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RESEARCH ARTICLE

Middle Norian conodonts from the Buda Hills, Hungary: an exceptional record from the western Tethys

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Abstract
Purpose Recent biostratigraphic investigations of pelagic dolomites in the Buda Hills area, Hungary provided unique Middle Norian conodont assemblages. Due to the poorly represented Tethyan record of similar faunas and the present state of our knowledge of Alaunian conodonts, finer age assignment could not have been carried out. The purpose of this study is to discuss the natural cause (sedimentary, tectonic and paleoecological) and artificial biases (lumping taxonomy and inadequate figuration) that led to a scarce representation of the Alaunian conodont record. Further aims are to present here several taxonomic, systematic, and biostratigraphic notes on the Middle Norian conodonts based on the rich material recovered.
Methods Rock samples were processed using standard dissolution technique of dilute acetic acid. Scanning microphotographs were taken of the conodont specimens from three views.
Results Remarks are added to the problematic species *Epigondolella abneptis* and *Mockina postera*, and some aspects for improvement of the Middle Norian conodont biostratigraphy are suggested. Detailed systematic descriptions of 3 genera and 15 species are given. The observed faunas include 5 previously unknown forms, namely *Epigondolella* aff. *vialovi*, *Mockina* aff. *matthewi, M*. aff. *postera, M*. aff. *spiculata* and *Mockina* sp. A. The Tethyan occurrence of Epigondolella transitia, a transitional Lower/Middle Norian conodont species previously known only from North America, is documented.
Conclusions The assemblage lets an insight into the main characteristics of the Lacian/Alaunian faunal turnover and into the evolutionary trends that resulted in the origination of the last representatives of conodonts of the Sevatian and the Rhaetian. The new conodont record of the Buda Hills highlights the fact that Alaunian conodonts are less known among Upper Triassic faunas. This work suggests the route of the future studies for a more precise and global applicability of conodonts in the Middle Norian biostratigraphy.

Keywords Conodonts · Biostratigraphy · Alaunian · State-of-the-art · Buda Hills · Hungary

Resúmen
Objetivo Recientes investigaciones bioestratigráficas de dolomitas pelágicas en el área de las Colinas de Buda, Hungría ofrecen ensamblajes únicos de conodontos del Noriense Medio. Debido a la poca representación del registro Tetiano de faunas similares, y al actual estado de nuestro conocimiento de conodontos Alaunienses, una asignación de edad más precisa no habría podido llevarse a cabo. El propósito de este estudio es examinar las causas naturales (sedimentarias, tectónicas y paleoecológicas) y sesgos artificiales (taxonomía de agrupamiento y figuración inadecuada) que condujeron a la escasa representación del registro de conodontos Alaunienses. Otro objetivo es exponer varias observaciones taxonómicas, sistemáticas y bioestratigráficas sobre conodontos del Noriense Medio, basadas en el rico material recuperado.
Métodos Muestras de rocas fueron procesadas usando la técnica de disolución estándar con ácido acético diluido. Se escanearon micrografías de los ejemplares de conodontos desde tres vistas.
Resultados Se añaden observaciones a las especies problemáticas *Epigondolella abneptis* y *Mockina postera*, y se sugieren algunos aspectos para la mejora de la

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bioestratigrafía de los conodontos del Noriense Medio. Se proporcionan descripciones sistemáticas detalladas de 3 géneros y de 15 especies. Las faunas observadas incluyen 5 formas anteriormente desconocidas, a saber, *Epigondolella* aff. *vialovi*, *Mockina* aff. *matthewi, M*. aff. *postera, M*. aff. *spiculata* y *Mockina* sp. A. Se documenta la ocurrencia Tetiana de Epigondolella transitia, una especie de conodonto transitoria del Noriense Inferior/Medio, anteriormente documentada solo en Norteamérica.

Conclusiones La asignación contribuye a comprender las características fundamentales del volumen de fauna Laciense/Alauniense, y las tendencias evolutivas que resultaron en la creación de los últimos representantes de conodontos del Sevatiense y del Rhaetiense. El nuevo registro de conodontos de las Colinas de Buda pone de manifiesto que los conodontos Alaunienses son menos conocidos entre las faunas del Triásico Superior. Este trabajo sugiere vías para futura investigación sobre una aplicación más precisa y global de los conodontos en la bioestratigrafía del Noriense Medio.

Palabras clave Conodontos · Bioestratigrafía · Alauniense · Estado-del-arte · Colinas de Buda · Hungría

1 Introduction

In the last 25 years Upper Triassic successions became the subjects of intense biostratigraphic studies in order to establish the Global Stratotype Section and Points (GSSPs) of the Carnian, Norian and Rhaetian Stages. Conodonts were proved to be one of the most important fossil groups for biostratigraphic dating of this time interval due to their rapid evolution and widespread distribution. Detailed studies were carried out on the conodont faunas of the Carnian/Norian (e.g. Mazza et al. 2012; Orchard 2014) and Norian/Rhaetian boundary intervals (e.g. Giordano et al. 2010, Bertinelli et al. 2016), and in many cases magneto- and/or chemostratigraphic works were supported by conodont biostratigraphic range charts (e.g. Gallet et al. 1992, 1994, 1996; Channell et al. 2003; Muttoni et al. 2005, 2010, 2014; Krystyn et al. 2007; Korte and Kozur 2011; Bertinelli et al. 2016; Rigo et al. 2016). However, less investigation has been focused on the Middle Norian (Alaunian) falling out of the ranges of both stage boundary intervals. In contrast to the North American province, where thorough studies on rich conodont faunas enabled the establishment of a fine zonation for the Alaunian substage (e.g. Orchard 1991b), Middle Norian conodont biostratigraphy is strongly affected by natural and artificial biases in the Tethyan Realm.

The recent geological mapping of the Buda Hills (Hungary) highlighted the necessity of a detailed age determination of the Triassic pelagic carbonates that build up large part of the area. In order to refine the age of the formation, samples for conodont biostratigraphic investigations were taken from several outcrops throughout the hills. Some of the collected material yielded rich and diverse Middle Norian conodont faunas. Present study aims to provide new Alaunian conodont data from the Buda Hills complementing our knowledge on Middle Norian conodonts of the Tethys.

2 Problems of Alaunian conodont biostratigraphy

Based on the evaluation of the conodont literature it can definitely be affirmed that our knowledge of Alaunian conodonts and their biostratigraphic implication is hampered by a number of factors, such as sedimentary, tectonic and paleoecological phenomena, as well as lumping taxonomy and insufficient illustration. In many Middle Norian Tethyan successions that have so far been the subjects of conodont research, detailed investigation of the Alaunian intervals was impossible due to incompleteness, tectonic or sedimentary disturbance, condensation or poor exposure of the sections. The lower Alaunian is missing in the Sasso di Castalda section (Lagonegro Basin, Italy) as the lowermost beds are dated middle Alaunian by Rigo et al. (2005). In the Fırıntaş Block (Mersin Mélange, Turkey) the lack is even more pronounced: the base of the section is upper Alaunian in age (Moix et al. 2007). Both in the Kavaalani and Kavur Tepe sections (Antalya nappes, Turkey) there are stratigraphic gaps and some levels of the Alaunian parts of the successions are missing (Gallet el al. 1993, 2000). Moreover, these last two successions, just like the Scheiblkogel section (Austria) are highly condensed as well (Gallet el al. 1996), which may cause the mixture of fossils of different biozones. Brecciation and slump structures characterize the uppermost level of the Lower Norian and large part of the Middle Norian in the Silická Brezová section (Slovakia) (Channell et al. 2003). Disturbance was also observed in the Bolücektası Tepe section (Antalya nappes, Turkey) where the Alaunian strata are represented by allodapic limestones and they have a tectonic contact downward (Gallet et al. 1992). Middle Norian beds of the Gavuruçtuğu Block (Mersin Mélange, Turkey) were deposited in a restricted basin and yielded a monospecific conodont fauna. Exclusively the uppermost part of the Alaunian represents open marine environment, however the conodont assemblage remains poor, composed only of three species, namely *Epigondolella praeslovakensis* Kozur, Masset and Moix in Moix et al. (2007), *Mockina medionorica* Kozur, 2003 and *M. zapfei* (Kozur, 1973) (Moix et al., 2007). Though diverse Middle Norian faunas were reported from Pizzo Mondello (Sicily, Italy) (Mazza et al. 2012) and from the Buda Hills (Hungary) (Karádi et al., 2016), the poorly exposed Alaunian strata at these localities are unsuitable for phylogenetic research, that would be fundamental for precise biostratigraphic interpretations. Further difficulties are caused by the seeming competition between the conodont genera *Norigondolella* and *Epigondolella/Mockina* (Kozur, 2003; Mazza et al., 2010). This feature is quite common throughout the Norian, although it is rather resulted by ecological control (most likely temperature) than real competition. Genus *Norigondolella* was stenothermal and it inhabited cooler water environments (Trotter et al. 2015). When conditions were favourable for norigondolellids, they appeared in mass occurrences and dominated in the assemblages over epigondolellids and mockinae that were usually represented only by a few and mostly juvenile forms. Moreover, conodont animals presumably suffered some kind of environmental stress during the Alaunian, because many assemblages are characterized by a high rate of juvenile mortality and a very low number of adult specimens regardless of which genera are present. For instance this is the case in the succession of the Csővár borehole (Karádi 2015). This could also be another reason of scarcity of conodont data from the Alaunian.

