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Early Tithonian ammonites, microfacies, biostratigraphy, and biogeography from the Mészkemence section (Zengővárkony, Mecsek Mountains, South Hungary)

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Abstract

A rich but poorly preserved Lower Tithonian faunal assemblage is reported from the abandoned quarry/lime kiln at Zengővárkony (Mecsek Mountains, Hungary). Some Lower Tithonian Tethyan ammonite zones (Hybonotum, Semiforme, and Fallauxi) are recognised. The Fallauxi Zone is recorded for the first time from the region. The pelagic fauna is dominated by ammonites and their aptychi. Brachiopods, belemnites, and very rarely bivalves are accessory elements of the fauna. The mollusc fauna comprises 167 specimens that represent 18 genera and 13 species. *Sublithacoceras rhodaniforme, Pseudopallasiceras toucasi*, *Biplisphinctes pseudocolubrinus*, and *Physodoceras* cf. *widerai* are recorded for the first time from the Mecsek Mountains. The ammonite fauna has a typical Mediterranean character. Based on cluster analysis, the Mecsek ammonite fauna is closest to the ammonite assemblages of the Transdanubian Range (Hungary). Based on quantitative analysis, the fauna is similar to the ammonite assemblages of the Apennines Veneto – Trento (Southern Alps, Italy), and Rogozník (Pieniny Klippen Belt). The microfacies is the Globochaete – Saccocoma microfacies. Large-sized pygopid brachiopods, serpulid tube worms on inoceramid shells, and benthic foraminifera indicate optimal bottom conditions. Pelagic faunal elements (*Saccocoma* sp., globuligerinid planktonic foraminifera) are also present, and calcareous dinoflagellate cysts (*Carpistomiosphaera malmica/tithonica*) are also recorded.

1. INTRODUCTION

Upper Jurassic strata from the Mecsek Mountains were first reported by PETERS (1862, p. 270, fig. 7) as "Ammonitenkalkstein von Pusztafalu" referring to the Stramberg-type limestones from the vicinity of Zengővárkony and Pusztakisfalu in the Mecsek Mountains (South Hungary). Tithonian strata were reported by BÖCKH (1880) from the exact, same abandoned quarry, where the present author collected the ammonite assemblages for this study. BÖCKH (1880) collected some specimens of *Pygope diphya* (von BUCH) from the quarry that had already been abandoned at that time. Later, VADÁSZ (1914) referred to *Perisphinctes cimbricus* (NEUMAYR) and *P.* cf. *transitorius* (OPPEL) beside some aptychi collected from the quarry. VADÁSZ (1935) enlarged the list of Tithonian ammonites with the following forms: *Holcophylloceras* cf. *silesiacum* (OPPEL), *Lytoceras* cf. *montanum* (OPPEL), *Protetragonites* cf. *quadrisulcatum* (D'ORBIGNY), *Lissoceras hungaricum* (VADÁSZ), *Oppelia zonarius* (OPPEL), and *Aspidoceras* cf. *binodum* (OPPEL). The abandoned quarry of Zengővárkony became a reference section for the Tithonian strata of the Mecsek Mountains. FÜLÖP (1967) made a detailed geological sketch of the Upper Tithonian part exposed in the western quarry wall and indicated the Jurassic/Cretaceous boundary. NAGY (1971) also added previously unknown Tithonian ammonite taxa to the faunal list: *Ptychophylloceras ptychoicum* (QUENSTEDT), *Lytoceras sutile* (OPPEL), *Berriasella Callisto* (D'ORBIGNY), *B. richteri* (OPPEL), *Physodoceras* cf. *cyclotum* (OPPEL), and *Prorasenia witteana* (OPPEL); however, none of them were figured or taxonomically described. It is noteworthy here that PETERS (1862, p. 282 – 284) already listed *P. ptychoicum, P. witteana*, and *B. callisto*; however, he did not figure them and did not refer to the Tithonian or the Berriasian.

FŐZY (1993), conducted fieldwork in the Mecsek Mountains, visited the limekilns, and collected ammonites from the quarry, adding some previously unknown forms such as *Haploceras* cf. *elimatum* (OPPEL), *Anaspidoceras neoburgense* (OPPEL), *Virgatosimoceras*, ?*Pseudolissoceras*, *Usseliceras*, and *Simoceratidae*? sp., referring to the Lower Tithonian and the possible presence of Semiforme Zone levels. From other sections in the Mecsek Mountains, FŐZY (1993, p. 200 – 202) reported previously unknown forms from the Mecsek Mountains: *Haploceras carachtheis* (ZEJSZNER), *Semiformiceras* cf. *darwini* (NEUMAYR), and *Virgatosimoceras* cf. *rothpletzi* (SCHNEID). Regarding the biogeographical affinities, FŐZY (1993, p. 203) stated that the Tithonian ammonite assemblage of the Mecsek Mountains reflected typical Tethyan aspects with certain Mediterranean affinities. Later, SCHERZINGER et al. (2010) reported a *Virgatosimoceras* sp. with photographic documentation from Kárász, (Northern Imbrication Zone, Mecsek Mountains), collected by FŐZY (1993). Recently, BUJTOR et al. (2021a) reported Early

Tithonian ammonites (*Lithacoceras* aff. *siliceum* (QUENSTEDT), *Malagasites*? *denseplicatus* (WAAGEN), and *Gravesia* aff. *gigas* (ZIETEN) from Zengővárkony; however, not from the Mészkemence section but from an abandoned small quarry situated NE from the locality described herein, on the other bank of the Vasbányavölgy Creek, indicating the lower part of the Lower Tithonian Hybonoticeras Zone.

Regarding the microfauna, NOSZKY (1952) reported for the first time the calpionellids from the Mecsek Mountains, (*Calpionella alpina* (LORENZ) from the Tithonian around Komló). SIDÓ (in: PANTÓ et al., 1955) recognised some calpionellid species from Zengővárkony: *Calpionella alpina*, *C. elliptica* (CADISH), and *Tintinnopsella carpathica* (MURGEANU & FIPILESCU) from the Berriasian part of the section. SIDÓ (1957), published the first comprehensive description of the Hungarian calpionellids and reported *Calpionella undelloides* (COLOM) from the Tithonian of Zengővárkony. BÁLDI-BEKE (1965) summarised the Hungarian *Nannoconus* fauna and referred to the Zengővárkony Mészkemence section as the only locality for nannoconids in the Mecsek Mountains, reporting the presence of *Nannoconus steinmanni* (KAMPTNER). NAGY (1964), investigated the microfauna of the western wall of the quarry and reported a rich Tithonian/Berriasian calpionellid assemblage of 21 species. He divided the sequence into a lower Tithonian part, (Lombardia Zone and Lombardia-Globochaete facies) and an upper Tithonian part (Calpionella Zone), and referred to a rich Berriasian calpionellid assemblage from the upper part. KNAUER (1964) introduced a new taxonomic name (*Tintinnopsella colomi* KNAUER) for a particular population of a *Calpionellopsis oblonga* assemblage that came from the Berriasian strata at Zengővárkony, collected by István NAGY. KNAUER & NAGY (1964) described a new calpionellid genus, (*Lorenziella*) and its species from the western quarry wall (*L. hungarica* KNAUER & NAGY, *L. transdanubica* KNAUER & NAGY). NAGY (1966a) made a microfacies analysis of the Upper Jurassic strata of the Mecsek Mountains and outlined a biostratigraphic division based on microfossils. Later NAGY (1966b) reported six *Cadosina* species from the Upper Jurassic of the Mecsek Mountains. Finally, NAGY (1986) set up a regional calpionellid biostratigraphy for the Mecsek Mountains, including 27 new species and 22 regional calpionellid zones. Sections/localities are not described, and all the new species are *nomen nudum*.

Regarding the old collections, there are ambiguities around the precise localities of some ammonites collected by E. VADÁSZ and deposited at SARA (= Supervisory Authority for Regulatory Affairs Hungary) but never published. Based on analysis of the original hand-written labels and the revision of the related specimens, the following conclusions were drawn: A *Pseudowaagenia* cfr. *pressulum* (NEUMAYR) under the J 710 label referred to the Mészkemence quarry; however, based on the lithological features (grey, spotted, and pinkish-brown limestone), it came from the lower part of the Kimmeridgian; therefore, it is excluded from this study. Another ambiguous specimen is a *Pseudowaagenia* cfr. *haynaldi* (HERBICH) under the J 5697 label collected by E. VADÁSZ, which refers to the Kimmeridgian, and was possibly not derived from the quarry; therefore, it is also excluded from this study. The final dubious specimen is a *Sowerbyceras* cfr. *tortisulcatum* (D'ORBIGNY) under the J 1972 label. Its locality is indicated as the quarries around Zengővárkony, which did not allow recognition of the original locality and therefore was also excluded.

The present author visited the Palaeontological Collection of the Hungarian Mining and Geological Survey (now SARA) to see the original material of János BÖCKH and Elemér VADÁSZ. This material is included in this study, after revision and with reassignments proposed.

The aim of the paper is to report the taxonomic description and photographic documentation of the Early Tithonian ammonites from the Mecsek Mountains for the first time based on a new collection in the Mészkemence section, a revision of the old collection from the quarry and a description of biostratigraphy and palaeobiogeographical analysis.

2. GEOLOGICAL SETTING

The Mecsek Mountains are located in South Hungary (Fig. 1) as a part of a nappe system that is considered a microcontinent (CSONTOS & VÖRÖS, 2004). The nappe system consists of five units (HAAS & PÉRÓ, 2004), out of which the Mecsek nappe is the northernmost one. Its continuation towards East Hungary is reported from boreholes drilled on the southern part of the Great Hungarian Plain. The southern tectonic termination of the Mecsek Mountains (South Mecsek Line, cf. CSONTOS et al., 2002) is a complex area along which the Zengővárkony area is located. The South Mecsek Line separated the Zengővárkony region from most of the Jurassic – Cretaceous basinal structure of the Mecsek Mountains and created scattered tectonic blocks along the line.

The sedimentary regime changed in the Middle Jurassic. The previously siliciclastic, shallow marine environment was replaced by pelagic sedimentation from the turn of the Bathonian/Callovian (GALÁCZ, 1984) and carbonatic sedimentation prevailed in the Late Jurassic. From the Oxfordian, sedimentation is characterised by undisturbed, hemipelagic carbonate deposits, beginning with characteristic ammonitico rosso lithofacies. From the upper Kimmeridgian, the ammonitico rosso facies was replaced by spotty and light brown micritic limestones which continued in the Lower Tithonian. Ammonites became rare, and somewhere around the mid-Tithonian, chert nodules and levels appeared. In the Upper Tithonian a typical Biancone facies developed in the Mecsek Mountains (except for the Zengővárkony region, where Upper Tithonian is represented by thin and brownish-white massive limestones with ferruginous and red-coloured levels). In the Mészkemence sequence, the first indication of volcanic activity also appeared, slightly below the chert levels. The Jurassic – Cretaceous boundary is well known in the Mészkemence section (FÜLÖP, 1967) and thought to be discontinuous. Volcanic activity strengthened upwards in the sequence; more and more tuffaceous content appears, and the volcanic activity reached its acme during the Berriasian – Valanginian, building up a volcanic edifice during the Early Cretaceous. In the Zengővárkony region, the Upper Jurassic – Lower Cretaceous calcareous sedimentary sequence is terminated by volcanic rocks (ankaramite, hyaloclastite, and

