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SPATHIAN (LOWER TRIASSIC) CONODONTS FROM THE *TIROLITES CASSIANUS* BEDS IN PALEOTETHYS-ISSUED NORTH DOBROGEA OROGEN (ROMANIA)

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Abstract. The paper documents a conodont fauna from Lower Triassic deposits of Paleotethys-issued North Dobrogea Orogen. The studied strata exposed in the Tulcea Veche Quarry are characterized by the presence of diversified molluscs, including the ammonoid *Tirolites cassianus* (Quenstedt) and the bivalve *Crittendenia decidens* (Bittner). The site also represents the type locality of the coelacanth fish *Dobrogeria aegyssensis* Cavin & Grădinaru. The recovered conodont fauna is marked by *Icriospathodus crassatus* (Orchard), *Neospathodus robustispinus* Zhao & Orchard, *Novispathodus abruptus* (Orchard), *Nv. brochus* (Orchard), *Nv.* aff. *brochus* (Orchard), *Tr.* ex gr. *homeri* (Bender), *Tr. hungaricus* (Kozur & Mostler), *Tr.* ex gr. *hungaricus* (Kozur & Mostler), *Tr. symmetricus* (Orchard), *Tr.* aff. *symmetricus* (Orchard), and *Triassospathodus* sp. that is correlated with the *Tr. symmetricus* Zone.

Introduction

North Dobrogea, which lies south of the Danube Delta, is a fold-and-thrust belt called the North Dobrogean Orogen (Fig.1A), which is located in the foreland of the Alpine Carpathian Orogen (e.g. Săndulescu 1995). The North Dobrogean Orogen represents the westernmost segment of the Paleotethys-issued Cimmeride orogenic system that includes the Mountainous Crimea and the Greater Caucasus (Săndulescu 1995) (Fig. 1, inset map), and which extends eastwards to the Asian Cimmerides (Şengör 1984).

For a long time, the richly fossiliferous Triassic of North Dobrogea Orogen has been known for its Tethyan-type facies (Arthaber 1906; Kittl 1908; Simionescu 1908, 1910, 1911, 1913, 1925, 1927; Tozer 1984; Grădinaru 1995, 2000). The Tethyan-type Triassic of the North Dobrogean Orogen is tectonically confined by the Moesian and Scythian platforms where the Triassic is of Germanic-type (Fig. 1A). The present-day remote location of the North Dobrogean Triassic, which is placed outside the Mediterranean Triassic, is currently interpreted

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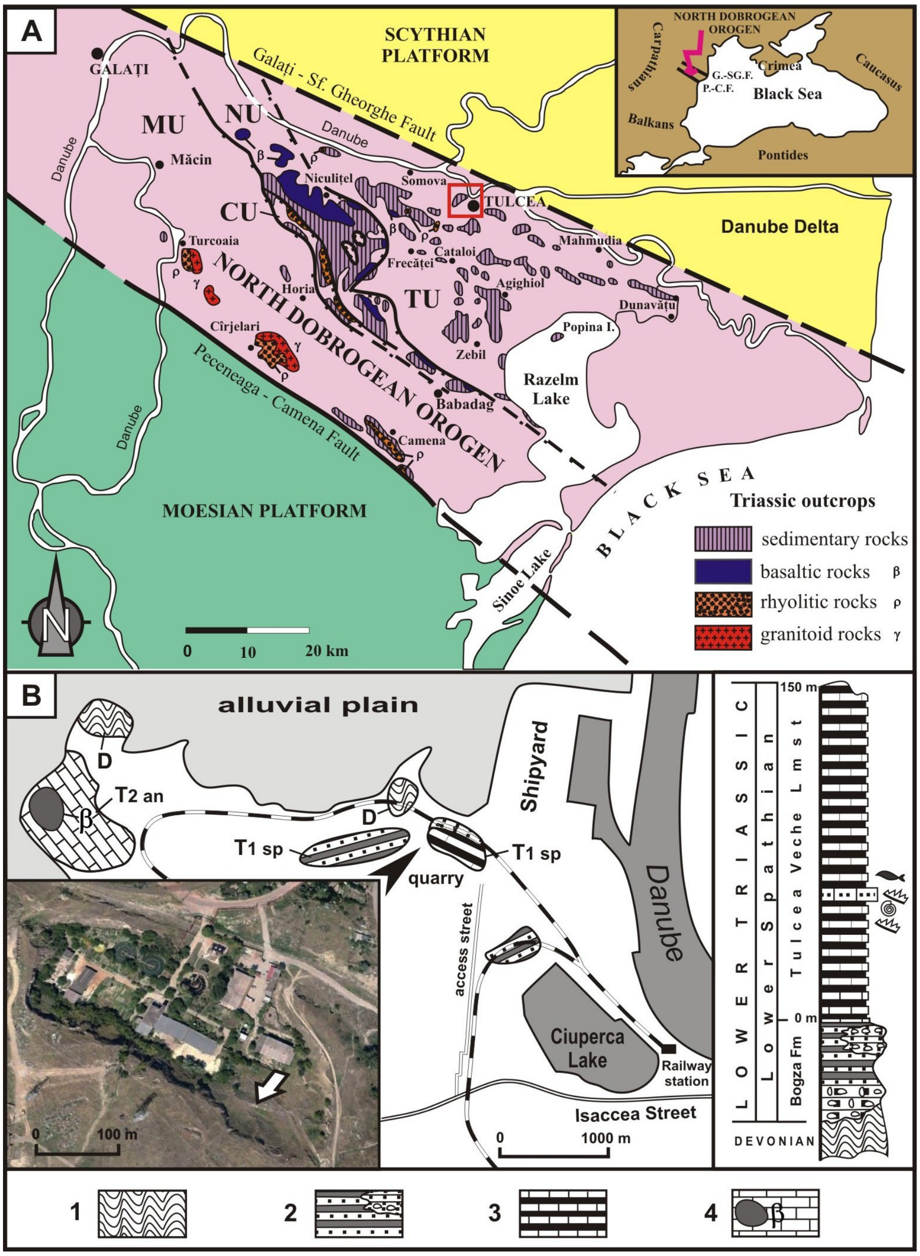

Fig. 1 - A) Geological sketch map of the Cimmerian North Dobrogean Orogen: MU – Măcin Unit; CU – Consul Unit; NU – Niculiţel Unit; TU – Tulcea Unit. Inset map shows the location of the North Dobrogean Orogen (after Grădinaru 2000, modified). The box shows the studied locality. B) Geological map and the stratigraphic column of the Tulcea Veche (Old Tulcea) Promontory. 1 – Devonian (D); 2 & 3 – Lower Spathian (T_{1sp}), terrigenous sequence (2), limestone and marly shale (3); 4 – Middle Triassic, Anisian (T_{2an}), massive limestone with basalt intrusion (β). Inset Google Earth image of the Tulcea Veche Quarry, with the arrow showing the sequence sampled for conodonts.

as the result of the post-Triassic large-scale horizontal displacements of Tethyan terranes and the opening of the West Black Sea Basin (e.g. Grădinaru 1988; Okay et al. 1994; Banks & Robinson 1997).

The Triassic sedimentary series that unconformably overlies a Variscan basement extends extensively in the Tulcea Unit of the North Dobrogean Orogen (Grădinaru 1995, 2000); basinal facies is developed westwards in its inner part, whereas a well-developed carbonate platform facies extends in the mid-eastern part (Fig. 1A). In the Tulcea Unit the Triassic sedimentation started with transgressive varicoloured terrigenous deposits and continued with an alternation of black marls and marly limestones in deeper-water settings; grey oncoidal/bioclastic limestones that are locally dolomitized began, on the other hand, to initiate the development of a carbonate platform in shallow-water settings. Based on biostratigraphic evidence, Triassic sedimentation started in some places during the Olenekian. The first fossiliferous strata are characterized by lower Spathian molluscs and the sequence was compared to the "Werfener Schichten" (Simionescu 1908); these strata occur also in the Tulcea Veche promontory (Grădinaru 2000). A new taxon of a coelacanth, *Dobrogeria aegyssensis* Cavin & Grădinaru, 2014, has been described from the Tulcea Veche Quarry (Cavin & Grădinaru 2014). The purpose of this study is to document the associated conodont fauna and its stratigraphic range, with the aim of constraining the early Spathian age of the *Tirolites* beds that yielded the coelacanth *Dobrogeria aegyssensis*. The conodont data from the lower Spathian of the studied locality represent an important step in achieving an ammonoid-calibrated conodont biostratigraphy for the Triassic (Lucas 2013; Lucas & Tanner 2014). In addition, such data contribute to improve the emerging knowledge on paleobiogeography of the Triassic conodont faunas of the region.