Beside the above mentioned natural causes, artificially induced issues also set back the development of Alaunian conodont zonation. Stratigraphically important Middle Norian conodont species have been described from the Canadian Cordillera on the western margin of North America; *Epigondolella multidentata* by Mosher (1970) and *E. carinata*, *E. elongata*, *E. matthewi*, *E. serrulata*, *E. spiculata* and *E. tozeri* by Orchard (1991b). In contrast, many workers in the Tethyan Realm use an oversimplified taxonomical concept assigning the majority of different forms into three species, namely *E. abneptis*, *E. multidentata* and *E. postera* (e.g. Krystyn, 1973; Cafiero and De Capoa-Bonardi, 1981; Wang and Dong, 1985; Mao and Tian, 1987; Wang and Wang, 1990; Gallet et al., 1992, 1993, 1996). This is resulted in extremely long ranges for these taxa. Although they are well-known from the Middle Norian literature, neither genus *Norigondolella*, nor the conodont species *Epigondolella praeslovakensis* Kozur, Masset and Moix in Moix et al. 2007 and *Mockina slovakensis* (Kozur, 1972) are considered here in the context of biostratigraphic problems, because firstly, they are easily recognizable due to their distinct morphologies and secondly, they have local biostratigraphic value. The former taxa contain long-ranged and facies-controlled forms (Channell et al. 2003; Orchard 2007), and the latter two species are extremely rare in the northern Tethys or compose monospecific assemblages (Budai and Kovács 1986; Kovács and Nagy 1989; Channell et al. 2003).

Epigondolella abneptis (Huckriede, 1958) is one of the most problematic Upper Triassic conodont species leading to serious biostratigraphic misinterpretations. In many cases this name was used for almost all the uppermost Carnian to Middle Norian epigondolellids (see section Systematic paleontology for details). *Epigondolella multidentata* turned out to be restricted to North America (Kozur 2003; Orchard 2006), so this name became less used for Tethyan forms by now. The neotenic characters of '*Epigondolella*' *postera* (Kozur and Mostler, 1971) make this species very similar to juvenile or subadult stages of other species; hence a lot of specimens are assigned erroneously to '*Epigondolella*' *postera* especially in those sections where the Alaunian is represented by juvenile forms only, as mentioned before. For correct determination it is very important to consider strictly the original description of *Mockina postera* (='*Epigondolella*' *postera*) and the illustrated figures of the holotype.

Very few attempts were made to describe new Alaunian conodont species from the Tethys. One of them is *Mockina zapfei* (Kozur, 1973), which is stated to be a guide form of the uppermost Alaunian to lower Sevatian interval (Moix et al. 2007). This species was only rarely recognized by conodont specialists (Mazza et al. 2012; Rigo et al. 2016), but more frequently it was assigned to other taxa, e.g. to *Mockina postera* (e.g. Bazzucchi et al., 2005, fig. 11/1) or to *Mockina slovakensis* (e.g. Martini et al., 2000, pl. V, figs. 13–14). *Mockina medionorica* Kozur, 2003 is a good example of a species that is hardly ever considered by any conodont workers besides its author. The only two mentions of this taxon (without Kozur as co-author) are by Onoue and Tanaka (2005) and Onoue et al. (2011). Just like many other species, *Mockina medionorica* raises the problem of inadequate figuration of Middle Norian conodonts, as its holotype is illustrated from upper view only. In figured specimens that Kozur classified as *M. medionorica* the lower side is only visible in Kovács and Kozur (1980, pl. 14, fig. 5). Similar is the case with the so problematic *Epigondolella abneptis*, the holotype of which is figured from an oblique upper view. Kozur in Moix et al. (2007) presented a short revision on this species and illustrated two specimens from the Mersin Mélange (Turkey). However, no figuration was made from lower view that would be necessary for appropriate classification, because the position of the pit and the characters of the keel are key features in Lower and Middle Norian conodonts. All three views (i.e. upper, lower and lateral) are shown in the holotypes of *Epigondolella transitia* Orchard, 1991b, *Mockina matthewi* (Orchard, 1991b) and *Mockina serrulata* (Orchard, 1991b), but the low number of illustrated specimens does not allow an insight into the intraspecific variability of these taxa. Without clarifying the morphological variations of Alaunian conodont species, their

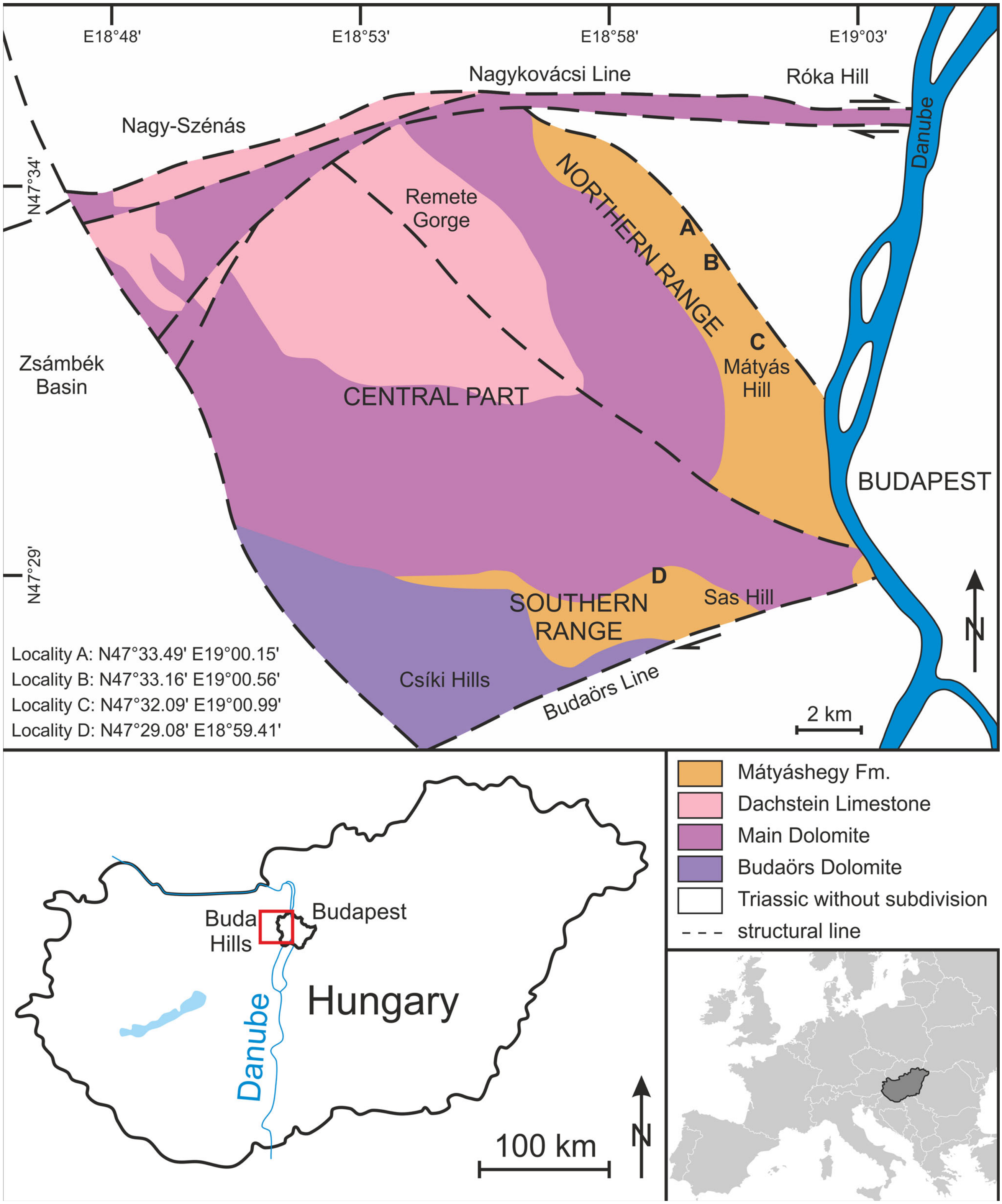


Fig. 1 Simplified basement map of the Buda Hills with the Triassic formations and the sampled localities (*A*–*D*). *Inset map* showing the position of Hungary and the position of the studied area (modified after Haas et al. 2000)

ranges and their evolutionary lineages cannot be established. It is also necessary to reconsider the upper ranges of typical Lower Norian epigondolellids, *Epigondolella rigoi* Kozur in Noyan & Kozur (2007), *E. triangularis* (Budurov, 1972) and *E. uniformis* (Orchard, 1991b), which definitely range up in the Middle Norian (Channell et al. 2003; Katvala and Stanley 2008; Mazza et al. 2012; Mazza and Martínez-Pérez 2015).

All the biases discussed above played a key role in conceiving of such false ideas that conodonts are unsuitable for the refinement of Triassic chronostratigraphy and conodont biostratigraphy needs to be abandoned (Lucas 2013, 2016). However, other studies (Orchard 2016; Rigo et al. 2017) as well as this research prove just the opposite: improvement of conodont biostratigraphy is possible and most of the drawbacks can be resolved by performing more thorough and precise studies, using up-to-date nomenclature and including distribution charts and proper figuration of the conodont elements.

