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MIDDLE TRIASSIC (ANISIAN) CEPHALOPODS FROM THE MECSEK MOUNTAINS, HUNGARY

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Abstract. Recent nautiloid and ammonoid finds from the Middle Triassic Zuhánya Limestone Formation in the Mecsek Mountains (south Hungary) proved that the formation encompasses the whole Pelsonian and the lower Illyrian substages of the Anisian Stage. On the basis of 11 identified ammonoid species, the Balatonicus and Trinodosus zones have a complete record. The stratigraphical position of the Zuhánya Limestone on the whole corresponds to the Felsőörs Limestone in the Balaton Highland. The palaeobiogeographical evaluation of the cephalopod fauna showed that the elements of the nautilid fauna point mostly to Germanic and partly to Sephardic affinity. On the other hand, the ammonoid fauna has no Germanic elements; most of the species are Alpine in character, while the species *Procladiscites brancoi* indicates Dinaridic connection, or at least an occasional appearance of pelagic organisms. These results endorse the previous palaeogeographical assumption and suggest that during the Middle Triassic the Mecsek succession was situated along the European shelf, between the Vindelician-Bohemian Land and the open Tethyan Ocean.

Introduction

The Mecsek Mountains in southern Hungary expose a tripartite Triassic sedimentary succession: Middle Triassic marine carbonates sandwiched between Lower and Upper Triassic continental and peritidal siliciclastic sediments. The apparent similarity of the Mecsek succession to the Germanic Triassic was recognized long ago (Vadász 1935; Nagy 1968). As for the Middle Triassic carbonates, the "Germanic affinity" was further supported by details of the lithofacies, and the bivalve and brachiopod fauna (Török 1993, 1997, 2000).

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Among the Anisian formations of the Mecsek Mountains the Zuhánya Limestone Formation is the richest in marine fossils. In contrast to the abundant, at places massive, occurrence of bivalves and brachiopods, cephalopods and especially ammonoids count as extreme rarities in the formation. Only a few taxa, represented mostly by single specimens, have been reported so far (Böckh 1876, 1881; Vadász 1935; Nagy 1968; Detre 1973). The described specimens are absent from public collections, their present locations are unknown.

In the past decades new cephalopod fossils have been found in outcrops of the Zuhánya Limestone Fm. These not only significantly increased (more than doubled) the number of cephalopod

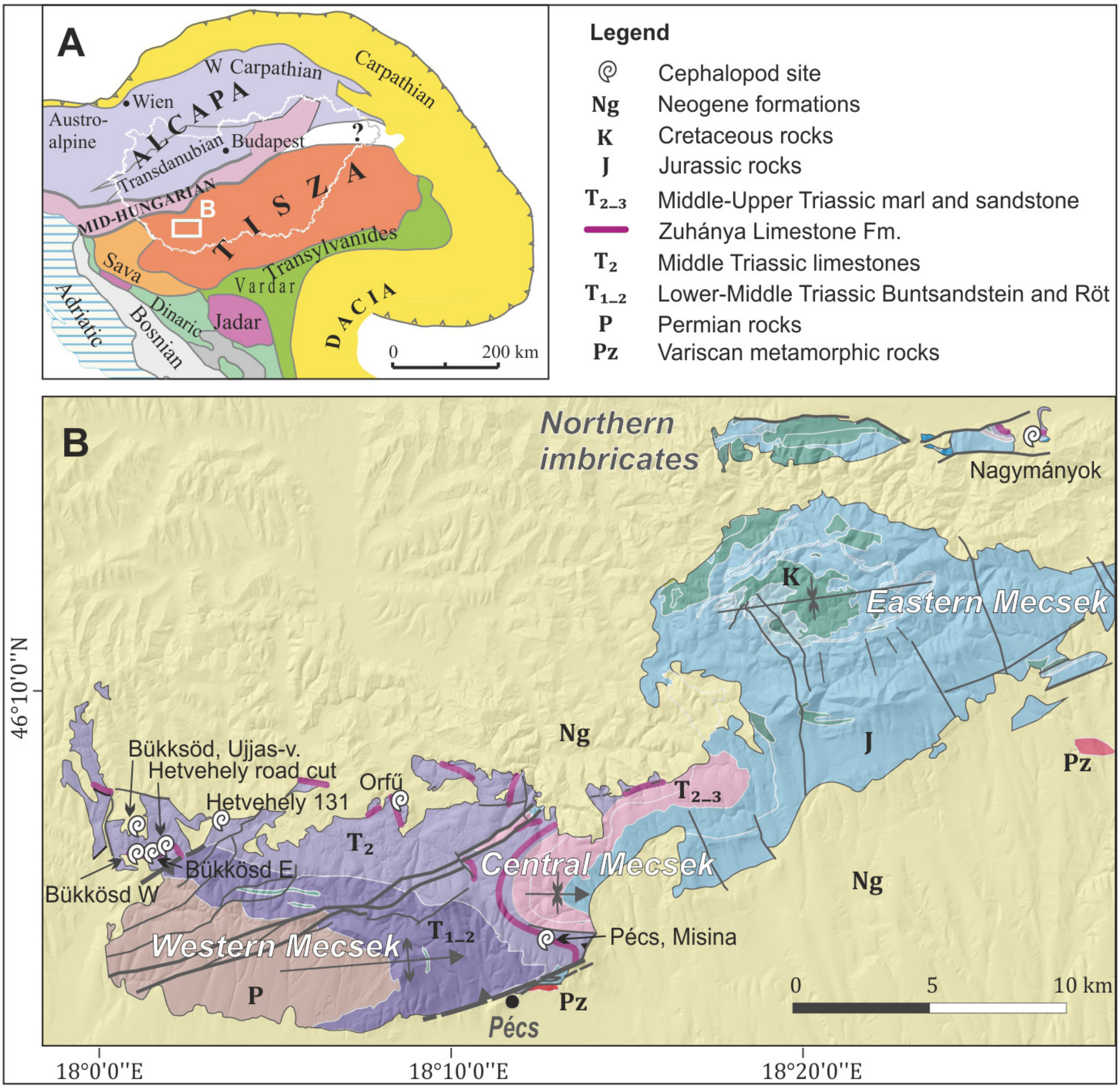


Fig. 1 - Location of the study area. A) Tectonic units of the Pannonian Basin and its surroundings (Haas et al. 2010). B) The Mecsek Mts. with the cephalopod locations. Base map after Kercsmár et al. (2015) and Konrád & Sebe (2010).

remains known from the Anisian of the area, but included age indicators as well, and also taxa unexpected for the German-type Triassic of the region. Here we describe the new finds, and after the revision of previously reported specimens, we give a stratigraphic and palaeogeographical evaluation.

Geological setting

The Tisza or Tisza-Dacia Unit or microplate, which hosts the Mecsek Mts., is a lithospheric plate fragment forming the basement in the southeastern half of the Pannonian Basin (Haas et al. 2010; Csontos & Vörös 2004; Haas & Péró 2004; Kovács et al. 2011) (Fig. 1A). It separated from the European continent during the Jurassic and occupied its present position in the Miocene. Within Hungary, this tectonic unit crops out in only two relatively small areas in the southwest, the Mecsek Mts. and the Villány Hills. Triassic rocks are exposed in both ranges, although the entire series is accessible only in the Mecsek Mts. During the Triassic, the area was located on the northern shelf of the Tethys Ocean,

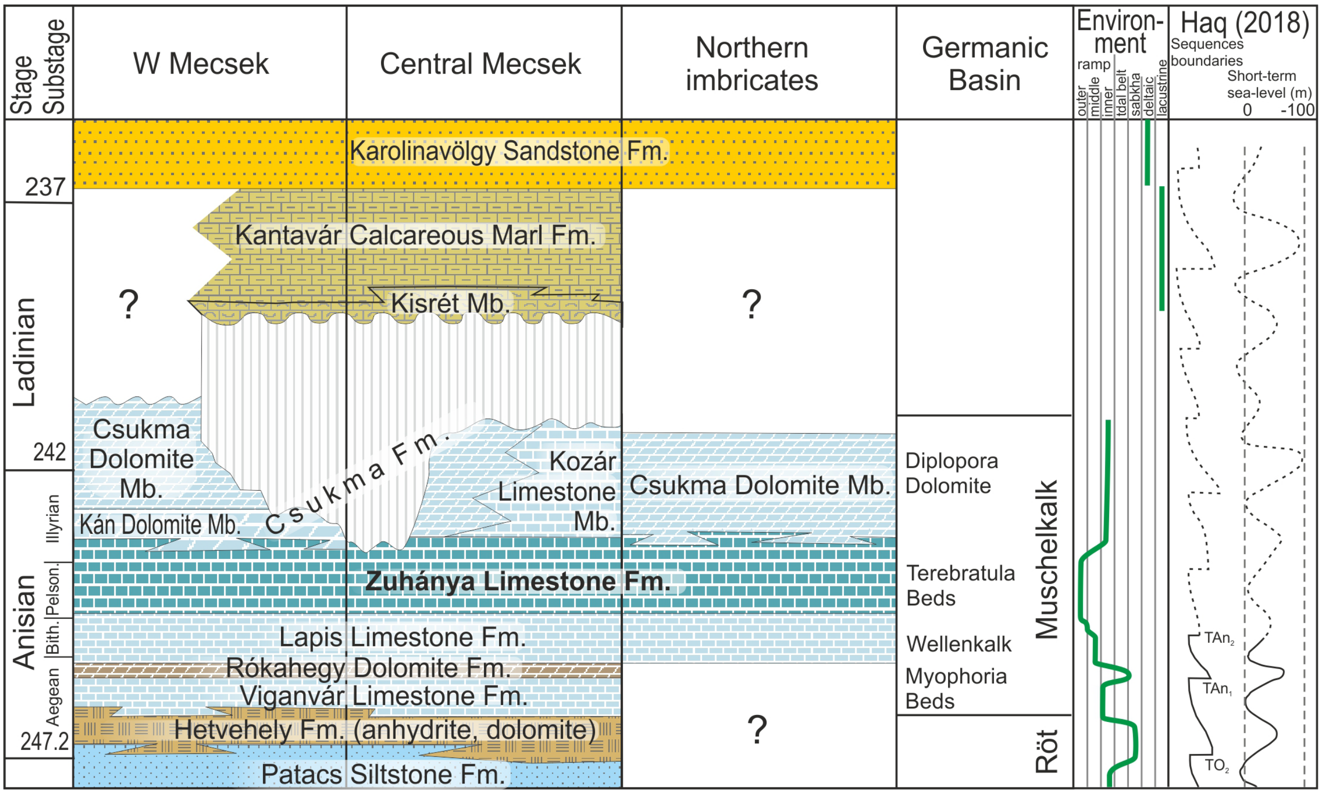


Fig. 2 - Middle Triassic stratigraphy of the study area. Numerical calibration of the chronostratigraphic scale from Haq (2018).

southeast of the mainland of the Bohemian (Vindelician) Massif (Dercourt et al. 2000; Szulc 2000; Pozsgai et al. 2017). Despite its location along the open Tethys margin, the Middle Triassic sedimentary succession ("Röt", "Wellenkalk", "Terebratula beds") and the enclosed benthic fauna shows strong affinities to the Germanic Basin, and the Middle Triassic formations display the highest similarity to the Germanic facies (Török 1997).

Stratigraphy

Among the Middle Triassic stratigraphic units of the Tisza Unit, the Anisian Zuhánya Limestone Fm. (Fig. 2) was deposited in the deepest water (Nagy 1968). Its typical lithofacies include thick-bedded nodular limestone with marlstone matrix, alternation of thin limestone and marl beds, and thick coquinas of brachiopod and bivalve shells. Its thickness ranges between 50 and 100 m. Among the Triassic sediments this is the only one to host brachiopods – with the dominance of *Coenothyris vulgaris* (Schlotheim, 1820) – cephalopods and conodonts. The abundant and diverse fauna represents the final stage of biotic recovery after the end-Permian mass extinction (Foster & Sebe 2017). Sedimentary structures and the foraminifer *Glomospira* indicate deposition in a relatively deepwater environment, on a distal carbonate ramp (Rálischné Felgenhauer & Török 1993). The large limestone nodules (intraclasts) and frequent slumps pointing to re-deposition and the significant lateral thickness changes refer to the disintegration of the Tethyan shelf and the formation of fault-controlled sub-basins during sediment accumulation (Konrád 1998). The formation used to be subdivided into the fauna-rich Bertalanhegy Limestone Member and the Dömörkapu Limestone Member dominated by nodular limestones (Nagy 1968); however, later investigations revealed that these lithotypes alternate within the succession (Konrád & Sebe 2007).

Based on the conodont assemblage *Gondolella bifurcata*, *G. bifurcata hanbulogi* and *G. bulgarica* the formation was ascribed by Kovács & Papšová (1986) to the uppermost Pelsonian or lowermost Illyrian, namely into the *Paraceratites binodosus* ammonoid zone, which was previously indicated by Detre (1973). Hagdorn et al. (1997) considered the key section of the Zuhánya Limestone Fm. (Pécs-Misina) to belong to the *Holocrinus dubius* crinoid biozone in the upper Pelsonian. Rálischné Felgenhauer & Török (1993) consider that fauna-rich layers belong to the Pelsonian and Illyrian substages, while the upper, fauna-poor part may extend to the lower Ladinian as well.

Previous publications mentioned six ammonoid taxa besides an "*Orthoceras* sp." and partly illustrated them, without giving the exact location where the fossils were found, as follows:

Böckh (1876, 1881):	*Ammonites thuillieri*
Vadász (1935):	*Orthoceras* sp.
	Ceratites binodosus Hau. sp.
	Ceratites Thuilleri Opp. sp.
	Ceratites sp. ind.
	Ptychites involvens Mojs. [sic]
Nagy (1968):	*Ceratites* cf. *thuillieri* Opp.
	Ceratites binodosus Hau.
	Ceratites cf. *lennanus* Mojs.
	Ceratites sp.
	Ptychites evolvens Mojs.
	Acrochordiceras cf. *carolinae* Mojs.

The specimens of the above listed taxa were available in 1990 in the collections of the Geological Institute of Hungary, where the first author (A.V.) checked them, but in the last years our attempts to locate them in any public collection have failed.

Detre (1973) illustrated a specimen of *Paraceratites binodosus* (Hauer, 1851) from Pécs, and mentioned the same species in an unpublished manuscript report from Hetvehely. These specimens also appear to be lost.