Geological setting and locality stratigraphic data

The studied rock samples originate from an abandoned Tulcea Veche Quarry (Fig. 1B, inset Google image), from which limestone was extracted up until the early decades of the 20th century. The Variscan basement that occurs in the Tulcea Veche Quarry is made up of Devonian quartzite and calcschist, disconformably overlain by Lower Triassic sedimentary rocks (Mirăuţă 1966). The Triassic succession (Fig. 1B, inset stratigraphic column) starts with thick-bedded, matrix-supported conglomerate with quartz clasts and coarse-grained quartzose sandstone grading upwards or interfingering with varicoloured medium- to thick-bedded sandstone interbedded with clay-rich shale. Strata of this transgressive terrigenous sequence are included in the Bogza Formation (Baltreş 2003). Fully marine deposition started with a basinal carbonate sequence attributed to the Tulcea Veche Limestone that is a distinct member of the Somova Formation (Baltreş 2003). It consists of thin-bedded dark greyish mudstone interbedded with dark black, bituminous marly shale, occasionally with thin beds of fine-grained grainstone. According to previous data, the studied strata were deposited in an anoxic to dysoxic environment based on the absence of trace fossils and the high content of organic matter (Cavin & Grădinaru 2014). The age of this carbonate sequence based on the fossil content was first reported by Simionescu (1908, 1911, 1927), who compared these strata with the Werfen Beds. The early Spathian age of the Tulcea Veche Limestone is well documented by a newly collected ammonoid fauna comprising *Tirolites cassianus* (Quenstedt,1845), *T. haueri* Mojsisovics, 1882, and bivalves, *Leptochondria alberti* (Goldfuss, 1838), *Eumorphotis venetiana* (Hauer, 1850), and *Crittendenia decidens* (Bittner, 1899). The ammonoid fauna is indicative of the base Spathian *Tirolites cassianus* Zone. The fossil content also includes a new coelacanth taxon, *Dobrogeria aegyssensis* Cavin & Grădinaru, 2014 and its good state of preservation indicates that the anoxic/dysoxic environment precluded destruction of the bones by scavengers (Cavin & Grădinaru 2014).

The studied lower Spathian carbonate sequence of the abandoned quarry is highly tectonized by block faulting, due to the proximity of the Galaţi - Sf. Gheorghe fault (Fig.1). These strata are mostly vertically standing, with highly boudinaged limestone in cleaved shale. Most conodonts were extracted from the samples taken from the ammonoid-bearing sequence located right around the level with the bones of *Dobrogeria aegyssensis*, and one sample each was taken at the western (6167) and eastern bases (6166), respectively (Figs. 1, 2).

Material and methods

The studied rock samples come from the Tulcea Veche Quarry (image, $45^{0}11^{l}28^{ll}$ N; $28^{0}46^{l}40^{ll}$ E; elev. 18 m; Figs. 1B, 2). Mudstone and grainstone samples with minimum weight of 2 kg were chemically processed with diluted 5–10% acetic or formic acid for conodonts, which operation was carried out at the University of Bucharest and the Geological Survey of Slovenia. The residues were later sieved and dried. Heavy liquid separation was completed at the Geological Survey of Slovenia. The conodonts were picked out under a binocular microscope. SEM photos were taken at Graz University (Zeiss DSM 982 Gemini) and are illustrated in Fig. 5, whereas the conodonts illustrated in Figs. 6–8 were photographed by the JEOL JSM 6490LV Scanning Electron Microscope at the Geological Survey of Slovenia. All micropaleontological material from Tulcea Veche is stored and inventoried under the repository numbers 107–110, 4864, 4867–4877, 4879–4881, and 6166–6168 at the Geological Survey of Slovenia.

Conodonts

Previous studies on the Lower Triassic conodont faunas in North Dobrogea

Triassic conodonts from North Dobrogea were studied by Mirăuţă (1974, 1982), Mirăuţă & Iordan (1982), and Mirăuţă et al. (1984), whereas unpublished data can be found in various archived

Mb.	TIROLITES MUDSTONES							BIOCLASTIC BEDS										CRITTENDENIA B.			
Conodonts \ Sample	4869	4870	4873	4874	4875	4876	4877	4867	4868	4871	4879	4880	4881	107a	107b	108	109	6166	6167	6168	110
I. crassatus						3	1	3		4	1	1	4	1	1	1		1		3	7
Ns. robustispinus																		3			
Nv. abruptus	4		5				1	34	14	18	15	37	15			4	2	5	3	4	9
Nv. brochus								3	1												
Nv. aff. *brochus*	1		1		1					1											1
Tr. ex gr. *homeri*									3												
Tr. hungaricus																			4	3	
Tr. ex gr. *hungaricus*								4				3				1		2	3	4	
Tr. symmetricus	7		4		1	1	2	29	17	25	17	24	27	1	1	9	3	6	2	3	12
Tr. aff. *symmetricus*																		3			
Triassospathodus sp.			1	4				10	1		3	3	2					7	21	20	

Fig. 2 - Conodont distribution in the studied samples of Tulcea Veche. See Fig. 3 for abbreviations.

reports of the Geological Institute of Romania. Relying on the taxonomy and based on the knowledge of Triassic conodont biostratigraphy of the time, Mirăuţă (1974) dated the rock sequences with *Triassospathodus triangularis* (Bender, 1970) and *Tr. homeri* (Bender, 1970) in the Tulcea Zone as Spathian, whereas the strata with *Chiosella gondolelloides* (Bender, 1970) were dated as early Anisian (Aegean). A Spathian conodont fauna yielding *Tr. triangularis* and *Tr. homeri*, in association with ramiform elements, was collected from a grey sparry limestone cropping out south of the village of Beştepe and south-east of the village of Malcoci (Mirăuţă & Iordan 1982). A conodont fauna with similar composition has been also reported from grey limestone occurring in the Somova-Sarica Hill area (Mirăuţă 1982; Mirăuţă et al. 1984), where a diverse range of bivalve and brachiopod species occur next to the ammonoid *Tirolites* cf. *spinosus* Mojsisovics, 1892. Moreover, the more recent macrofauna collection from the Tulcea Veche Quarry was also compared to the one studied by Simionescu (1911).

The lower Anisian (Aegean) has been identified by Mirăuţă et al. (1984) in the Somova-Sarica Hill area with the identification of the species *C. timorensis* (Nogami, 1968). Debates on the taxonomy of the two species of *Chiosella* emerged, with some authors placing the *C. gondolelloides* (originally described as *Spathognathodus gondolelloides*) in the synonymy of *C. timorensis* (originally described as *Gondolella timorensis*); the latter taxon is currently identified as a distinct species of the *Chiosella* genus (e.g. Grădinaru et al. 2006; Orchard et al. 2007, Chen et al. 2015). In this view the recognition of Spathian versus early Anisian (Aegean) in some localities in North Dobrogea, as noted in the above mentioned studies, is still open, and is not the subject of this study.

Conodont fauna of the Tulcea Veche Quarry

The focus of our study was the documentation of a conodont fauna originating from a short stratigraphic interval of the Tulcea Veche Quarry (Fig. 1B) and its correlation within the lower Spathian conodont zonation. All recovered conodonts have a Conodont Alteration Index (CAI) value of between 5 and 5.5 and are black in colour (Epstein et al. 1977).

The conodont samples were collected from a short section yielding an abundance of ammonoid fauna with *Tirolites* and composed of mudstone interbedded with shale. Four units can be distinguished and are listed here in stratigraphic ascending order: *Tirolites* mudstones, *Dobrogeria* beds, Bioclastic beds, and *Crittendenia* beds. A total of 23 samples were processed. The majority of the samples were productive for conodonts, and only two samples from the *Dobrogeria* beds (samples 4864, 4872) were barren and therefore excluded from Fig. 2 which shows the conodont distribution in the studied samples of the Tulcea Veche section. The composition of the recovered conodont associations is very similar in all samples, and they are marked by the dominant representation of species of the genera *Novispathodus* and *Triassospathodus*. The list of the identified conodont elements comprises: *Icriospathodus crassatus* (Orchard, 1995), *Neospathodus robustispinus* Zhao & Orchard, 2008, *Novispathodus abruptus* (Orchard, 1995), *Nv. brochus* (Orchard, 1995), *Nv.* aff. *brochus* (Orchard, 1995), *Triassospathodus* ex gr. *homeri* (Bender, 1970), *Tr. hungaricus* (Kozur & Mostler, 1970), *Tr.* ex gr. *hungaricus* (Kozur & Mostler, 1970), *Tr. symmetricus* (Orchard, 1995), *Tr.* aff. *symmetricus* (Orchard, 1995), and *Triassospathodus* sp. (Figs. 5–8). Based on the dominant occurrence of *Tr. sym-*