3 Geological setting

The Buda Hills are located west of the River Danube in the vicinity of Budapest in north-central Hungary as the northeastern member of the Transdanubian Range (Fig. 1). Based on facies characteristics of the Triassic formations the area can be subdivided into three parts: a central part, a northern range (SE–NW striking) and a southern range (E–W striking). The central part represents a carbonate platform, made up by Upper Ladinian to Rhaetian dolomites and limestones (Budaörs Dolomite, Main Dolomite and Dachstein Limestone). In the northern and southern ranges the platform carbonates characterize the lower part of the succession, which are overlain by cherty dolomites and cherty limestones upsection (Mátyáshegy Formation). The cherty carbonates were deposited in a fault-controlled extensional basin developed on the northwestern margin of the Neotethys; a large part of the succession was subjected to dolomitization (Haas 2002; Hips et al. 2016). In the southern range only cherty dolomite of uppermost Carnian to Upper Norian age is present, whereas in the northern range uppermost Carnian to Upper Norian cherty dolomite and Rhaetian cherty limestone occur. Age assignment of the pelagic carbonates is mostly based on conodonts (Kozur and Mock 1991; Karádi et al. 2016), in some cases on radiolarians, foraminifers and sporomorphs (Haas et al. 2000). Due to Late Cretaceous to Early Palaeogene uplift, post-Triassic Mesozoic strata were eroded in the Buda Hills (Fodor et al. 1994).

The poor exposure of the cherty carbonates does not allow bed-by-bed sampling in most of the outcrops. The conodont fauna presented herein was collected from 4 localities: outcrops along a hiking road (A on fig. 1), a cave section (B on fig. 1) and a quarry section (C on fig. 1) in the northern range and a private house building site (D on fig. 1) in the southern range.

Locality A—Several outcrops are present along the Guckler hiking road on the northeastern margin of the northern range. The one included in this study is a short wall with a thickness of 2 m, located southeast of the Guckler Cliff. It is made up by 5–8 cm thick beds of grey, reddish grey dolomite with few red chert nodules of 3–5 cm size (Fig. 2).

Locality B—The Tűzköves Chamber and the Murvabánya Hall of the Királylaki Cave exposes a 12 m thick section of yellowish grey, 10–40 cm thick dolomite beds with a large number of layer-parallel, dark grey chert nodules and lenses at their bases. Thickness often varies within the layers. The two chambers are connected along a layer-parallel squeeze, so it did not interrupt the continuous sampling of the section. 7 m above, at the cave entrance in the artificial tunnel, few dolomite beds are exposed (Fig. 2).

Locality C—The 8 m thick succession at the northwestern margin of the Mátyáshegy quarry is the type locality of the Mátyáshegy Formation. It consists of light brown marly dolomite with red chert nodules of ~5 cm in diameter. The beds are generally 10–20 cm thick, but in the lower part of the section one bed with a thickness of 25 cm is present (Fig. 2).

Locality D—The 3.5 m high wall was exposed during the groundwork of a house building site at 45 Rácz Aladár Road in district XII of Budapest. Light coloured yellowish grey dolomite layers alternate with white, friable dolomite. Sporadically dark grey chert nodules are present (Fig. 2). Further sampling is no more possible as the outcrop is built-in by now.

4 Materials and methods

For preliminary studies 2 samples were taken from *locality A* (24P on Fig. 2), 9 from *locality B* (KBG on Fig. 2), 2 from *locality C* (34P, 35P on Fig. 2) and 1 from *locality D* (58P on Fig. 2), for age determination only. Samples from *locality B* weighed ca. 1 kg, whereas all the other samples weighed ca. 0.1 kg. The dolomites and cherty dolomites were processed at the Department of Palaeontology of the Eötvös Loránd University in Budapest using standard dissolution technique of dilute (10%) acetic acid. Conodonts were present in all the samples. For detailed investigation of the conodont faunas, the cave section (*locality B*) and the building site (*locality D*) were re-sampled; 30 samples (ca. 1 kg each) were taken from the former (KLB on Fig. 2) and five samples (ca. 2 kg each) from the latter (RA

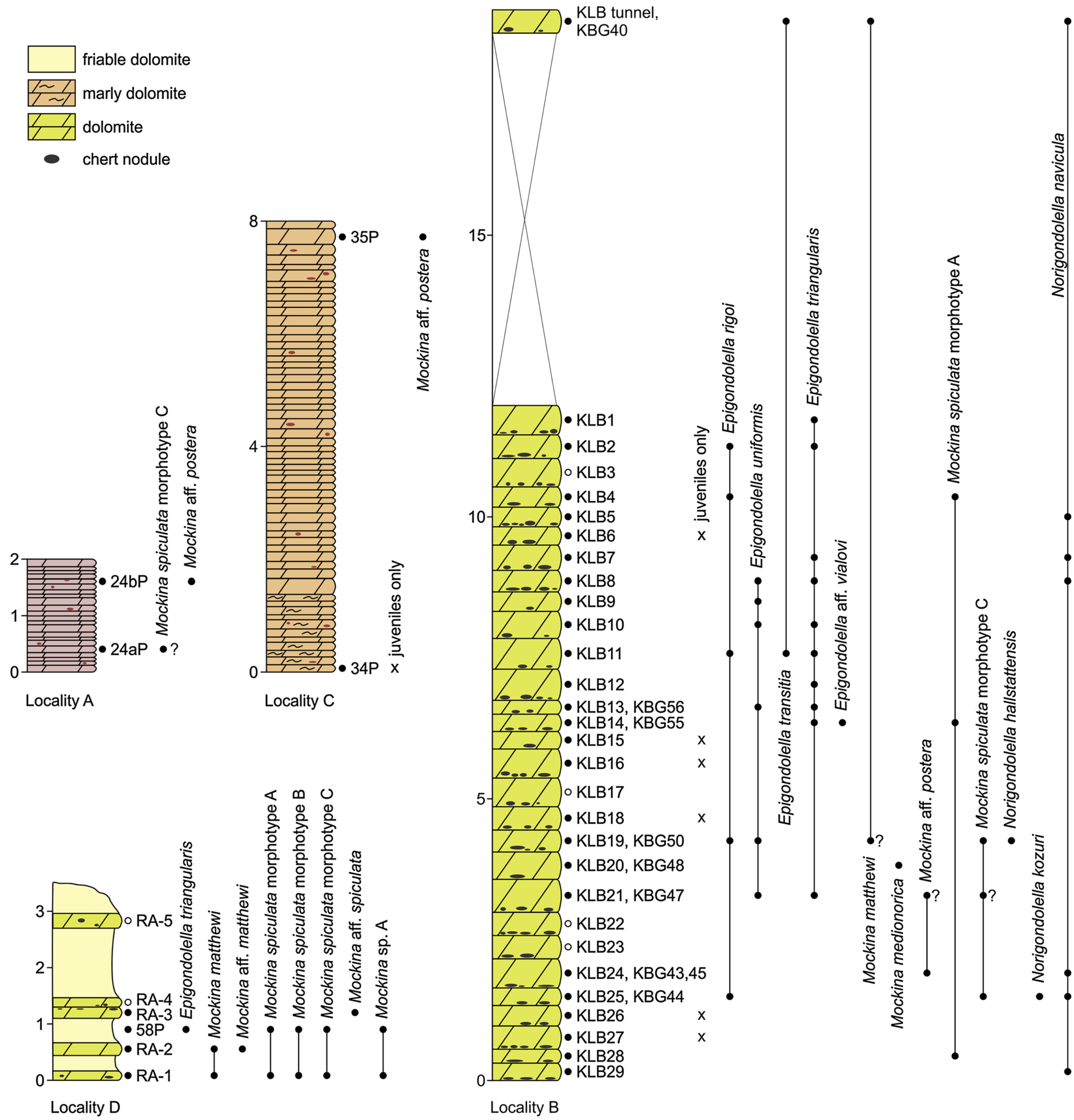


Fig. 2 Stratigraphic logs of the investigated successions with the position of the samples taken (*solid circles* conodonts present; *open circles* conodonts absent) and the range charts of conodonts discussed in Sect. 6. Samples with exclusively juvenile specimens are *marked by x*. *Scale* is in meter

on Fig. 2). Stratigraphically important conodont elements were found in 29 out of the 35 additional samples (26 from the cave and 3 from the building site). Conodonts show a Colour Alteration Index (CAI) of 1–1.5. Beside conodonts several fish teeth and two specimens of poorly preserved ostracods were found. Scanning micro-photographs of the conodonts were taken partly at the Dipartimento di Scienze della Terra "A. Desio", University of Milan, Italy and partly at the Department of Botany of the Hungarian Natural History Museum. The specimens are reposited at the Department of Palaeontology of the Eötvös Loránd University, Budapest.