Localities

The studied cephalopod specimens originate from various localities within the western Mecsek Mts. (Fig. 1). Their geographical co-ordinates are listed in Tab. 1.

Three of the listed sites are active quarries, with continuously changing exposures (Fig. 3). They all expose the lower boundary and the lower part of the Zuhánya Limestone Fm. The valley west of the spring Sárkány-kút, southwest of the village Orfű, is another large outcrop, exposing nearly the whole thickness of the studied formation. The Misina road cut in the city of Pécs is the key section of the Zuhánya Limestone Fm.; however, it is mostly covered these days and the rock can hardly be seen.

Cephalopods have been collected from both typical lithofacies of the formation, from thin-bedded, wavy limestone-marlstone alternations, and from nodular limestones (Fig. 3 A, B). Especially in the latter, fossils are hard to recognise, they are often fragmentary, and their surface is commonly dissolved and covered with marlstone (Fig. 3 C-D). Several cephalopods were found on talus cones (Fig. 3 A).

Site	Longitude	Latitude
Bükkösd, W quarry	18.0170749234	46.1251321743
Bükkösd, E quarry	18.0237513956	46.1249762789
Bükkösd, Ujjas-völgy	18.0169850081	46.1293334866
Hetvehely, road cut	18.029297667	46.1251980968
Hetvehely, outcrop 131	18.0544711204	46.1364792326
Orfű, valley west of Sárkány-kút	18.1470963861	46.1438091604
Pécs-Misina, key section	18.2268880254	46.0992089781
Nagymányok, quarry	18.4490733066	46.2642933017

Tab. 1 - Location of sites with cephalopod fossils.

Methods

Most of the specimens were found by chance during stratigraphic or sedimentological field work. Organised collecting campaigns with numerous participants did not produce more finds than field work with only a few people. The studied fossils were collected by Gyula Konrád, Krisztina Sebe, Tamás Müller, István-Róbert Bartha, Tamás Budai and Ákos Török. The *Procladiscites* cf. *brancoi* specimen was collected by István Venkovics in 1952.

Cephalopod fauna

The cephalopod material available from the Anisian Zuhánya Formation consists of 16 specimens (5 nautilida, 11 ammonoidea), and represents 11 taxa, ten of which are identified at the genus and/or species level. The full list of the fauna (including indeterminate ones) is as follows:

Germanonautilus salinarius (Mojsisovics, 1882)
Germanonautilus bidorsatus (Schlotheim, 1820)
Germanonautilus sp. indet.
Acrochordiceras carolinae Mojsisovics, 1882
Schreyerites ? *binodosus* (Hauer, 1851)
Lardaroceras ? *barrandei* (Mojsisovics, 1882)
Procladiscites brancoi Mojsisovics, 1882
Discoptychites megalodiscus (Beyrich, 1867)
Discoptychites sp.
Ceratitidae spp.

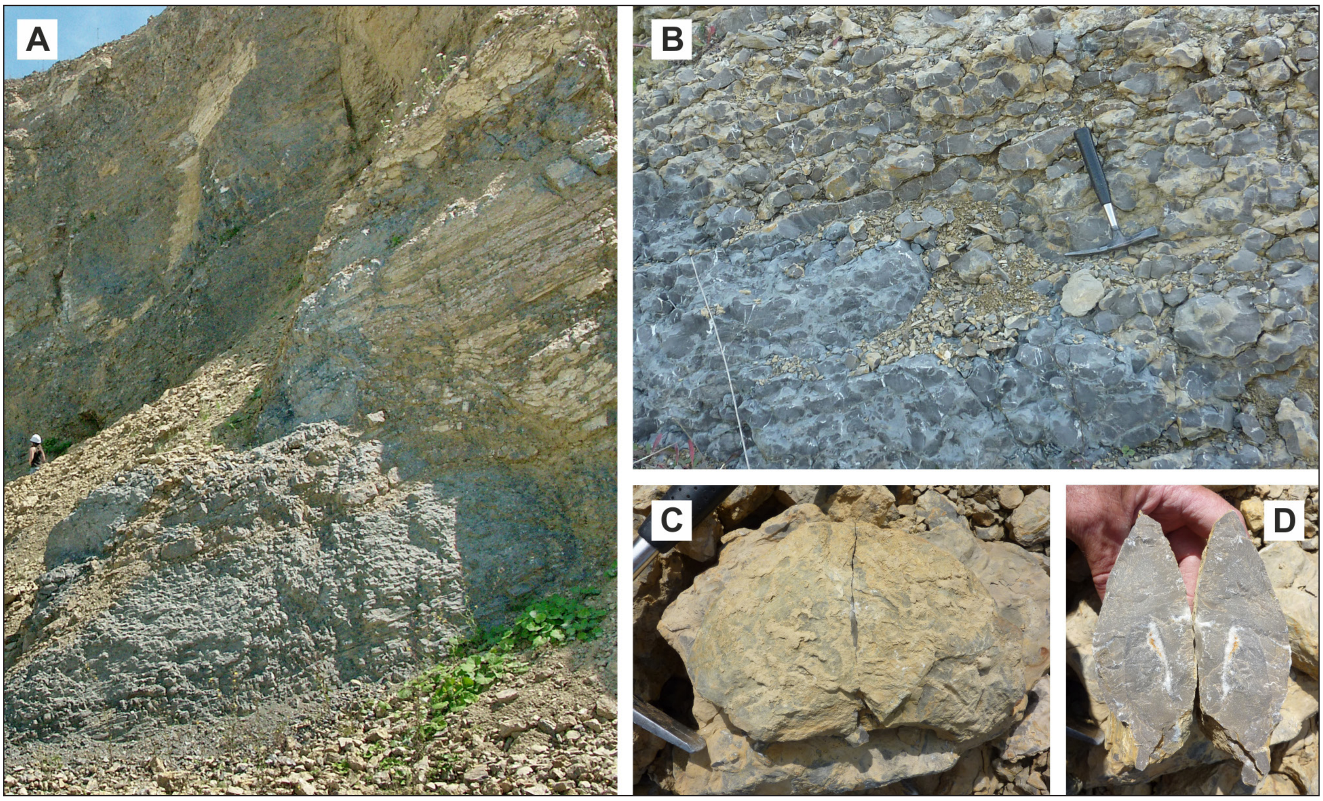


Fig. 3 - Outcrops of the Zuhánya Limestone Fm. and its cephalopod fossils. A) Exposure in the western quarry near the village Bükkösd, with nodular and thin-bedded limestone (lower outcrop of 'Bükkösd, western quarry' with *Acrochordiceras* in Fig. 4). Person for scale. B) Close-up view of nodular limestone with marly matrix; C-D) *Discoptlychites* as it was found in the field.

Considering the low number of specimens the taxonomic diversity of the cephalopod fauna is rather high. The formation probably contains more cephalopod fossils than previously thought, but the poor preservation, primarily the dissolved surface of the remains, hinders their detection in the field. The hardly noticeable and identifiable cephalopod fragments suggest that some shells might have been broken by sediment reworking processes like slumping, which produced the frequent intraclastic layers of the formation.

Biochronostratigraphic evaluation

Some of the ammonoid taxa found in the Zuhánya Limestone Formation bear biochronostratigraphical significance. On the basis of the ample stratigraphical record from the Southern Alps (Monnet et al. 2008), the Northern Calcareous Alps (Tatzreiter & Vörös 1991) and the Balaton Highland (Vörös 2003, 2018) the presence of *Acrochordiceras* marks the lower horizon of the middle Anisian *Balatonites balatonicus* ammonoid zone. This endorses the previously assumed stratigraphical position of the section of the Bükkösd quarry. The *Lardaroceras* species characterizes the higher part of the Illyrian *Paraceratites trinodosus* ammonoid zone (Balini 1992; Vörös 2018); this proves the presence of beds considerably younger than those previously mentioned (Detre 1973) in the Pécs-Misina section.

Fig. 4 summarizes the new biochronostratigraphical results and the inferred correlation between the Anisian ammonite-bearing strata of the Mecsek Mts. and the ammonoid biochronostratigraphical units established at the Balaton Highland (Vörös 2003, 2018). The section of the Bükkösd western quarry encompasses mostly the interval of the *Balatonites balatonicus* ammonoid zone, i.e. almost the entire Pelsonian. The Orfű, Sárkány-kút section reaches up to the Illyrian *Schreyerites binodosus* ammonoid subzone.

The stratigraphical position of the Pécs, Misina key section is substantially re-evaluated (Fig. 4). The ammonoid specimen identified by Detre (1973) as *Paraceratites binodosus* seems to be lost (at least our attempts to locate it in any collections have failed), but the drawing published by Detre (1973, fig. 1) shows suture lines clearly of ceratitic type (with entirely smooth saddles). This contradicts the attribu-

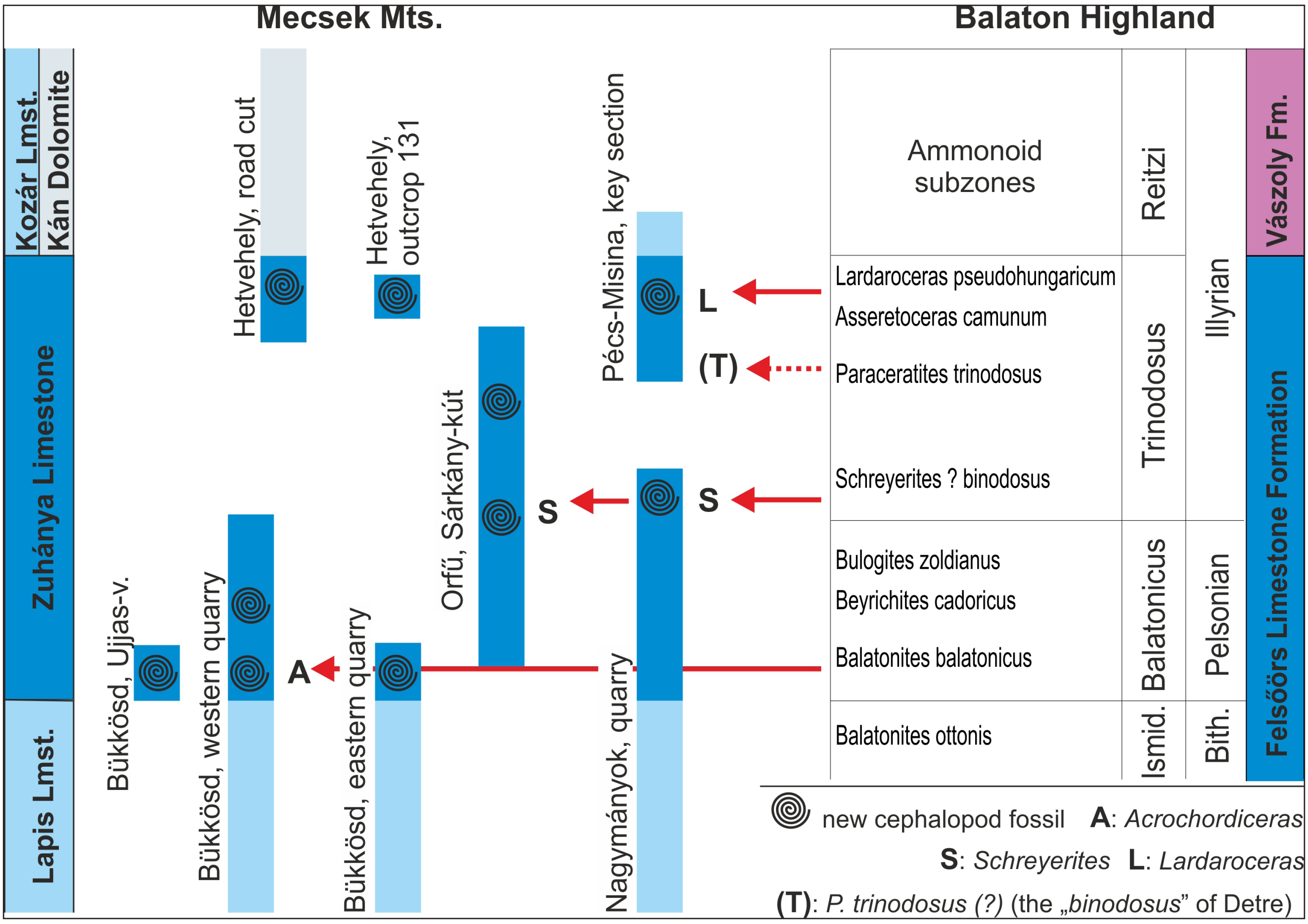


Fig. 4 - Stratigraphic position of the studied cephalopod specimens and correlation with the biochronostratigraphic units established in the Balaton Highland (after Vörös 2003, 2018).

tion to the genus *Schreyerites* (the host of the species *binodosus*), which has a subammonitic suture (Tatzreiter & Balini 1993). Consequently, Detre's specimen may not belong to "*Paraceratites*" *binodosus* but, considering its sutures, rather to *Paraceratites trinodosus*. This is indirect evidence of the Illyrian (*Paraceratites trinodosus* ammonoid zone) age of the respective part of the Misina section, further supported by the presence of *Lardaroceras* in the same locality.

This correlation extends the lower boundary of the Zuhánya Limestone Fm. compared to recent investigations on carbon isotopes (Foster et al. 2021), to the Bithynian/Pelsonian boundary.

Palaeobiogeographic discussion

The Triassic faunal provinces were recognized long ago in Europe. The separation between the facies and fauna of Alpine (Tethyan) and the "ausseralpinen" (German) Triassic was discussed early by Alberti (1864) and Gümbel (1873). The significance of the cephalopod distributions was pointed out by Mojsisovics (1874), who, besides the "ausseralpinen", outlined two Alpine cephalopod provinces (Juvavic and Mediterranean). The same recognition was implied in his magnificent monograph (Mojsisovics 1882), emphasized even by the title: "Die Cephalopoden der mediterranen Triasprovinz".

A further, Sephardic province, along the African margin of the Tethys, was recognized by Hirsch (1972, 1976, 1977) first on the basis of conodont faunas, but later supported also by ammonoid distributions in the Middle Triassic (Parnes et al. 1985). These modern evaluations defined and illustrated three provinces in the western Tethys: Germanic, Sephardic and Alpine (= Mediterranean = Tethyan), with local transitional zones between the latter two.

Urlichs & Mundlos (1985) and recently Siegel et al. (2022) gave a detailed study on the geographical distribution of ammonoids within the Germanic province with special emphasis on the phenomenon

Tab. 2 - Geographical distribution of Middle Triassic ammonoid taxa of the Mecsek fauna outside the Mecsek Mountains.