Series	Stage	Substage	Tulcea Veche	Global synthesis	Jiarong, China	Chaohu, China	Spiti, India	Spiti, India	Kashmir	Vietnam	Slovenia
			This study	Kozur 2003	Chen et al. 2013	Zhao et al. 2007	Krystyn 2005	Sun et al. 2021	Lyu et al. 2021	Maekawa & Komatsu 2014	Kolar-Jurkovšek & Jurkovšek 2019
Lower Triassic	Olenekian	Spathian		*Tr. triangularis*	*Tr. triangularis*	*Ns. anhuinensis*	Undifferentiated	*Tr. triangularis*			*Tr. triangularis*
			Tr. symmetricus	*Tr. homeri*	*Tr. homeri*	*Tr. homeri*		*Tr. homeri* / *Tr. symmetricus*	*Nv. abruptus* *Nv. brevissimus*	*Tr. symmetricus*	*Tr. homeri-Tr. robustisp.*
				I. collinsoni	*I. collinsoni*		*I. collinsoni*	*I. collinsoni*			*Tr. symmetricus*
				Tr. hungaricus	*Nv. pingdingsh.*	*Nv. pingdingsh.*		*Nv. pingdingsh.*	*Nv. pingdingsh.*	*Nv. pingdingsh.*	*Tr. hungaricus*
		Smithian		*Nv. waageni* *Sc. milleri*	*Par. - Pac.*	*Nv. w. waageni*	*Sc. milleri*	*Sc. mosheri*	*Sc. mosheri*	*Nv.* ex gr. *waageni*	*Pl.regularis*; *Foliella gardenae*
					Ds. discreta						*Pl.corniger*
				Nv. waageni *Sc. meeki*			*Nv. waageni*	*Nv. waageni*	*Nv. waageni*		*Pac. obliqua*
					Nv. w. waageni						
				Ng. nepalensis	*Nv. w. eowaageni*	*Nv.w.eowaageni*	*Nv.w.eowaageni*	*Eu. costatus*			*Eu. costatus*

Fig. 3 - Correlation of the conodont sequence of Tulcea Veche area with synthesis zones and some Tethyan sections. Abbreviations: *Ds. – Discretella, Eu. – Eurygnathodus, I. – Icriospathodus, Ng. – Neogondolella, Ns. – Neospathodus, Nv. – Novispathodus, Pac. – Pachycladina, Par. – Parachirognathus, Pl. – Platyvillosus, Sc. – Scythogondolella, Tr. – Triassospathodus.*

metricus the recovered fauna is correlated with the *Tr. symmetricus* Zone.

Triassospathodus symmetricus was first described from Oman and North America by Orchard (1995), which description is based in part on other similar species previously attributed to *Neospathodus (Ns. cristagalli* (Huckriede, 1958)*, Ns. homeri, Ns. triangularis*). In Oman and in North America, *Tr. symmetricus* co-occurs with *Icriospathodus collinsoni* (Solien, 1979) and *Tr. homeri* (Mosher 1968; Orchard 1995). *Tr. symmetricus* has a long stratigraphic range over most of the Spathian and correlates with ammonoid faunas including *Columbites, Procolumbites, Prohungatites/ Subcolumbites* and *Neopopanoceras* (Orchard 1995). *Tr. symmetricus* has also been reported from Italy (Perri 1986), Greece (Dürkoop et al. 1986; Gaetani et al. 1992), Albania (Muttoni et al. 1996) and many sections in North America and Asia. For a more comprehensive and precise geographic picture of the occurrence of *Tr. symmetricus* and *Tr. homeri* the reader is referred to Orchard (1995) and Chen et al. (2013).

Specimens of *Novispathodus abruptus* are described as rectangular units with a moderately arched upper edge, usually bearing 10 denticles, having a basal cavity with subrounded outline and some specimens reveal also a lateral rib. It was first described from Oman; certain short and high segminate elements previously attributed to *Tr. homeri* and *Tr. triangularis* (Orchard, 1995) have also been included on its synonymy list. This species has also been reported from many sections of North America (Orchard 1995), China (Chen et al. 2015), Vietnam (Maekawa & Komatsu 2014), and in Japan, where it occurs in the *Nv. pingdingshanensis* and *Tr. brevissimus* Zones (Maekawa et al. 2018).

Icriospathodus crassatus and *Novispathodus brochus* are two species occurring in low frequency in the Tulcea Veche material, and which were also first described from Oman (Orchard 1995). *Nv. brochus* reveals many similarities with *Tr. homeri,* but the two taxa differ in their distribution of denticles and which are more discrete in *Nv. brochus*. The presence of *I. crassatus* was documented from the Spathian of Italy (Perri & Andraghetti 1987), North America (Orchard 1995), Oman (Orchard 1995; Chen et al. 2019, 2021), Japan (Koike 1992; Maekawa et al. 2018), and China (Chen et al. 2015).

Neospathodus robustispinus, featuring rather short elements with few denticles and spacious basal cavity, was first described from South China (Zhao et al. 2007, 2008). This species was found in the *Žiri* section of Slovenia (Chen et al. 2016). In Tulcea Veche, it was only found to be present in a single sample (6166). Few specimens here assigned to *Tr.* ex gr. *homeri* also occur in the collections of Tulcea Veche. *Triassospathodus homeri* is a well-documented species that has been reported from many sections worldwide (Koike 1981; Orchard 1995; Chen et al. 2015).

Comparison and discussion of lower Spathian conodont zones

The *Triassospathodus symmetricus* Zone was defined from Northeastern Vietnam, where it includes the ammonoids *Tirolites* and *Columbites*; these strata are correlated with the lower Spathian (Maekawa & Komatsu 2014). The zonal marker, *Tr. symmetricus* co-occurs with *Nv. pingdingshanensis, Tr. homeri*, *Tr. triangularis,* and icriospathodids, including *I. collinsoni* and *I.? crassatus*. In Slovenia, the *Tr. symmetricus* Zone

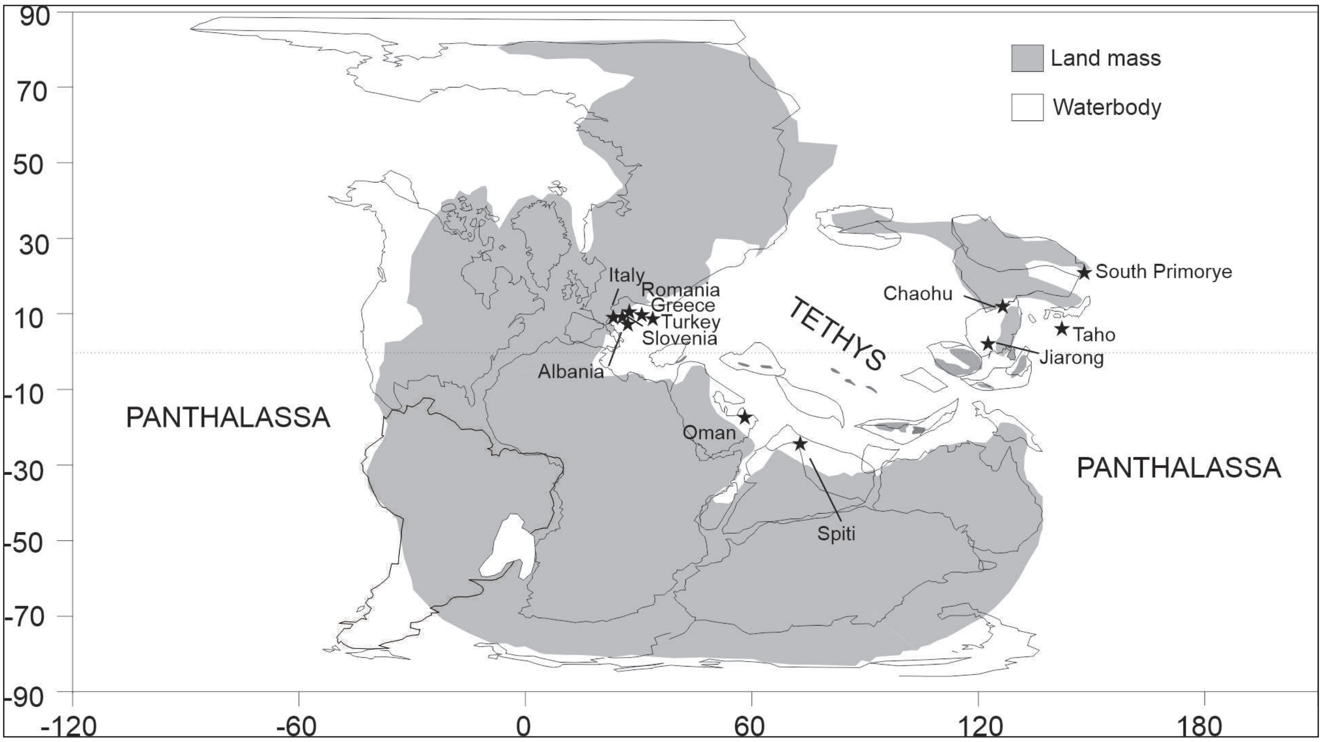

Fig. 4 - Paleogeography of the Olenekian world (modified after Péron et al. 2005). Asterisks indicate important localities mentioned in the text.