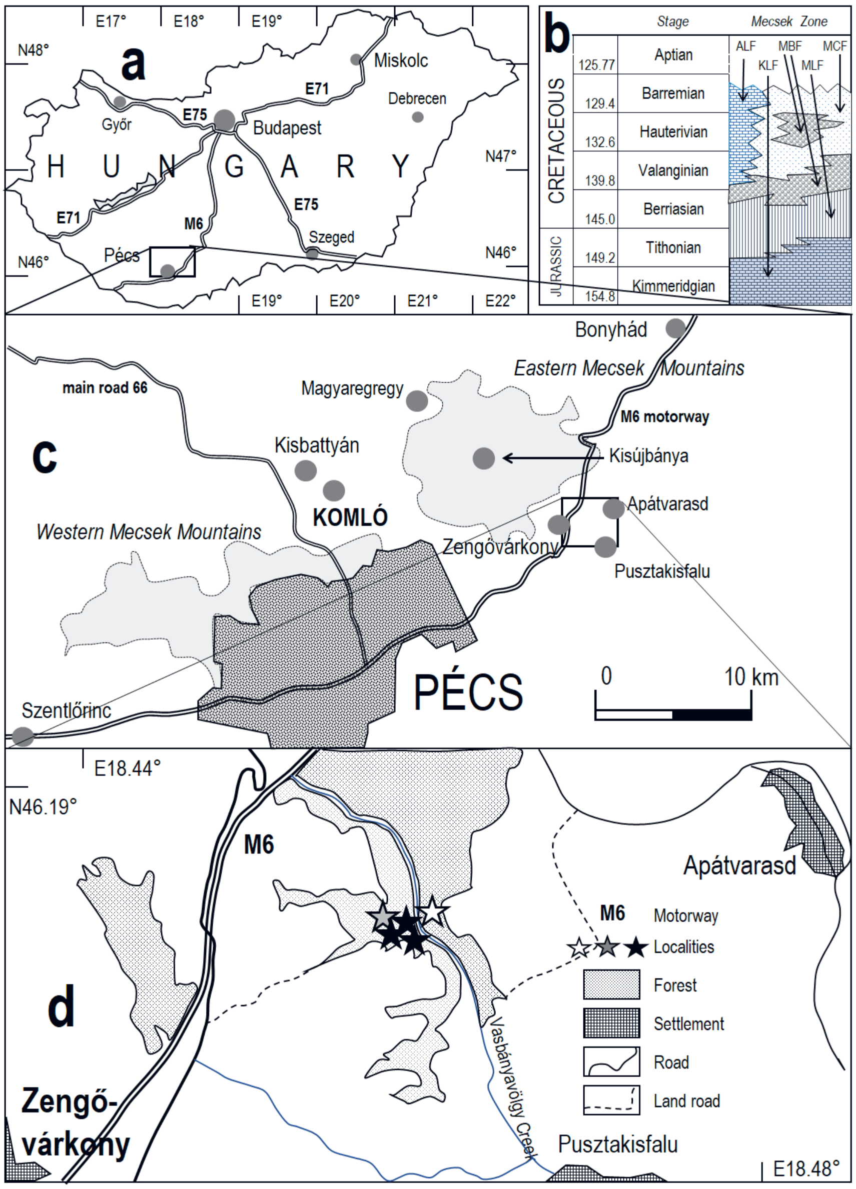

Figure 1. Locality map and lithostratigraphy of the investigated area. **a** Map of Hungary. The rectangle indicates the study area; **b** Lithostratigraphic units of the Mecsek Mountains in the Upper Jurassic and Lower Cretaceous from RAUCSIK (in FŐZY, 2012). ALF: Apátvarasd Limestone Fm; KLF: Kisújbánya Limestone Fm; MBF: Mecsekjánosi Basalt Fm; MCF: Magyaregregy Conglomerate Fm; MLF: Márévár Limestone Fm. Numeric ages from COHEN et al. (2013, updated); **c** Simplified map of the Mecsek Mountains (Hungary). The rectangle indicates the study area east of Zengővárkony; **d** A simplified map of the Zengővárkony Mészkemence area. Stars indicate the investigated sections in and around the abandoned quarry. Grey asterisk: lowermost Berriasian section; black asterisk: Tithonian sections; white asterisk: uppermost Kimmeridgian – lowermost Tithonian locality.

basaltic pillow lava flows). Early Cretaceous (Valanginian – Hauterivian) limestones were deposited on the surface of the volcanite. Younger sediments are not exposed in the area.

The Zengővárkony Mészkemence section is the most thoroughly analysed section of the Tithonian/Berriasian strata of the Mecsek Mountains. The lithological column of the Mészkemence section traverses the Tithonian/Berriasian strata (Fig. 2).

2.1. Studied sections

The abandoned quarry (= limekilns of Várkony) traverses the continuous uppermost Kimmeridgian to the lowermost Berriasian strata in an east-to-west direction (Fig. 3). The thickness of the Tithonian strata is 22 metres (NAGY, 1964; BUJTOR et al., 2021a, 2021b). The eastern slope of the quarry traverses the uppermost Kimmeridgian – lowermost Tithonian sequence and provided the majority of the ammonite specimens described herein. Descriptions of the investigated localities are introduced from the oldest to the youngest.

2.1.1. Locality 1 (coordinates in WGS84 system: 46.1834° N, 18.4583° E)

This locality is situated outside the quarry on the opposite side of the Vasbányavölgy Creek, where a smaller, also abandoned quarry is located (Fig. 3a) traversing the Kisújbánya Limestone Fm. The debris and soil at the southern edge of this small, abandoned quarry provided a rich, chiefly late Kimmeridgian fauna, with some individuals referring to the early Tithonian and described in detail by BUJTOR et al. (2021a), and provided some Early Tithonian ammonites (Fig. 2).

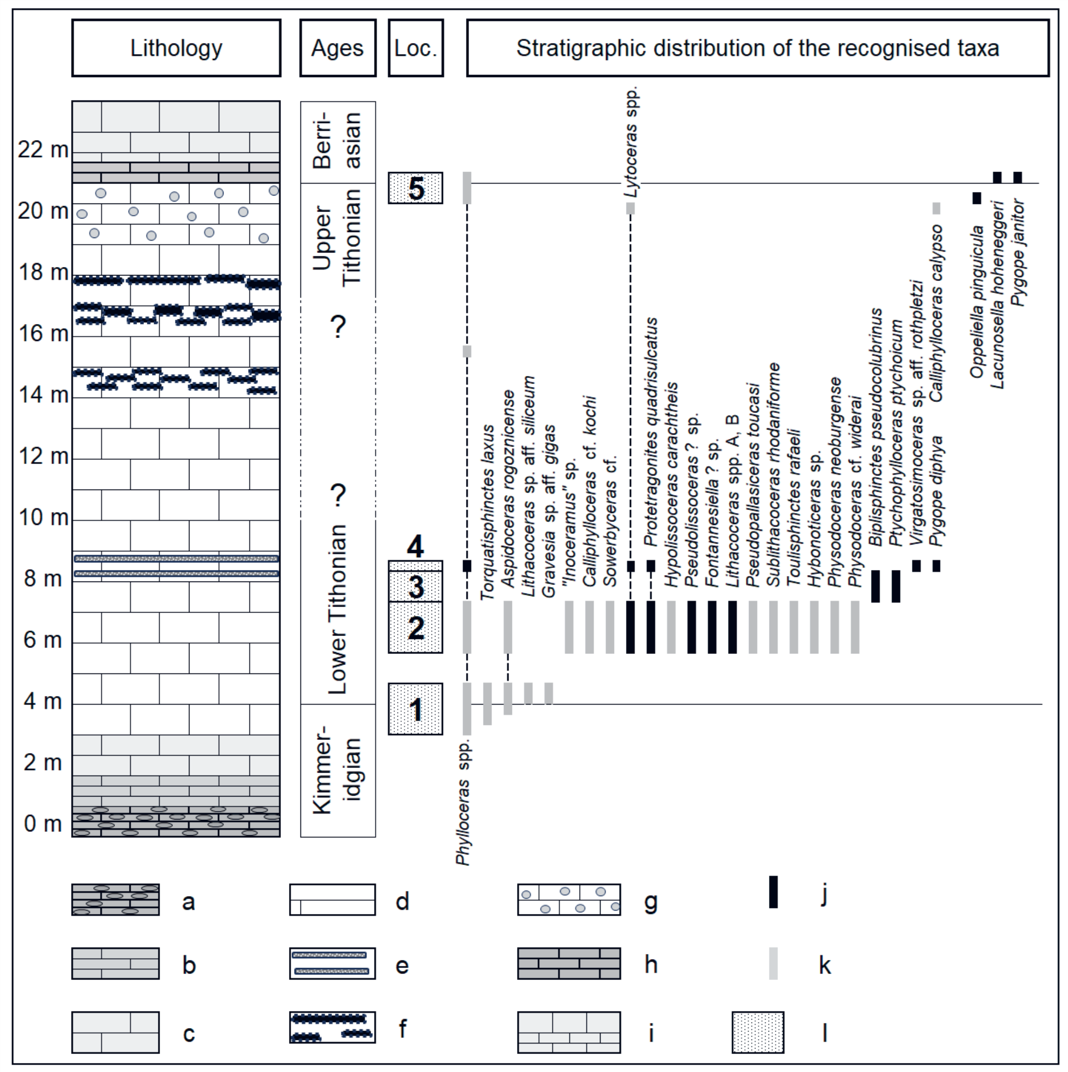

Figure 2. The Mészkemence section and stratigraphic distribution of the collected fossils in the abandoned quarry at Zengővárkony (Mecsek Mountains, Hungary). Lithology after NAGY (1964), BUJTOR et al. (2021a), modified. Legend: **a** nodular, marly ammonitico rosso-type red limestone; **b** yellow spotted, red-coloured ammonitico rosso-type, poorly stratified limestone; **c** red spotted, grey-coloured poorly stratified limestone; **d** white coloured, nodules at the base, poorly stratified limestone; **e** white-coloured, sometimes greenish-coloured tuffaceous thin intercalation; **f** chert nodules, levels; **g** white to whitish grey coloured massive limestone with frequent intraclasts; **h** thin-bedded, red coloured limestone; **i** light brown-coloured, thick-bedded limestone; **j** fauna collected from bed; **k** fauna collected from debris, soil, scree; **l** investigated locality. Lithology after NAGY (1964), BUJTOR et al. (2021a, b), and BUJTOR (2025), simplified. Black shaded occurrence: collected from bed; grey shaded occurrence: collected from scree.

2.1.2. Locality 2 (coordinates in WGS84 system: 46.1846° N, 18.4574° E)

This is the western slope of the abandoned quarry that unearthed a bedding plane (Fig. 3b). Dip direction is 310°/40°, representing the deepest Tithonian (? terminal Kimmeridgian) strata of the quarry. The section traverses three limestone beds of 5 – 15 cm thickness separated by thin marly levels of less than 1 cm thickness. The limestone is a massive, micritic, light-grey or light-brown coloured rock with yellowish-ochreous coloured marl films. On the eroded surface of the bedding plane ammonites, and belemnite rostra are exposed. From beds 2 and 3, some poorly preserved ammonites and ammonite whorl fragments (*Calliphylloceras* cf. *kochi* (OPPEL), *Taramelliceras* (*Taramelliceras*) *compsum* (OPPEL), *Fontannesiella* sp., ?*Pseudolissoceras* sp., *Aspidoceras* sp.) were collected, but no zonal marker was unearthed. It traverses the upper part of the Kisújbánya Limestone Formation. The majority of the fauna described herein was collected here.

2.1.3. Locality 3 (coordinates in WGS84 system: 46.1833° N, 18.4584° E)

The forest road (Fig. 1d) that divides the forest from the ploughland provided a few but valuable ammonite specimens from the scree (*Biplisphinctes pseudocolubrinus* (KILIAN) and *Ptychophylloceras ptychoicum* (QUENSTEDT)). Being a public cart road, no excavation was possible.

2.1.4. Locality 4 (coordinates in WGS84 system: 46.1841° N, 18.4584° E)

On the edge of the southern slope of the quarry, an artificial trench was prepared that provided brachiopods and a few stratigraphically important ammonites (Fig. 3c). The section traverses a tuffaceous limestone sequence in which some light, grey-coloured beds occur and provided brachiopods (*Pygope diphya*). The tuffaceous beds unearthed some poorly preserved ammonites (*Phylloceras* sp., *Lytoceras* sp., *Protetragonites quadrisulcatus*, *Virgatosimoceras* sp. aff. *rothpletzi* (SCHNEID)).

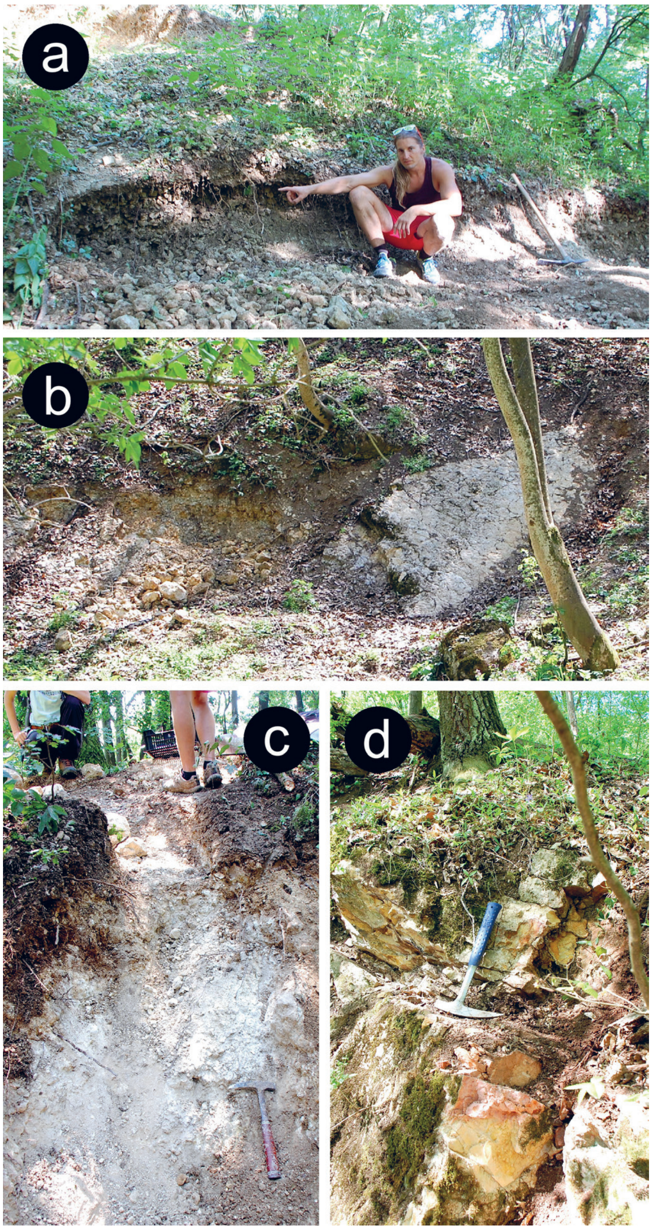

Figure 3. Investigated outcrops around the Zengővárkony Mészkemence section. **a** Upper Kimmeridgian – lowermost Tithonian section at the southern flank of the small quarry of the left bank of the Vasbányavölgy Creek after BUJTOR et al. (2021a). BSc student Á. MIKLÓSY points to the source of the fauna; **b** Eastern quarry wall at the Mészkemence section traversing the Lower Tithonian. Dipping 310°/40°; **c** An artificial trench on the southern edge of the abandoned quarry traversing the upper part of the Lower Tithonian; **d** Lowermost Berriasian section of the Western quarry wall. Hammer rests on the bed that yielded brachiopods.