Middle Triassic ammonoid taxa of the Mecsek fauna			
N.	Locality	Taxa	Source
1.	Northern Calcareous Alps (Austria)	*Acrochordiceras carolinae* *Schreyerites binodosus* *Procladiscites brancoi* *Discoptychites megalodiscus*	Mojsisovics (1882) Arthaber (1896)
2.	Balaton Highland (Hungary)	*Acrochordiceras carolinae* *Schreyerites binodosus* *Lardaroceras barrandei* *Discoptychites megalodiscus*	Vörös (2003, 2018)
3.	Southern Alps (Italy)	*Acrochordiceras carolinae* *Schreyerites binodosus* *Discoptychites megalodiscus*	Hauer (1851) Mojsisovics (1882) Sacchi Vialli & Vai (1958)
4.	Drvar, Peći (Bosnia-Herzegovina)	*Discoptychites megalodiscus*	Toula (1913)
5.	Han Bulog, Sarajevo (Bosnia-Herzegovina)	*Acrochordiceras carolinae*	Spath (1934)
6.	Budva (Montenegro)	*Procladiscites brancoi*	Salopek (1913)
7.	Golo-Bârdo (Bulgaria)	*Discoptychites megalodiscus*	Stefanoff (1936)
8.	Gebze, Izmit (Turkey)	*Acrochordiceras carolinae* *Schreyerites binodosus* *Discoptychites megalodiscus*	Toula (1896) Arthaber (1915)

of immigrations of the Alpine faunal elements. Vörös (1992) published a palaeobiogeographical analysis of the Middle Triassic ammonoids of the Alpine-Carpathian-Dinaric area, on the basis of the distribution of some diagnostic taxa, with an outlook to the Germanic province. A few data, taken from Nagy (1968), showed that the Mecsek fauna was Alpine in character. Recently, Pérez-Valera et al. (2017) made a valuable work on Middle Triassic nautiloids of the western Tethyan region. They confirmed that southern Spain belonged to the Sephardic province, but Germanic nautiloid taxa occurred here along with Sephardic taxa.

Large-scale palaeobiogeographical analyses of Middle Triassic ammonoids were also prepared (e.g., Tozer 1982; Dagys 1988; Page 1996). The scope of these works was of Panthalassic scale, therefore they provided less details for the provinces of the western part of the Tethys. The same is true for the most recent contribution by Brayard et al. (2015), where multivariate methods (e.g.: hierarchical cluster analysis and nonmetric multidimensional scaling) were applied. The faunal similarities and the palaeogeographical relationships were expressed by bootstrapped spanning network, but the resolution of this study for the bulk faunas of the western Tethyan part was regrettably restricted.

The low diversity and abundance of the Anisian cephalopod fauna of the Mecsek Mts. (nine taxa, 16 specimens) obviously do not permit a similar detailed multivariate palaeobiogeographical analysis. Nevertheless, the geographical distributions of particular taxa show a remarkable pattern, which deserves consideration. The section "Systematic descriptions" enumerates the occurrence data of the described taxa but in a rather narrative style; therefore here the dataset is given in a tabular form, arranged according to localities (Tabs. 2, 3).

The present study is focused on the western part of the Tethys, including the European and African margins, i.e., the Middle Triassic shelf and epicontinental basins. An array of Mesozoic palaeotectonic, palaeogeographic maps of the western Tethyan region were published in the last decades (e.g. Dercourt et al. 2000; Stampfli & Borel 2002; Golonka 2004), and some others also appeared with focus on the Middle Triassic (e.g. Muttoni et al. 2000; Szulc 2000; Feist-Burkhardt et al. 2008; Hagdorn 2020). Considering the later (Jurassic and Cretaceous) history of palaeogeographic movements of the Tisza Unit (e.g. Csontos & Vörös 2004), for the purpose of the present palaeobiogeographical approach we used a simplified map based mainly on Dercourt et al. (2000) and Muttoni et al. (2000) (Figs. 5, 6). Here the inferred palaeogeographical position of the Mecsek Mts. is along the Tethyan shelf margin on the southern side of the Vindelician-Bohemian landmass.

Looking at our database it was obvious at the first glance that there were significant differences between the distributions of the nautiloid and ammonoid taxa recorded in the Mecsek fauna, therefore the occurrence data of the two fossil groups are presented in two separate tables (Tabs. 2, 3). The same dataset is portrayed in palaeogeographical sketch maps (Figs. 5 and 6).

Middle Triassic nautiloid taxa of the Mecsek fauna			
N.	Locality	Taxa	Source
1.	Northern Calcareous Alps (Austria)	*Germanonautilus salinarius*	Mojsisovics (1882)
2.	Balaton Highland (Hungary)	*Germanonautilus salinarius*	Vörös (2001)
3.	Silesia (Poland)	*Germanonautilus salinarius* *Germanonautilus bidorsatus*	Assmann (1937) Dzik (1984)
4.	Würzburg (Germany)	*Germanonautilus bidorsatus*	Mundlos & Urlichs (1984) Urlichs (2000)
5.	Heidelberg (Germany)	*Germanonautilus salinarius* *Germanonautilus bidorsatus*	Mundlos & Urlichs (1984) Urlichs (2000)
6.	Betic Cordilleras (Spain)	*Germanonautilus bidorsatus*	Goy & Martinez (1996) Pérez-Valera et al. (2017)
7.	Negev (Israel)	*Germanonautilus salinarius* *Germanonautilus bidorsatus*	Parnes (1986)

Tab. 3 - Geographical distribution of Middle Triassic nautiloid taxa of the Mecsek fauna outside the Mecsek Mountains.

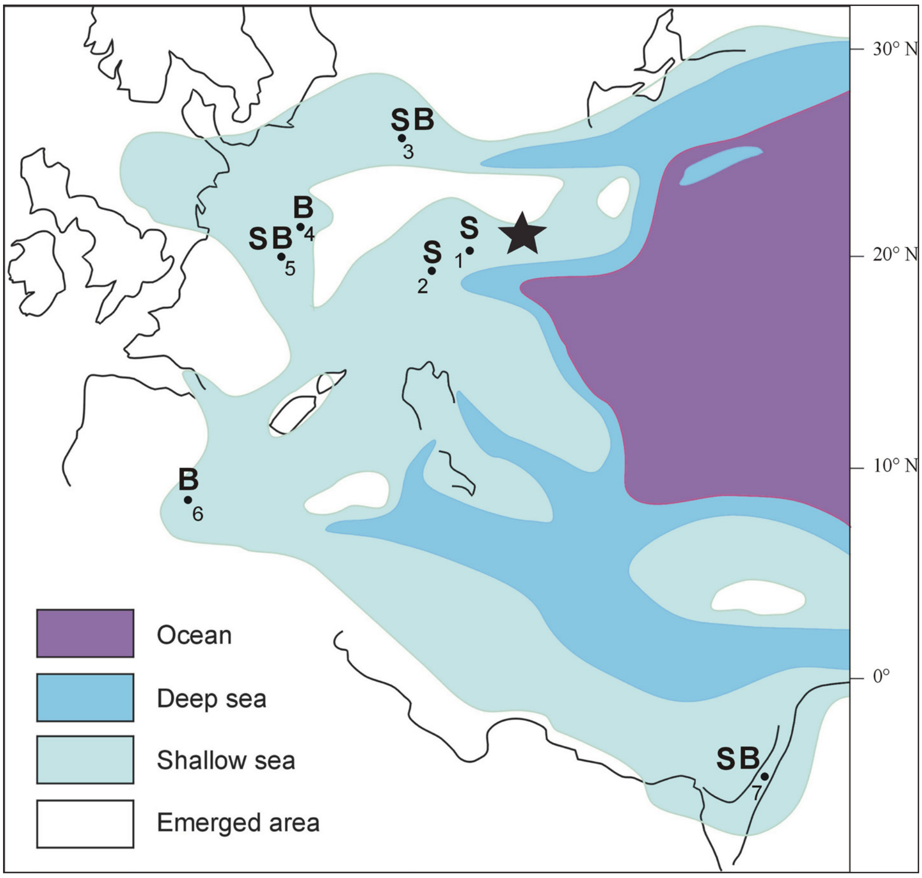


Fig. 5 - Middle Triassic palaeogeographical map of the western Tethyan region showing the distribution of the nautiloid species of the Mecsek fauna. Numbers correspond to localities listed in Tab. 1. B: *Germanonautilus bidorsatus* S: *G. salinarius*. Asterisk indicates the inferred palaeogeographical position of the Mecsek Mountains. Base map combined from Dercourt et al. (2000) and Muttoni et al. (2000).

One of the Anisian nautiloid species of the Mecsek fauna (*Germanonautilus salinarius*) was widespread in the western Tethyan region, from the Germanic Basin to Israel including a few Alpine localities. The distribution pattern of the other species (*G. bidorsatus*) is somewhat different: it was common all through the Germanic and the Sephardic provinces and occurred in the Mecsek, but was not recorded from the Alpine localities (Fig. 5).

The distribution of the ammonoids species reveals a quite different pattern (Fig. 6). All records lie along the margins of the oceanic Tethys, i.e. in the Alpine province; there are no occurrences in the Germanic or Sephardic provinces. Moreover, this picture suggests that the ammonoid fauna of the Mecsek Mts. is most akin to those of the Northern Calcareous Alps and the Balaton Highland. Somewhat surprising is the rather strong similarity to the Gebze fauna (Turkey), tentatively placed to the intra-Tethyan Sakarya microcontinent in our map (Fig. 6).

One of the most exotic species of the Mecsek fauna is *Procladiscites brancoi,* which was described previously only from the so-called "Triassic rosso ammonitico", i.e. the Schreyeralm Limestone of the Northern Calcareous Alps (Mojsisovics 1882) and the Han Bulog Limestone of the Dinarides (Salopek 1913), but similar or closely related species of *Procladiscites* were indicated also from Dobrogea (Si-

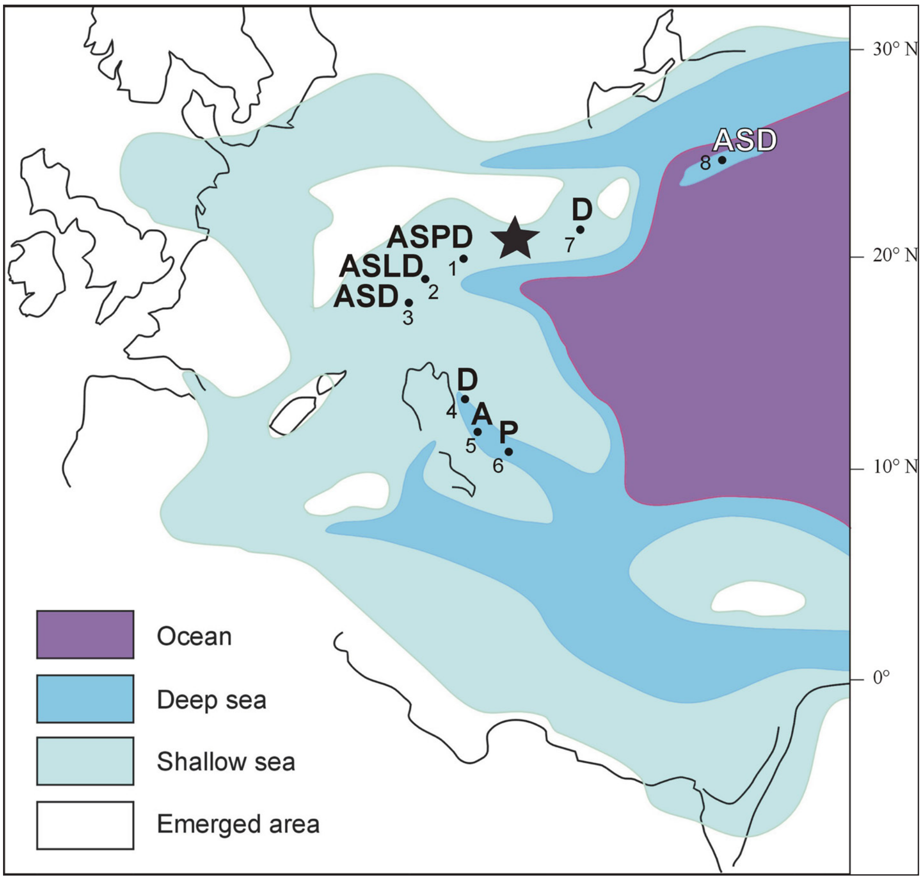


Fig. 6 - Middle Triassic palaeogeographical map of the western Tethyan region showing the distribution of the ammonoid species of the Mecsek fauna. Numbers correspond to localities listed in Tab. 2. A: *Acrochordiceras carolinae*, D: *Discoptychites megalodiscus*, L: *Lardaroceras barrandei*, P: *Procladiscites brancoi*, S: *Schreyerites binodosus*. Asterisk indicates the inferred palaeogeographical position of the Mecsek Mountains. Base map combined from Dercourt et al. (2000) and Muttoni et al. (2000).

mionescu 1910) and Epidaurus (Pomoni & Tselepidis 2013). These Hallstatt-type, condensed red limestones deposited in deep, open-marine outer shelf environments in belts facing the oceanic Tethys (see Sudar et al. 2013 for a review). The occurrence of the genus *Procladiscites* itself seems to be confined to these outer shelf regions, adjacent to the oceanic Tethys, at least in the Anisian: it appeared later, only in the Ladinian, in the Southern Alps and the Balaton Highland (Vörös 2010). In any case, the record of *Procladiscites brancoi* in the Anisian dark grey Zuhánya Limestone Fm. of the Mecsek Mts. is rather unexpected. Even if we consider that it is only a single specimen, this record may suggest occasional pelagic influence.

The overall palaeobiogeographical picture of the Anisian cephalopod fauna of the Mecsek Mts. bears conflicting data for the distributions of the nautiloids vs. the ammonoids. The nautiloid species suggest relationships with the Germanic and even the Sephardic provinces, although *Germanonautilus salinarius* occurred also in Alpine faunas. On the other hand, the ammonoids are definitely Alpine in faunal character. The inferred palaeogeographical position of the Mecsek succession in the Anisian, between the Vindelician-Bohemian land and the open Tethyan ocean (Figs. 5, 6), is consistent with the ammonoid data. Most of the Mecsek ammonoids occurred in the faunas of the Northern Calcareous Alps and the Balaton Highland, situated along the same shelf zone (localities 1 and 2 in Fig. 6). Thus, the essentially Alpine character of the Anisian cephalopod fauna of the Mecsek Mts., as suggested by Vörös (1992), seems to be approved. The single specimens of the more pelagic *Procladiscites brancoi* and the nautiloid *Germanonautilus bidorsatus* of Germanic affinity may be regarded as stray individuals. The Alpine affinity is supported by the other pelagic group present only in the Zuhánya Limestone, the conodonts, which also show Tethyan relations (Kozur 1993).