was also recognized based on the co-occurrence of the name-bearing taxon accompanied by *Tr.* ex gr. *homeri* and *Tr.* ex gr. *hungaricus*. The first occurrence of *Tr. symmetricus* marks the lower boundary of the corresponding zone, whereas the first occurrence of *Ns. robustispinus* defines its upper limit (Kolar-Jurkovšek & Jurkovšek 2015, 2019). The *Tr. symmetricus* Zone can be correlated with the *I. collinsoni* Zone of the integrated zonation (Kozur 2003), as well as the *I. collinsoni* Zone of Jiarong, South China where a diversified conodont fauna includes the index taxon as well as some gondolellids and several other segminate elements including *I. collinsoni* (Chen et al. 2013, 2015). Just recently, a new taxonomy for neogondolellin conodonts has been described from North America and the associated taxa enable to distinguish the *Neostrachanognathus* sp. – *Nv.? triangularis* and *Tr. symmetricus* Zones from the middle and upper Spathian strata (Orchard 2022).

The *Tr. symmetricus* Zone of Northeastern Vietnam and the contemporaneous *I. collinsoni* Zone of Jiarong, South China, lie stratigraphically just above the *Nv. pingdingshanensis* Zone (Figs. 3, 4). In Slovenia, as well as in the Dinarides, the *Tirolites* beds yield faunas that were referred to the *Tr. hungaricus* Zone (Kolar-Jurkovšek et al. 2021); the recovered specimens are represented by segminate elements of small size. The positive trend of a $\delta^{13}C_{org}$ value reaches a maximum in the subsequent *I. collinsoni* Zone and it has been documented worldwide (Maekawa & Komatsu 2014; Chen et al. 2015).

The genus *Icriospathodus* has a distinct platform morphology with developed ridges instead of denticles. It is an important stratigraphic marker owing to its short range and extensive geographic distribution in North America and Asia, including South Primorye (e.g. Orchard 1995; Maekawa & Komatsu 2014). Outside these areas, the best represented species of the genus, *I. collinsoni* has rather scarce occurrence and has not been recovered in this study.

In the integrated ammonoid-, conodont and radiolarian zonation of the Triassic of Kozur (2003), the *Tr. hungaricus* Zone is equivalent to the *Tirolites cassianus* ammonoid Zone (Fig. 3). In the Dinarides, the strata with *Tirolites* are associated with *Tr. hungaricus* that was first described from Hungary (Kozur & Mostler 1970), and more recently reported from few locations in Slovenia (Kolar-Jurkovšek et al. 2013, 2017) and other sections in the Dinarides (Kolar-Jurkovšek et al. 2014; Aljinović et al. 2018). *Tr. hungaricus* has been recognized in the Sichuan province, southwest China (Tian et al. 1983). Moreover, a similar species determined as "*Ns.*" cf.

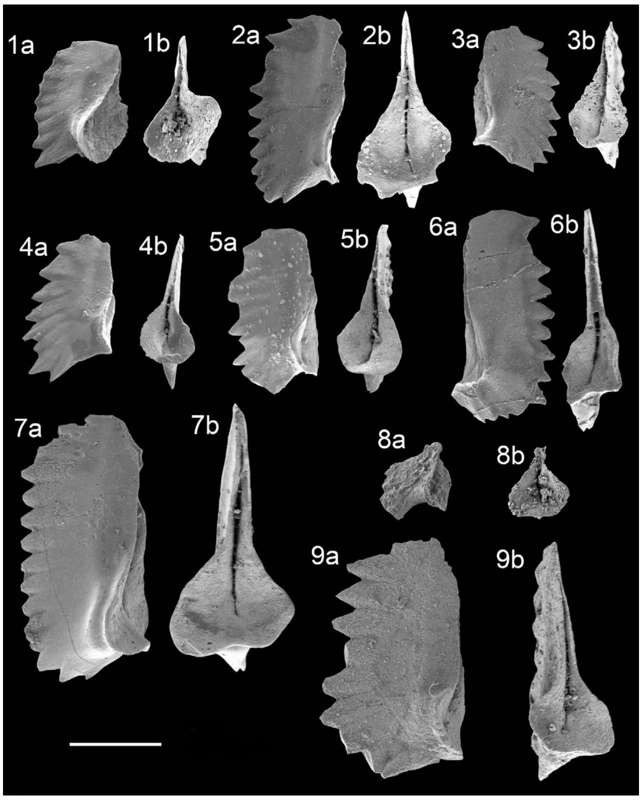

Fig. 5 - SEM images of conodonts from the Tulcea Veche locality. 1, 3–5, 9) *Novispathodus abruptus* (Orchard); 6) *Triassospathodus* ex gr. *homeri* (Bender); 8) *Novispathodus* sp.; 2, 7) *Triassospathodus symmetricus* (Orchard). 1–5) sample GeoZS 4867; 6) sample GeoZS 4868; 7) sample GeoZS 4871; 8) sample GeoZS 4875; 9) sample GeoZS 4877.
Scale bar: 200 microns; a) lateral, b) lower view.

hungaricus has been reported from Nevada, North America, USA (Lucas & Orchard 2007).

In the shallow western Tethys, the *Tr. hungaricus* Zone is documented in the lower Spathian in the Tirolites beds, where *I. collinsoni* is missing (Kolar-Jurkovšek et al. 2013). The *Tr. hungaricus* Zone of Slovenia probably correlates in part with the *Platyvillosus asperatus* Zone in Great Basin, USA (Clark et al. 1979), where *Pl. asperatus* Clark, Sincavage & Stone is the lowermost Spathian conodont zone (Chen et al. 2016; Kolar-Jurkovšek & Jurkovšek 2015). Stratigraphically, the base of the *Tr. hungaricus* Zone in the Žiri area should be quite close to the base of the Spathian (Chen et al. 2016).

The collected conodont fauna from the Tulcea Veche Quarry can be compared to the fauna of the Kçira section, Albania where the Spathian fauna is characterized by the co-occurrence of *Tr. symmetricus* and *Tr. homeri,* as well as *Nv. abruptus*, which is confined to the basal part of the section, with the sporadic presence of *Nv. brochus* (Muttoni et al. 1996). The authors compared this fauna with the middle Spathian fauna 3 of Orchard (1995: fig. 1).

The composition of the studied conodont fauna from Romania, is to a certain degree, similar to the faunas of Oman that are more diversified, yielding conodont elements of higher and lower paleolatitudes. The following species are common among the Omani and Romanian sections: *I. crassatus*, *Nv. abruptus*, *Nv. brochus*, *Tr. homeri*, *Tr. symmetricus* and this fauna characterizes the unitary association zone UAZ6 in Oman (Chen et al. 2019). The SSB is identified within the interval from UAZ4 to UAZ5 and demonstrated, along with chemostratigraphy, by the last appearance datum of *Nv. pingdingshanensis*, and the ecological dependence of *Icriospathodus* species as determined by the absence/presence of *I. collinsoni* over a short distance is also mentioned (Chen et al. 2019). The fauna from Oman records the presence of *I. collinsoni* that marks Zone 10 of Sweet et al. (1971) and occurs in many equivalent faunas of the Tethys; however, it seems to be restricted to low paleolatitude according to Orchard (1995). In Europe, *I. collinsoni* is rare and has a very limited distribution; to date, there has been a report of a single specimen from the Southern Apennines in Italy (Mietto et al. 1991), which was collected in west Anatolia in Turkey (Steuber 1992) and on Crete in Greece (Krahl et al. 1983). There are no reports of this taxon in the Dinarides (Kolar-Jurkovšek & Jurkovšek 2015) nor in the eastern Albanides (Meço 1999; Gaetani et al. 2015). It should be mentioned here that certain Early Triassic taxa have very limited geographic distributions, confined to European localities, i.e. *Platyvillosus corniger* Kolar-Jurkovšek & Chen, 2016 and *Pl. regularis* (Budurov & Pantić, 1973) are known to occur only in the Dinarides, whereas *Foliella* has been collected in the Southern Alps and the Dinarides, and its distribution was recently extended to Oman (Kolar-Jurkovšek & Jurkovšek 2015; Chen et al. 2019). Assemblages from the late Griesbachian to the Smithian are characterized by shallow water elements or ecologically controlled taxa that have adapted to the epeiric ramp environment (Aljinović et al. 2018). Therefore, conodont faunas from these areas differ from the equivalent faunas of other parts of the Tethys region (North America, Asia) and are instrumental in defining the western part of the Tethyan province (Kolar-Jurkovšek & Jurkovšek 2019).