The locality had previously been reported by BUJTOR et al. (2021b) in detail and represents the Márévár Limestone Formation.

2.1.5. Locality 5 (coordinates in WGS84 system: 46.1848° N, 18.4564° E)

This locality is at the western quarry wall (Fig. 3d) and provided some brachiopods: *Lacunosella hoheneggeri* (SUESS), *Pygope janitor* (BUJTOR et al., 2021b), and *Oppeliella pinguicula*. A lower continuation of the section (which is an unstratified, Maiolica-type, whitish-grey coloured massive limestone), is followed in an artificially prepared trench, but no macrofossils were recovered from the strata. Some poorly preserved ammonites were recovered from the debris during excavation (*Phylloceras* sp. ind., *Calliphylloceras calypso*). This section includes the Tithonian/Berriasian boundary, as the preliminary microfaunal analysis predicts and represents the Márévár Limestone Formation. The upper part of the section and its continuation towards the forest are of Berriasian age.

3. MATERIALS AND METHODS

Abbreviations: Fm: formation; D: diameter of the conch; W: width of conch; L: length of conch, lateral lobe – up to context; T: thickness of conch; Wb: width of the conch; Wh: height of the last whorl; U: diameter of the umbilicus. Dimensions are given in mm. Measurements in brackets refer to estimated data due to poor preservation.

Systematics: Systematics of Lytoceratoidea follows HOFFMANN (2015). Systematics of Perisphinctoidea follows ÉNAY & HOWARTH (2019) except for Aspidoceratoidea. For aspidoceratid ammonites, the systematics follows PARENT et al. (2020). The Jurassic timescale (incl. Tethyan ammonites) follows HESSELBO et al. (2020).

Repository: The macrofauna available for this study comprises ammonites and bivalves and are housed in several institutions. Specimens described or referred to herein prefixed as 'J' are housed in the old collection of the Mining and Geological Survey of Hungary (recently SARA) with the hand-written original labels of János BÖCKH and Andor SEMSEY from the 1870 – 1880s, Elemér VADÁSZ in 1931, and published for the first time herein. Specimens prefixed as 'KVC' are housed in the collection of the Komlóverzum Visitor Centre, City Library and Museum Collection, 1 Városház tér, Komló, H-7300, Hungary.

Technical details: Ammonites were coated with ammonium chloride for photography. Photographs were taken by the present author with a Nikon D3500 DSLR camera equipped with an AF-S DX Micro Nikkor 40 mm f/2.8 G lens. Measurements were acquired by a manual vernier calliper. For biogeographical analysis of the ammonite assemblages, occurrence data of ammonite species were collected in a matrix, then a cluster analysis was applied using the neighbour-joining method with version 4.14 of the PAST program (HAMMER et al., 2001).

During data analysis, Simpson index values were applied that originated from the initial data matrix.

Cephalopod collection: The material available to this study comprises 173 specimens. 13 specimens came from the old collection of the SARA, but only 6 specimens were included in this study. The collected fauna comprises 167 specimens (Table 1) and represents a pelagic assemblage. The taxonomic

Table 1. Taxonomic composition of the collected fauna from the Lower Tithonian strata of Zengővárkony Mészkemencék, Mecsek Mountains, Hungary.

Taxonomic unit	Number of specimens	Abundance (%)
Ammonites	151	90.4
Aptychi	8	4.8
Belemnites	2	1.2
Brachiopods	5	3.0
Bivalves	1	0.6
TOTAL	167	100.0

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Table 2. Taxonomic composition of the collected Lower Tithonian ammonite specimens from the Zengővárkony Mészkemencék, Mecsek Mountains, Hungary.

Taxonomic unit	Number of specimens	Abundance (%)
Phylloceratida	13	8.6
Lytoceratida	22	14.6
Haploceratoidea	43	28.5
Perisphinctoidea	30	19.8
Aspidoceratoidea	43	28.5
TOTAL	151	100.0

composition of the ammonite assemblages (Table 2) reveals a typical Tethyan character; however, the ratio of phyllo- and lytoceratid specimens is low (23%). Specimens derived from the old collection are not included in the taxonomic composition. The revision of the old collection produced reassignments (Table 3). Other specimens from the old collection are also excluded: these are *Taramelliceras* (*Taramelliceras*) *compsum* specimens (J 701, J 2078, J 5699, J 5703) without stratigraphic control.

4. SYSTEMATIC PALAEONTOLOGY

Phylum Mollusca LINNAEUS, 1758

Class Bivalvia LINNAEUS, 1758

Subclass Pteriomorphia BEURLEN, 1944

Order Pterioida NEWELL, 1965

Family Inoceramidae GIEBEL, 1852

"*Inoceramus*" sp.

Material: One double-valved, fairly well preserved, fragmentary internal mould with shell preserved from limestone, specimen KVC 2024.12.1 from Locality 2 (Fig. 3b).

Description: The specimen is medium-sized (preserved maximum height 75 mm; preserved maximum length 35 mm), inequilateral. General shape is elongate, valves slightly convex. Umbonal area not visible. The hinge area and the wing are not preserved. The ornament consists of 14 fine, rounded, regular, simple concentric ribs, which became less dense from the umbonal parts outward. Ribs are delicate, and very thin (0.1 mm wide). Other ornamental elements not preserved.

Remarks: Tithonian inoceramids are represented by three genera: *Inoceramus* PARKINSON, 1819; *Retroceramus* KOSHELKINA, 1963; and *Anopaea* EICHWALD, 1861.

Anopaea was never reported from any Tethyan localities (MYCZYŃSKI, 1999); therefore, the present specimen may belong to either of the first two genera. Unfortunately, the umbonal part is not visible; therefore, reliable generic determination is not possible. Two meandering annelid tubeworm remains preserved on the surface of the shell.

Occurrences: Inoceramids have worldwide distribution from the Early Jurassic until the end of the Cretaceous.

Class Cephalopoda CUVIER, 1797

Order Phylloceratida SCHINDEWOLF, 1923

Suborder Phylloceratina ARKELL, 1950

Superfamily Phylloceratoidea ZITTEL, 1884

Family Phylloceratidae ZITTEL, 1884

Subfamily Phylloceratinae ZITTEL, 1884

Genus *Phylloceras* SUESS, 1865

Type species: *Ammonites heterophyllus* J. SOWERBY, 1820

Phylloceras spp.

Material: Four poorly preserved, corroded, worn, and fragmentary internal moulds: KVC 2024.45.1, 2024.73.1, 2024.81.1, and 2024.149.1 from localities 1, 2, 4, and 5 (Figs. 3a– d).

Remarks: These worn, corroded and partial fragments do not preserve any specific features. Based on the various whorl sections and umbilical regions, they may represent different species.

Genus *Calliphylloceras* SPATH, 1927

Type species : *Phylloceras disputabile* ZITTEL, 1869

Calliphylloceras calypso D'ORBIGNY, 1841 (Fig. 4.2)

1841 *Ammonites Calypso* – D'ORBIGNY, p. 167, pl. 52, figs. 7–9

v 1993 *Calliphylloceras calypso* (D'ORBIGNY) – BUJTOR, p. 109, figs. 5B, 6C–E [cum syn.]

2022 *Calliphylloceras calypso* (D'ORBIGNY) – FŐZY et al., pl. 4, fig. 4

Table 3. Revision of the old collection from the Mészkemence section/quarry (Zengővárkony, Mecsek Mountains, Hungary) with amended names. Selection based on the original handwritten labels: *large quarry at limekiln*. An asterisk in the remarks indicates photographic documentation in this paper.

Rep. number	Original name	Collected by	Collected in	Emended name	Remarks
J 701	*Oppelia (Taramelliceras)* cfr. *trachynota* (Opp.)	J. Böckh	1874	*Taramelliceras* (*Taramelliceras*) *compsum*	excluded from study
J 710	*Pseudowaagenia* cfr. *pressulum*	E. Vadász	1931	*Hybonoticeras pressulum*	excluded from study
J 711	*Virgatosphinctes* ? sp.	J. Böckh	1877	*Sublithacoceras rhodaniforme* (OLÓRIZ, 1978)	BUJTOR et al. 2021a, fig. 9.C as *Malagasites* ? *denseplicatus*
J 1972	*Sowerbyceras* cfr. *tortisulcatum*	E. Vadász	1931	*Sowerbyceras* cf. *tortisulcatum*	excluded from study
J 1973	*Aspidoceras* sp.	E. Vadász	1931	*Aspidoceras* cf. *widerai*	*
J 2050	*Aspidoceras* sp.	A. Semsey	1881	*Aspidoceras rogoznicense*	
J 2078	*Oppelia (Taramelliceras)* cfr. *compsa*	J. Böckh	1877	*Taramelliceras* (*Taramelliceras*) *compsum*	excluded from study
J 2094	*Perisphinctes* sp.	J. Böckh	1877	*Pseudopallasiceras toucasi* (CECCA & ÉNAY, 1991)	*
J 2095	*Perisphinctes* sp.	J. Böckh	1877	*Pseudopallasiceras toucasi* (CECCA & ÉNAY, 1991)	*
J 2097	*Aspidoceras* cf. *binodum*	J. Böckh	1875	*Aspidoceras rogoznicense*	
J 5697	*Pseudowaagenia* cfr. *haynaldi*	E. Vadász	1931	*Pseudowaagenia acanthomphala*	excluded from study
J 5699	*Taramelliceras* cf. *compsa*	E. Vadász	1931	*Taramelliceras* (*Taramelliceras*) *compsum*	excluded from study
J 5703	*Taramelliceras* cfr. *pseudoflexuosum*	J. Böckh	?	*Taramelliceras* (*Taramelliceras*) *compsum*	excluded from study

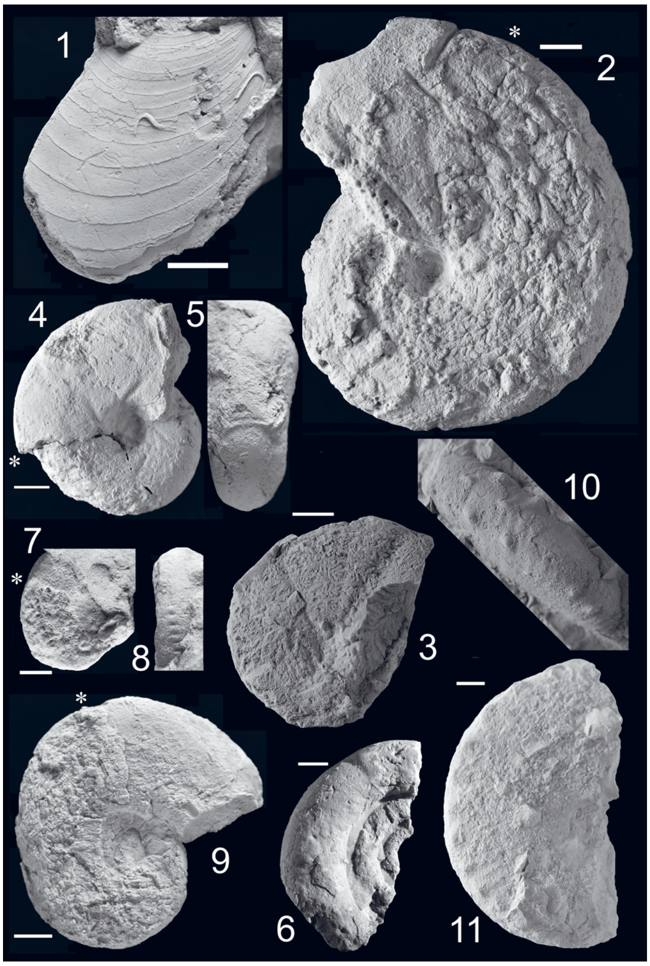

Figure 4. Early Tithonian bivalves and ammonites from the Mészkemence section of Zengővárkony (Mecsek Mountains, Hungary). **1** "*Inoceramus*" sp. from the quarry floor, loc. 2, probably right valve, with serpulid tube worm remains, specimen KVC 2024.12.1; **2** *Calliphylloceras calypso* (D'ORBIGNY, 1841) from debris at the foot of locality 5, specimen KVC 2024.141.1, lateral view; **3** *Calliphylloceras* cf. *kochi* (OPPEL, 1865) from debris of beds 1–6 of loc. 2, specimen KVC 2024.32.1, lateral view; **4–5** *Sowerbyceras* cf. *pseudosilenum* SARTI, 1993 from debris of the quarry floor, loc. 2, specimen KVC 2024.11.1; **4** lateral view; **5** ventral view; **6** *Protetragonites quadrisulcatus* (D'ORBIGNY, 1841) from locality 4, specimen KVC 2024.151.1, lateral view; **7–8** *Hypolissoceras carachtheis* (ZEJSZNER, 1846) from debris of beds 1–6 of loc. 2, specimen KVC 2024.145.1; **7** ventral view; **8** lateral view; **9** *Pseudolissoceras*? sp. from bed 3 of locality 2, specimen KVC 2024.22.1, lateral view; **10–11** *Fontannesiella*? sp. from the beds 1–6 of loc. 2, specimen KVC 2024.124.1; **10** lateral view; **11** ventral view. Scale bars indicate 1 cm for 2, 3, 8–16, while 0.5 mm for 1, 4, and 7. An asterisk indicates the beginning of the body chamber.