The presented palaeogeographical reconstruction explains the Germanic affinities of the lithofacies (Török 2000) and of the benthic fauna (*Costatoria costata*, *Lingula tenuissima*, *Entolium discites*, *Plagiostoma lineatum*, *Coenothyris vulgaris*, the crinoid species, and the common *Thalassinoides* and *Rhizocorallium* trace fossils) of the Mecsek area: the Vindelician mainland was surrounded by German-type environments near the Silesian Gate. The eightfold thickness of the Mecsek succession relative to the German one must be a result of the higher subsidence rate along the Tethys margin. These passive-margin tectonic processes caused the alongslope sediment movements in the Zuhánya Limestone Fm. as well, which are absent in the Germanic Basin, but similarly appear in Moesia (Milanovo Fm., Zgorigrad Mb.; Chatalov 2016), lying also along the Tethys margin.

Systematic descriptions

In the following descriptions the systematics of the Nautiloidea is applied from the "Treatise" (Kummel 1964). For the Ammonoidea, the systematics developed by Tozer (1981) is used, with one exception: the genus *Lardaroceras*, introduced later, is systematically arranged according to the opinion of its author (Balini 1992).

The material is deposited in the Department of Geology and Palaeontology of the Hungarian Natural History Museum (Budapest), under the inventory numbers prefixed by INV. The dimensions (D = diameter, WH = whorl-height, WW = whorl-width, U = diameter of umbilicus) are given in millimetres.

Class **CEPHALOPODA** Cuvier, 1795
Subclass **NAUTILOIDEA** Agassiz, 1847
Order **Nautilida** Agassiz, 1847
Superfamily Tainocerataceae Hyatt, 1883
Family Tainoceratidae Hyatt, 1883
Genus *Germanonautilus* Mojsisovics, 1902

This genus was listed among the family Grypoceratidae Hyatt, 1900 by Dzik (1984, p. 174). On the other hand, in Kummel (1964) and in many subsequent works (Mundlos & Urlichs 1984; Parnes 1986; Vörös 2001) *Germanonautilus* was attributed to the family Tainoceratidae Hyatt, 1883, and this latter opinion is accepted here. The genus *Germanonautilus* has a worldwide distribution (Western Tethys, Himalayas, North America).

Germanonautilus bidorsatus (Schlotheim, 1820)

Pl. 2, fig. 1

1820 *Nautilites bidorsatus*. Schlotheim, p. 82.
1823 *Nautilites bidorsatus,* – Schlotheim, p. 107, pl. XXXI, fig. 2.
1870 *Nautilus bidorsatus*, – Roemer, p. 146, pl. 12, fig. 23.
1955 *Nautilus bidorsatus*– Claus, p. 36, pl. I, fig. 2.
1984 *Germanonautilus bidorsatus* – Mundlos & Urlichs, p. 13, pl. 1, figs. 1-5, pl. 2, figs. 1-2, text-figs. 2, 3, 5, 6.
1984 *Germanonautilus bidorsatus* – Dzik, p. 166, fig. 64.
1986 *Germanonautilus bidorsatus jugosus* n. sp. Parnes, p. 43, pl.9, figs. 3, 4.
1986 *Germanonautilus saharonicus* n. sp. Parnes, p. 41, pl. 8, figs.7-9, pl. 16, figs. 7, 8.
1996 *Germanonautilus bidorsatus* – Goy & Martinez, p. 285 (partim), pl. 2, figs. 1-3 (only).
2000 *Germanonautilus bidorsatus* – Urlichs, p. 3, fig. 3.
2004 *Germanonautilus bidorsatus* – Klug & Lehmkuhl, p. 244, figs. 1, 2, 4A, 5A, 6, 7A.
2017 *Germanonautilus bidorsatus* – Pérez-Valera et al., p. 176, fig. 4.
? 2020 *Germanonautilus bidorsatus* – Pieroni, p. 77, figs. 16c, d.

Material: One incomplete specimen; internal cast of a body chamber, from Bükkösd.

Dimensions:

Inventory No.	D	WH	WW	U
INV 2019.93.	?	>32	~80	>32

Description. Rather large-sized, smooth *Germanonautilus* specimen; a body chamber with subquadrate, depressed trapezoidal cross section. The venter is flat to gently concave; the apertural part shows a deep and wide hyponomic sinus. The last formed septum seems to be uniformly convex.

Remarks. The genus *Germanonautilus* (including *G. bidorsatus*) was comprehensively revised by Mundlos & Urlichs (1984) and further improved by Urlichs (2000). Our partially preserved specimen seems to correspond to their illustrations, therefore its identification with *G. bidorsatus* seems satisfactory. The critical interpretations in the above synonymy, regarding the items by Parnes (l.c.), and Goy & Martinez (l.c.) follow the opinion of Urlichs (2000). The fragmentary and crushed specimen illustrated by Pieroni (2020), probably does not belong to *G. bidorsatus*.

Plate 1

Nautilids from the Zuhánya Limestone Formation, Anisian, Mecsek Mountains, Hungary.
1 - *Germanonautilus* sp. indet., INV 2019.94., Bükkösd, Western Quarry, lateral view (coll: K. Sebe);
2 - *Germanonautilus* sp. indet., INV 2019.95., Bükkösd, Ujjas Valley, ventral view (coll: Gy. Konrád);
3 - *Germanonautilus salinarius* (Mojsisovics, 1882), INV 2019.91., Bükkösd, entrance of the Eastern Quarry, 3a: lateral view, 3b: ventral view (coll: K. Sebe).

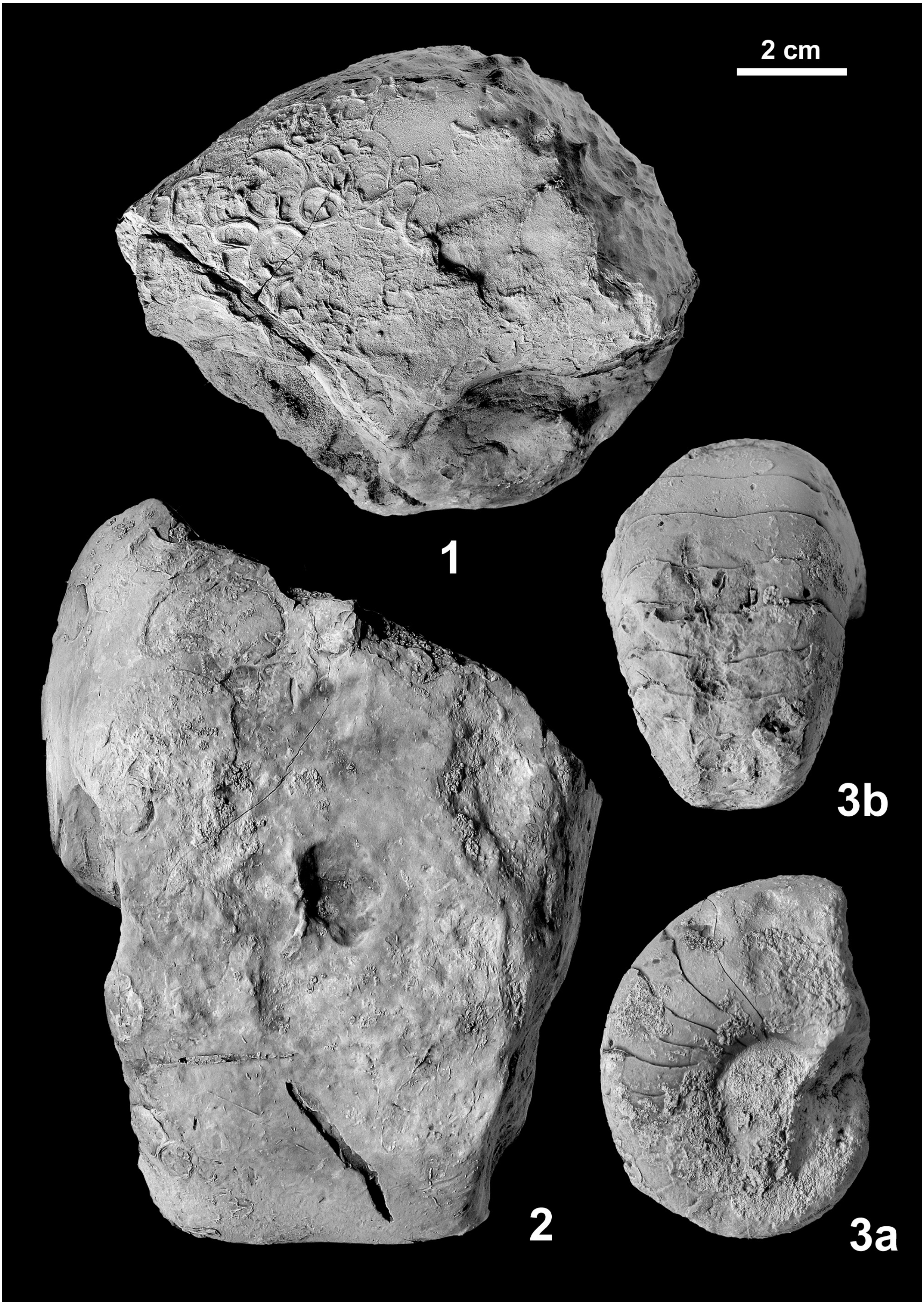


Plate 1

Distribution. *G. bidorsatus* was originally described and frequently recorded from the German Upper Muschelkalk (Germany, France, Poland). The species, or at least its synonyms, was also documented mostly from the Ladinian of the "Sephardic Province" (Southern Spain, Israel). Here it is reported from the Anisian of the Mecsek Mts. (Hungary).

Germanonautilus salinarius (Mojsisovics, 1882)

Pl. 1, fig. 3

1882 *Nautilus salinarius* E. v. Mojsisovics, p. 282, pl. XCI, fig. 3a-b.
1907 *Germanonautilus* cf. *salinarius* – Diener, p. 29, pl. III, fig. 1.
1937 *Nautilus gorasdzensis* n. sp. Assmann, p. 99, pl. 19, fig. 1.
? 1960 *Germanonautilus salinarius*– Kummel, p. 291, pl. 3, figs 1-2.
1984 *Germanonautilus salinarius*– Mundlos & Urlichs, p. 20, pl.3, figs 3-4, text-figs. 2b, 4a-b.
1986 *Germanonautilus salinarius* – Parnes, p. 41 (partim), pl. 20, figs 5-6 (only).
2001 *Germanonautilus* cf. *salinarius* – Vörös, p. 8, pl. II, fig. 6; text-fig. 6.
2004 *Germanonautilus salinarius* – Bércziné et al., p. 337, fig. 326.

Material: Two incomplete specimens; internal casts of phragmocones with moderate preservation, from Bükkösd.

Dimensions:

Inventory No.	D	WH	WW	U
INV 2019.91.	68.5	32.9	46.5	16.9
INV 2019.92.	64.1	28.2	>28.0	~18.0

Description. Rather small-sized, smooth *Germanonautilus* specimens with convolute coiling and rather rapidly expanding whorls. The subquadrate, slightly depressed trapezoidal whorls have flat to gently arched venter. The suture lines are simple, with a moderately deep lateral and a very shallow ventral lobe.

Remarks. The genus *Germanonautilus* (including *G. salinarius*) was comprehensively revised by Mundlos & Urlichs (1984). Their interpretation is followed here, therefore "*Nautilus gorasdzensis*" Assmann (l. c.) is included in the synonymy, whereas Kummel's (l. c.) record from Israel is taken as doubtful. One of the recently figured *salinarius* specimens from Israel (Parnes l. c.) seems to be a proper representative of this species, while the affiliation of the other specimens (pl. 9, figs 5-6 and pl. 20, fig. 7) is questionable.

Distribution. *G. salinarius* was originally described from the Alpine "Schreyeralm" limestones (middle to upper Anisian), and was documented in the Anisian of the Balaton Highland and the Mecsek Mts. (Hungary). It was recorded in the Anisian of the Germanic and Sephardic domains and in the Himalayas.

Germanonautilus sp. indet.

Pl. 1, fig. 1, 2.

Material: Two incomplete specimens; internal casts of body chambers with poor preservation, from Bükkösd.

Dimensions:

Inventory No.	D	WH	WW	U
INV 2019.94.	?	~61	79	?
INV 2019.95.	?	?	~113	?

Description. Rather large-sized, smooth *Germanonautilus* specimens; body chambers with subquadrate, depressed trapezoidal cross section. The venter is flat to gently concave.

Remarks. One of the large body chambers (Pl. 1, fig. 2) seems rather similar to *Germanonautilus bidorsatus* (Schlotheim, 1820) but the correct identification is not possible. Even less can be said about the other incomplete body chamber, though its attribution to *Germanonautilus* seems justified (Pl. 1, fig. 1). The shared, remarkable feature of both specimens is that their surfaces are densely covered by epifauna consisting encrusting oyster-like bivalve "*Placunopsis*". This is typically widespread among the fossils of the German Muschelkalk, as profusely illustrated by Klug & Lehmkuhl (2004, figs. 5-7). Considering that the epifaunal attachments cover the inner surface of the body chamber, we may postulate a degree of post-mortem reworking.

Subclass **AMMONOIDEA** Zittel, 1884
Order **Ceratitida** Hyatt, 1884
Superfamily Ceratitoidea Mojsisovics, 1879
Family Acrochordiceratidae Arthaber, 1911
Genus *Acrochordiceras* Hyatt, 1877

Acrochordiceras carolinae Mojsisovics, 1882

Pl. 2, figs. 2, 3; Fig. 7.