5 Biostratigraphy

All the investigated successions are assigned to the Alaunian. For most of the localities the more precise age is only presumable due to the previously mentioned causes. The lower sample (24aP) of *locality A* yielded one questionable specimen of *Mockina spiculata* (morphotype C) besides juvenile forms (Fig. 2). *Mockina spiculata* has a range throughout the Alaunian (except uppermost Alaunian). The upper sample (24bP) contained *M.* aff. *postera*. If *M.* aff. *postera* is a morphotype of true *M. postera* and not a separate species (see section Systematic paleontology), then this locality is suggested to be middle or upper Alaunian in age.

The bed-by-bed sampling of *locality B* yielded richer conodont assemblages. The typical Lower Norian epigondolellids (*Epigondolella rigoi*, *E. uniformis* and *E. triangularis*) occur together with the unequivocally Middle Norian species (*Mockina matthewi*, *M. medionorica*, morphotypes A and C of *M. spiculata* and *M.* aff. *postera*) (Fig. 2). *Mockina matthewi* is reported from the lower Alaunian of North America, but it is quite uncommon (Orchard 1991b), which is true for the fauna of the Buda Hills, too. Anyway, it suggests a lower Alaunian age for this cave section, supported also by *E. transitia*, based on its North American range (Katvala and Stanley 2008). The presence of *M.* aff. *postera* in the lower part of the succession again emphasizes the importance of this form just like in the case of *locality A*. If the collected specimen is a morphological variation of *M. postera*, the age of the cave section would be middle Alaunian. This would also confirm that the ranges of Lacian epigondolellids extend to the middle Alaunian. Noticeable is the competition (sensu Kozur 2003) between the genera *Norigondolella* and *Epigondolella*/*Mockina*, probably because of an ecological factor, such as temperature (Trotter et al. 2015). Norigondolellids are quite abundant in the lower and upper parts of the succession, whereas they are absent in the middle part. The genera *Epigondolella* and *Mockina* are present all along the section, but with fewer and less developed specimens when they co-occur with norigondolellids.

Locality C yielded poor conodont assemblages, however, it needs to be considered that the amount of the material was very low (0.1 kg per sample). The lower sample (34P) contained only juvenile specimens (Fig. 2). In the upper sample (35P) one specimen of *M.* aff. *postera* was found that does not allow precise dating due to its uncertain systematic position.

The conodont fauna of *locality D* is characterized by a large number of *M. spiculata* (all three morphotypes) and *Mockina* sp. A together with few *M. matthewi*, *M.* aff. *matthewi* and *M.* aff. *spiculata* (Fig. 2). One specimen of *E. triangularis* is also present. This assemblage suggests a lower to middle Alaunian age for the succession.

6 Systematic paleontology

Although *Epigondolella abneptis* (Huckriede, 1958) and *Mockina postera* (Kozur and Mostler, 1971) could not have been identified from the studied samples of the Buda Hills, the discussions on their taxonomy are fundamental for the Alaunian conodont biostratigraphy.

Phylum Chordata Bateson, 1886
Subphylum Vertebrata Linnaeus, 1758
Class Conodonta Eichenberg, 1930
Order Ozarkodinida Dzik, 1976
Superfamily Gondolellacea (Lindström, 1970)
Family Gondolellidea Lindström, 1970
Genus *Epigondolella* Mosher, 1968
Type species: *Polygnathus abneptis* Huckriede, 1958

Description This genus bears high denticles on the platform margins. In some species the denticles are only present on the anterior margins, in others on the lateral and posterior margins as well. It has a relatively wide platform with a significant posterior widening in many representatives. The free blade mostly has approximately the same length as the platform, but several species have shorter blades in the stratigraphically younger specimens. The pit is centrally located and the keel end is strongly bifurcated. The keel does not show posterior prolongation, as the bifurcation extends very close to the pit. In the stratigraphically younger species the bifurcation becomes asymmetric. The cusp is usually followed by one carinal node, but in some stratigraphically older species it can be the last denticle of the carina.

Comparison Genus *Mockina* has a narrower platform, a more forward shifted pit and a prolonged keel with mostly pointed, rounded or squared termination. Also, the posterior carina is longer in *Mockina*.

Epigondolella abneptis (Huckriede, 1958)

pars 1958 *Polygnathus abneptis* n. sp.—Huckriede, p. 156–157, pl. 14, figs. 12, 13, 16, 17; non! pl. 11, fig. 33; pl. 12, figs. 30–36; pl. 14, figs. 1–3, 5, 14, 18, 26, 27, 32, 47–58.
2007 *Epigondolella abneptis* (Huckriede, 1958)—Moix et al., p. 291, pl. 1, figs. 1, 2

Remarks The original description of *Polygnathus abneptis* (=*E. abneptis*) was based on a large variety of forms from the Upper Anisian to Upper Norian interval. It indicated only general characters, such as denticulated platform margins, a distally located pit and a long free blade. The illustrated specimens indeed had various platform shape and ornamentation. Mosher (1968) was probably inspired by these features in choosing *Polygnathus abneptis* as type species of genus *Epigondolella*. Kozur (2003, p. 70) mentioned *E. abneptis* in the description of *Epigondolella orchardi* (Kozur, 2003) and states that the holotype of *E. abneptis* is lost and a neotype is not yet established. He also notes that *E. abneptis* is very similar to *E. quadrata* Orchard, 1991b, but they differ only in the length of the blade that is shorter in the former species. Kozur in Moix et al. (2007) shortly discussed the problems concerning *E. abneptis* and restricted its occurrence to the type material from Someraukogel (lower Alaunian) and the material from the Mersin Mélange (upper Alaunian) illustrated therein. These occurrences suggest that *E. abneptis* is present throughout the Middle Norian.

According to the author, the blade length of a species may vary along its range, and thus it is not a key feature to separate species. To avoid further misunderstandings and misinterpretations a thorough revision and a detailed description (including proper figuration) of *E. abneptis* is urgently needed.

Stratigraphical range. Alaunian.

Epigondolella rigoi Kozur in Noyan and Kozur (2007)
Pl. 1, Fig. 5

2003 *Epigondolella abneptis* (Huckriede)—Channell et al., figs A2/27, 30, 33.

2007 *Epigondolella rigoi* Kozur n. sp.—Noyan and Kozur, p. 167, figs. 6.2–6.5.

2007 *Epigondolella rigoi* Kozur n. sp.—Moix et al., p. 293.

pars 2007 *Epigondolella rigoi* Kozur—Nicora et al., pl. 4, fig. 6; non! pl. 3, fig. 12

2010 *Epigondolella rigoi* Kozur, 2007—Balini et al., pl. 3, fig. 8. [re-figuration of Nicora et al. (2007), pl. 4, fig. 6].

2010 *Epigondolella rigoi* Kozur—Mazza et al., pl. II, fig. 5. [re-figuration of Nicora et al. (2007), pl. 4, fig. 6].

2012 *Epigondolella rigoi* Noyan & Kozur, 2007—Mazza et al., p. 108, pl. 6, figs. 1–7.

pars 2013 *Epigondolella rigoi* Kozur, 2007—Karádi et al., pl. 1, figs. 2, 11, 12; pl. 2, figs. 2, 5, 8, 20; pl. 3, figs. 3, 5; non! pl. 1, fig. 6.

2015 *Epigondolella rigoi* Noyan & Kozur, 2007—Mazza and Martízen-Pérez, p. 168, 170, pl. 4, figs. 1–16; fig. 3c.

2016 *Epigondolella rigoi*—Mazza and Martínez-Pérez, figs. 4.5–7.

Material: 11 specimens in 6 samples

Description The platform is strongly widened posteriorly (sometimes asymmetrically), which gives a sub-triangular shape for the element. The anterior platform margins bear 2–4 large denticles, often elongated towards the adcarinal groove. The posterior margin can be wavy, but always without denticulation. The pit is centrally located and the keel is strongly bifurcated. The cusp is always followed by a large carinal node and in some specimens low carinal ridges are present pointing towards the postero-lateral corners of the platform. This feature indicates the bifurcation of the keel. The free blade is long, anteriorly high and it decreases gradually towards the cusp. In lateral view the element can be straight, but more often it is slightly concave with the posterior platform bending downwards.

Comparison Epigondolella triangularis and *E. transitia* have strong denticles all around the platform margins. Furthermore, the keel of *E. transitia* is asymmetric with no (or only slight) bifurcation.

Stratigraphical range from uppermost Tuvalian to (middle?) Alaunian.

Plate 1 *Scale bar* 200 µm. Fig. **1**, **7** *Epigondolella transitia* Orchard, 1991b, lower Alaunian, locality B; Fig. **1** sample KLB11, rep.-no. KLB11_01; Fig. **7** sample KBG40, rep.-no. KBG40_01. Fig. **2** *Epigondolella uniformis* (Orchard, Orchard, 1991b), lower Alaunian, locality B; Fig. **2** sample KBG50, rep.-no. KBG50_03. Fig. **3** *Epigondolella* cf. *uniformis*, lower Alaunian, locality B, sample KLB19, rep.-no. KLB19_03. Fig. **4**, **8** *Epigondolella triangularis* (Budurov, 1972), lower Alaunian, locality B; Fig. **4** sample KLB11, rep.-no. KLB11_02; Fig. **8** sample KBG56, rep.-no. KBG56_01. Fig. **5** *Epigondolella rigoi* Kozur in Noyan & Kozur (2007), lower Alaunian, locality B, sample KLB2, rep.-no. KLB2_01. Fig. **6** *Epigondolella* aff. *vialovi* (Buryi, 1989), lower Alaunian, locality B, sample KLB14, rep.-no. KLB14_01 ▶

Epigondolella uniformis (Orchard, 1991b)
Pl. 1, Figs. 2, 3

1991b *Epigondolella triangularis uniformis* n. subsp.—Orchard, p. 315, pl. 3, figs. 1–3.