Material: One slightly corroded internal mould of phragmocone and partial body chamber KVC 2024.141.1 from locality 5 (Fig. 3d).

Dimensions: Table 4.

Remarks: The specimen shows a well-marked prosocline constriction which curves backwards in the upper part of the flank and then crosses the venter. The shallow, lower flank constrictions are also present, which clearly refers to this species.

Occurrences: Geographically, it is known from the northern part of the Mediterranean Tethys. Stratigraphically, it ranges from the Tithonian to the Valanginian (IMMEL, 1987).

Calliphylloceras cf. *kochi* (OPPEL, 1865) (Fig. 4.3)

1865 *Ammonites Kochi* – OPPEL, p. 550

1868 *Phylloceras Kochi* OPP. – ZITTEL, p. 65, pl. 6, fig. 1, pl. 7. figs. 1, 2

1879 *Ammonites* (*Phylloceras*) *Kochi,* OPPEL – FAVRE, p. 24, pl. 2, fig. 8

1984 *Calliphylloceras kochi* (OPPEL) – ROSSI, p. 83, pl. 30, fig. 13

2000 *Calliphylloceras kochi* (OPPEL) – JOLY, p. 81. pl. 17, figs. 5, 6

2011 *Calliphylloceras kochi* (OPPEL) – GRIGORE, p. 194, pl. 1, fig. 11

2020 *Calliphylloceras kochi* (OPPEL) – SARTI, p. 71, pl. 1, figs. 9, 10

Material: One slightly corroded internal mould of phragmocone, KVC 2024.32.1 from locality 2 (Fig. 3b).

Dimensions: Table 4.

Remarks: Due to the poor preservation, important characteristics are not preserved; however, the compressed oval section, number and shape of the constrictions refer to this species.

Occurrences: Stratigraphically, it has a wide range from the Upper Kimmeridgian to the Berriasian. Geographically, it has a Tethyan, Mediterranean geographic distribution.

Genus *Sowerbyceras* PARONA & BONARELLI, 1895

Type species: *Ammonites tortisulcatus* D'ORBIGNY, 1841

Sowerbyceras cf. *pseudosilenum* SARTI, 1993

(Figs. 4.4, 4.5)

Material: One poorly preserved internal mould of the phragmocone and partial body chamber KVC 2024.11.1 from locality 2 (Fig. 3b).

Dimensions: Table 4.

Description: Coiling involute, shell compressed, flanks parallel. Umbilicus rather deep, umbilical wall oblique, umbilical shoulder rounded. No sculpture except some constrictions that are shallow and cross the venter without interruption. Constrictions prorsiradiate on the upper flank, bending gently backward on the ventral shoulder and crosses the venter perpendicularly with shallow constriction. There are 5 constrictions on the last whorl. Septal suture not preserved.

Remarks: The ventral constriction shown by the present specimen superficially resembles that of *S. loryi* (SARTI, 1993, pl. 1, fig. 4); however, taking into consideration the weakness of the constrictions on the flank, their faint presence on the midflank, and that constrictions cross the venter gently, forming only a shallow band, this specimen more likely belongs to *S. pseudosilenum* (cf. SARTI, 2003, pl. 3. figs. e, f). *S. loryi* and *S. pseudosilenum* are closely related species. When SARTI erected *S. pseudosilenum* (SARTI, 1993) he introduced it as a morphotype of *S. loryi*.

Occurrences: It is reported from the Upper Kimmeridgian of the Eastern Carpathians, Romania (GRIGORE, 2011), the Beckeri Zone and the Kimmeridgian/Tithonian transitional beds from the Southern Alps, Italy (SARTI, 1993, 2020).

Table 4. Biometric data of the measured ammonite specimens. Data is given in mm. For abbreviations of repositories see Material and method section.

Taxon	Specimen	D	Wb	Wh	U	Wb/Wh	Wh/D	U/D
Calliphylloceras calypso	KVC 2024.141.1	114.1	(24)	65.4	7.9	0.367	0.573	0.069
Calliphylloceras cf. *kochi*	KVC 2024.32.1	(60)	n.d.	(30)	5	-	0.500	0.083
Sowerbyceras cf. *pseudosilenum*	KVC 2024.11.1	57.3	(22)	29.5	6.6	0.746	0.515	0.115
Protetragonites quadrisulcatus	KVC 2024.3.1	47.9	(14)	n.d.	n.d.	-	-	-
	KVC 2024.4.1	(69)	(26)	(21)	(32)	1.238	0.304	0.464
	KVC 2024.144.2	(55)	n.d	n.d.	(29)	-	-	0.527
	KVC 2024.151.1	n.d.	(16)	(16)	n.d.	1.000	-	-
Hypolissoceras carachtheis	KVC 2024.145.1	(25)	(8)	(17)	(3)	0.470	0.680	0.120
Pseudolissoceras ? sp.	KVC 2024.22.1	83	(19)	(44)	(12)	0.432	0.530	0.145
	KVC 2024.133.1	(65)	(26)	(30)	(15)	0.867	0.461	0.231
	KVC 2024.148.1	(78)	(23)	(35)	(16)	0.657	0.449	0.205
Fontannesiella ? sp.	KVC 2024.124.1	89.2	(22)	(48)	(11)	0.458	0.538	0.123
Virgatosimoceras sp. aff. *rothpletzi*	KVC 2024.144.1	106	(25)	(28)	(62)	0.892	0.264	0.585
	KVC 2024.135.1	(53)	(26)	(17)	(29)	1.529	0.320	0.547
Lithacoceras spp.	KVC 2024.25.1	(150)	(33)	(33)	(80)	1.000	0.220	0.533
	KVC 2024.48.1	n.d.	n.d.	(34)	n.d.	-	-	-
	KVC 2024.100.1	n.d.	n.d.	(73)	n.d.	-	-	-
	KVC 2024.104.1	n.d.	n.d.	n.d.	n.d.	-	-	-
	KVC 2024.114.1	(210)	(47)	(55)	(105)	0.854	0.262	0.500
	KVC 2024.120.1	n.d.	(34)	(42)	n.d.	-	-	-
	KVC 2024.130.1	(148)	n.d.	(47)	(69)	-	0.317	0.466
Parapallasiceras toucasi	J 2095	79.2	(18)	(23)	32.4	0.782	0.290	0.409
	J 2094	58.1	23.3	(17)	26.2	1.037	0.292	0.451
	KVC 2024.55.1	(73)	(19)	(22)	(32)	0.863	0.301	0.438
Biplisphinctes pseudocolubrinus	KVC 2024.66.1	(43)	(18)	n.d.	n.d.	-	-	-
	KVC 2024.127.1	51.5	19.8	(11)	(29)	1.800	0.213	0.563
Sublithacoceras rhodaniforme	J 711	94.6	29.4	(33)	35.8	0.891	0.349	0.378
	J 2020.150.1	93.8	(28)	(27)	39.9	1.037	0.288	0.425
Aspidoceras rogoznicense	KVC 2024.9.1	n.d.	(36)	(32)	(22)	1.125	-	-
	KVC 2024.10.1	72.0	(32)	(32)	19.0	1.000	0.444	0.264
	KVC 2024.72.1	(74)	(31)	(32)	(21)	0.969	0.432	0.284
	J 2050	76.4	36.5	(31)	(25)	1.177	0.405	0.327
	J 2097	57.1	30.4	(25)	16.3	1.216	0.438	0.285
Toulisphinctes rafaeli	KVC 2024.78.1	87	(36)	(37)	(26)	0.973	0.425	0.299
Physodoceras neoburgense	KVC 2024.43.1	28.8	n.d.	(16)	(3)	-	0.555	0.104
Physodoceras widerai	J 1973	(86)	(36)	(33)	31.0	1.091	0.384	0.360
Hybonoticeras sp.	KVC 2024.70.1	n.d.	(64)	(89)	n.d.	0.719	-	-

Order Ammonitida HAECKEL, 1866
Suborder Lytoceratina HYATT, 1889
Superfamily Lytoceratoidea NEUMAYR, 1875
Family Lytoceratidae NEUMAYR, 1875
Subfamily Lytoceratinae NEUMAYR, 1875
Genus *Lytoceras* SUESS, 1865
Type species: *Ammonites fimbriatus* J. SOWERBY, 1817

Lytoceras spp.

Material: 17 variously sized, poorly preserved and corroded internal moulds. In most cases these whorl fragments represent the phragmocone. Internal whorls are flattened or absent, KVC 2024.5.1, 2024.6.1, 2024.7.1, 2024.20.1, 2024.42.1, 2024.69.1, 2024.84.1, 2024.110.1, 2024.111.1, 2024.113.1, 2024.123.1, 2024.131.1, 2024.137.1, 2024.139.1, 2024.143.1, 2024.146.1, and 2024.150.1 from localities 2, 4, and 5 (Fig. 3b–d).

Remarks: These specimens show various whorl sections from circular to depressed oval, with low or sometimes high whorl height in a half whorl, but these features are not enough to identify the exact species.

Genus *Protetragonites* HYATT, 1900
Type species: *Ammonites quadrisulcatus* D'ORBIGNY, 1841

Protetragonites quadrisulcatus (D'ORBIGNY, 1841) (Fig. 4.6)

1841 *Ammonites quadrisulcatus* D'ORBIGNY, p. 150, pl. 49, figs. 1–3

1984 *Protetragonites quadrisulcatum* (D'ORBIGNY) – ROSSI, p. 87, pl. 31, figs. 13–15

v 1993 *Protetragonites quadrisulcatus* (D'ORBIGNY) – BUJTOR, p. 113, figs. 5C, 7B [cum syn.]

2012 *Protetragonites quadrisulcatus* (D'ORBIGNY) – JOLY & MERCIER, p. 157, figs. 52– 54

2013 *Protetragonites quadrisulcatus* (D'ORBIGNY) – GRIGORE, p. 95, pl. 3, fig. 5

2022 *Protetragonites quadrisulcatus* (D'ORBIGNY) – FŐZY et al., pl. 5, figs. 4, 6

Material: Four poorly preserved internal moulds, KVC 2024.3.1, 2024.4.1, 2024.144.2, and 2024.151.1. from localities 2 and 4 (Figs 3b, c).

Dimensions: Table 4.

Figure 5. Early Tithonian ammonites from the Mészkemence section of Zengővárkony (Mecsek Mountains, Hungary). **1** *Virgatosimoceras* sp. aff. *rothpletzi* (SCHNEID, 1915) from locality 4, specimen KVC 2024.144.1, lateral view; **2** *Lithacoceras* sp. A from debris of beds 1–6 of loc. 2, specimen KVC 2024.25.1, lateral view; **3** *Lithacoceras* sp. B from debris of beds 1–6 of loc. 2, specimen KVC 2024.114.1, lateral view; **4** *Pseudopallasiceras toucasi* (CECCA & ÉNAY, 1991) from the quarry collected by J. BÖCKH, specimen J 2095, lateral view; **5–6** *Biplisphinctes pseudocolubrinus* (KILIAN, 1895) from locality 3, specimen KVC 2024.127.1; **5** lateral view; **6** ventral view; **7** *Sublithacoceras rhodaniforme* OLÓRIZ, 1978, specimen J 711, lateral view; **8** *Pseudopallasiceras toucasi* (CECCA & ÉNAY, 1991) from the quarry collected by J. BÖCKH, specimen J 2094, lateral view; **9** *Aspidoceras rogoznicense* (ZEJSZNER, 1846) from debris of beds 1–6 of loc. 2, specimen KVC 2024.10.1, lateral view; **10** *Toulisphinctes* cf. *rafaeli* (OPPEL, 1863) from debris of beds 1–6 of loc. 2, specimen KVC 2024.78.1, lateral view; **11–12** *Physodoceras neoburgense* (OPPEL, 1863) from debris of beds 1–6 of loc. 2, specimen KVC 2024.43.1; **11** lateral view; **12** ventral view; **13** *Physodoceras* cf. *widerai* SCHERZINGER et al., 2018, from the quarry collected by E. VADÁSZ, specimen J 1973, lateral view; **14–15** *Hybonoticeras* sp. from debris of beds 1–6 of loc. 2, specimen KVC 2024.70.1; **14** Cross section through spines; **15** lateral view. Scale bars indicate 1 cm. An asterisk indicates the beginning of the body chamber.