1882 *Acrochordiceras Carolinae* E. v. Mojsisovics , p.141, pl. XXVIII, fig. 14a-b., pl. XXXVI, fig. 3a-b.
1882 *Acrochordiceras Fischeri*– Mojsisovics, p.142, pl. XXXIII, fig. 8a-b.
1896 *Acrochordiceras undatum* – Arthaber, p. 235, pl. XV, fig. 2a-d.
1934 *Acrochordiceras carolinae* – Spath, p. 395.
1958 *Acrochordiceras carolinae* – Sacchi Vialli & Vai, p. 69, pl. IV, fig. 17.
2003 *Acrochordiceras carolinae* – Vörös, p. 83, pl. A-I, figs. 11-14, text-fig. A-13
2010 *Acrochordiceras carolinae* – Monnet et al., p. 973, pls. 6–11, text-figs. 3–6, 10–12.

Material: Two incomplete specimens; one internal cast of a body chamber and one incomplete phragmocone of rather good preservation, from Bükkösd.

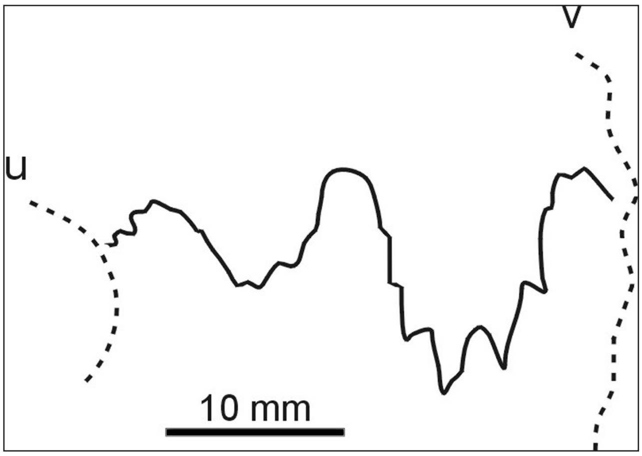


Fig. 7 - Suture line of *Acrochordiceras carolinae* Mojsisovics, 1882, INV 2019.97., at 26 mm whorl-height; Bükkösd, Western Quarry, Anisian, u: umbilical margin, v: ventrolateral margin.

Dimensions:

Inventory No.	D	WH	WW	U
INV 2019.96.	?	?	34.7	?
INV 2019.97.	53.1	28.2	20.5	9.1

Description. This medium sized *Acrochordiceras* species has involute coiling with slightly compressed whorls tending to be more inflated towards the body chamber. The ornamentation consists of umbilical nodes and simple, strong, slightly projected ribs or rather plicae, 18 to 22 on a half whorl. The plicae start near the umbilical margin or at the nodes and, with increasing amplitude, they run across the venter where they reach maximum strength. The umbilical nodes are poorly seen in the studied specimens, due to the poor preservation. The suture lines are subammonitic, the first lateral lobe is very large, deep and strongly denticulated (Fig. 7).

Remarks. Vörös (2003), including examination of type specimens in the collection of the Austrian Geologische Bundesanstalt (Vienna), revised most of the previous records of Pelsonian *Acrochordiceras* and stated that *A. fischeri* Mojsisovics, 1882 and *A. undatum* Arthaber, 1896 are synonymous of *A. carolinae*. This was endorsed by the recent, comprehensive monograph on *Acrochordiceras* by Monnet et al. (2010). They extended the morphological range of *A. carolinae* and included further species, described from Gebze (Turkey), e.g. *A. bithynicum* Arthaber, 1915.

Distribution. *A. carolinae* was described from the Anisian Schreyeralm Limestone of the Northern Calcareous Alps. Later on, the species and its synonyms were recorded from the Southern Alps and the Balaton Highland, from the Hallstatt (Han Bulog) Limestone of the Dinarides, Gebze (Turkey), Tibet and Nevada. In the Balaton Highland, the range of *A. carolinae* is restricted to the lower part of the *Balatonites balatonicus* ammonoid zone, within the Pelsonian.

Family Ceratitidae Mojsisovics, 1879
Ceratitidae indet.
Pl. 2, fig. 5

Material: One incomplete phragmocone of medium preservation, from Bükkösd.

Dimensions:

Inventory No.	D	WH	WW	U
INV 2019.98.	18.7	7.6	7.2	6.7

Remarks. Due to its small size and poor preservation, the studied specimen is not attributed to any of the ceratitide genera. The rather strong ribbing, the strong ventrolateral nodes and the arched venter without keel somewhat resemble *Bulogites*.

Subfamily Beyrichitinae Spath, 1934
Genus *Schreyerites* Tatzreiter & Balini, 1993

Schreyerites* ? *binodosus (Hauer, 1851)
Pl. 2, fig. 4

1851 *A[mmonites]* (*Ceratites*) *binodosus* Hauer, p. 114 (partim), pl. XIX, fig. 1a-c. (non figs. 2, 3, 4).
1882 *Ceratites binodosus* – Mojsisovics, p. 19, pl. XI, figs. 1a-c, 2a-b, 3 (?), 4, 5a-b.
1915 *Ceratites binodosus* – Arthaber, p. 121, pl. XII, fig. 1a-d.
2003 *Schreyerites* ? *binodosus* – Vörös, p. 99, pl. A-VIII, figs. 4-7, text-fig. A-29 (cum syn).
? 2020 *Schreyerites binodosus* – Hagdorn, p. 250, figs. f, g.

Material: Two incomplete shells (body chambers) of rather poor preservation, from Orfű and Nagymányok.

Dimensions:

Inventory No.	D	WH	WW	U
INV 2019.99.	38.5	19.5	>10.0	7.5
INV 2022.5.	32.9	~13.0	?	?

Description. The specimens under examination have rounded venters without a keel, moderately marked marginal shoulders with numerous, weakly pointed, slightly projected ventrolateral nodes, very weak lateral nodes below mid-flanks and rather sinuous ribs. Proper suture lines are not visible, but the last septum is observed on one body chamber (Pl. 2, fig. 4b) showing four saddles. Due to the poor preservation, neither the lobes, nor the saddles portray any denticulation.

Remarks. On the basis of the above characters the specimens under examination differ from the species of *Paraceratites* and stand closer to those of *Schreyerites*. This generic attribution was preferred by Vörös (2003), despite the fact that this species was definitely excluded from *Schreyerites* by Tatzreiter & Balini (1993) on the basis of some details of the suture lines. On the other hand, Mietto & Manfrin (1995) and Monnet et al. (2008, p. 75) suggested that the best place of *A. (C.) binodosus* is in the genus *Schreyerites*. The present authors also believe that these differences are within the variability of the genus, yet, the uncertainty of the attribution is indicated by a question mark. The four specimens of *A. (C.) binodosus* illustrated by Mojsisovics (1882) cover a large range of variation both in the lateral ornamentation and in the width (proportion) of the umbilicus (varying between 14.9% and 24.4%). Two of them (herein, pl. XI, figs. 1 and 2) were considered "typical" by Vörös (2003, p. 99), which were best comparable to the specimens collected and illustrated from the Balaton Highland (Vörös 2003, pl. A-VIII, figs. 4-7). The Mecsek specimens seem to fit into this wide interpretation of the species.

The attribution of the poorly preserved specimens illustrated by Hagdorn (2020, l.c.) is questionable.

Distribution. *S. binodosus* was recorded from the Southern Alps, Northern Calcareous Alps, Balaton Highland and from Gebze (Turkey). At the Balaton Highland, its range is restricted to the *Schreyerites binodosus* ammonoid subzone (transferred by Vörös 2018 from the Pelsonian to the lowermost Illyrian).

Genus *Lardaroceras* Balini, 1992

Lardaroceras* ? *barrandei (Mojsisovics, 1882)
Pl. 2, fig. 6

1882 *Ceratites Barrandei* E. v. Mojsisovics, p. 25, pl. XII, fig. 8.
1998 *Lardaroceras krystyni*– Vörös, p. 20, 22, 59 (partim), pl. I, fig. 7.
1998 *Lardaroceras*– Vörös, p. 22, 59 (partim), pl. I, fig. 8.
2018 *Lardaroceras barrandei* – Vörös, p. 50, pl. I, figs. 7, 8, 10, 11 (cum syn.).

Material: One incomplete specimen; a body chamber of rather good preservation, from Pécs.

Dimensions:

Inventory No.	D	WH	WW	U
INV 2019.100.	62.5	>26.0	20.2	>11.0

Description. Moderately involute, compressed conch with high subtrapezoidal whorl-section. The flanks are gently convex; the venter is rather highly arched. The very weak, sinuous radial ribs have pronounced lateral nodes; their number is 6-7 on a half whorl. The ventrolateral nodes (18 on a half whorl) are strong, mostly pointed. On this basis it is identified with *L. barrandei* despite that it is an incomplete specimen.

Remarks. *L. barrandei* was properly defined and illustrated by Mojsisovics (l. c.), yet it was misidentified by Vörös (1998, l. c.) and was taken as a variant of *L. krystyni* Balini, 1992. Later Vörös (2018, l.c.) differentiated *L. barrandei* by its definite lateral row of nodes, missing in *L. krystyni*. The closely related *L. pseudohungaricum* Balini, 1992 shows much coarser ornamentation mostly in the ribbing. The specimen under examination (body chamber) does not show suture lines, which would be needed for a proper attribution to the genus *Lardaroceras*. Regrettably, this regards all other known specimens of *barrandei*. In spite of the uncertainty of the generic attribution, based on its external morphology, the

Plate 2

A nautilid and five ammonoids from the Zuhánya Limestone Formation, Anisian, Mecsek Mountains, Hungary.

1 - *Germanonautilus bidorsatus* (Schlotheim, 1820), INV 2019.93., Bükkösd, locality K131/7, 1a: ventral view, 1b: lateral view (coll: Gy. Konrád);

2 - *Acrochordiceras carolinae* Mojsisovics, 1882, INV 2019.96., Bükkösd, Western Quarry, 2a: lateral view, 2b: ventral view (coll: T. Müller);

3 - *Acrochordiceras carolinae* Mojsisovics, 1882, INV 2019.97., Bükkösd, Western Quarry, 3a: lateral view, 3b: ventral view (coll: I. Bartha);

4 - *Schreyerites* ? *binodosus* (Hauer, 1851), INV 2019.99., Orfű, Sárkánykút, (coll: Gy. Konrád ?), 4a: lateral view, 4b: posterior end of the body chamber with traces of the last septum;

5 - Ceratitidae indet., INV 2019.98., Bükkösd, Western Quarry (?), 5a: lateral view, 5b: ventral view (coll: Gy. Konrád);

6 - *Lardaroceras* ? *barrandei* (Mojsisovics, 1882), INV 2019.100., Pécs, Misina key section, 6a: lateral view, 6b: ventral view (coll: Gy. Konrád).

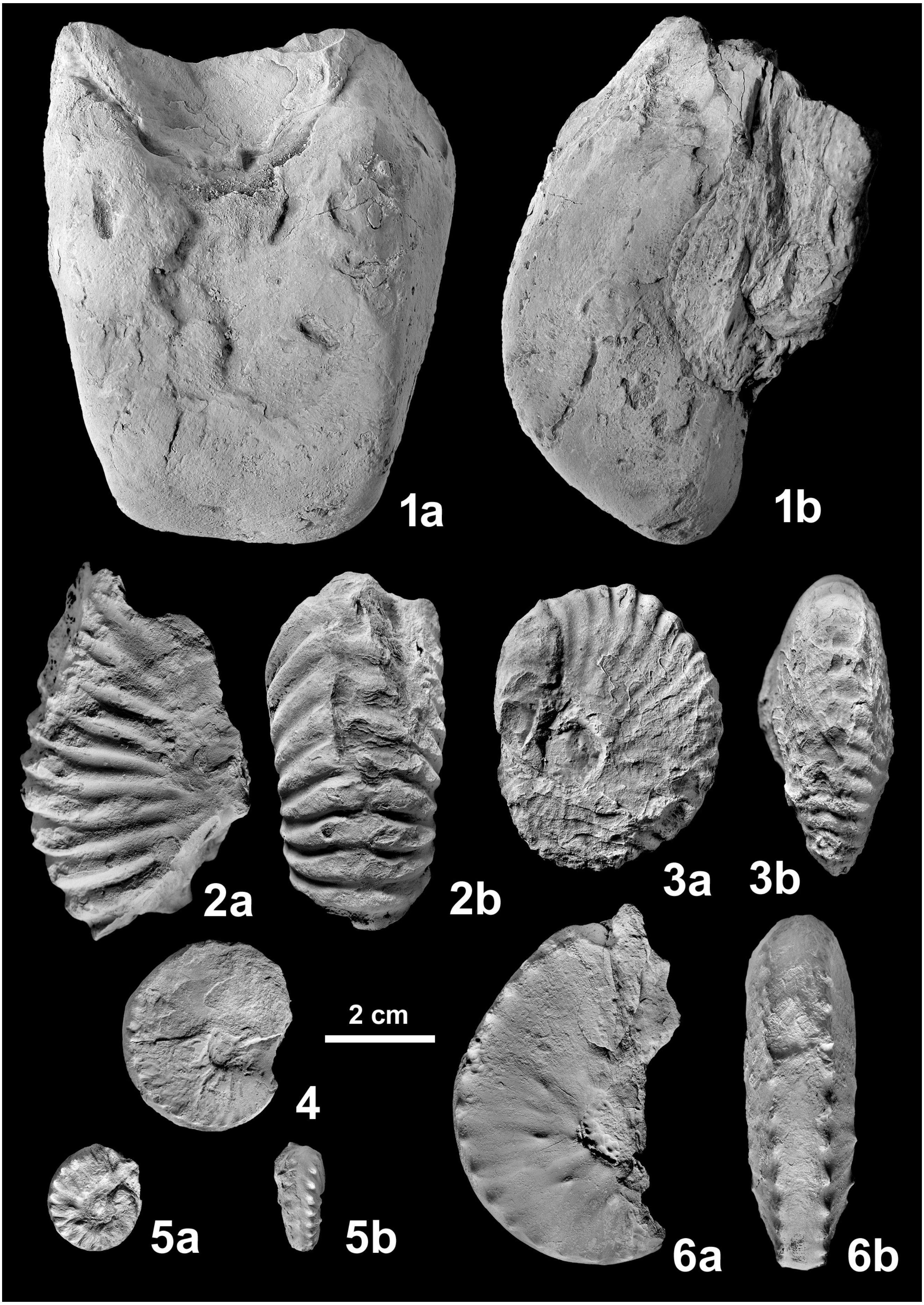


Plate 2

Mecsek specimen is considered conspecific with those of *L. barrandei* described by Vörös (2018) from the Balaton Highland.