2003 *Epigondolella triangularis uniformis* Orchard—Channell et al., fig. A3/13.

2003 *Epigondolella triangularis* (Budurov)—Channell et al., figs A3/17, 38.

2006 *Epigondolella triangularis uniformis* Orchard—Orchard, pl. 8, fig. 6.

2007 *Epigondolella triangularis* (Budurov)—Nicora et al., pl. 4, figs. 8, 9.

2010 *Epigondolella uniformis* (Orchard, 1991)—Balini et al., pl. 4, fig. 5 [re-figuration of Nicora et al. (2007), pl. 4, fig. 9].

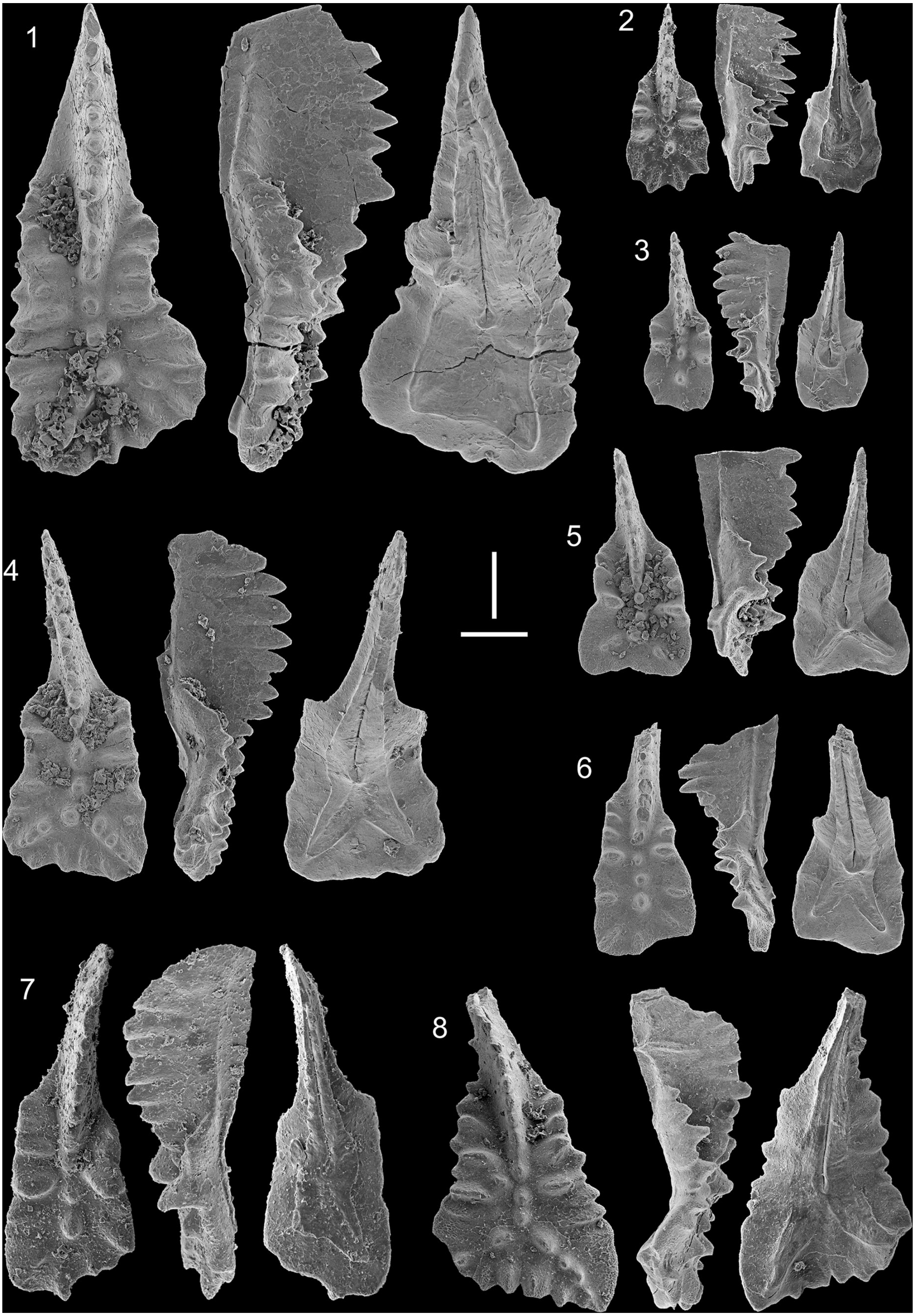
2010*Epigondolella uniformis* (Orchard)—Mazza et al., pl. III, fig. 7. [re-figuration of Nicora et al. (2007), pl. 4, fig. 9].

2012 *Epigondolella uniformis* (Orchard, 1991b)—Mazza et al., p. 110–111, pl. 7, fig. 1.

2013 *Epigondolella uniformis* Orchard, 1991—Karádi et al., pl. 3, figs. 9, 10.

2015 *Epigondolella uniformis* (Orchard, 1991)—Mazza and Martínez-Pérez, p. 173, pl. 5, figs. 13–25; figs. 3a, b.

2016 *Epigondolella uniformis*—Mazza and Martínez-Pérez, Figs. 3.5–6, 5.2–3.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Material: 13 specimens in 7 samples

Description The platform has sub-parallel margins with a sub-squared or slightly enlarged and rounded posterior end. On the anterior margins 2–4 large denticles are present that can be elongated into the adcarinal groove. The lateral and posterior margins have lower, ridge-like denticles that are radially projected. The pit lies in platform midlength. The keel end is usually bifurcated, but rarely it can be squared. A large carinal node is present behind the cusp in the centre of the posterior platform. The free blade is half to 1/3 of the element length; it is anteriorly high and descends gradually towards the cusp. Laterally the element is straight or can be slightly concave with the posterior end bending downwards.

Comparison Epigondolella uniformis differs from *E. triangularis* and *E. transitia* for the uniform, posteriorly not so expanded platform and the weaker posterior ornamentation. *Epigondolella rigoi* has a wide posterior margin with no denticulation. *Epigondolella vialovi* has an irregular platform outline.

Stratigraphical range from uppermost Tuvalian to (middle?) Alaunian.

Epigondolella transitia Orchard, 1991b
Pl. 1, Figs. 1, 7

1991b *Epigondolella transitia* n. sp.—Orchard, p. 314, pl. 3, figs. 11–13.

2006 *Epigondolella transitia* Orchard—Orchard, pl. 4, fig. 10; pl. 8, fig. 8.

2008 *Epigondolella transitia* Orchard, 1991b—Katvala and Stanley, fig. 41, photos 19, 20.

Material: 2 specimens in 2 samples

Description The main character of this species is the asymmetric posterior platform with one postero-lateral lobe more developed. The anterior platform margins bear 2–4 large denticles that are elongated into the adcarinal groove. The lateral and posterior margins are strongly denticulated. The pit is slightly forward shifted and lies just in front of the middle of the platform. The keel is not bifurcated, but typically asymmetric and follows the shape of the posterior platform. Behind the cusp a large carinal node is present from where a posterior carina of mainly two nodes continues towards the posterior tip of the more developed lobe. The free blade is about 1/3 of the element length. It is high anteriorly and descends gradually towards the cusp. In lateral view the element has a concave lower profile.

Comparison Epigondolella triangularis has a more symmetric platform and a bifurcated keel termination. *Epigondolella transitia* has similar characters to *Mockina spiculata*, but the main difference is in their lower profiles. That of *E. transitia* is concave, whereas in *M. spiculata* it is convex with the posterior platform bending upwards. Moreover, the latter species have higher and sharper anterior denticles.

Remarks Epigondolella transitia has only four illustrated specimens, all of them from North America (Orchard 1991b, 2006; Katvala and Stanley, 2008), thus the two specimens illustrated herein are the first records from the Tethys.

Stratigraphical range from upper Lacian to (middle?) Alaunian.

Epigondolella triangularis (Budurov, 1972)
Pl. 1, Figs. 4, 8

1972 *Ancyrogondolella triangularis* n. sp.—Budurov, p. 857, pl. 1, figs. 3–6.

1991a *Epigondolella triangularis* (Budurov)—Orchard, pl. 4, Fig. 12.

1991b *Epigondolella triangularis triangularis* (Budurov)—Orchard, p. 315, pl. 3, figs. 7–9.

2003 *Epigondolella triangularis* (Budurov)—Channell et al., fig. A3/88.

2006 *Epigondolella triangularis triangularis* (Budurov)—Orchard, pl. 8, figs. 3, 5.

2010 *Epigondolella triangularis* (Budurov, 1972)—Balini et al., pl. 4, fig. 7.

pars 2013 *Epigondolella triangularis* (Budurov, 1972)—Karádi et al., pl. 2, fig. 17; pl. 3, figs. 11, 16, 17; non! pl. 3, fig. 15.