Remarks: These specimens represent the typical *P. quadrisulcatus* with a subcircular whorl section, wide and shallow umbilicus, and one shallow constriction per quarter whorl.

Occurrences: It has a wide stratigraphical distribution from the Tithonian to the Lower Barremian. Geographically, it is typical of the northern part of the Mediterranean Tethys, with rare individuals observed in the Submediterranean region (SAPUNOV, 1979; BUJTOR, 1993; GRIGORE, 2013).

Suborder Ammonitina FISCHER, 1882
Superfamily Haploceratoidea ZITTEL, 1884
Family Haploceratidae ZITTEL, 1884
Subfamily Haploceratinae ZITTEL, 1884
Genus *Hypolissoceras* BREISTROFFER, 1947
Type species: *Ammonites carachtheis* ZEJSZNER, 1846
Hypolissoceras carachtheis (ZEJSZNER, 1846) (Figs. 4.7, 4.8)
1846 *Ammonites carachtheis* – ZEJSZNER, pl. 4, fig. 1
1962 *Glochiceras carachtheis* (ZEJSZNER) – BARTHEL, p. 17, pl. 2, figs. 1–4; pl. 3, figs. 1–7
1983 «*Haploceras*» *carachteis* (ZEUSCHNER) – CECCA et al., p. 114, pl. 1, fig. 3 1984 «*Haploceras*» *carachtheis* (ZEUSCHNER) – ROSSI, p. 31, fig. 3
2013 *Haploceras carachtheis* (ZEUSCHNER) – FŐZY & SCHERZINGER, p. 215, pl. 4, figs. 3, 4, pl. 5, figs. 1, 2, 10 [cum syn.]
2020 *Haploceras carachtheis carachtheis* (ZEUSCHNER) – SARTI, p. 91, pl. 4, fig. 7
2022 *Haploceras carachtheis* (ZEUSCHNER) – FŐZY et al., pl. 8, figs. 2a, b
2025 *Hypolissoceras carachtheis* (ZEJSZNER) – VAŠÍČEK & SKUPIEN, p. 432, figs. 3D, 8G–J

Material: One poorly preserved, fragmented internal mould, KVC 2024.145.1. from locality 2 (Fig. 3b).

Dimensions: Table 4.

Remarks: Although this very poorly preserved, small-sized and half-whorled specimen did not preserve strong specific features, based on the cross-section, coiling, and, more importantly, the specific crenulate venter (e.g., CECCA et al., 1983, pl. 1., fig. 3b), it clearly refers to this species.

Occurrences: It has a wide stratigraphic range from the upper part of the Hybonotum to the Fallauxi Zone (KUTEK & WIERZBOWSKI, 1986; VAŠÍČEK & SKUPIEN, 2025) in the Tethyan settings (Mediterranean and Submediterranean provinces).

Genus *Pseudolissoceras* SPATH, 1925
Type species: *Neumayria Zitteli* BURCKHARDT, 1903
Pseudolissoceras? sp. (Fig. 4.9)

Material: Three poorly preserved, corroded, and worn specimens from limestone, KVC 2024.22.1, 2024.133.1, and 2024.148.1 from locality 2 (Fig. 3b).

Dimensions: Table 4.

Description: Coiling involute, shell compressed, flanks slightly rounded. Cross-section high oval with slightly rounded flanks. Umbilicus shallow, umbilical wall low and oblique, umbilical shoulder rounded. No sculpture except some constrictions that are shallow and cross the venter without interruption. Suture not seen.

Remarks: Cross-section, coiling, and lack of sculpture refer to this genus; however, the preservation is so poor that ambiguity remains. The most consistent diagnostic feature of the genus is the suture line (PARENT, 2001), which is not seen here. VADÁSZ (1935, p. 63) described a species (*Lissoceras hungaricum*) from the Upper Tithonian. Unfortunately, the specimen is not found in the SARA collection; therefore, scientific description or comparison with the recently collected material was not possible.

Occurrences: The genus has wide geographical distribution over the entire Tethys.

Stratigraphically, it occurs in the Lower Tithonian (BARTHEL, 1962).

Family Oppeliidae DOUVILLÉ, 1890
Subfamily Taramelliceratinae SPATH, 1928
Genus *Fontannesiella* SPATH, 1925
Type species: *Oppelia Valentina* FONTANNES, 1879
Fontannesiella? sp. (Figs. 4.10, 4.11)

Material: One poorly preserved, fragmentary internal mould representing a phragmocone, KVC 2024.124.1 from locality 2 (Fig. 3b).

Dimensions: Table 4.

Description: Coiling involute, umbilicus shallow, umbilical wall very low, umbilical shoulder rounded. Cross-section trapezoidal, compressed. Flanks are parallel on the lower flank but converge on the upper flank to the ventral shoulder, which is rounded. There is a row of tubercles on the ventral shoulders. There are 15 tubercles on the last half whorl. Traces of ribs seen on the upper flank originated from the tubercles. Ribs also rise on the upper flank, slightly below the ventral shoulder. Ribs are equal in width and equally spaced. Suture not seen.

Remarks: The number of tubercles on the ventral shoulder varies between 15 and 22on the last half whorl. On the present specimen there are 15. On large-sized conchs these tubercles are elongated, which were not seen here. The specimen shows similarities to the highly variable *T.* (*T.*) *compsum*; however, the cross-section and finely tuberculated ventral area rather refer to this subgenus.

Occurrences: Stratigraphically, it ranges from the Hybonotum Zone to the Darwini Zone. Geographically it is reported from the Mediterranean and Submediterranean provinces of the Tethys (OLÓRIZ, 1978; SARTI, 2020).

Superfamily Perisphinctoidea STEINMANN, 1890
Family Simoceratidae SPATH, 1924
Genus *Virgatosimoceras* SPATH, 1925
Type species: *Simoceras Rothpletzi* SCHNEID, 1915
Virgatosimoceras sp. aff. *rothpletzi* (SCHNEID, 1915) (Fig. 5.1)

Material: Two poorly preserved, fragmentary, and worn specimens from tuffaceous limestone, KVC 2024.135.1 and 2024.144.1. from locality 4 (Fig. 3c).

Dimensions: Table 4.

Description: Coiling very evolute. Cross-section compressed oval. Umbilicus very wide and shallow. Four whorls on the smaller and five whorls on the larger specimen are observed. Umbilical wall oblique and low. Umbilical shoulder well rounded. Flanks convex, rounded. Strong, straight, prorsiradiate single ribs rise at the umbilical shoulder and travel radially through the flanks. There are 13 ribs on the last half whorl. Primary ribs are regularly placed. The regular ribbing is rarely interrupted by a double, closely spaced pair of ribs. Ventral shoulder not preserved. Venter not seen. Suture not preserved.

Remarks: The poor preservation (weathered umbilicus, some part of the last whorl cut by fault, venter not seen) raises ambiguity; however, the irregularly spaced set of ribs, the rather slim ribbing and the lack of tubercles at the umbilical and ventral shoulder indicate *Virgatosimoceras*. There are similarities to *V. albertinum*; however, the distance between the widely spaced ribs in *V. rothpletzi* is larger than that observed in *V. albertinum*, therefore the present poorly preserved specimens may be closer to *V. rothpletzi*. Unfortunately, the tripartite ribbing is not preserved on the outer whorls, therefore poor preservation justifies the uncertain assignment. It is noteworthy that the stratigraphic position of the specimens also fits that of *V. rothpletzi*.

Occurrences: *Virgatosimoceras rothpletzi* is reported from the Fallauxi Zone of the Lower Tithonian from SE France, southern Germany, and Hungary (SCHERZINGER et al., 2010).

Family Ataxioceratidae BUCKMAN, 1921
Subfamily Lithacoceratinae ZEISS, 1968
Genus *Lithacoceras* HYATT, 1900
Type species : *Ammonites ulmensis* OPPEL, 1858
Lithacoceras spp. A, B. (Figs. 5.2, 5.3)

Material: Seven large-sized, fragmentary, and corroded internal moulds of the phragmocone and partial body chamber, KVC 2024.25.1, 2024.48.1, 2024.100.1, 2024.104.1, 2024.114.1, 2024.120.1, and 2024.130.1 from locality 2 (Fig. 3b).

Dimensions: Table 4.

Remarks: This highly varied genus was previously reported by BUJTOR et al. (2021a). *Lithacoceras* sp. A, Fig. 5.2: This specimen shows features of the penultimate whorl sculpture of some *Lithacoceras* species as several macroconch *Lithacoceras* species, such as *L. albulum*, *L. eigeltingense*, *L. eystettense*, or *L. ulmense*. *Lithacoceras* sp. B, Fig. 5.3: This poorly preserved external mould shows features similar to the ribbing of the upper flank of *Lithacoceras moernsheimense–riedlingense*; however, venter, umbilical region, lower flank not preserved, therefore specific determination is not possible.

Occurrences: Uppermost Kimmeridgian (Beckeri Zone) to Lower Tithonian (Hybonotum Zone) in the Tethyan and peri-Tethyan areas (SARTI, 2020).

Genus *Sublithacoceras* SPATH, 1925
Type species: *Perisphinctes* (*Aulacosphinctes*?) *penicillatus* SCHNEID, 1915
Sublithacoceras rhodaniforme OLÓRIZ, 1978 (Fig. 5.7)

1905 *Perisphinctes rhodanicus* DUMORTIER in DEL CAMPANA, p. 87, pl. 3, fig. 3

1978 *Discosphinctoides* (*Pseudodiscosphinctes*) *rhodaniforme* nom. nov. – OLÓRIZ, p. 494, pl. 41, fig. 2

2011 *Discosphinctoides rhodaniforme* OLÓRIZ – FŐZY et al., p. 420, figs. 5.9, 5.10

2020 *Pseudodiscosphinctes rhodaniforme* OLÓRIZ – SARTI, p. 114, pl. 10, figs. 1, 2

2021 *Malagasites* ? *denseplicatus* (WAAGEN) – BUJTOR et al., p. 288, fig. 9.C

Material: Two poorly preserved, fragmented internal moulds of the phragmocone and partial body chamber, J 711 and J 2020.150.1 from the quarry floor, undefined stratigraphic position.

Dimensions: Table 4.

Remarks: The specimen J 711 was collected by J. BÖCKH. According to the handwriting of János BÖCKH, it was collected from the deepest strata of the quarry, which refer to the uppermost Kimmeridgian – lowermost Tithonian. The specimen was published by BUJTOR et al. (2021a, p. 288, fig. 9.c). The other specimen J 2020.150.1 was collected from the left bank of the Vasbányavölgy Creek (Locality 1, Fig. 3a) and assigned tentatively to *Malagasites*? Based on the close similarities between the sculptures of *Malagasites* and *Sublithacoceras* and taking into consideration that *Malagasites* is restricted to the Indo-Malagasy Province, it is more reliable to place these specimens in *Sublithacoceras*.

Occurrence: *Sublithacoceras rhodaniforme* is reported from the Lower Tithonian Semiforme Zone from the Western Tethys: Spain (Betic Cordillearas), Italy (Southern Alps), and Hungary (SARTI, 2020).

Genus *Pseudopallasiceras* SARTI, 2017

Type species: *Subplanitoides mediterraneus* CECCA, 1990a

Pseudopallasiceras toucasi (CECCA & ÉNAY, 1991)

(Fig. 5.4, 5.8)

1991 *Parapallasiceras toucasi* n. sp. (m) – CECCA & ÉNAY, p. 66, pl. 8, fig. 6; pl. 9, figs. 1–3, 6

pars 1994 *Parapallasiceras* (aff.) *toucasi* CECCA – ZEISS et al., p. 372, pl. 4, fig. 4; pl. 5, fig. 4

1997 *Parapallasiceras toucasi* CECCA & ÉNAY – BENZAGGAGH & ATROPS, p. 154

2017 *Pseudopallasiceras toucasi* (CECCA & ÉNAY) – SARTI, p. 52, pl. 5, fig. 3

2020 *Pseudopallasiceras toucasi* (CECCA & ÉNAY) – SARTI, p. 121 [in litteris]

Material: Three poorly preserved internal moulds representing a phragmocone and a partial body chamber collected by the present author and J. BÖCKH and figured for the first time herein, J 2094, J 2095 and KVC 2024.55.1. Localities: quarry floor, undefined stratigraphic position.

Dimensions: Table 4.

Description: Perisphinctid microconch specimens with evolute coiling. Cross-section is a high oval, and the umbilicus is shallow. Umbilical wall low and vertical. At the umbilical shoulder, distinct, fine ribs rise. At the beginning the ribs are radial, then they become prorsiradiate. On the upper flank the ribs bend slightly backward, forming a gentle S-shape on the flanks. Ribs bifurcate somewhat over the midflank. Very rarely, the ribs do not bifurcate.

There are around 30 primaries on the last whorl (however, due to the poor preservation, there may be three ribs less or more) corresponding to 58 ribs on the venter. Ribs cross the venter continuously and radially. Suture not seen.