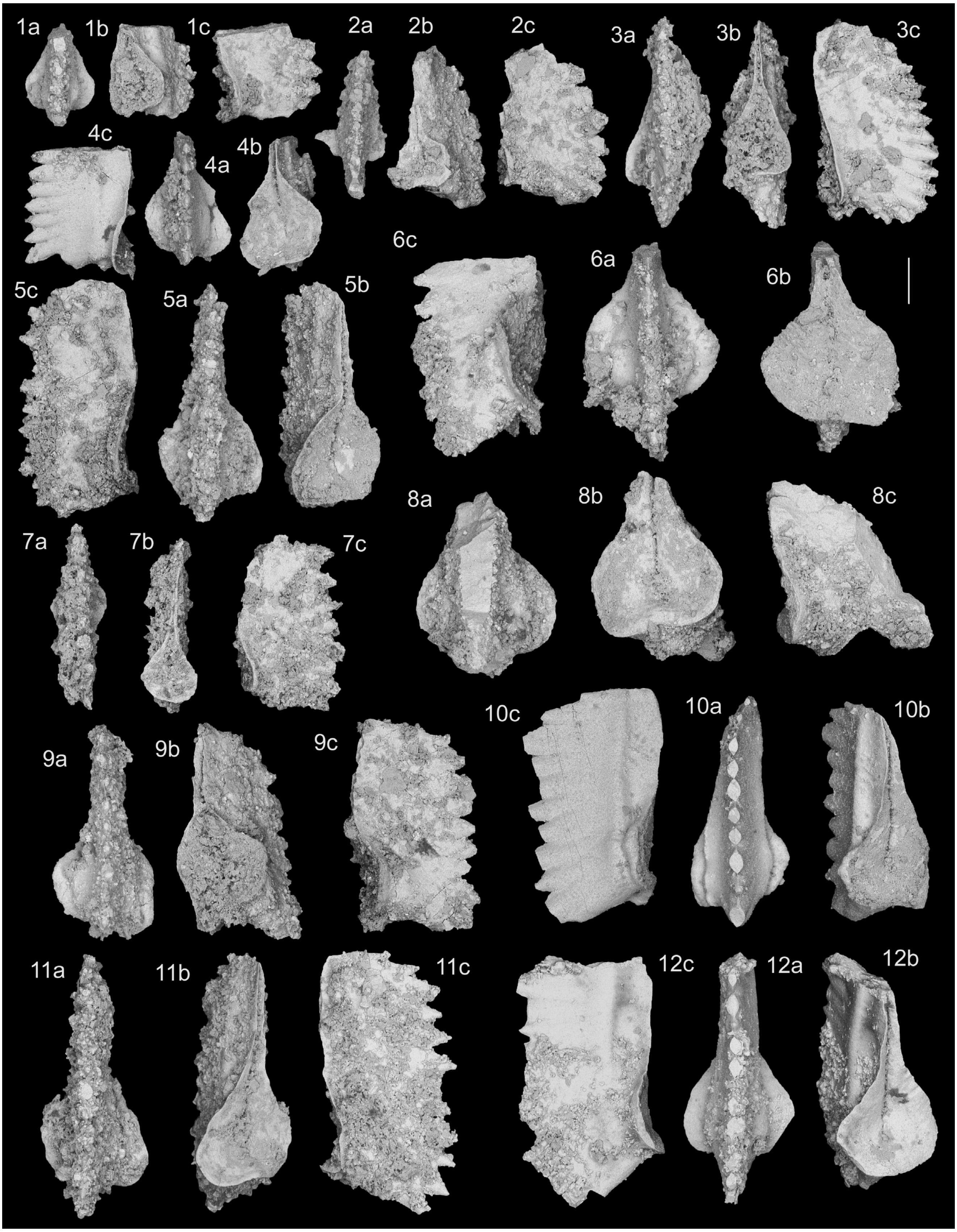

Fig. 6 - SEM images of conodonts from the Tulcea Veche locality, sample TV eastern base (GeoZS 6166).
1, 6, 8) *Neospathodus robustispinus* Zhao and Orchard; 2, 3) *Triassospathodus* aff. *symmetricus* (Orchard); 4, 7) *Novispathodus abruptus* (Orchard); 7, 9) *Triassospathodus* aff. *symmetricus* (Orchard); 10) *Icriospathodus crassatus* (Orchard); 11–12) *Novispathodus* aff. *abruptus* (Orchard).
Scale bar: 100 microns; a) upper, b) lower, c) lateral view.

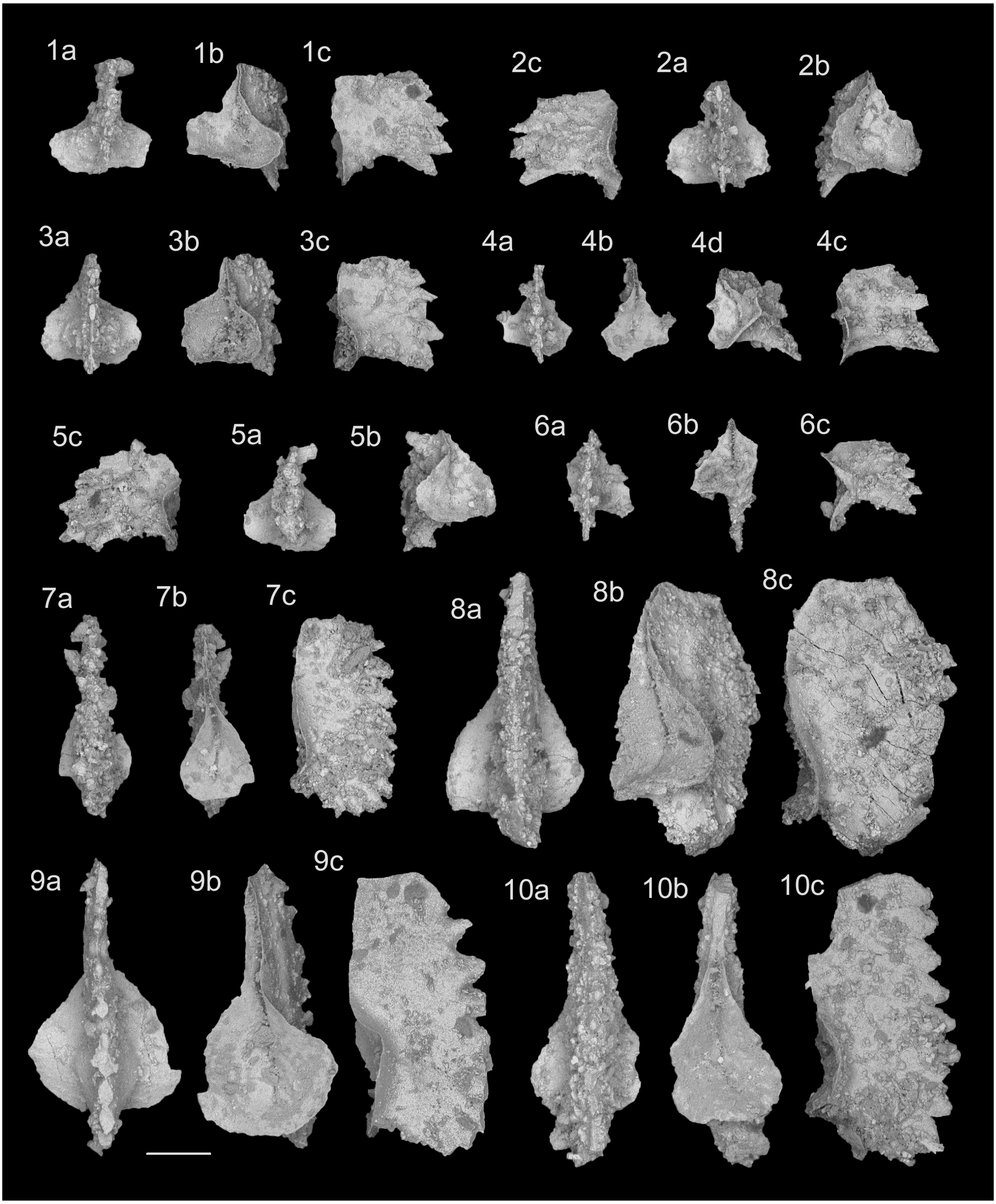

Fig. 7 - SEM images of conodonts from the Tulcea Veche locality, sample TV western base (GeoZS 6167). 1–3) *Triassospathodus* ex gr. *hungaricus* (Kozur & Mostler); 4) *Triassospathodus hungaricus* (Kozur & Mostler); 5–6) *Triassospathodus* sp.; 7–10) *Triassospathodus symmetricus* (Orchard).
Scale bar: 100 microns; a) upper, b) lower, c) lateral view.