2015 *Epigondolella triangularis* (Budurov, 1972)—Mazza and Martínez-Pérez, p. 170, 173, pl. 5, figs. 1–12; fig. 3d.

2016 *Epigondolella triangularis*—Mazza and Martínez-Pérez, figs. 5.4–5.

Material: 26 specimens in 11 samples

Description The platform is strongly widened posteriorly giving a triangular outline for the platform. The platform margins are strongly denticulated. The pit is centrally located and the keel end is bifurcated. The cusp is followed by a carinal node from where two carinal ridges continue towards the postero-lateral corners of the platform. The free blade is half to 1/3 of the entire element length; it is anteriorly high and descends gradually towards the cusp. In lateral view the lower profile can be straight, but more often it is concave.

Comparison Epigondolella transitia has similar ornamentation, but an asymmetric posterior platform. The posterior platform of *E. uniformis* is not so widely expanded as that of *E. triangularis*. *Epigondolella rigoi* has a similar platform outline, but without lateral and posterior denticulation.

Stratigraphical range from uppermost Tuvalian to (middle?) Alaunian.

Epigondolella aff. *vialovi* (Buryi, 1989)
Pl. 1, Fig. 6
Material: 2 specimens in 1 sample

Description This conodont is characterized by a posteriorly widened platform in which one postero-lateral lobe is more developed, and thus longer than the other. Large denticles are present on the anterior margins in a number of 2–4. The ridge-like denticles of the lateral and posterior margins are shorter in height and radially projected. The pit is slightly forward shifted and lies somewhat before the middle of the platform. The keel end is strongly bifurcated, however a slight prolongation occurs in correspondence to the pit. The cusp is followed by two, well separated carinal nodes. The free blade is about 1/3 of the entire length of the element. It is high in its anterior part and descends gradually but rapidly towards the cusp. Laterally the element has a slightly concave lower profile.

Comparison True *Epigondolella vialovi* likewise has an irregular platform outline, but it has only one carinal node behind the cusp and its pit is located in the platform midlength or slightly behind it. *Epigondolella uniformis* has a similar marginal ornamentation, but its platform is not asymmetric.

Remarks The illustrated specimen (Pl. 1, Fig. 6) is a good example for the evolutionary trend that can be observed in the uppermost Lacian to lower Alaunian interval and is characterized by the forward shifting of the pit, the prolongation of the keel and the rise in the number of carinal nodes behind the cusp from 1 to 2–3. This form is possibly the descendant of *E. vialovi*.

Stratigraphical range. Lower (to middle?) Alaunian.

Genus *Mockina* Kozur, 1989

Type species: *Tardogondolella abneptis postera* Kozur and Mostler, 1971

Description Genus *Mockina* is characterized by high, sharp and slightly or moderately backwardly inclined denticles on the anterior platform margins. The lateral and posterior margins can be smooth or can bear low denticles. The width of the platform is reduced, and in the stratigraphically youngest forms it is even absent. In most of the species the free blade is short, 1/3 to 1/4 of the platform length, but in a few forms it can be as long as the platform. The pit can be slightly or strongly forward shifted, but it always lies in the anterior half of the platform. The keel is posteriorly prolonged behind the pit. Its termination can be pointed, rounded, squared or rarely even weakly bifurcated, but in this case the bifurcation never reaches the pit. The cusp is always followed by 2–3 additional nodes. (See comparison under *Epigondolella*.)

Mockina matthewi (Orchard, 1991b)
Pl. 2, Figs. 1, 4, 6

	1991b *Epigondolella matthewi* n. sp.—Orchard, p. 309, pl. 4, figs. 8–10.
non	2005 *Epigondolella matthewi* Orchard—Onoue and Tanaka, fig. 3/22.
	2006 *Epigondolella matthewi* Orchard—Orchard, pl. 8, fig. 16.
	2008 *Epigondolella matthewi* Orchard, 1991b—Katvala and Stanley, p. 222, fig. 42, ?photo 8.
	2016 *Mockina matthewi* (Orchard, 1991)—Karádi et al., pl. 4, fig. 6.

Material: 7 specimens in 4 samples

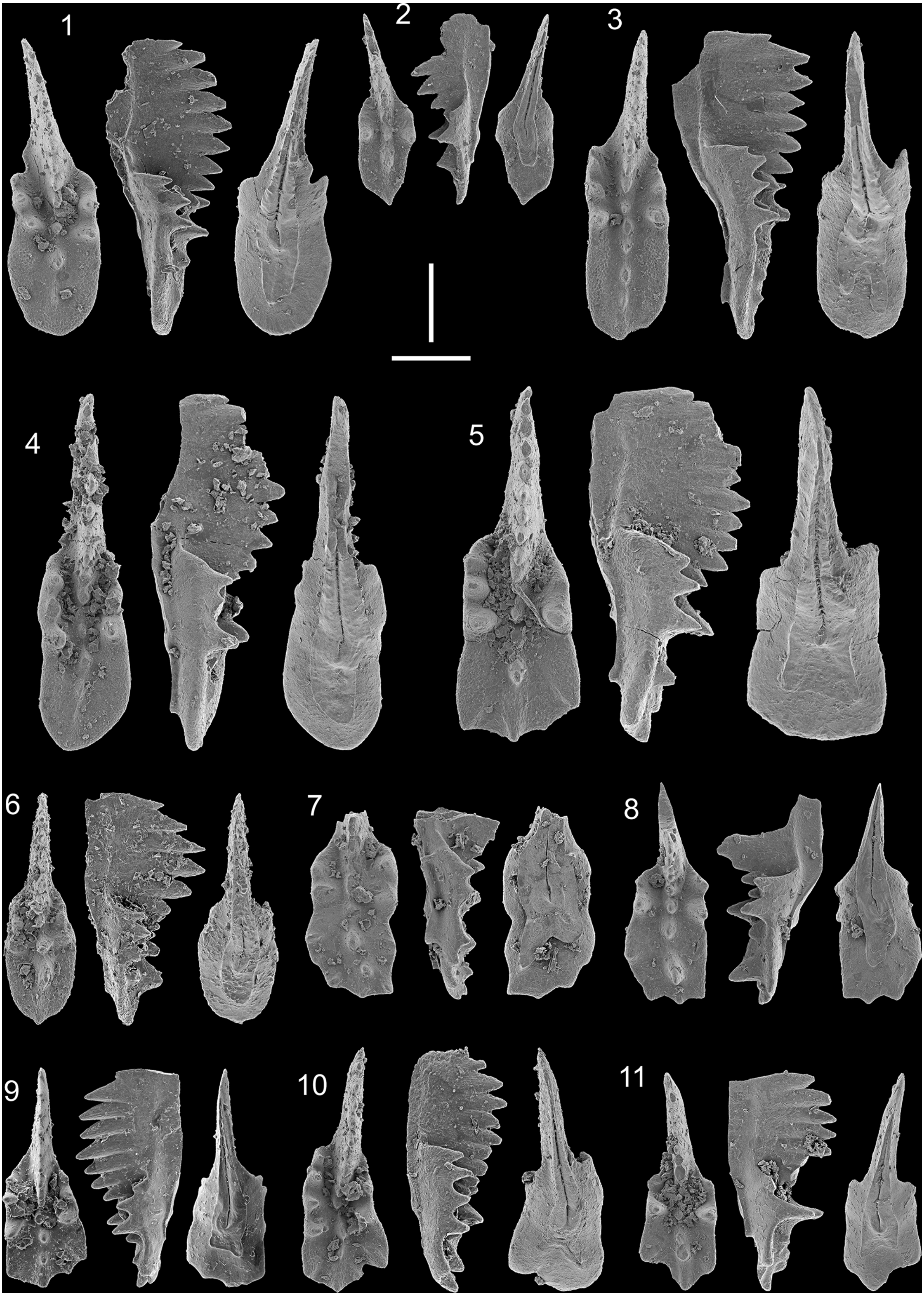
Description The element is symmetric and is characterized by a biconvex platform that is the broadest at the middle part and posteriorly rounded. The anterior margins bear 2–3 large denticles, but the lateral and posterior margins are unornamented. The pit is forward shifted and lies distinctly in front of the platform midlength. The keel is prolonged behind the pit and its termination is narrowly rounded. The cusp is followed by two separated carinal nodes from which the second one is quite low. The posterior carina does not reach the posterior end of the platform. The free blade is about 1/3 of the element length. In lateral view the lower profile is slightly stepped at the blade/platform junction but below the platform it remains straight.

Comparison Mockina medionorica has similar platform ornamentation, but it has less denticles on the anterior margins and its platform is the broadest in its anterior part.

Stratigraphical range Lower (to middle?) Alaunian.