Remarks: *Pseudopallasiceras* species are distinguished from each other by small differences. The present specimens are surely assigned to *P. toucasi* based on the ribbing style, and bifurcation of the primaries.

Occurrences: *Pseudopallasiceras toucasi* is reported from the Lower Tithonian Semiforme and Fallauxi zones from the Western Tethys (SE France, Southern Alps, Italy, Transdanubian

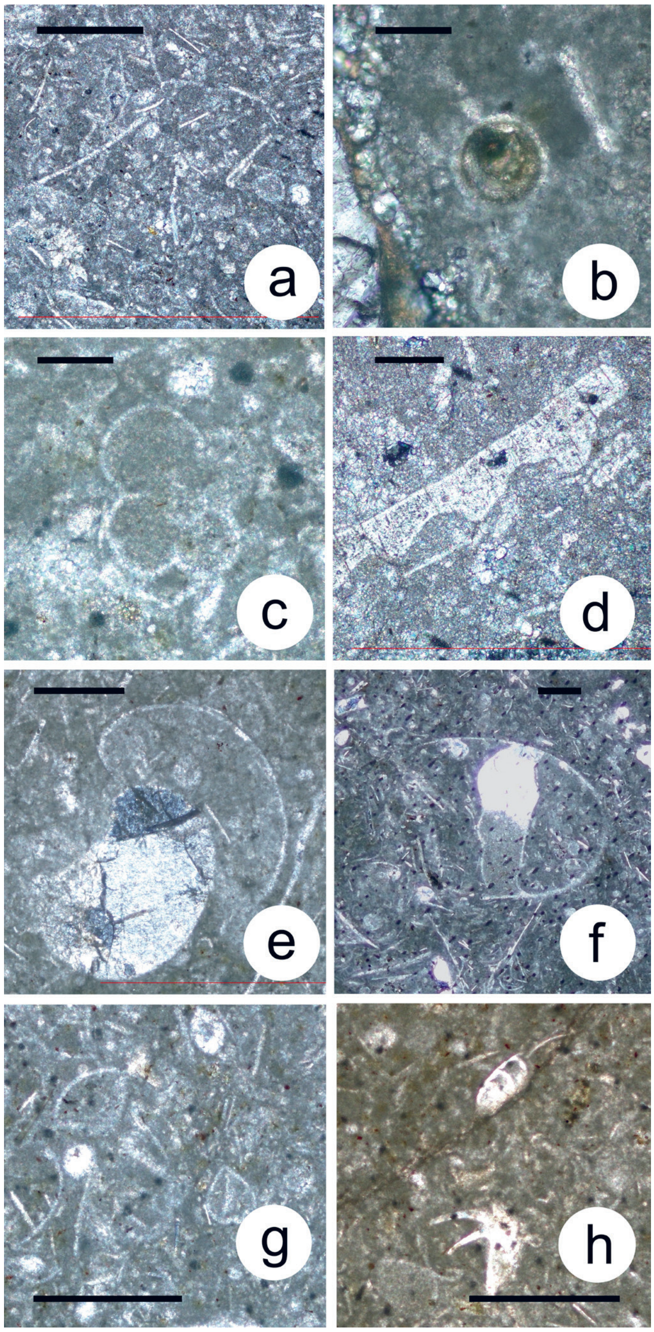

Figure 6. Microfacies of Locality 2 (Lower Tithonian), part of the Zengővárkony section (Mecsek Mountains, South Hungary). **a** Filamentous *Saccocoma* wackestone with planktonic foraminifera remains; **b** *Carpistomiosphaera malmica/tithonica*; **c** Globuligerinid planktonic foraminifera gen. et sp. ind.; **d** Aptychus fragment in *Saccocoma* wackestone; **e** Ammonite embryo in *Saccocoma* wackestone; **f** Ammonite phragmocone fragment. Note the different chamber fills: sparitic calcite and lighter grey-coloured micrite in the middle chamber may indicate transportation. Elongated tiny elliptical spots due to improper processing of the sample; **g** Juvenile bivalve/ostracod? double shells with a benthic foraminifera test remain in wackestone; **h** Benthic foraminifera test fragments in biomicritic wackestone. Scale bars indicate 0.5 mm on a, e, f, g, and h; and 100 microns on b, c, and d.

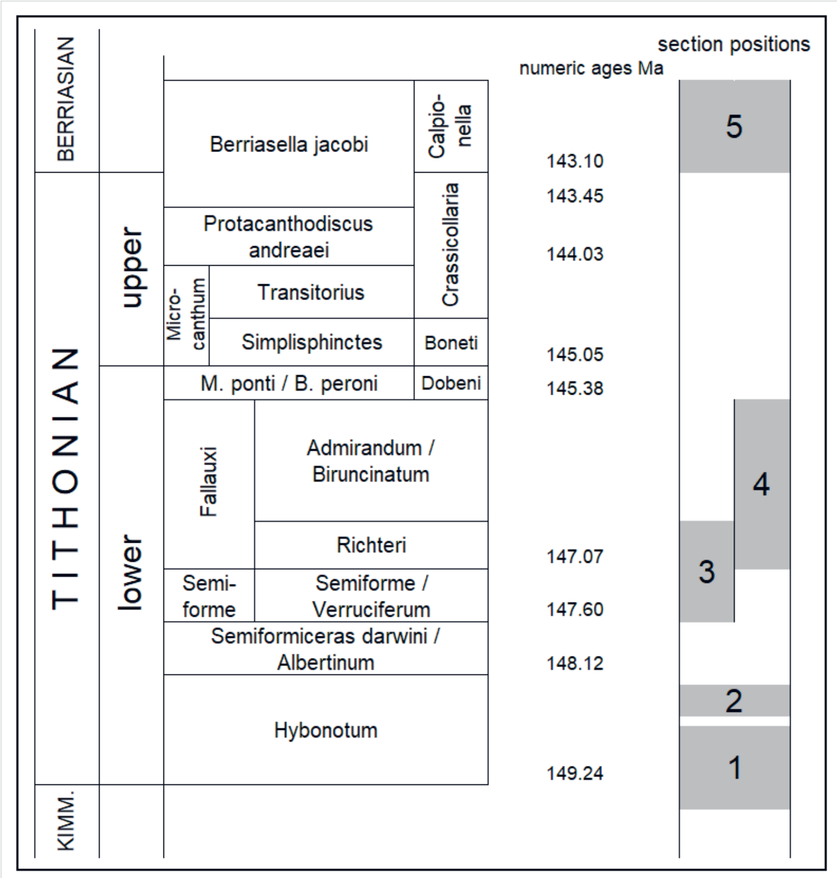

Figure 7. Proposed chronostratigraphic positioning of the investigated sections studied. Chronostratigraphic subdivision after VAŠÍČEK et al. (2017) for the Mediterranean and HESSELBO et al. (2020) for the Tethyan regions. The indication of the chronozones suggests a continuous lower Tithonian sequence at the Mészkemence abandoned quarry. Numbers indicate the section investigated herein; grey shading indicates the chronostratigraphic positions of the sections.

Range, Hungary) An interesting record is reported from the Fallauxi Zone of Morocco by BENZAGGAGH & ATROPS (1997, p. 154) but not documented photographically.

Subfamily Torquatisphinctinae TAVERA, 1985

Genus *Biplisphinctes* OLÓRIZ, 1978

Type species: *Perisphinctes cimbricus* NEUMAYR, 1873

Biplisphinctes pseudocolubrinus (KILIAN, 1895)

(Figs. 5.5, 5.6)

1895 *Perisphinctes pseudocolubrinus* n. sp. – KILIAN, p. 679

2013 *Kutekiceras pseudocolubrinum* (KILIAN) – FŐZY & SCHERZINGER, p. 233, pl. 16, figs. 1, 2, 6 [cum syn.]

2017 *Kutekiceras pseudocolubrinum* (KILIAN) – VAŠÍČEK et al., p. 590, figs. 6A, B

2019 *Biplisphinctes pseudocolubrinus* (KILIAN) – ÉNAY & HOWARTH, p. 135, fig. 91.1c, 1d

2020 *Kutekiceras pseudocolubrinum* (KILIAN) – SARTI, p. 118, pl. 13, fig. 2, pl. 14, figs. 1, 2

Material: Two poorly preserved internal moulds representing a phragmocone andbody chamber KVC 2024.66.1 and 2024.127.1, from locality 3.

Dimensions: Table 4.

Description: Cross-section depressed oval. Coiling very evolute, umbilicus wide and shallow. Flanks inflated; venter rounded. Fine, distinct, radial, or slightly prorsiradiate ribs rise at the umbilical shoulder and bifurcate above the midflank. There are 25 primary ribs on the last half whorl. One constriction per whorl is present. Ribs cross the venter perpendicularly to the midsiphonal symmetry plane and are interrupted by a shallow midsiphonal groove. Aperture, suture not seen.

Remarks: Although they were not collected from a bed, the place from where they were unearthed on the cart road corresponds to the appropriate stratigraphic position in the Zengővárkony sequence.

Occurrences: Upper part of Semiforme and lower part of Fallauxi zones in the Mediterranean Tethys; however, usually the precise stratigraphic position of this species is obscure (VAŠÍČEK et al., 2017, p. 601).

Superfamily Aspidoceratoidea ZITTEL, 1895

Family Aspidoceratidae ZITTEL, 1895

Subfamily Aspidoceratinae ZITTEL, 1895

Genus *Aspidoceras* ZITTEL, 1868

Type species: *Ammonites Rogoznicensis* ZEJSZNER, 1846

Aspidoceras spp.

Material: 14 poorly preserved, worn internal moulds, KVC 2024.14.1, 2024.21.1, 2024.68.1, 2024.80.1, 2024.83.1, 2024.90.1, 2024.96.1, 2024.97.1, 2024.98.1, 2024.116.1, 2024.125.1, 2024.132.1, 2024.134.1, and 2024.142.1 from localities 1 and 2 (Fig. 3a, b).

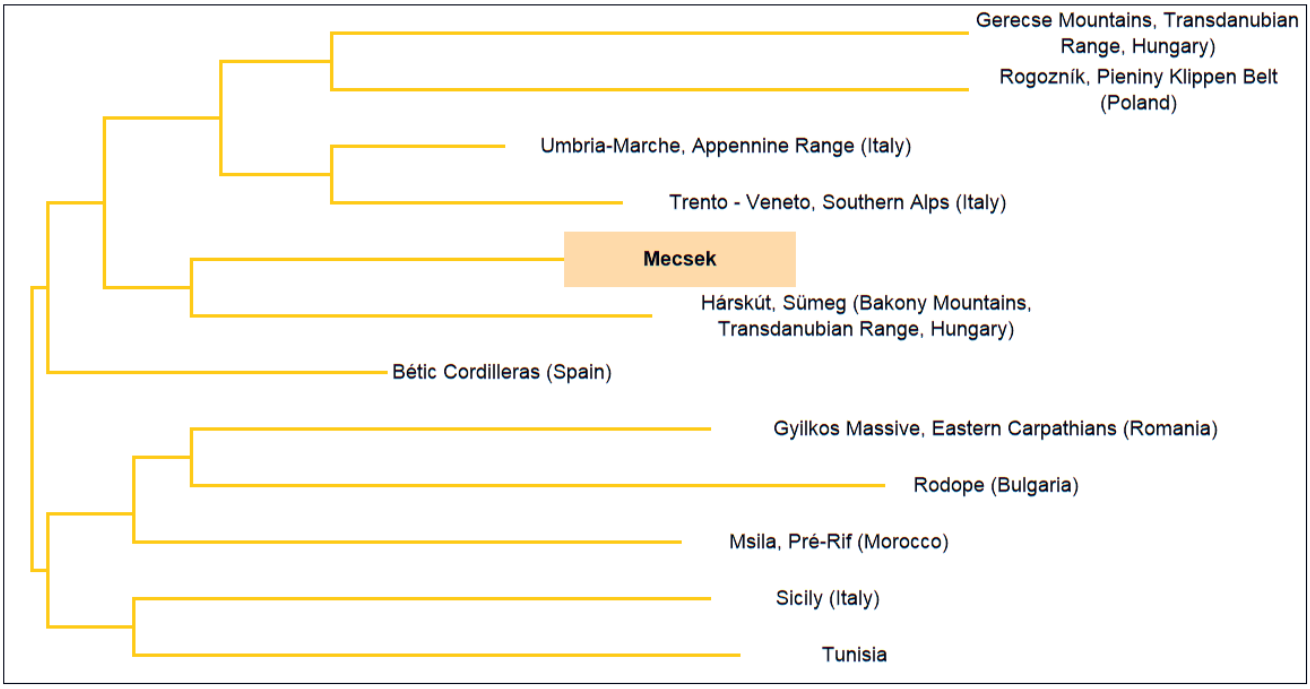

Figure 8. Similarity relationships between twelve early Tithonian ammonite faunas of Europe and North Africa representing 247 species based on the Simpson similarity index. Dendrogram depicting the results from neighbour-joining cluster analysis of the dataset introduced in Table 22. European localities from Spain (Bétic Cordilleras), Italy (Sicily, Umbria – Marche, and Trento – Veneto), Poland (Rogozník), Hungary (Bakony and Gerecse Mountains of the Transdanubian Range, Mecsek Mountains), Romania (Gyilkos Massif, Carpathians), and Bulgaria (Rodope), African localities from Morocco (PréRif) and Tunisia.