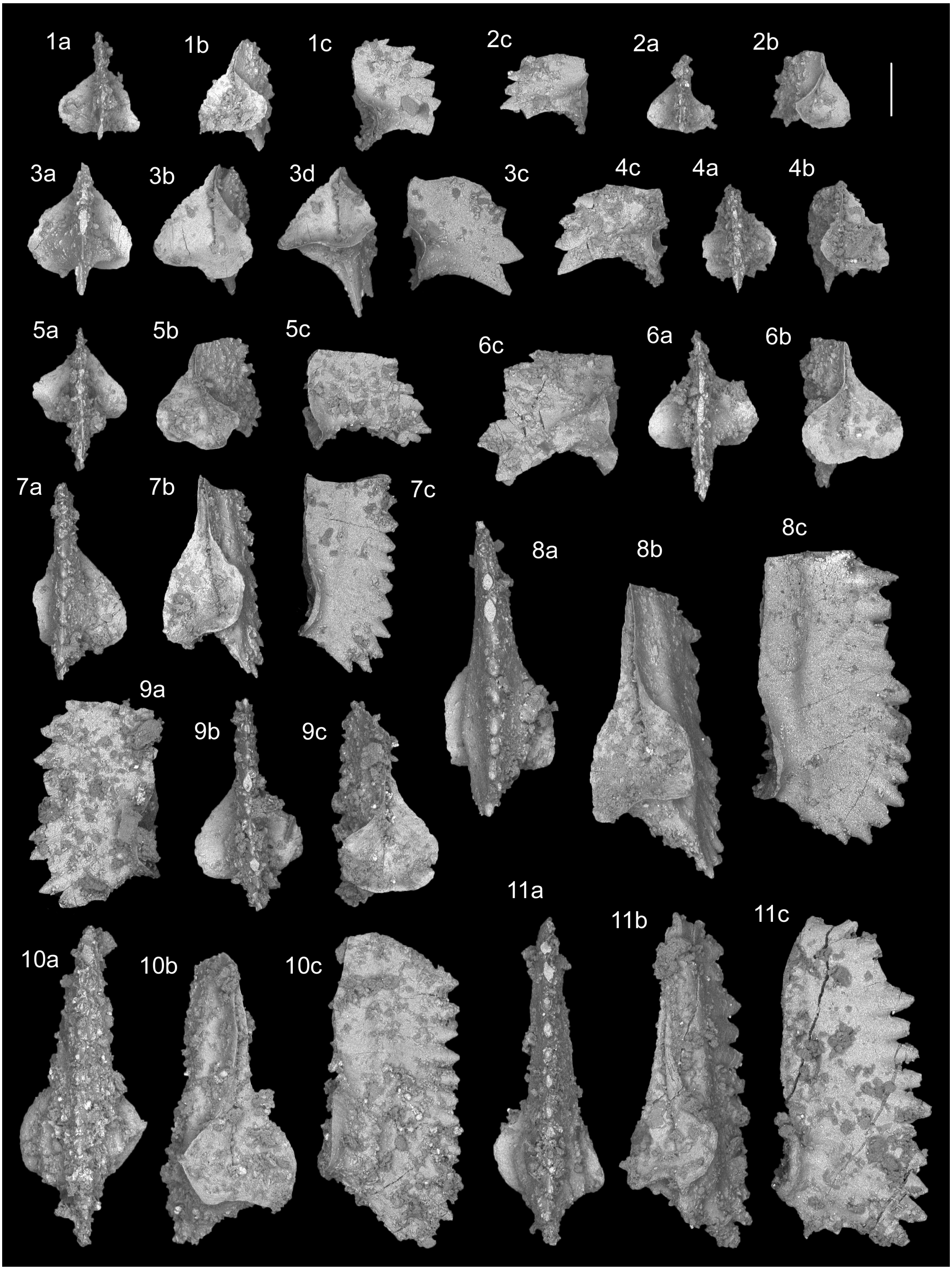

Fig. 8 - SEM images of conodonts from the Tulcea Veche locality, sample TV 110a (GeoZS 6168). 1–3, 5) *Triassospathodus* sp.; 4) *Triassospathodus hungaricus* (Kozur & Mostler); 6) *Triassospathodus* ex gr. *hungaricus* (Kozur & Mostler); 7, 9) *Triassospathodus symmetricus* (Orchard); 8, 10–11) *Icriospathodus crassatus* (Orchard).
Scale bar: 100 microns; a) upper, b) lower, c) lateral view.

Conclusion

A Lower Triassic conodont fauna was recovered from the Tulcea Quarry and the recovered associations are characterized by the domination of species of two genera, *Novispathodus* and *Triassospathodus*. The list of identified conodont elements includes the following taxa: *Icriospathodus crassatus* (Orchard), *Neospathodus robustispinus* Zhao & Orchard, *Novispathodus abruptus* (Orchard), *Nv. brochus* (Orchard), *Nv.* aff. *brochus* (Orchard), *Triassospathodus* ex gr. *homeri* (Bender), *Tr. hungaricus* (Kozur & Mostler), *Tr.* ex gr. *hungaricus* (Kozur & Mostler), *Tr. symmetricus* (Orchard), *Tr.* aff. *symmetricus* (Orchard), and *Triassospathodus* sp. Based on the dominant occurrence of the species *Tr. symmetricus*, the recovered fauna is attributed to the *Tr. symmetricus* Zone. The absence of some stratigraphically important Tethyan taxa is noted, such as *Icriospathodus collinsoni*, *Novispathodus waageni*, and *Nv. pingdingshanensis,* which are missing in the Tulcea Veche Quarry, as they are in the Dinarides and Albanides.

Tr. hungaricus has been reported from the Julian Alps, northwestern Slovenia, in rocks characterized by tempestite, bioturbated mudstone, and claystone. They have been interpreted to be deposited below the fair-weather wave base, but shallower than storm-wave base (Kolar-Jurkovšek et al. 2013). The Olenekian strata yielding *Triassospathodus* were reported from shallow ramp environments of the Jajce area in Bosnia and Herzegovina (Kolar-Jurkovšek et al. 2014). The occurrence of the *Tr. hungaricus* indicates a relatively shallow marine environment (Chen et al. 2016; Aljinović et al. 2018) which suggests that the strata of the Tulcea Quarry were deposited on a ramp marginal to the Tethys Sea.

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References

Aljinović D., Horacek M., Krystyn L., Richoz S., Kolar-Jurkovšek T., Smirčić D. & Jurkovšek B. (2018) - Western Tethyan Epeiric Ramp setting in the Early Triassic: an example from the Central Dinarides (Croatia). *Journal of Earth Science*, 29: 806-823. https://doi.org/10.1007/s12583-018-0787-3

Arthaber G. von. (1906) - Die alpine Trias des Mediterran-Gebietes. In: Lethaea geognostica II. Teil, Mesozoicum, Band I: 223-475. Verlag der E. Schweizerbart'schen Verlagshandlung (E. Nägele), Stuttgart.

Baltreş A. (2003) - Unităţile litostratigrafice Mezozoice, Pre-Cenomaniene din Dobrogea de Nord. Partea I. *Studii şi cercetări de geologie*, 48: 49-90.

Banks C.J. & Robinson A.G. (1997) - Mesozoic Strike-Slip Back-Arc Basins of the Western Black Sea Region. In: Robinson A.G. (Ed.) - Regional and petroleum geology of the Black Sea and surrounding region. AAPG Mem., 68: 53-61.

Cavin L. & Grădinaru E. (2014) - *Dobrogeria aegyssensis*, a new early Spathian (Early Triassic) coelacanth from North Dobrogea (Romania). *Acta Geologica Polonica*, 64(2): 161-187. DOI: 10.2478/agp-2014-0010

Chen Y.L., Twitchett R.J., Jiang H.S., Richoz S., Lai X.L., Yan C.B., Sun Y.D., Liu X.D. & Wang L.N. (2013) - Size variation of conodonts during the Smithian-Spathian (Early-Triassic) global warming event. *Geology,* 41(8): 823-826.