Mockina aff. *matthewi* (Orchard, 1991b)
Pl. 2, Fig. 3
Material: 1 specimen in 1 sample

Description This conodont is characterized by a long platform with parallel margins and a rounded posterior end. The anterior platform margins bear 2–4 large denticles and the rest of the platform is undenticulated. The pit is distinctly forward shifted and is located in the anterior half of the platform. The keel is posteriorly prolonged. Its termination is strongly bifurcated, but the two lobes do not diverge, they remain parallel that is an uncommon feature. The lobes have rounded ends and one is longer than the other. Behind the cusp a long posterior carina is present, composed of three separated carinal nodes. The posterior carina does not reach the end of the platform, but there is a small, rounded tip in its continuation giving the posterior platform a slightly asymmetric appearance. The free blade is about 1/3–1/4 of the element length. In lateral view the lower profile is stepped approximately at the middle of the element and remains straight below the platform.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◀**Plate 2** scale bar: 200 µm. Figs. **1**, **4**, **6** *Mockina matthewi* (Orchard, 1991b), lower Alaunian; Fig. **1** locality D, sample RA2, rep.-no. RA2_01; Fig. **4** locality D, sample RA2, rep.-no. RA2_05; Fig. **6** locality B, sample KLB tunnel, rep.-no. KLB_tunnel_02. Fig. **2** *Mockina* aff. *postera* (Kozur and Mostler, Kozur and Mostler 1971), lower Alaunian, locality C, sample 35P, rep.-no. 35P_01. Fig. **3** *Mockina* aff. *matthewi* (Orchard, 1991b), lower Alaunian, locality D, sample RA2, rep.-no. RA2_03. Fig. **5** *Mockina* aff. *spiculata* (Orchard, 1991b), lower Alaunian, locality D, sample RA3, rep.-no. RA3_02. Figs. **7–11** *Mockina spiculata* (Orchard, 1991b), lower Alaunian; Fig. **7** morphotype A, locality D, sample 58P, rep.-no. 58P_02; Fig. **8** morphotype B, locality D, sample 58P, rep.-no. 58P_01; Fig. **9** morphotype C, locality B, sample KBG50, rep.-no. KBG50_01; Fig. **10** morphotype C, locality B, sample KBG50, rep.-no. KGB50_05; Fig. **11** morphotype C, locality B, sample KLB19, rep.-no. KLB19_04

Comparison Mockina matthewi has a biconvex platform and its keel end is not bifurcated. Its posterior carina is shorter than that of *Mockina* aff. *matthewi*.

Stratigraphical range Lower (to middle?) Alaunian.

Mockina medionorica Kozur, 2003
Pl. 3, Fig. 3

1980 *Metapolygnathus multidentatus* (Mosher)—Kovács and Kozur, pl. 14, fig. 5.

2003 *Mockina medionorica* n. sp.—Kozur, p. 70, pl. 1, figs. 5, 6.

non 2005 *Epigondolella medionorica* (Kozur)—Onoue and Tanaka, fig. 3/21.

Material: 1 specimen in 1 sample

Description The platform has a sub-oval outline with rounded or narrowly blunt termination. It is the widest in its anterior part and tapers gradually backwards. Always 2 denticles are present on the external anterior margin; the internal margin can bear 1 or 2 denticles. The lateral and posterior margins are without denticulation. The pit is forward shifted and is located in front of the middle of the platform. The keel is posteriorly prolonged and its termination can be rounded, narrowly blunt or weakly bifurcated. The cusp is low and it is followed by 2 larger, separated carinal nodes that do not reach the posterior end of the platform. The free blade is long, half or 1/3 of the element length. It is high anteriorly and it descends gradually towards the cusp. The lower profile of the element is slightly concave in lateral view.

Comparison Mockina matthewi has more denticles on the anterior platform margins and its platform is the broadest at midlength. The denticulation of the platform in *Mockina postera* is similar, but the platform is more reduced and asymmetric and the keel end is pointed. *M. postera* has a large step in the lower profile behind the pit in lateral view.

Remarks In the original description of *M. medionorica* the posterior carina is composed of 2–3 denticles. However, Kozur (2003) only figured specimens with two denticles behind the cusp. Furthermore, weak bifurcation as possible keel termination was not mentioned in the original description, nevertheless the only specimen where the lower side is visible was figured by Kovács and Kozur (1980). It is likely that stratigraphically older specimens can have a weakly bifurcated keel end.

Stratigraphical range From lower to upper Alaunian.

Mockina postera (Kozur and Mostler, 1971)

pars 1971 *Tardogondolella abneptis postera* n. subsp.—Kozur and Mostler, p. 14–15, pl. 2, fig. 4; non! pl. 2, figs. 5, 6.

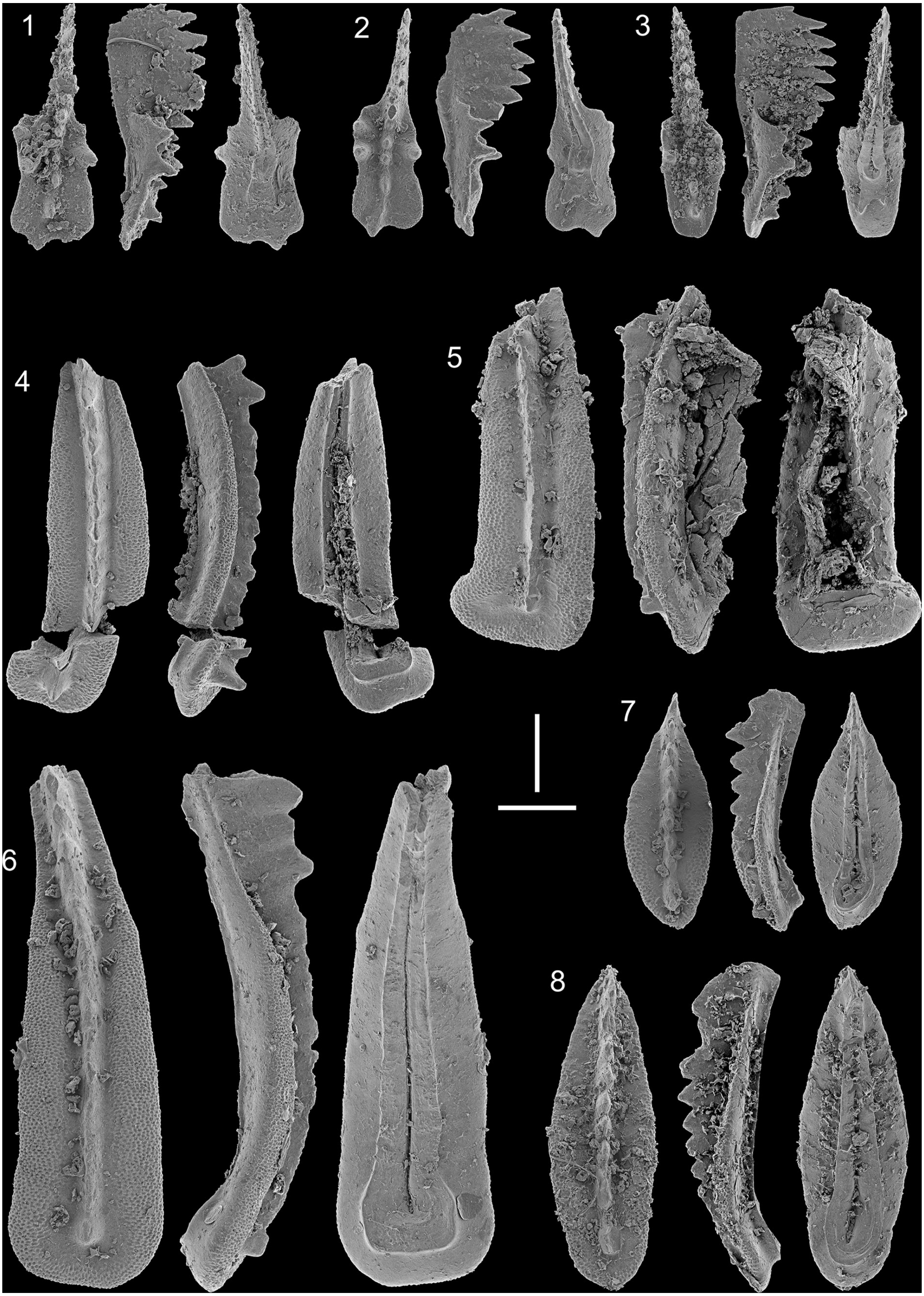
2007 *Mockina postera* (Kozur and Mostler, 1971)—Moix et al., pl. 1, fig. 3.

2016 *Mockina postera* (Kozur & Mostler, 1971)—Karádi et al., pl. I, fig. 4.

Remarks Mockina postera is a small-sized conodont species with neotenic characters. Moreover, it was among the first conodont species established from the Middle Norian of the Tethys, hence this name became well-known and commonly used. As a result, in many cases it was confused with juveniles of other taxa. To avoid misclassifications and consequently misinterpretations it is really important to adhere to the original description and to consider the figures of the holotype, in which the most significant characters are visible. It has a reduced, somewhat asymmetrical platform with a pointed termination and two denticles on the external anterior margin and one denticle on the internal. The pit is strongly forward shifted and is located in the anterior third of the platform. The keel is posteriorly prolonged and narrowly rounded or pointed. The cusp is followed by a posterior carina of 1 or 2 nodes that do not reach the platform end. The free blade is about half of the element length, but it consists only of 2–3 denticles. One of the main features of *M. postera* is the strongly stepped lower profile.

The specimen illustrated by Karádi et al. (2016, pl. I, fig. 4) was also found in the Buda Hills, however, in debris. For this reason it cannot be placed in a succession and it is not considered in this study.