Remarks: Cross-section, sculpture, number of tubercles, depth of umbilicus, and coiling are highly variable in these specimens; however, the fragmentary status and poor preservation did not allow reliable specific determinations.

Aspidoceras rogoznicense ZEJSZNER, 1846 (Fig. 5.9)

1846 *Ammonites Rogoznicensis* – ZEJSZNER, pl. 4, fig. 4a–d

v 2021a *Aspidoceras binodum* (OPPEL) – BUJTOR et al., p. 291, fig. 9.E1–2

v 2021a *Aspidoceras rogoznicense* (ZEJSZNER) – BUJTOR et al., p. 292, figs. 9.H1–3 [cum syn.]

2023 *Aspidoceras rogoznicense* (ZEUSCHNER) – GRIGORE, p. 22, pl. 1, fig. 7

Material: Five poorly preserved, corroded internal moulds, J 2050, J 2097, KVC 2024.9.1, 2024.10.1, and 2024.72.1 from localities 1 and 2 (Fig. 3a, b).

Dimensions: Table 4.

Remarks: This species was previously reported by BUJTOR et al. (2021a) in detail.

Occurrences: According to CHECA (1985), it has a wide stratigraphic distribution from the Upper Kimmeridgian to the basal Berriasian in major provinces (Mediterranean, Indo-Malagasy, and Andes) of the Tethyan Realm; however, it is most abundant in the Upper Kimmeridgian (Beckeri Zone) and the Lower Tithonian (Hybonotum Zone).

Genus *Physodoceras* HYATT, 1900

Type species: *Ammonites circumspinosus* OPPEL, 1863

Physodoceras neoburgense (OPPEL, 1863)

(Figs. 5.11, 5.12)

1863 *Ammonites Neoburgensis* – OPPEL, p. 223, pl. 58, figs. 5a–b

1915 *Aspidoceras neoburgense* OPP. – SCHNEID, p. 93[395], pl. 4[20], fig. 5

1984 *Physodoceras neoburgense neoburgense* (OPPEL) – ROSSI, p. 110, pl. 34, fig. 8, pl. 35, fig. 13

1985 *Schaireria neoburgensis* (OPPEL) – CHECA, p. 199, pl. 40, figs. 3–5, pl. 42, fig. 1

1994 *Anaspidoceras neoburgense* (OPPEL) – FŐZY et al., pl. 2, fig. 6

2005 *Schaireria neoburgensis* (OPPEL) – VILLASEÑOR et al., p. 71, figs. 4e–g, 5b

2020 *Schaieria* (*Anaspidoceras*) *neoburgensis* (OPPEL) – SARTI, p. 172, pl. 32, fig. 1

2022 *Physodoceras neoburgense* (OPPEL) – FŐZY et al., pl. 53, fig. 6, pl. 56, figs. 2, 5

Material: One poorly preserved internal mould from a tuffaceous marl bed, KVC 2024.43.1 from locality 2, (Fig. 3b).

Dimensions: Table 4.

Remarks: FŐZY (1993) previously mentioned it from this locality. Although the present specimen represents a juvenile stage, the cross-section, coiling, lack of sculpture, and narrow umbilicus clearly refer to this species.

Occurrences: It is reported from the Lower Tithonian, usually from the Darwini Zone or higher in Italy and France (SARTI, 2020). KUTEK & WIERZBOWSKI (1986) reported from the Hybonotum Zone of the Pieniny Klippen Belt (Rogozník, Poland), and also from the Hybonotum Zone of the Eastern Carpathians (GRIGORE, 2025).

Physodoceras cf. *widerai* SCHERZINGER, PARENT & SCHWEIGERT, 2018

(Fig. 5.13)

2018 *Physodoceras widerai* n. sp. – SCHERZINGER et al., p. 13, figs. 2–5

Material: One poorly preserved, fragmentary internal mould of a phragmocone and partial body chamber collected by E. VADÁSZ, figured for the first time herein, J 1973. Locality: quarry floor, undefined stratigraphic position.

Dimensions: Table 4.

Description: Incomplete specimen of a moderately evolute *Physodoceras* that represents a partial body chamber. Aperture not preserved. Cross-section compressed oval. Three whorls seen. There are eight clavi on the last half whorl. Umbilicus wide, steep. Umbilical wall high, vertical, umbilical shoulder rounded. Flanks are flat or very slightly rounded. No ventral shoulder. Venter rounded, circular to oval, smooth. No midsiphonal ridge is present. Sculpture consists of two independent rows of spines or tubercles. An inner row of tubercles settled on the umbilical shoulder. There are 14 tubercles on the last whorl and 8 tubercles/spines on the last whorl. These tubercles were irregularly placed on the umbilical shoulder from which three spines developed on the last quarter of the whorl. The other row of tubercles is placed on the midflank and irregularly corresponds to some internal tubercles on the umbilical wall. No other sculpture was seen. Some elements of the lobe were preserved, but no complete suture line was seen. L is trifid.

Remarks: The present specimen represents Stage III of the ontogeny (SCHERZINGER et al., 2018, p. 17). Although the earlier stages are not seen, and the closest species is *Ph. acanthicum*, the different stratigraphic position helps to differentiate the present specimen because it comes from the Hybonotum Zone.

Occurrences: *Ph. widerai* was reported from the Hybonotum Zone of Liptingen Quarry, Baden-Württemberg, SW Germany (SCHERZINGER et al., 2018).

Genus *Toulisphinctes* SAPUNOV, 1979

Type species: *Toulisphinctes ziegleri* SAPUNOV, 1979, p. 106

Toulisphinctes rafaeli (OPPEL, 1863) (Fig. 5.10)

1863 *Ammonites Rafaeli* – OPPEL, p. 223, pl. 62, fig. 1–b

1878 *Aspidoceras Raphaeli* OPP. – HERBICH, p. 185[167]

1915 *Aspidoceras Rafaeli* OPP. – SCHNEID, p. 94[396], pl. 5[21], fig. 5, pl. 12[28], figs. 5, 6

1985 *Aspidoceras rafaeli* (OPPEL) – CHECA, p. 107, pl. 16, fig. 5, pl. 17, figs. 1, 2, pl. 18, fig. 1

1990 *Aspidoceras rafaeli* (OPPEL) – FŐZY, pl. 2, fig. 1

2020 *Toulisphinctes* sp. Aff. Rafaeli (OPPEL) – SARTI, p. 178, pl. 33, fig. 2, pl. 34, fig. 1, pl. 35, fig. 2

2023 *Aspidoceras rafaeli* (OPPEL) – GRIGORE, p. 22

Material: One internal mould of the body chamber that represents a half whorl, KVC 2024.78.1 from locality 2 (Fig. 3b).

Dimensions: Table 4.

Description: Cross-section depressed subcircular. Umbilicus rather wide and shallow. Umbilical wall low, slightly bending towards the flank. Umbilical shoulder rounded. Flanks are convex, with no ventral shoulder. The venter is smooth and rounded, with no midsiphonal ridge. No suture preserved. Sculpture consists of two rows of tubercles and delicate ribbing. The first row of tubercles arises at the umbilical shoulder. There are six tubercles on the last half whorl. The second row of tubercles arises slightly below midflank. Midflank tubercles correspond to the tubercles of the first row. Weak, shallow ribs cross the venter continuously. Ribs originate at the lower flank, slightly above the first row of tubercles. There are three ribs between the radially placed pair of tubercles.

Remarks: The weak ribs crossing the venter are less pronounced here compared to the type, which raises ambiguity; however, there is a wide range of variation in the thicknesses of the ribs of this species. GRIGORE (2023, p. 22) noted that this species mentioned by NEUMAYR (1873) and HERBICH (1878) are whorl fragments and were never published, and until now, no more specimens have been revealed from the Gyilkos Massif (Eastern Carpathians, Romania). Early growth stages show the similar weak ribbing, as SCHNEID (1915, pl. 5, fig. 5) demonstrated. With its less than 100 mm diameter, the present specimen is considered a juvenile stage, where the strong ribbing is not yet developed.

Occurrences: Upper Kimmeridgian (Acanthicum to Beckeri zones) to Lower Tithonian (Hybonotum Zone) (SARTI, 1988).

Subfamily Hybonoticeratinae NEUMAYR, 1878

Genus *Hybonoticeras* BREISTROFFER, 1947

Type species *Ammonites hybonotus* OPPEL, 1863, p. 254

Hybonoticeras sp.

(Figs. 5.14, 5.15)

Material: One whorl fragment of a body chamber, KVC 2024.70.1 from locality 2 (Fig. 3b).

Dimensions: Table 4.

Description: A whorl fragment of the body chamber of a giant specimen. Cross-section is high trapezoidal. Umbilical region not preserved, umbilical shoulder rounded, flanks are flat and converging towards the venter. Ventral shoulder rounded. On the ventral shoulders a pair of spines rise. Three pairs of spines seen, which were placed 45 mm from each other. Venter smooth, the spines interconnected with a low band.

Remarks: Based on the cross-section and ribbing, the specific determination is well established. Having a large-sized whorl fragment, which has a smooth and unsculptured venter, the specific sculpture of the venter of the early growth stage (a shallow groove placed at the midsiphonal region) is not present here. GRIGORE (2011, pl. 2, fig. 5) presented an external mould with straight ribbing; however, the characteristic tubercles are not seen.

Occurrences: Kimmeridgian Beckeri Zone and Tithonian Hybonotum Zone in the Tethys, chiefly in the Mediterranean province (SARTI, 2020). First record from the Mecsek Mountains.

5. RESULTS

The lower Tithonian part of the Mészkemence section at the abandoned quarry of Zengővárkony provided previously unreported ammonites that aid refinement of the ammonite biostratigraphy and recognition of previously unrecognised ammonite chronozones. The microfaunal observations are in line with the ammonite biostratigraphy results and are in accordance with previous results. Some ammonite and bivalve taxa are first reported from the Mecsek Mountains, providing a more reliable biogeographical analysis of the Mecsek Mountains around the northern part of the central Tethys.

5.1. Microfacies

The Lower Tithonian microfacies of the Zengővárkony section (Fig. 6) is a packstone – wackestone that contains a typical Tethyan microfossil assemblage identical with the Saccocoma – Globochaete microfacies (PSZCZÓŁKOWSKI et al., 2016). Variously preserved skeletal elements of saccocomids are present. It indicates a rich benthic and planktonic community, with individuals belonging to the following groups: benthic and planktonic foraminifera, calcareous dinoflagellates, bivalves, ?ostracods, echinoderms, ammonite embryos, and aptychi. Many fragments of the *Saccocoma* occur in thin sections (Fig. 6a, f, g). A calcareous dinoflagellate cyst of the group of *Carpistomiosphaera malmica/tithonica* also occurs (Fig. 6b), resembling *C. malmica* (BORZA) of NAGY (1966b, pl. 5, fig. 4) and PSZCZÓŁKOWSKI et al. (2016, fig. 8.d). Aptychi are also present in thin sections, and two types are identified: lamellaptychi fragments (Fig. 6d) and, rarely, laevaptychi tubular regions.

5.2. Biostratigraphy

The ammonite fauna – although most of the specimens were not collected from continuously sampled strata (in the cases of localities 1, partly 2, and 5 without strict stratigraphical control) indicates the presence of the lower Tithonian ammonite zones, although precise biostratigraphical subdivision was not possible. Despite that, a tentative chronostratigraphic zonal subdivision is proposed for the Zengővárkony section (Fig. 7), which suggests the presence of most parts of the Tithonian (or at least a more complete lower Tithonian) sequence. The recognised ammonite chronozones are characterised in detail.

5.2.1. Lower Tithonian, Tethyan Hybonotum Zone

Gravesia aff. *gigas* from the smaller quarry (BUJTOR et al., 2021a) confirms the presence of the Hybonotum Zone. *Gravesia* species have a continuous record through the Kimmeridgian/Tithonian boundary beds (GALLOIS & ETCHES, 2010), and in the Franco-German Biome, the following succession is reported by HANTZPERGUE (1989, p. 25): latest Kimmeridgian *Gravesia irius* (D'ORBIGNY), then earliest Tithonian *G. gigas* (ZIETEN) and later *G. gravesiana* (D'ORBIGNY), and the Tithonian is defined by the fauna with *Gravesia gravesiana* and *G. gigas* (HANTZPERGUE, 1989, p. 33). The presence of *Lithacoceras* sp. aff. *siliceum* also indicates the lowermost Tithonian.

5.2.2. Lower Tithonian Darwini Zone

The presence of this zone is not confirmed from any of the investigated sections.

5.2.3. Lower Tithonian Semiforme and Fallauxi zones

The presence of these zones is indicated by *Biplisphinctes pseudocolubrinus* collected from the cart-road bordering the forest and the ploughland. According to OLÓRIZ (1978) and VAŠÍČEK et al. (2017), this species occurs in the Verruciferum and Richteri subzones of these zones. The *Pseudopallasiceras toucasi* specimens also suggest the presence of these zones (SARTI, 2017, p. 34, fig. 1; SARTI, 2020, p. 121) as well as the *Virgatosimoceras* sp. aff. *rothpletzi* (SCHERZINGER et al., 2010).