Distribution. *L. barrandei* was described by Mojsisovics (1882, l.c.) from the Balaton Highland, where it occurs at numerous sites, and it ranges from the *Asseretoceras camunum* to the *Kellnerites felsoeoersensis* ammonoid subzones of the Illyrian (Vörös 2018).

Superfamily Pinacoceratoidea Mojsisovics, 1879
Family Sturiidae Kiparisova, 1958
Genus *Discoptychites* Diener, 1916

Discoptychites megalodiscus (Beyrich, 1867)

Pl. 3, fig. 1

1867 *Ammonites megalodiscus* Beyrich, p. 135, pl. II.
1882 *Ptychites megalodiscus* – Mojsisovics, p. 253, pl. LXXVII, fig. 1, pl. LXXVIII, figs. 1, 2.
1896 *Ptychites megalodiscus* – Toula, p. 174, pl. XXI, fig. 1.
1913 *Ptychites megalodiscus* – Toula, p. 677, pl. XXIII, fig. 1.
1936 *Ptychites megalodiscus* – Stefanoff, p. 152, pl. II, figs. 7, 8.
2010 *Discoptychites megalodiscus* – Vörös, p. 10, pl. IV, fig. 3.
2018 *Discoptychites* cf. *megalodiscus* – Vörös, p. 134, fig. 82 (cum syn.).

Material: One incomplete (half) specimen of poor preservation; body chamber with a few inner whorls; from Bükkösd.

Dimensions:

Inventory No.	D	WH	WW	U
INV 2019.102.	>221.0	>120.0	>49.0	?

Remarks. *D. megalodiscus* is among the largest sized species within the genus; it differs from other species of *Discoptychites* by its narrower umbilicus and much compressed conch and by the fact that the early globose stage is restricted to the innermost part of the phragmocone. The specimen under examination, due to its poor preservation, does not show this latter feature, but the extremely large diameter and the compressed and sharp shape justify the tentative identification with *D. megalodiscus*. It was found at the same locality as the specimens of *Acrochordiceras carolinae*, proving a Pelsonian age. This record may imply an unusually early occurrence of *D. megalodiscus*.

Distribution. *D. megalodiscus* was described from the Southern Alps, Northern Calcareous Alps, Balaton Highland, Northern Hungary, Dinarides, Balkan Mountains and Gebze (Turkey), but seems to have worldwide distribution (e.g. in Nevada and New Zealand). At the Balaton Highland it ranges from the *Schreyerites binodosus* to the *Aplococeras avisianum* ammonoid subzones of the Illyrian.

Discoptychites sp.

Pl. 4, fig. 1

Material: One incomplete (half) body chamber of poor preservation from the Nagymányok quarry.

Dimensions:

Inventory No.	D	WH	WW	U
INV 2022.6.	>300.0	>185.0	?	?

Remarks. This extremely large specimen (estimated diameter is around 400 mm) has a relatively wide umbilicus and a subrounded, arched venter. These features may be compared to those of *Discoptychites reductus* (Mojsisovics, 1882) and *D. dux* (Giebel, 1853). The former was described by Mojsisovics (1882, p. 252, pl. LXVII), who gave a value of 186 mm as the largest diameter of a phragmocone. *D. dux* was reported and well illustrated from Silesia by Kaim & Niedźwiedzki (1999, p. 101, figs. 5-8) and from Thüringia by Claus (1955, p. 40, pl. III, fig. 2), who mentioned that the diameter of this species might reach 500 mm. According to the above cited authors, the diagnostic difference between *D. reductus* and *D. dux* lies in the features of their suture lines. Since suture lines are not observed in the studied specimen, its closer specific identification is not possible. Recently Siegel et al. (2022) described a copious material of *D. dux* from Brandenburg; here the diameters of the specimens ranged between 180 and 250 mm. Considering its size, the studied specimen seems to stand close to *D. dux*.

Superfamily Arcestoidea Mojsisovics, 1875
Family Cladiscitidae Zittel, 1884
Genus *Procladiscites* Mojsisovics, 1882

Procladiscites brancoi Mojsisovics, 1882

Pl. 5, fig. 1

1882 *Procladiscites Brancoi* E. v. Mojsisovics, p. 171, pl. XLVIII, figs. 1, 2.
1913 *Procladiscites Brancoi* – Salopek, p. 24, pl. II, fig. 3.

Material: One incomplete (half) specimen; partial phragmocone with body chamber of medium preservation; from Orfű. The specimen, embedded in the host rock, was longitudinally halved by surface erosion, thus it showed only an equatorial section. It was artificially cut in order to observe its axial section (Pl. 4, figs. 1a, b); and a portion of the ventral part was released from the host rock.

Dimensions:

Inventory No.	D	WH	WW	U
INV 2019.101.	63.1	>32.0	?	>8.0

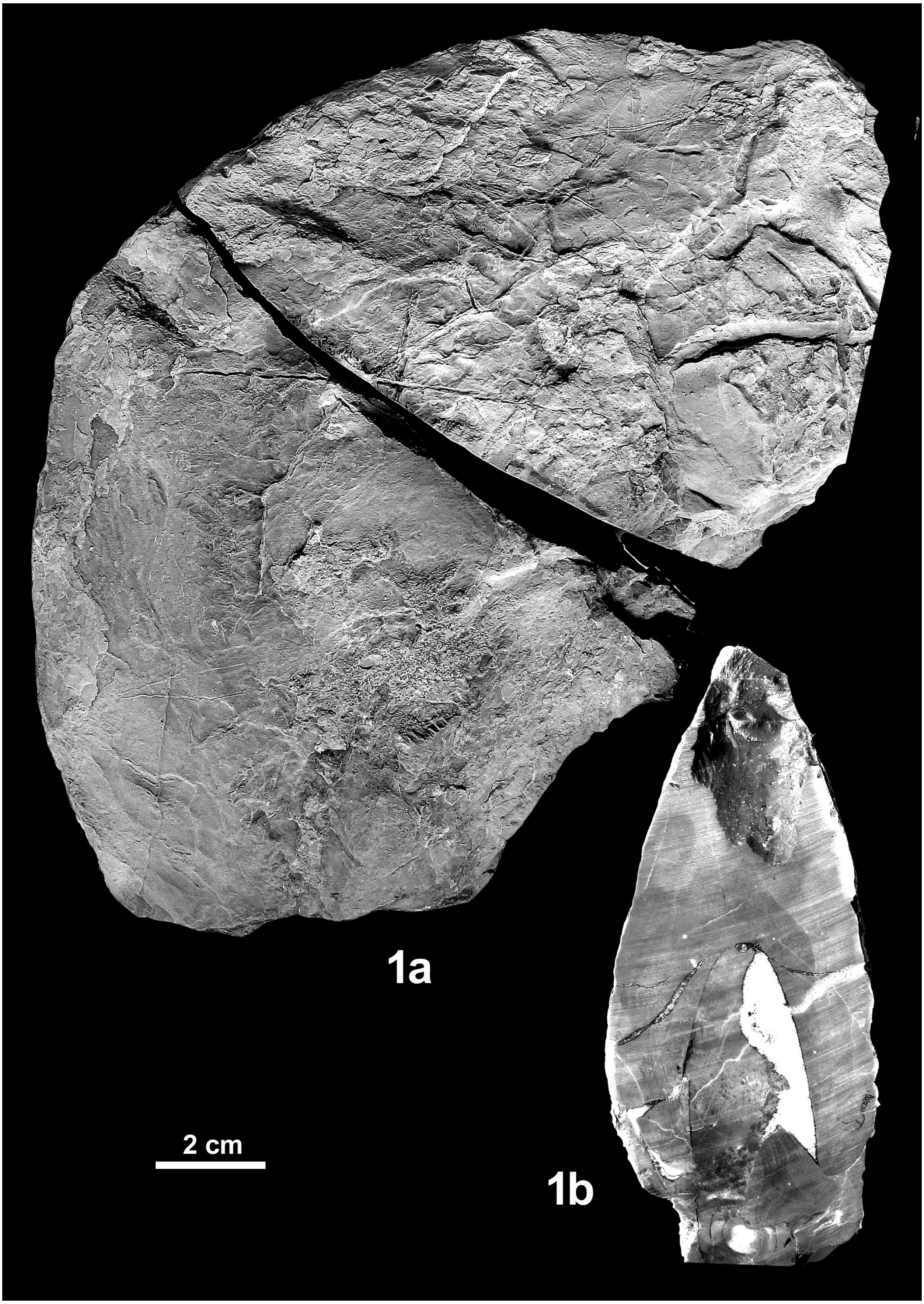


Plate 3

1 - *Discoptychites megalodiscus* (Beyrich, 1867), INV 2019.102., from the Zuhánya Limestone Formation, Anisian, Bükkösd, Western Quarry, Mecsek Mountains, Hungary, 1a: lateral view, 1b: cross section (coll: K. Sebe).

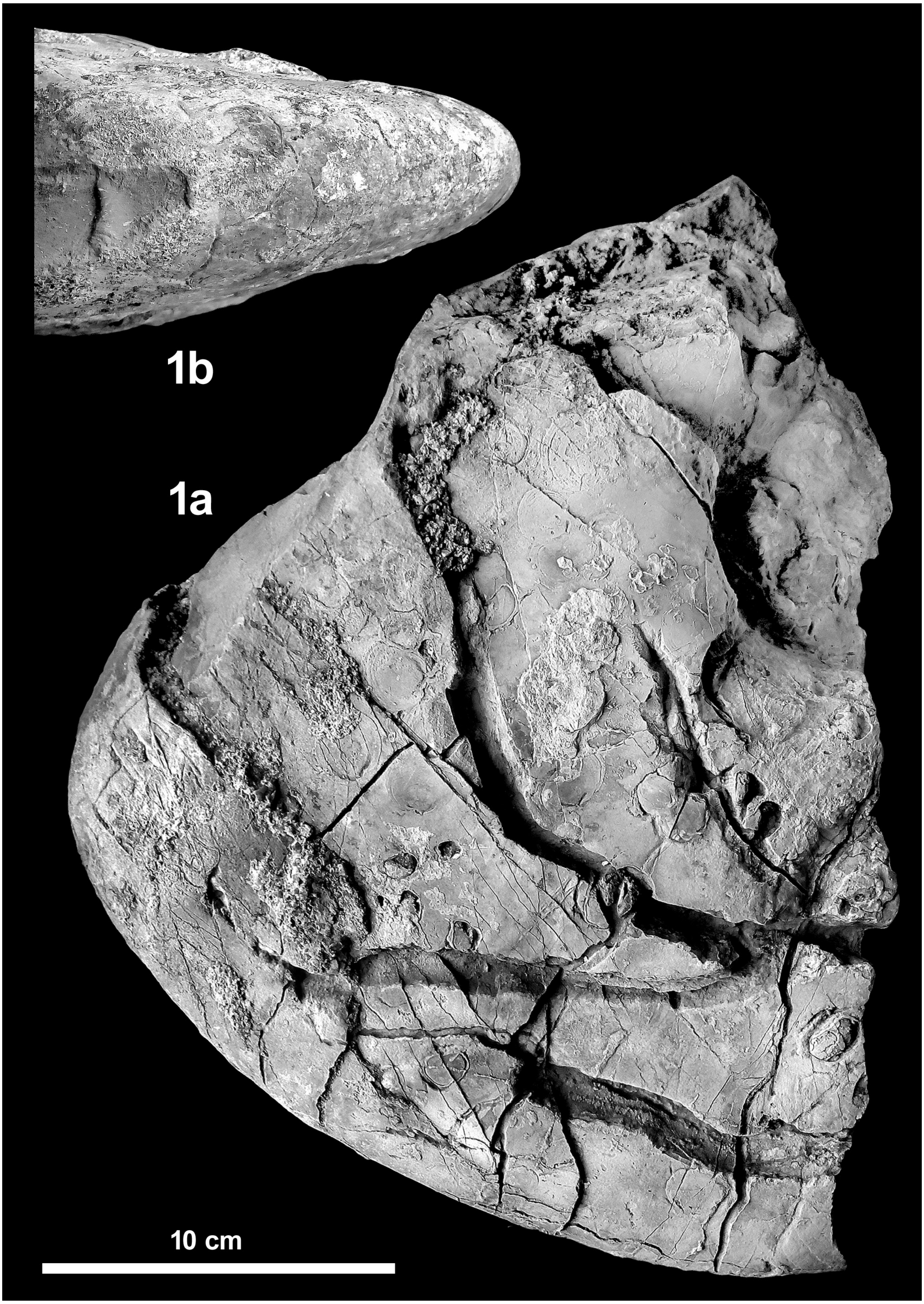
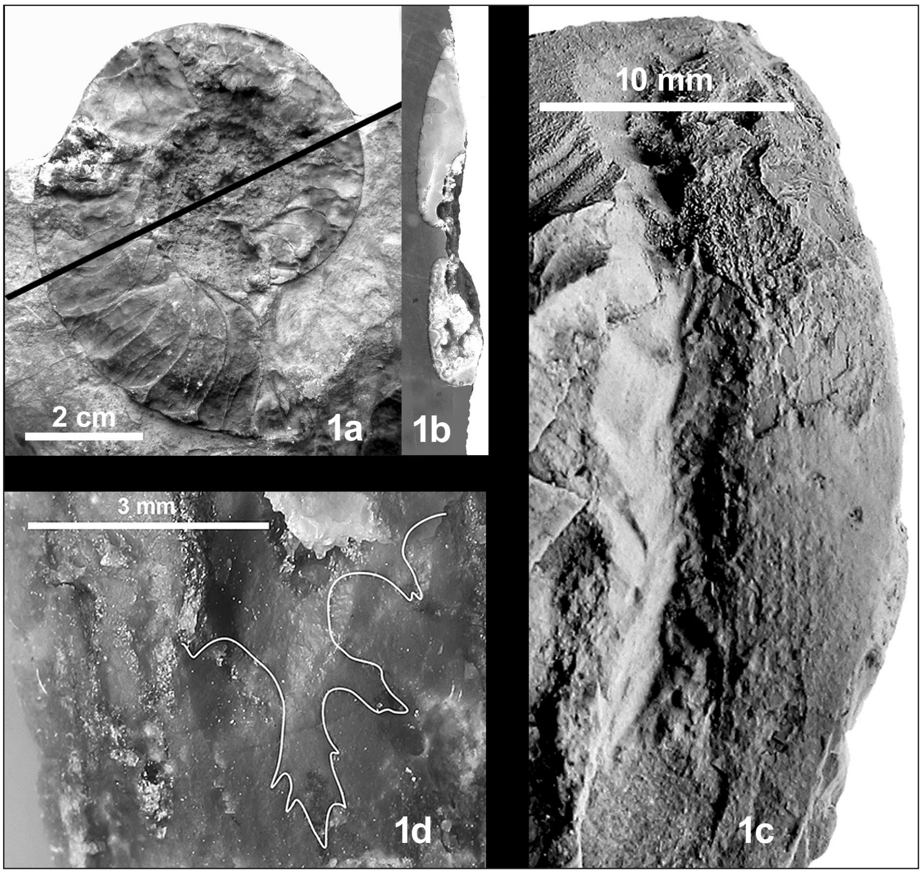


Plate 4

1 - *Discoptychites* sp. INV 2022.6. from the Zuhánya Limestone Formation, Anisian, Nagymányok, quarry, Mecsek Mountains, Hungary. 1a: lateral view, 1b: partial view of the arched venter (coll.: Gy. Konrád).

