved radiolarian assemblages. The investigated radiolarite samples from the Western Vardar Ophiolitic Unit (Gostilje, Krš Gradac and Bukovi) yielded Upper Triassic (Carnian-?Norian) poorly preserved radiolarians.

2. Pre-Jurassic radiolarite formation in the western Neotethyan subbasins took place from the Middle Triassic (Illyrian to Longobardian) to the Late Triassic (Carnian-Norian).

3. Co-occurrences of Middle and Late Triassic radiolarians in the Darnó and Szarvaskő Complex suggest resedimentation during Carnian times or later.

4. The new radiolarian data from Mély-völgy (Darnó Unit) presented here constrains the beginning of basaltic volcanism in the Darnó and Szarvaskő Complex as pre-Ladinian.

5. Remnants of the Triassic oceanic crust (from early-rift related through rift/ocean transition to MOR-type) are preserved in a continuous mélange belt from Euboia Island (Greece), through Pindos (Greece), the Mirdita Zone (Albania), Western Vardar Ophiolitic Unit in Serbia, Bosnia and Croatia, to the displaced Darnó – Szarvaskő – Meliata units. Thus the existence of a single Triassic Ocean is inferred since the Anisian between the Adriatic – Dinaridic (Jadar – Drina-Ivanjica – Korabi-Pelagonian zone) and the Serbo-Macedonian zone.

Acknowledgements. – Comments by the reviewers Senecio Schefer and Paulian Dumitrica, and the editors Špela Goričan and Taniel Danelian helped to improve the clarity and presentation. We are very grateful to Szilvia Kövér for valuable comments on tectonic problems. We thank very much Prof. Dr. József Pálfy, Eötvös University, Budapest for improving our English and Patrice Moix for the French translation. Péter Ozsvárt acknowledges a grant of the Hungarian Scientific Foundation (OTKA F048341) in support of his studies on Triassic and Jurassic radiolarians. This work was also supported by OTKA grants 61872 and 81298.

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