5.2.4. Lower Tithonian Ponti/Peroni Zone

The presence of this zone is not confirmed from any of the investigated sections.

5.2.5. Upper Tithonian Jacobi Zone

In the western quarry wall (locality 5), no zonal marker ammonites were recovered, only a poorly preserved, corroded *Calliphylloceras calypso* from the soil is suggestive of the Berriasian; however, this part of the quarry is thoroughly investigated, and the presence of the Upper Tithonian and Lower Berriasian is well established by calpionellids (SZINGER & CSÁSZÁR, 2010).

Based on these observations we may conclude that the abandoned quarry at the Zengővárkony Mészkemence may traverse a continuous Lower Tithonian sequence that developed from the topmost Kimmeridgian. These results confirm the previous biostratigraphical results and outline a more detailed biostratigraphical framework.

Table 5. Selected Early Tithonian ammonite localities used in the palaeobiogeographical comparison.

Selected location	Species richness	References
Bakony Mountains, Transdanubian Range, Hungary	86	FŐZY, 1989; FŐZY et al., 2022
Bétic Cordilleras, Spain	131	OLÓRIZ, 1978
Bulgaria	46	SAPUNOV, 1979
Gerecse Mountains, Transdanubian Range, Hungary	34	VÍGH, 1984; FŐZY et al., 1994
Gyilkos Massif, Eastern Carpathians, Romania	18	GRIGORE, 2011
Mecsek Mountains, Hungary	19	FŐZY, 1993; BUJTOR et al., 2021a; present work
PréRif, Msila, Morocco	30	BENZAGGAGH, 2000; BENZAGGAGH et al., 2010
Rogozník, Pieniny Klippen Belt, Poland	26	KUTEK & WIERZBOWSKI, 1979, 1986; WIERZBOWSKI, 1997
Sicily, Italy	34	GEMMELLARO, 1871; PAVIA et al., 2004
Tunisia	37	BOUGHDIRI et al., 2005; ÉNAY et al., 2005; OLÓRIZ et al., 2006
Umbria-Marche, Apennines, Italy	79	CECCA et al., 1985, 1986, 1989; CECCA & SANTANTONIO, 1989
Veneto-Trento, Italy	21	SARTI, 1986, 2020

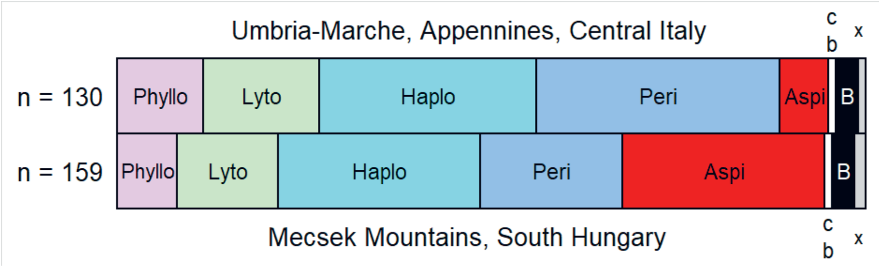

Figure 9. Quantitative faunal composition at family/superfamily level of some Tethyan Early Tithonian faunas from the Apennines and the Mecsek Mountains. Data from CECCA (1990a) and present research. Abbreviations: Phyllo: Phylloceratids; Lyto: Lytoceratids; Haplo: Haploceratids; Peri: Perisphinctids; Aspi: Aspidoceratids; c: Anthozoans; B: Brachiopoda; b: bivalves; x: Belemnites; n: number of specimens. Specimens from localities 1, 3, 4, and 5 are excluded from the quantitative analysis.

5.3. Palaeobiogeography

VÖRÖS & BUJTOR (2020) prepared a detailed palaeobiogeographical analysis of the late Valanginian – early Hauterivian brachiopod fauna of Zengővárkony (Mecsek Mountains, Hungary). It clearly outlined that those brachiopods created a distinct biogeographical group (called Sub-Tethyan) including Štramberk (Czechia), Codlea (Brassó, Romania) and Zengővárkony faunas. Although the faunistic data were reliable and their conclusions well supported, this research challenged some of the widely accepted palaeogeographical reconstructions. It implied that detailed analysis and inclusion of groups that were not analysed yet may elucidate the gloomy and/or contradictory conclusions. This is also the case for the Tithonian ammonite fauna of Zengővárkony. Table 5 includes the selected Early Tithonian faunas used for palaeobiogeographical analysis. Despite the limited number of species recorded, a numerical comparison of the Zengővárkony fauna to some other contemporaneous Tethyan ammonite assemblages seems to be reasonable. For the numerical comparison, twelve localities with well-documented Early Tithonian ammonite faunas were selected in the Western Tethys from Morocco to Bulgaria, representing the Mediterranean faunas, respectively (Table 5).

Cluster analysis (Neighbour Joining) was carried out from the Simpson index data and resulted in a bipartite dendrogram (Fig. 8). The first cluster includes six localities that are considered to represent the typical Mediterranean Tethyan faunas. The other cluster includes five localities and seems to be slightly surprising. There is a subcluster of two localities, the Gyilkos Massif (Eastern Carpathians) and Bulgaria, which is usually termed “Tethyan”; however, it shows closer similarities towards the farther southern Tethyan faunas (Morocco, Tunisia, and Sicily). The fauna of the Bétic Cordilleras seems to be independent from the other two clusters. The early Tithonian ammonite assemblage of the Mecsek Mountains falls in the first cluster, which is considered to be the typical Mediterranean Tethyan faunal setting and is the closest to the fauna of the Transdanubian Range (Hárskút, Hungary).

6. DISCUSSION

NAGY (1964, 1966a, 1966b, 1971) probably knew the most about this quarry (Western quarry at the lime kilns of Zengővárkony; cf. NAGY, 1964). He also referred to the fact that he made artificial trenching in the quarry (NAGY, 1964, p. 98) and exposed the well-known and characteristic Bathonian red-coloured calcareous marl (= ammonitico rosso), which is a general guide level in the Eastern Mecsek Mountains. This is confusing, because his text contradicted the figures: in the figure NAGY (1964, p. 102, fig. 2) introduced the section with Callovian limestones, and no Bathonian was indicated. During the fieldwork in the period between 2018 and 2022, I have never found any indications of the Bathonian, Callovian, or Oxfordian in the quarry. Having a long-abandoned quarry, nothing has changed the geography of the territory since the field works of István NAGY in the 1960s. The only ground works were undertaken between 1952 and 1954, when iron-ore prospecting mining activities took place 300 m west of the quarry (MOLNÁR, 1961). The only disturbance has been the activity of private fossil collectors because the locality is popular with them.

6.1. Remarks on the calcareous dinoflagellate cysts

NAGY (1966b) reported a rich calcareous dinoflagellate cyst microfauna from the Mecsek Mountains that consists of 12 *Cadosina* species and he introduced four new *C.* species from the Mecsek Mountains (*C. borzai* NAGY, *C. fibrata* NAGY, *C. parvula* NAGY, and *C. tenuis* NAGY). He referred to *C. borzai* as the most abundant in the upper Kimmeridgian with rare individuals in the lower Tithonian, and *C. malmica* as abundant in the lower Tithonian.

Regarding the foraminifera, ARENILLAS et al. (2022) proposed a new phylogeny and taxonomy for the planktonic foraminifera. According to these authors, the early Tithonian globotruncanids belong either to Globuligerinidae (genus *Compactogerina*) or Conoglobigerinidae (genus *Conoglobigerina*). Having the globotruncanid remains only from thin section here, their reliable taxonomic assignments are ambiguous; therefore, these microfossils (Fig. 6c) are considered here as globotruncanid gen. et sp. indet.

Carpistomiosphaera malmica occurs from the upper part of the Lower Tithonian to the middle Upper Tithonian (NOWAK, 1968, fig. 3) in the Polish Carpathians; however, at other localities it has a wider stratigraphic distribution from the Kimmeridgian to the Tithonian (IVANOVA, 1994, p. 93). FAD (= First Appearance Date) of *C. tithonica* (NOWAK) is in the uppermost Kimmeridgian, while the FAD of *C. malmica* is in the lowermost Tithonian (LAKOVA et al., 1999). These dinocysts coexist in the lower part of the Lower Tithonian,and separation of these species needs thorough practice. Both species have double walls (e.g., JACH et al., 2012, figs. 10j, l), as the present specimen (Fig. 6b) shows; however, having only one specimen from a thin section, the reliable specific assignment is not justified; therefore, the present specimen is referred to as *Carpistomiosphaera malmica/tithonica*.

Remarks on the faunal composition and benthic fauna. An interesting finding is the presence of an *"Inoceramus"* sp. in the Lower Tithonian strata, which has not been previously reported. However, inoceramids are known from the Mecsek Mountains. SZENTE (2003, p. 489) mentioned an inoceramid (*Parainoceramus fuscus* QUENSTEDT) from the Oxfordian of Zengővárkony, but it is probably misdated because *Parainoceramus* and its species occur only in the Lower Jurassic and the lower part of the Middle Jurassic (COX et al., 1969, p. N320; MONARI, 1994, p. 162). On the outer (convex) surface of the inoceramid bivalve (Fig. 4.1), serpulid tube worm remains are observed. Their presence refers to the ideal environmental bottom conditions in this ooze-like, soft sediment, in which the large-sized inoceramid offered an ideal hard substrate for the epibionts, as LUCI & LAZO (2015) reported from a similar Lower Cretaceous environment in Argentina. It is probably a fraction of the right valve because the recumbent orientation of the inoceramid bivalves is mainly left valve down on the seafloor (KAUFFMAN et al., 2007). The optimal and deeper marine seafloor conditions are supported by the large-sized pygopid brachiopods present in the section and other benthic faunal elements (foraminifera and ostracods; see Fig. 6).

CECCA (1999) presented a thorough biogeographical analysis of the Early Tithonian ammonite assemblages; however, intra-Tethyan or quantitative analysis is still not yet available. Not surprisingly, the quantitative faunal composition of the fauna described here, shows close similarities to the Early Tithonian fauna of the Umbria – Marche region in the Apennines (CECCA, 1990b, p. 48, fig. 4a–c). In both assemblages, phyllo- and lytoceratids represent less than 30% (27% in Umbria – Marche and 23.5% herein) of the fossil content. Haploceratids are proportionally similarly represented (29.2% in the Apennines and 28.9% in the Mecsek). The only difference is the remarkably different proportions of aspidoceratids: 6.1% in Umbria – Marche and 28.9% in the Mecsek area. Each fauna is pelagic, with rare occurrences of brachiopod individuals (3.8% in Italy and 3% in the Mecsek Mountains). Figure 9 shows the quantitative composition of both faunas.

There is an ongoing debate on placing the Tisza microcontinent in the Tethyan system. The latest model of VAN HINSBERGEN et al. (2020) proposed a modest approach: least movement of the microcontinent and a stable position from the Ladinian until the end of the Tithonian (VAN HINSBERGEN et al., figs. 43–46). It seems plausible, based on the ammonites presented here, that the Mecsek Unit (as part of the Tisza microcontinent) was not moving thousands of kilometres, but instead sea level rise brought the open Tethyan, Mediterranean conditions, to the area as BUJTOR (2025) hinted for the Kimmeridgian ammonite assemblage of Zengővárkony. Based on the Kimmeridgian (BUJTOR, 2025) and Early Tithonian (present work) detailed faunal data and affinities, it seems plausible that at least during the Kimmeridgian and the Tithonian, the Mecsek microplate remained in close vicinity of the southern European margin. During the Tithonian, the Maiolica-type ooze sedimentation indicated deeper marine conditions and platform-like environments with similar ammonite faunal composition to that of the platform facies (Umbria – Marche, Italy), indicating a particular proximity from the stable European shelf. This is in accordance with the palaeogeographical reconstruction of the Tisza microplate for the Berriasian by VAN HINSBERGEN et al. (2020).

7. CONCLUSION

The Mészkemence section in the vicinity of Zengővárkony (Mecsek Mountains, Hungary) traverses a continuous Lower Tithonian sequence and provides a rich but poorly preserved ammonite assemblage and a handful of well-preserved brachiopod specimens. Biostratigraphical subdivision of the Lower Tithonian became possible and confirmed the presence of some Lower Tithonian ammonite zones. The qualitative and quantitative faunal composition of the ammonite fauna correlates with the typical Tethyan Mediterranean settings with close resemblances to the fauna of the Transdanubian Range (Hungary) and Umbria – Marche (Apennines, Italy). Occurrence of "exotic" ammonite taxa such as *Gravesia* in the Mecsek Mountains indicate an open basin and connections with other faunal provinces in the Tethys along its northern shelf margin. Tethyan-originated benthic faunal elements, as pygopids also support the strong Mediterranean faunal influence. Normal, usual pelagic seafloor and water conditions are supported by the ammonites, rare brachiopods and belemnites, foraminiferans, pelagic crinoids, and serpulids.

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