Plate 5

1 - *Procladiscites brancoi* Mojsisovics, 1882, INV 2019.101., from the Zuhánya Limestone Formation, Anisian, Mecsekrákos, Orfű Hill, Mecsek Mountains, Hungary, 1a: naturally weathered equatorial section, 1b: cross-section (cut along the black line shown in 1a), 1c: oblique view of the venter, showing the strigation; 1d: partial suture line with phylloid elements (coll: I. Venkovits).



Description. The cross-section revealed that it is a very involute conch, with a compressed whorl section. The umbilicus is almost occluded; the umbilical margin is indistinct. The flanks are flattened and pass gradually to the highly arched venter. The strigate ornamentation consists of fine longitudinal (spiral) cords and is better developed on the ventral part of the flanks (Pl. 4, fig. 1c). A partial suture line shows phylloid elements (Pl. 4, fig. 1d). On the basis of these features, the identification of the studied specimen with *Procladiscites brancoi* is justified.

Remarks. The Anisian species of *Procladiscites* bear rather similar strigate ornamentation; they differ principally in the width/height proportions of their whorls. *P. brancoi* is the most strongly compressed and differs from the much more robust (wider) *P. griesbachi* Mojsisovics, 1882.

Distribution. *P. brancoi* was described from the Anisian of the Northern Calcareous Alps and the Dinarides.

Conclusions

The Middle Triassic formations of the Mecsek Mountains abound in bivalves and brachiopods. However, cephalopods and especially ammonoids, which could be used for confining the age of the sediments, occur only occasionally, and exclusively in the Zuhánya Limestone Formation. A few taxa were reported by some authors in the last century, but the pertinent specimens are absent from public collections. From the newly collected cephalopod material described in the present paper it was possible to gain significant new information on the marine biota and the biochronostratigraphic correlation of the Zuhánya Limestone Fm. as well as on the paleogeographic position of the study area.

The taxonomic investigation of the new cephalopod finds showed that the ammonoid biochronostratigraphical units established in the Alpine Triassic successions of the Balaton Higland in NW Hungary are valid and can be used in the German-type Triassic succession of the Mecsek Mts. as well. Based on the presence of the ammonoid taxa *Acrochordiceras carolinae*, *Paraceratites trinodosus, Schreyerites binodosus* and *Lardaroceras ?barrandei*, the Zuhánya Limestone Fm. of the Mecsek Mts. encompasses the whole Pelsonian and the lower Illyrian; the *Balatonites balatonicus* and *Paraceratites trinodosus* ammonoid zones have a nearly complete record. The stratigraphical position of the Zuhánya Limestone Fm. corresponds to the Felsőörs Limestone Fm. of the Balaton Highland.

The evaluation of the new cephalopod finds allows for drawing paleogeographic conclusions as well. The elements of the nautiloid fauna point mostly to Germanic affinity, in accord with previous views on the German-type nature of the sedimentary succession of the Mecsek Mts. However, they also show some Sephardic affinity. Intriguingly, in contrast with the nautiloids, the ammonoid fauna has no Germanic elements. Most of the species are Alpine in character, and the fauna shows most similarities to that of the Northern Calcareous Alps and the Balaton Highland. The species *Procladiscites brancoi* indicates Dinaridic connection, or at least an occasional appearance of pelagic organisms. The new data on the cephalopods endorse the previously assumed palaeogeographical position of the Mecsek Mountains in the Anisian, between the Vindelician-Bohemian Land and the open Tethyan ocean. Environments near the Silesian Gate similar to those of the Gerrmanic Basin explain the German-type lithofacies of the Mecsek Mts., while the position of the study area on the outer passive margin of the European continent can account for the high thickness of the Mecsek succession and of the dominantly neritic, Alpine-type ammonoid fauna, with temporal pelagic influence.

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References

Agassiz L. (1847) - An introduction to the study of natural history, in a series of lectures delivered in the hall of the College of Physicians and Surgeons, Greeley & McElrath (Eds.), New York, 58 pp.

Alberti F. von (1864) - Ueberblick über die Trias, mit Berücksichtigung ihres Vorkommens in den Alpen. Cotta, Stuttgart 353 pp.

Arthaber G. (1896) - Die Cephalopodenfauna der Reiflinger Kalke. II. *Beiträge zur Paläontologie und Geologie* Österreich-*Ungarns und des Orients*, 10(4): 192-242.

Arthaber G. (1911) - Die Trias von Albanien. *Beiträge zur Paläontologie und Geologie Österreich-Ungarns und des Orients*, 24: 169-288.

Arthaber G. (1915) - Die Trias von Bithynien (Anatolien). *Beiträge zur Paläontologie und Geologie Österreich-Ungarns und des Orients*, 27(2-3): 85-206.

Assmann P. (1937) - Revision der Fauna der Wirbellosen der oberschlesischen Trias. *Abhandlungen der Preussischen Geologischen Landesanstalt, N.F.*, 170: 1-134.

Balini M. (1992) - *Lardaroceras* gen. n., a new Late Anisian ammonoid genus from the Prezzo Limestone (Southern Alps). *Rivista Italiana di Paleontologia e Stratigrafia*, 98(1): 3-28.

Bércziné Makk Á., Konrád Gy., Rálischné Felgenhauer E. & Török Á. (2004) - Tiszai Egység [Tisza Unit]. In: Haas, J. (Ed.) - Magyarország geológiája. Triász [Geology of Hungary. Triassic], Eötvös Press, Budapest: 303-360.

Beyrich E. (1867) - Über einige Cephalopoden aus dem Muschelkalk der Alpen und über verwandte Arten. *Abhandlungen der Königlichen Akademie der Wissenschaften zu Berlin*, 2(1866): 105-149.

Böckh J. (1876) - Pécs városa környékének földtani és vizi viszonyai. *A Magyar Királyi Földtani Intézet Évkönyve*, 4 (4): 129-287.

Böckh J. (1881) - Geologische und Wasser-Verhältnisse der Umgebung der Stadt Fünfkirchen. *Mitteilungen aus dem Jahrbuche der Königlich Ungarischen Geologischen Anstalt*, 4(4): 151-328.

Brayard A., Escarguel G., Monnet C., Jenks J.F. & Bucher H. (2015) - Biogeography of Triassic Ammonoids. In: Klug C., Korn D., De Baets K., Kruta I. & Mapes R.H. (Eds.) - Ammonoid Paleobiology: From macroevolution to paleogeography, Topics in Geobiology 44, Springer, Dordrecht: 163-187.

Chatalov A. (2016) - Global, regional and local controls on the development of a Triassic carbonate ramp system, Western Balkanides, Bulgaria. *Geological Magazine*, 155 (3): 641-673. doi:10.1017/S0016756816000923.

Claus H. (1955) - Die Kopffüsser des deutschen Muschelkalks. Ziemsen, Wittenberg, 76 pp.

Csontos L. & Vörös A. (2004) - Mesozoic plate tectonic reconstruction of the Carpathian region. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 210: 1-56.

Cuvier G. (1795) - Second mémoire sur l'organisation et les rapports des animaux à sang blanc, dans lequel on traite de la structure des Mollusques et de leur division en ordre, lu à la société d'Histoire Naturelle de Paris, le 11 prairial an troisième. - *Magazin Encyclopédique, ou Journal des Sciences, des Lettres et des Arts*, 2: 433-449.

Dagys A.S., (1988) - Major features of the geographic differentiation of Triassic ammonoids. In: Wiedmann J. & Kullmann J. (Eds) - Cephalopods-present and past. Schweizerbart, Stuttgart, 341-350.

Dercourt J., Gaetani M., Vrielynck B., Barrier E., Biju-Duval B., Brunet M.F., Cadet J.P., Crasquin S. & Sandulescu M. (Eds.) (2000) - Atlas Peri-Tethys, Palaeogeographical Maps. 24 Maps and Explanatory Notes: 1-XX, CCGM/CGMW, Paris, 269 pp.

Detre Cs. (1973) - A mecseki triász legjobb megtartású és első rétegtanilag értékelhető Ammonoidea lelete (Über den ersten, stratigraphisch auswertbaren Ammonoiden-Fund von bester Erhaltung der mecseker Trias). *A Magyar Állami Földtani Intézet Évi Jelentése* 1971-ről: 276-282.

Diener C. (1907) - The Fauna of the Himalayan Muschelkalk, India. *Palaeontologia Indica*, (Ser. 15) 5(2): 1-139.

Diener C. (1916) - Untersuchungen über die Wohnkammerlänge als Grundlage einer natürlichen Systematik der Ammoniten. *Sitzungsberichte der Österreichische Akademie der Wissenschaften. Mathematisch-naturwissenschaftliche Klasse. Wien*, Abt I. 125: 253-309.

Dzik J. (1984) - Phylogeny of the Nautiloidea. *Palaeontologia Polonica*, 45: 1-219.

Feist-Burkhardt S., Götz A. E., Szulc J., Borkhataria R., Geluk M., Haas J., Hornung J., Jordan P., Kempf O., Michalík J., Nawrocki J., Reinhardt L., Ricken W., Röhling H.-G., Rüffer T., Török Á. & Zühlke R. (2008) - Triassic. In: McCann T. (Ed.) - The Geology of Central Europe, 2: Mesozoic and Cenozoic. Geological Society, London, 749-821.

Foster W.J. & Sebe K. (2017) - Recovery and diversification of marine communities following the late Permian mass extinction event in the western Palaeotethys. *Global and Planetary Change*, 155: 165-177.

Foster W.J., Lukoczki G., Sebe K. & Price G.D. (2021) - Middle Triassic carbon isotope fluctuations in the Mecsek Mountains, Hungary. *Newsletters on Stratigraphy*, 54(4): 483-496.

Giebel C.G. (1853) - Ueber *Ammonites dux* sp. aus dem Muschelkalk von Schraplau. *Zeitschrift für die gesamte Naturwissenschaft*, 1: 341-345.

Golonka J. (2004) - Plate tectonic evolution of the southern margin of Eurasia in the Mesozoic and Cenozoic. *Tectonophysics*, 381: 235-273.

Goy A. & Martinez G. (1996) - Nautiloideos del Triásico Medio en la Cordillera Ibérica y en la parte oriental de las Cordilleras Béticas. *Cuadernos de Geología Ibérica*, 20: 271-300.

Gümbel C.W. (1873) - Geognostische Mittheilungen aus den Alpen. *Sitzungsberichte der mathematisch-physikalischen Classe der königlich bayerischen Akademie der Wissenschaften*, München, 3: 14-88.

Haas J. & Péró Cs. (2004) - Mesozoic evolution of the Tisza Mega-unit. *International Journal of Earth Sciences*, 93: 297-313.

Haas J., Budai T., Csontos L., Fodor L. & Konrád Gy. (2010) - Pre-Cenozoic geological map of Hungary 1:500 000. Geological Institute of Hungary, Budapest.

Hagdorn H. (2020) - Biostratigraphie der Muschelkalk-Cephalopoden. In: Deutsche Stratigraphische Kommission (Hrsg.; Koordination und Redaktion: Hagdorn, H. & Simon, T., für die Subkommission Perm-Trias) - Stratigraphie von Deutschland XIII. Muschelkalk. *Schriftenreihe der Deutschen Gesellschaft für Geowissenschaften*, 91: 246-273.

Hagdorn H., Konrád Gy. & Török Á. (1997) - Crinoids from the Muschelkalk of the Mecsek Mountains and their stratigraphical significance. *Acta Geologica Hungarica*, 40 (2): 391-410.

Haq B.U. (2018) - Triassic sequences and variations of sea level. GSA Today, 28(12): 4-9. https://doi.org/10.1130/GSATG381A.1.

Hauer F. (1851) - Ueber die vom Herrn Bergrath W. Fuchs in den Venetianer Alpen gesammelten Fossilien. *Denkschriften der mathematisch-naturwissenschaftlichen Classe der Kaiserlichen Akademie der Wissenschaften*, 2(1) (1850): 109-126.

Hirsch F. (1972) - Middle Triassic Conodonts from Israel, Southern France and Spain. *Mitteilungen der Gesellschaft der Geologie- und Bergbaustudenten Österreichs*, 21: 811-828.

Hirsch F. (1976) - Sur l'origine des particularismes de la faune du Trias et du Jurassique de la plate-forme africano-arabe. *Bulletin de la Société géologique de France*, (7) 18(2): 543-552.

Hirsch F. (1977) - Essai de correlation biostratigraphique des niveaux meso- et neotriasiques de facies "Muschelkalk" du domaine sepharade. *Cuadernos de Geología Ibérica*, 4: 511-526.

Hyatt A. (1877) - Paleontology. *U.S. Geological Exploration of the Fourtieth Parallel, Report*, 4: 99-129.

Hyatt A. (1883-1884) - Genera of fossil cephalopods. Boston, *Society of Natural History Proceedings*, 22: 253-338 [pp. 253-274 issued in December 1883, pp. 273-338 in January 1884].

Hyatt A. (1900) - Cephalopoda. In: Zittel-Eastman textbook of paleontology, 1: 502-592.

Kaim A. & Niedźwiedzki R. (1999) - Middle Triassic ammonoids from Silesia, Poland. *Acta Palaeontologica Polonica*, 44(1): 93-115.

Kercsmár Zs. (Ed.), Budai T., Csillag G., Selmeczi I., Sztanó O. (2015) - Surface geology of Hungary. Explanatory notes to the Geological map of Hungary (1:500 000). Geological and Geophysical Institute of Hungary, Budapest, 62 pp.