Chen Y.L., Jiang H.S., Lai X.L., Yan C.B., Richoz S., Liu X.D. & Wang L.N. (2015) - Early Triassic conodonts of Jiarong, Nanpanjiang Basin, southern Guizhou Province, South China. *Journal of Asian Earth Sciences*, 105: 104-121.

Chen. Y. L., Kolar-Jurkovšek T., Jurkovšek B., Aljinović D. & Richoz S. (2016) - Early Triassic conodonts and carbonate carbon isotope record of the Idrija-Žiri area, Slovenia. *Palaeogeography, Palaeoclimatology, Palaeoecology,* 444: 84-100.

Chen Y.L., Richoz S., Krystyn L. & Zhang Z. (2019) - Quantitative stratigraphic correlation of Tethyan conodonts across the Smithian-Spathian (Early Triassic) extinction event. *Earth Science Review*, 195: 37-51. https://doi.org/10.1016/j.earscirev.2019.03.004

Chen Y.L., Joachimski M.M., Richoz S., Krystyn L., Aljinović D., Smirčić D., Kolar-Jurkovšek T., Lai X. & Zhang Z. (2021) - Smithian and Spathian (Early Triassic) conodonts from Oman and Croatia and their depth habitat revealed. *Global and Planetary Change*, 196: 103362. https://doi.org/10.1016/j.gloplacha.2020.103362

Clark D.L., Paull R.K., Solien M.A. & Morgan W.A. (1979) - Triassic Conodont Biostratigraphy in the Great Basin. *Brigham Young University Geology Studies* 36(3): 179-183.

Dürkoop A., Richter D.K. & Stritzke R. (1986) - Facies, age and correlation of Triassic Red Limestones ("Hallstatt Type") from Epidavros, Adhami and Hydra (Greece). *Facies,* 14: 105-150.

Epstein A.G., Epstein J.B. & Harris L.D. (1977) - Conodont Color Alteration- an Index to Organic Metamorphism. *U. S. Geologicla Survey Professional Paper,* 995: 1-27.

Gaetani M., Jacobshagen, V., Nicora A., Kauffmann G., Tselepidis V., Fantini Sestini N., Mertmanann D. & Skourtsis-Coroneou V. (1992) - The Early-Middle Triassic boundary at Chios (Greece). *Rivista Italiana di Paleontologia e Stratigrafia*, 98: 181-204.

Gaetani M., Meço S., Rettori R., Henderson C.M. & Tulone A. (2015) - The Permian and Triassic in the Albanian Alps. *Acta Geologica Polonica*, 65(3): 271-295. DOI: 10.1515/agp-2015-0012

Grădinaru E. (1988) - Jurassic sedimentary rocks and bimodal volcanics of the Cârjelari-Camena Outcrop Belt: evidence for a transtensile regime of the Peceneaga-Camena Fault. *Studii si cercetari de Geologie, Geofizica, Geografie, Seria Geologie.* 33: 97-121.

Grădinaru E. (1995) - Mesozoic rocks in North Dobrogea: an overview. In: Săndulescu M. & Grădinaru E. (Eds) - Field Guidebook, Central and North Dobrogea, Romania, October 1-4, 1995. IGCP Project No. 369: 17-26. Comparative Evolution of Peri-Tethyan Rift Basins. Geological Institute of Romania, Bucharest.

Grădinaru E. (2000) - Introduction to the Triassic Geology of North Dobrogea Orogen - an overview of the Triassic System in the Tulcea Unit and the ammonoid biostratigraphy. In: Grădinaru E. (Ed.) - Workshop on the Lower-Middle Triassic (Olenekian-Anisian) boundary, 7-10 June 2000, Tulcea, Romania, Conference and Field Trip. Field Trip Guide: 5-37 Romanian Academy & University of Bucharest, Bucharest.

Grădinaru E., Kozur H.W., Nicora A. & Orchard M.J. (2006) - The *Chiosella timorensis* lineage and correlation of the ammonoids and conodonts around the base of the Anisian in the GSSP candidate at Deşli Caira (North Dobrogea, Romania). *Albertiana,* 34: 34-38.

Kittl E. (1908) - Beiträge zur Kenntnis der Triasbildungen der nordöstlichen Dobrudscha. *Denkschriften der kaiserlichen Akademie der Wissenschaften Wien. Mathematisch - naturwissenschaftliche Klasse,* 81: 447-532.

Koike T. (1981) - Biostratigraphy of Triassic conodonts in Japan. *Science Reports of Yokohama National University, Section* 2, 28: 25-42.

Koike T. (1992) - Morphological variation in Spathian conodonts *Spathoicriodus collinsoni* (Solien) from the Taho Limestone, Japan. In: Ishizaki K. & Saito T. (Eds) - Centenary of Japanese Micropaleontology: 355-364. Terra Scientific Publishing Company, Tokyo.

Kolar-Jurkovšek T., Chen Y.L., Jurkovšek B., Poljak M., Aljinović D. & Richoz S. (2017) - Conodont biostratigraphy of the Early Triassic in eastern Slovenia. *Paleontological Journal*, 51(7): 687-703.

Kolar-Jurkovšek T. & Jurkovšek B. (2015) - Conodont zonation of Lower Triassic strata of Slovenia. *Geologija,* 58(2): 155-174. http://dx.doi.org/10.5474/geologija.2015.012

Kolar-Jurkovšek T. & Jurkovšek B. (2019) - Konodonti Slovenije / Conodonts of Slovenia. Geološki zavod Slovenije, Ljubljana, 260 pp.

Kolar-Jurkovšek T., Jurkovšek B., Vuks V.J., Hrvatović H., Aljinović D., Šarić Ć. & Skopljak F. (2014) - The Lower Triassic platy limestone in the Jajce area (Bosnia and Herzegovina). *Geologija,* 57(2):105-118. doi:10.5474/geologija.2014.009

Kolar-Jurkovšek T., Vuks J.V., Aljinović D., Hautmann M., Kaim A. & Jurkovšek B. (2013) - Olenekian (Early Triassic) fossil assemblage from Eastern Julian Alps (Slovenia). *Annales Societatis Geologorum Poloniae* 83: 213-227.

Kolar-Jurkovšek T., Hrvatović H., Aljinović D., Nestell G.P., Jurkovšek B. & Skopljak F. (2021) - Permian-Triassic biofacies of the Teočak section, Bosnia and Herzegovina. *Global and Planetary Change*, 200: 103458. https://doi.org/10.1016/j.gloplacha.2021.103458

Kozur H. (2003) - Integrated ammonoid, conodont and radiolarian zonation of the Triassic and some remarks to Stage/Substage subdivision and the numeric age of the Triassic stages. *Albertiana,* 28: 57-74.

Kozur H. & Mostler H. (1970) - Neue Conodonten aus der Trias. *Berichte des Naturwissenschaftlich-medizinischen Vereins in Innsbruck*, 58: 429-464.

Krahl J., Kauffmann G., Kozur H., Richter D., Foerster O. & Heinritzi F. (1983) - Neue Daten zur Biostratigraphie und zur tektonischen Lagerung der Phyllit-Gruppe und der Trypali-Gruppe auf den Insel Kreta (Griechenland). *Geologische Rundschau,* 72: 1147-1166.

Krystyn L. (2005) - A revised Lower Triassic intercalibrated ammonoid-conodont time scale of the eastern Tethys Realm based on Himalayan data. *Albertiana,* 33: 53-54.

Lindström M. (1970) - A suprageneric taxonomy of the conodonts. *Lethaia,* 3: 427-445.

Lucas S.G. (2013) - A new Triassic Timescale. In: Tanner L.H., Spielmann J.A. & Lucas S.G. (Eds) - The Triassic System: 366-374. *New Mexico Museum of Natural History Bulletins,* 61.

Lucas S.G. & Orchard M.J. (2007) - Triassic lithostratigraphy and biostratigraphy north of Currie, Elko County, Nevada. *New Mexico Museum of Natural History Bulletins,* 40: 119-126.

Lucas S.G. & Tanner L.H. (2014) - The Triassic Timescale 2013. In: Rocha R. et al. (Eds) - STRATI 2013: 19-22. Springer Geology.

Lyu Z., Orchard M.J., Golding M.L., Henderson C.M., Chen Z.-Q., Zhang L., Han C., Wu S., Huang Y., Zhao L., Bhat G.M. & Baud A. (2021) - Lower Triassic conodont biostratigraphy of the Guryul Ravine section, Kashmir. *Global and Planetary Change*, 207: 103671.