Klug C. & Lehmkuhl A. (2004) - Soft-tissue attachment structures and taphonomy of the Middle Triassic nautiloid *Germanonautilus*. *Acta Palaeontologica Polonica*, 49(2): 243-258.

Konrád Gy. (1998) - Synsedimentary tectonic events in the Middle Triassic evolution of the SE Transdanubian part of the Tisza Unit. *Acta Geologica Hungarica* 41(3): 327-341.

Konrád Gy. & Sebe K. (2007) - Bükkösd. Középső-triász, Lapisi és Zuhányai Mészkő formációk. [Bükkösd. Middle Triassic, Lapis and Zuhánya Limestone Formations.] In: Pálfy J. & Pazonyi P. (Eds.) - Őslénytani kirándulások Magyarországon és Erdélyben [Paleontological excursions in Hungary and Transylvania]. Hantken Press, Budapest: 140-147.

Konrád Gy. & Sebe K. (2010) - Fiatal tektonikai jelenségek új észlelései a Nyugati-Mecsekben és környezetében (New details of young tectonic phenomena in the Western Mecsek Mts. and their surroundings). *Földtani Közlöny*, 140(2): 135-162.

Kovács S. & Papšová J. (1986) - Conodonts from the Paraceratites binodosus zone (Middle Triassic) from the Mecsek Mts., Southern Hungary and from the Choc Nappe of the Low Tatra Mts., Czechoslovakia. *Geologica Carpathica*, 37 (1): 59-74.

Kovács S., Sudar M., Grădinaru E., Gawlick H-J., Karamata S., Haas J., Péró Cs., Gaetani M., Mello J., Polák M., Aljinović D., Ogorelić B., Kolar-Jurkovšek T., Jurkovšek B. & Buser S. (2011) - Triassic Evolution of the Tectonostratigraphic Units of the Circum-Pannonian Region. *Jahrbuch der Geologischen Bundesanstalt*, 151: 199-280.

Kiparisova L.D. (1958) - Osnovy Paleontologii, Molliuski - Golovonogie 2, Nedra, Moskva, 33-39.

Kozur H. (1993) - First evidence of *Pseudofurnishius* (Conodonta) in the Triassic of Hungary. *Jahrbuch der Geologischen Bundesanstalt*, 136: 783-193.

Kummel B. (1960) - Middle Triassic nautiloids from Sinai, Egypt, and Israel. *Bulletin of the Museum of Comparative Zoology*, 123(7): 285-302.

Kummel B. (1964) - Nautiloidea - Nautilida. In: Moore R.C. (Ed.) - Treatise on Invertebrate Paleontology (K), University of Kansas Press, Lawrence: 383-457.

Mietto P. & Manfrin S. (1995) - A high resolution Middle Triassic ammonoid standard scale in the Tethys Realm. A preliminary report. *Bulletin de la Société Géologique de la France*, 1995(5): 539-563.

Mojsisovics E. (1873-1902) - Das Gebirge um Hallstatt. I Abteilung. Die Cephalopoden der Hallstätter Kalke, *Abhandlungen der Geologischen Reichsanstalt.* Wien. Band 6(1, 2), Band 1, Supplement-Heft (1, 2): 1-356.

Mojsisovics E. (1874) - Faunengebiete und Faciesgebilde der Trias-Periode in den Ost-Alpen. *Jahrbuch der kaiserlich-königlichen geologischen Reichsanstalt*, 24(1): 81-134.

Mojsisovics E. (1882) - Die Cephalopoden der mediterranen Triasprovinz. *Abhandlungen der kaiserlich-königlichen geologischen Reichsanstalt*, 10: 1-322.

Monnet C., Brack P., Bucher H. & Rieber H. (2008) - Ammonoids of the middle/late Anisian boundary (Middle Triassic) and the transgression of the Prezzo Limestone in eastern Lombardy-Giudicarie (Italy). *Swiss Journal of Geosciences*, 101: 61-84.

Monnet C., Bucher H., Wasmer M. & Guex J. (2010) - Revision of the genus *Acrochordiceras* Hyatt, 1877 (Ammonoidea, Middle Triassic): morphology, biometry, biostratigraphy and intra-specific variability. *Palaeontology*, 53(5): 961-996.

Mundlos R. & Urlichs M. (1984) - Revision von *Germanonautilus* aus dem germanischen Muschelkalk (Oberanis - Ladin). *Stuttgarter Beiträge zur Naturkunde* (B) 99: 1-43.

Muttoni G., Gaetani M., Budurov K., Zagorchev I, Trifonova E., Ivanova D., Petrounova & Lowrie W. (2000) - Middle Triassic paleomagnetic data from northern Bulgaria: constraints on Tethyan magnetostratigraphy and paleogeography. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 160: 223-237.

Nagy E. (1968) - Triasbildungen des Mecsek-Gebirges [Triassic formations of the Mecsek Mts.]. *Annals of the Geological Institute of Hungary,* 51(1): 1-198.

Page K.N. (1996) - Mesozoic Ammonoids in Space and Time. In: Landman N.H., Tanabe K. & Davis R.A. (Eds.) - Ammonoid Paleobiology. Plenum, New York, London: 755-794.

Parnes A. (1986) - Middle Triassic cephalopods from the Negev (Israel) and Sinai (Egypt). *Geological Survey of Israel, Bulletin*, 79: 1-59.

Parnes A., Benjamini C. & Hirsch F. (1985) - New Aspects of Triassic Ammonoid Biostratigraphy, Paleoenvironments and Paleobiogeography in Southern Israel (Sepharadic Province). *Journal of Paleontology*, 59(3): 656-666.

Pérez-Valera J. A., Barroso-Barcenilla F., Goy A. & Pérez-Valera F. (2017) - Nautiloids from the Muschelkalk facies of the Southiberian Triassic (Betic Cordillera, southern Spain). *Journal of Systematic Palaeontology*, 15(3): 171-191.

Pieroni V. (2020) - I nautiloidi spirali della collezione Gervasutti (Calcare di Esino, Triassico medio, Val Parina), *Rivista del Museo Civico di Scienze Naturali "Enrico Caffi", Bergamo*, 32: 65-83.

Pomoni F.A. & Tselepidis V. (2013) - Lithofacies palaeogeography and biostratigraphy of the lowermost horizons of the Middle Triassic Hallstatt Limestones (Argolis Peninsula, Greece). *Journal of Palaeogeography*, 2(3): 252-274. DOI: 10.3724/SP.J.1261.2013.00030

Pozsgai E., Józsa S., Dunkl I., Sebe K., Thamó-Bozsó E., Sajó I., Dezső J. & von Eynatten H. (2017) - Provenance of the Upper Triassic siliciclastics of the Mecsek Mountains and Villány Hills (Pannonian Basin, Hungary): constraints to the Early Mesozoic paleogeography of the Tisza Megaunit. *International Journal of Earth Sciences* (*Geol. Rundsch.*) 106: 2005-2024.

Rálischné Felgenhauer E. & Török Á. (1993) - Zuhányai Mészkő Formáció [Zuhánya Limestone Formation]. In: Haas J. (Ed.) - Magyarország litosztratigráfiai alapegységei. Triász [Lithostratigraphic units of Hungary. Triassic]. Geological Institute of Hungary, Budapest: 244-247.

Roemer F. (1870) - Geologie von Oberschlesien. Nischkowsky, Breslau, XXIV + 587 + XXII pp.

Sacchi Vialli G. & Vai A. (1958) - Revisione della fauna triassica bresciana: la fauna dell'Anisico. *Atti dell'Istituto Geologico della Università di Pavia*, 8: 41-91.

Salopek M. (1913) - Über die Cephalopodenfaunen der mittleren Trias von Süddalmatien und Montenegro. *Abhandlungen der kaiserlich-königlichen geologischen Reichsanstalt*, 16 (1911), 3: 1-44.

Schlotheim E.F. von (1820) - Die Petrefactenkunde auf ihrem jetzigen Standpunkte durch die Beschreibung seiner Sammlung versteinerter und fossiler Überreste des Thier- und Pflanzenreichs der Vorwelt erläutert. Becker, Gotha, 436 pp.

Schlotheim E.F. von (1823) - Nachträge zur Petrefactenkunde. II. Abteilung. Becker, Gotha, 114 pp.

Siegel F., Wiese F. & Klug K. (2022) - Middle Anisian (Bithynian to Illyrian?, Middle Triassic) Ammonoidea from Rüdersdorf (Brandenburg, Germany) with a revision of *Beneckeia* Mojsisovics, 1882 and notes on migratory pathways. *Bulletin of Geosciences*: 97(3): DOI 10.3140/bull.geosci.1850

Simionescu I. (1910) - Studii geologici şi paleontologice din Dobrogea, III. Fauna triasică dela Deşli-Caïra. La faune triasique de Deşli-Caïra (Dobrogea). *Publicatiunile fondului Vasile Adamachi*, 26: 465-493.

Spath L.F. (1934) - Catalogue of the fossil Cephalopoda in the British Museum (Natural History). Part IV. The Ammonoidea of the Trias. London, 521 pp.

Stampfli G.M. & Borel G.D. (2002) - A plate tectonic model for the Paleozoic and Mesozoic constrained by dynamic plate boundaries and restored synthetic oceanic isochrons. *Earth and Planetary Science Letters*, 196: 17-33.

Stefanoff A. (1936) - Die Fauna aus der Trias von Golo-Bârdo in S.W. Bulgarien. *Mitteilungen aus den Königlichen Naturwissenschaftlichen Instituten in Sofia*, 9: 147-162.

Sudar M.N, Gawlick H.-J., Lein R., Missoni S., Kovács S. & Jovanović D. (2013) - Depositional environment, age and facies of the Middle Triassic Bulog and Rid formations in the Inner Dinarides (Zlatibor Mountain, SW Serbia): evidence for the Anisian break-up of the Neotethys Ocean. *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen*, 269(3): 291-320.

Szulc J. (2000) - Middle Triassic evolution of the northern Peri-Tethys area as influenced by early opening of the Tethys ocean. *Annales Societatis Geologorum Poloniae*, 70: 1-48.

Tatzreiter F. & Balini M. (1993) - The new genus *Schreyerites* and its type species *Ceratites abichi* Mojsisovics, 1882 (Ammonoidea, Anisian, Middle Triassic). *Atti Ticinensi di Scienze della Terra (Pavia)*, 36: 1-10.

Tatzreiter F. & Vörös A. (1991) - Vergleich der pelsonischen (Anis, Mitteltrias) Ammonitefaunen von Grossreifling (Nördliche Kalkalpen) und Aszófõ (Balaton-Gebiet). - In: Jubiläumsschrift 20 Jahre Geologische Zusammenarbeit Österreich-Ungarn, Teil 1. Geologische Bundesanstalt, Wien: 247-259.

Toula F. (1896) - Eine Muschelkalkfauna am Golfe von Ismid in Kleinasien. *Beiträge zur Paläontologie und Geologie Österreich-Ungarns und des Orients,* 10: 153-191.

Toula F. (1913) - Geologisch-paläontologische Beobachtungen aus der Gegend von Drvar, Peći und Duler in Westbosnien. *Jahrbuch der kaiserlich-königlichen geologischen Reichsanstalt*, 63: 621-694.

Török Á. (1993) - Brachiopod beds as indicators of storm events: an example from the Muschelkalk of Southern Hungary. In: Pálfy J. & Vörös A. (Eds.) - Mesozoic brachiopods of Alpine Europe. Hungarian Geological Society, Budapest: 161-172.

Török Á. (1997) - Triassic ramp evolution in Southern Hungary and its similarities to Germano-type Triassic. *Acta Geologica Hungarica*, 40: 365-390.

Török Á. (2000) - Muschelkalk carbonates in southern Hungary: an overview and comparison to German Muschelkalk. *Zentralblatt für Geologie und Paläontologie*, Teil I. 9-10: 1085-1103.

Tozer E.T. (1981) - Triassic Ammonoidea: classification, evolution and relationship with Permian and Jurassic forms. In: House M.R. & Senior J.R. (Eds.) - The Ammonoidea. - Systematics Association Special Volume, 18: 65-100, Academic Press, London, New York.

Tozer E.T. (1982) - Marine Triassic faunas of North America: their significance for assessing plate and terrane movements. *Geologische Rundschau*, 71: 1077-1104.

Urlichs M. (2000) - Zur Entwicklungsreihe *Germanonautilus bidorsatus* - *G. suevicus* aus dem Germanischen Oberen Muschelkalk (Nautiloidea, Mitteltrias). *Stuttgarter Beiträge zur Naturkunde*, (B) 292: 1-16.

Urlichs M. & Mundlos R. (1985) - Immigration of Cephalopods into the Germanic Muschelkalk basin and its influence on their suture line. *Lecture Notes in Earth Sciences*, 1: 221-235.

Vadász E. (1935) - A Mecsekhegység. [Das Mecsek Gebirge.]. Magyar Tájak Földtani Leírása. Budapest,180 pp.

Vörös A. (1992) - Középső-triász (felső-anizuszi) ammonoidea paleobiogeográfia az alp-kárpáti régióban (Middle Triassic [Late Anisian] ammonoid palaeobiogeography in the Alpine-Carpathian region). *Őslénytani Viták*, 38: 71-77.

Vörös A. (1998) - A Balaton-felvidék triász ammonoideái és biosztratigráfiája (Triassic ammonoids and biostratigraphy of the Balaton Highland). *Studia Naturalia*, 12: 1-104, Budapest.

Vörös A. (2001) - Middle Triassic (Anisian) nautilid cephalopods from Aszófő (Balaton Highland, Hungary). *Fragmenta Palaeontologica*, 19: 1-14.

Vörös A. (2003) - The Pelsonian ammonoid fauna of the Balaton Highland. In: Vörös A. (Ed.) - The Pelsonian Substage on the Balaton Highland (Middle Triassic, Hungary). *Geologica Hungarica, series Palaeontologica*, 55: 71-121.

Vörös A. (2010) - Late Anisian Ammonoidea from Szár-hegy (Rudabánya Mts); a Dinaric-type fauna from North Hungary. *Fragmenta Palaeontologica Hungarica*, 28: 1-20.

Vörös A. (2018) - The Upper Anisian ammonoids of the Balaton Highland (Middle Triassic, Hungary). *Geologica Hungarica series Palaeontologica*, 60: 1-241.

Zittel K.A. von (1884) - Handbuch der Palaeontologie. Abt. I. (2), Oldenbourg, München & Leipzig, 893 pp.