Maekawa T. & Komatsu T. (2014) - Conodont succession. In: Shigeta Y., Komatsu T., Maekawa T. & Tran H.D. (Eds) - Olenekian (Early Triassic) Stratigraphy and Fossil Assemblages in Northeastern Vietnam, vol. 45: 51-54. National Museum of Nature and Science Monographs, Tokyo, Japan

Maekawa T., Komatsu T., Koike T. (2018) - Early Triassic conodonts from the Tahogawa Member of the Taho Formation, Ehime Prefecture, Southwest Japan. *Paleontological Research*, supplement to vol. 22: 1-62. DOI: 10.2517/2018PR001

Meço S. (1999) - Conodont biostratigraphy of Triassic pelagic strata, Albania. *Rivista Italiana di Paleontologia e Stratigrafia*, 105(2): 251-266.

Mietto P., Fratoni R.P. & Perri M.C. (1991) - Spathian and Aegean conodonts from the Capelluzzo Calcarenites of the Monte Facito Group (Lagonegro Sequence, southern Apennines). *Memorie di Scienze Geologiche, Universita di Padova*, 43: 305-317.

Mirăuţă O. (1966) - Dévonien et Trias des collines de Mahmudia (Dobrogea septentrionale). *Dări de Seamă ale Şedinţelor, Institutul Geologic al României*, 52(2): 115-134.

Mirăuţă E. (1974) - Über die Conodontenfaunen des oberen Werfens und des tieferen Anis der nördlichen Dobrudscha/Rumänien. *Geology and Palaeontology* 8: 149-158.

Mirăuţă E. (1982) - Biostratigraphy of the Triassic deposits in the Somova-Sarica Hill zone (North Dobrogea) with special regard on the eruption age. Dări de seamă, Institutul de *Geologie* ş*i Geofizică,* 67(4): 63-78.

Mirăuţă E. & Iordan M. (1982) - New Triassic fossiliferous localities in the Tulcea Zone (North Dobrogea). *Dări de seamă, Institutul de Geologie* ş*i Geofizică,* 66: 15-22.

Mirăuţă E., Iordan M. & Gheorghian D. (1984) - New biostratigraphic data on the Triassic from the Somova-Sarica Hill area (Tulcea Zone, North Dobrogea). *Dări de seamă ale Şedinţelor, Institutul de Geologie* ş*i Geofizică,* 68: 35-48.

Mosher L.C. (1968) - Triassic conodonts from western North America and Europe and their correlation. *Journal of Paleontology*, 42: 895-946.

Muttoni G., Kent D.V., Meço S., Nicora A., Gaetani M., Balini M., Germani D. & Rettori R. (1996) - Magnetobiostratigraphy of the Spathian to Anisian (Lower to Middle Triassic) Kçira section, Albania. *Geophysical Journal International,* 127: 503-514.

Okay A.I., Şengör A.M.C. & Görür N. (1994) - Kinematic history of the opening of the Black Sea and its effect on the surrounding regions. *Geology,* 22: 267-270.

Orchard M.J. (1995) - Taxonomy and correlation of Lower Triassic (Spathian) segminate conodonts from Oman and revision of some species of *Neospathodus*. *Journal of Paleontology,* 69(1): 110-122.

Orchard M.J. (2005) - Multielement conodont apparatuses of Triassic Gondolelloidea. *Special Papers in Palaeontology,* 73: 1-29.

Orchard M.J. (2022) - North American Spathian (Upper Olenekian, Lower Triassic) neogondolellin conodonts. *Papers in Palaeontology,* 8(1): e1409. doi: 10.1002/ssp2.1409

Orchard M J., Grădinaru E. & Nicora A. (2007) - A summary of the conodont succession around the Olenekian-Anisian boundary at Deşli Caira, North Dobrogea, Romania. In: Lucas S.G., Spielmann J.A. (Eds) - The Global Triassic: 341-346. *New Mexico Museum of Natural History Bulletins,* 41.

Péron S., Bourquin S., Fluteau F., Guillocheau F. (2005) - Paleoenvironment reconstructions and climate simulations of the Early Triassic: Impact of the water and sediment supply on the preservation of fluvial systems. *Geodinamica Acta,* 18(6): 431-446.

Perri M.C. (1986) - A Spathian conodont fauna from the Cencenighe Member of Werfen Formation (Scythian), southeastern Dolomites, Italy. *Bollettino della Società Paleontologica Italiana*, 24: 23-28.

Perri M.C. & Andraghetti M. (1987) - Permian-Triassic boundary and Early Triassic conodonts from the southern Alps, Italy. *Rivista Italiana di Paleontologia e Stratigrafia*, 93: 291-328.

Săndulescu M. (1995) - Dobrogea within the Carpathian Foreland. In: Săndulescu M. & Grădinaru E. (Eds.) - IGCP Project No. 369: 1-4. Comparative Evolution of Peri Tethyan Rift Basins. Central and North Dobrogea, Romania, October 1-4, 1995. Field Guidebook. Geological Institute of Romania & University of Bucharest, Bucharest.

Şengör A.M.C. (1984) - The Cimmeride orogenic system and the tectonics of Eurasia. *Geological Society of America Special Papers* 195: 1-82.

Simionescu I. (1908) - Über das Vorkommen der Werfener Schichten in Dobrogea (Rumänien). *Verhandlungen der Kaiserlich-Königlichen Geologischen Reichsanstalt* 7: 159-161.

Simionescu I. (1910) - Studii geologice şi paleontologice din Dobrogea. III. Fauna triasică dela Deşli-Caıra. La faune triasique de Deşli-Caıra (Dobrogea). *Academia Română, publicaţiunile fondului Vasile Adamachi,* 26: 495-524. [in Romanian, French summary].

Simionescu I. (1911) - Studii geologice şi paleontologice din Dobrogea. V. Fauna triasică inferioarâ din Dobrogea (La faune du Trias inferieur de Dobrogea). *Academia Română, publicaţiunile fondului Vasile Adamachi,* 5(29): 63-79. [in Romanian, French summary]

Simionescu I. (1913) - Studii geologice şi paleontologice din Dobrogea. VI. Fauna amoniţilor triasici dela Hagighiol. Les ammonites triasiques de Hagighiol (Dobrogea). *Academia Română, publicaţiunile fondului Vasile Adamachi,* 34: 271-371. [in Romanian, French summary]

Simionescu I. (1925) - Păturile cu Daonella în Dobrogea (Les couches à Daonella de Dobrogea). *Academia Română, publicaţiunile fondului Vasile Adamachi,* 43:1-10 [in Romanian, French summary].

Simionescu I. (1927) - Aperçu géologique sur la Dobrogea. In: Guide des excursions, Cultura Naţională: 353-378. Association pour l'avancement de la géologie des Carpates. Deuxième réunion en Roumanie. Bucarest.

Steuber T. (1992) - Condonten-Stratigraphie triadischer Ablagerungen am Golf von Korinth (Griechenland) und von der Halbinsel Karaburun (Türkei). *Neues Jahrbuch für Geologie und Paläontologie*, 3: 171-191.

Sun Y.D., Richoz S., Krystyn L., Grasby S.E., Chen Y.L., Banerjee D. & Joachimski M.M. (2021) - Integrated bio-chemostratigraphy of lower and Middle Triassic marine successions at Spiti in the Indian Himalaya: Implications for the early Triassic nutrient crisis. *Glob. Planet. Chan.*, 196: 103363.

Sweet W.C., Mosher L.C., Clark D.L., Collinson J.W. & Hasenmueller W.H. (1971) - Conodont biostratigraphy of the Triassic. In: Sweet W.C. & Bergström S.M. (Eds) - Symposium on Conodont Biostratigraphy: 441-465. Geological Society of America Memoir, 127.

Tian C.R., Dai J. & Tian S.G. (1983) - Triassic Conodonts. In: Chengdu Institute of Geology and Mineral Resources (Eds) - Paleontological Atlas of Southwest China, Volume of microfossils: 345-398. pls. 79-100. Geological Publishing House, Beijing.

Tozer E.T. (1984) - The Trias and its Ammonoids, The Evolution of a Time Scale. Geological Survey of Canada,

Miscellaneous Report 35, 170 pp.
Zhao L.S., Orchard M.J., Tong J.N., Sun Z.M., Zuo J.X., Zhang S.X. & Yun A.L. (2007) - Lower Triassic conodont sequence in Chaohu, Anhui Province, China and its global correlation. *Palaeogeography, Palaeoclimatology, Palaeoecology,* 252: 24-38.
Zhao L.S., Tong J.N., Zhang S.X. & Sun Z.M. (2008) - An Update of Conodonts in the Induan-Olenekian Boundary Strata at West Pingdingshan Section, Chaohu, Anhui Province. *Journal of China University of Geosciences,* 19(3): 207-216.