Comparison Mockina postera is very often confused with *M. zapfei*. Also the latter species has an asymmetrical platform with a pointed end, but its free blade is shorter, only 1/3 of the platform length. It has more denticles on the anterior platform margins, 3 on one side and 1–2 on the other side. Its pit is located just in front of the platform midlength, whereas in *M. postera* it is more forward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◀**Plate 3** *Scale bar* 200 µm. Figs. **1**, **2** *Mockina* sp. A, lower Alaunian, locality D, sample RA1; Fig. **1** rep.-no. RA1_02; Fig. **2** rep.-no. RA1_01. Fig. **3:** *Mockina medionorica* Kozur, 2003, lower Alaunian, locality B, sample KLB20, rep.-no. KLB20_01. Fig. **4** *Norigondolella kozuri* (Gedik, 1981), lower Alaunian, locality B, sample KBG44, rep.-no. KBG44_04. Figs. **5**, **6** *Norigondolella navicula* (Huckriede, 1958), lower Alaunian, locality B, sample KLB24; Fig. **5** rep.-no. KLB24_02; Fig. **6** rep.-no. KLB24_01. Figs. **7**, **8** *Norigondolella hallstattensis* (Mosher, 1968), lower Alaunian, locality B, sample KLB19; Fig. **7** rep.-no. KLB19_02; Fig. **8** rep.-no. KLB19_01

shifted. The posterior carina of *M. zapfei* is bent towards the posterior tip of the platform and reaches it. The step of the lower profile in lateral view is not so pronounced in *M. zapfei.*

Stratigraphical range From middle Alaunian to lowermost Sevatian.

Mockina aff. *postera* (Kozur and Mostler, 1971)
Pl. 2, Fig. 2

Material: 5 specimens in 5 samples

Description The platform of this species is the widest in its anterior part and slightly tapers towards the end. The posterior platform is pointed and asymmetric. The anterior platform margins bear 2 denticles on the external side and one denticle on the internal side. The rest of the platform is without ornamentation. The forward shifted pit is located in the anterior half of the platform. The keel is posteriorly prolonged with a narrowly blunt termination. Behind the cusp a large carinal node is present and the posterior carina does not reach the posterior margin. The free blade is about half of the element length and it is composed of 3–4 denticles. It is anteriorly high and descends gradually towards the cusp. In lateral view the element has a slightly convex lower profile as the posterior platform is bending up gently and gradually without an abrupt step.

Comparison This conodont differs from *M. postera* for the keel termination, the position of the pit that is closer to the centre of the platform than in *M. postera*, the higher number of denticles of the free blade and the lower profile that lacks the abrupt step. *Mockina medionorica* very often bears 2 denticles on both anterior margins. Occasionally it has the same ornamentation as *M.* aff. *postera*, but in these cases they can be distinguished based on their platforms and lower profiles. In *M. medionorica* the platform is not asymmetric and its termination is not pointed, and the lower profile is slightly concave.

Remarks It is notable that there are only slight differences between this conodont and *M. postera*, namely they differ in their keel terminations and the outlines of their lower profiles. The significance of these differences is not yet completely clear. If they fit into intraspecific variability, then this form can be identical with *M. postera*.

Stratigraphical range Lower (to middle?) Alaunian.

Mockina spiculata (Orchard, 1991b)
Pl. 2, Figs. 7–11

	1983 *Epigondolella* n. sp. C—Orchard, p. 185–186, fig. 15, M–O.
	1985 *Epigondolella multidentata* Mosher, 1970—Wang and Dong, pl. I, ?fig. 17.
	1987 *Epigondolella multidentata* Mosher, 1970—Mao and Tian, pl. I, figs. 16, 20.
	1990 *Epigondolella abneptis spatulatus* (Hayashi)—Wang and Wang, pl. 2, ?fig. 8.
	1991a *Epigondolella* n. sp. C Orchard—Orchard, pl. 4, figs. 18–20.
	1991b *Epigondolella spiculata* n. sp.—Orchard, p. 312–313, pl. 3, figs. 10, 14, 15.
	2003 *Epigondolella spiculata* Orchard—Ji et al., p. 388, pl. I, figs ?4, 5–9.
pars	2003 *Epigondolella* cf. *spiculata* Orchard—Ji et al., pl. I, fig. 11; non! fig. 10.
pars	2003 *Epigondolella tozeri* Orchard—Ji et al., pl. I, figs. 13, 14, ?16; non! fig. 12, 15.
non	2005 *Epigondolella spiculata* Orchard—Onoue and Tanaka, fig. 13/18.
	2005 *Epigondolella* cfr. *spiculata* Orchard, 1991—Rigo et al., fig. 4/1.
	2008 *Epigondolella spiculata* Orchard, 1991b—Katvala and Stanley, p. 223, fig. 42, photos 1–7.

Material: 25 specimens in 10 samples

Description This species has an asymmetrical platform with the internal margin being convex and the external margin being straight. The convex margin is always shorter and has a truncated postero-lateral end. The anterior margins bear 2–4 large denticles and the lateral and posterior margins have flat denticles as ornamentation. In general the convex platform margin is more denticulated. The pit is forward shifted and is placed in front of the platform midlength. The keel is posteriorly prolonged and has an asymmetrical termination with a pronounced lobe pointing to the more developed postero-lateral corner of the platform. The cusp is followed by two large carinal nodes and a ridge-like node on the posterior margin in the continuation of the posterior carina. The free blade is half to 1/3 of the element length, it is anteriorly high and descends gradually towards the cusp. Very typical character of this species is its convex lower profile as the platform bends upwards. Together with its slightly upturned platform margins it gives the element a spoon-like appearance.

Comparison Epigondolella transitia has a similar platform outline, but in lateral view its lower profile is always concave. It is even much larger in size than *M. spiculata*.

Remarks In the material from the Buda Hills it was possible to distinguish three morphotypes of *M. spiculata*. Morphotype A is the morphotype to which the holotype belongs (Orchard, 1991b, pl. 3, figs. 10, 14, 15). It has strong platform ornamentation and a somewhat rounded postero-lateral end of the less developed margin (Pl. 2, Fig. 7). Morphotype B is very similar to morphotype A, but the platform ornamentation is not so strong (Pl. 2, Fig. 8). The lower profile of morphotype B has a more evident step than in the other two morphotypes. Morphotype C has a well pronounced node on the outermost part of the convex margin and the truncation of the postero-lateral end is straighter than in the other two morphotypes (Pl. 2, Figs. 9–11). A small incision may occur on the truncated margin.

Stratigraphical range Alaunian (except uppermost Alaunian).

Mockina aff. *spiculata* (Orchard, 1991b)

Pl. 2, Fig. 5

Material: 3 specimens in 1 sample

Description This conodont has a platform with an asymmetric termination, just like as that of *M. spiculata*. The platform is posteriorly slightly widened. The anterior margins have 2–3 large denticles. The lateral margins are unornamented and the posterior margin bears 3–4 very low, ridge-like denticles that are radially projected. The pit lies distinctly in front of the middle of the platform. The keel is posteriorly prolonged and slightly widened. Its termination is straight, but one lobe is more developed than the other. The cusp is followed by two carinal nodes. The free blade is about half of the element length, it is high anteriorly and descends gradually towards the cusp. The lower profile is stepped, but the posterior platform slightly bends downwards which gives the element a concave appearance in lateral view.

Comparison Mockina spiculata is smaller and has a different lower profile. Furthermore, one side of its platform is more convex. *Epigondolella transitia* is more denticulated and has a posterior carina pointing to the more developed postero-lateral corner of the platform.

Stratigraphical range Lower (to middle?) Alaunian.

Mockina sp. A

Pl. 3, Figs. 1, 2

Material: 18 specimens in 2 samples

Description The platform has the shape of a guitar with rounded posterior corners. A pronounced constriction is present in the platform midlength. The external anterior margin bears 2–3 large denticles, the internal margin has 1–2 of them. The rest of the margins are unornamented, apart from one low, ridge like node on the posterior margin, located closer to one of the postero-lateral corners. This feature gives an asymmetrical appearance for the otherwise symmetrical platform. The pit lies in the anterior half of the platform distinctly in front of the constriction. The keel is posteriorly prolonged and its termination is slightly bifurcated. The cusp is followed by one large carinal node. The free blade is long, about half of the element length. It is anteriorly high and descends gradually towards the cusp. The lower profile can be straight or slightly concave.

Remarks The most distinctive characters of this form are the platform outline with the evident constriction and the asymmetrically located ridge-like node on the otherwise undenticulated posterior platform margin.

Stratigraphical range Lower (to middle?) Alaunian.

Genus *Norigondolella* Kozur, 1990

Type species: *Paragondolella navicula steinbergensis* Mosher, 1968

Description Genus *Norigondolella* has an elongated platform that extends in the whole length of the element or it may rarely leave a very short free blade. The platform margins are flat, unornamented, they only bear intense microcrenulation. The carina is anteriorly high and it descends posteriorly until the large cusp that is always the last denticle. The pit is terminally located. The keel is prominent and deeply excavated with a rounded or squared termination. In lateral view the element is slightly or moderately arched.

Norigondolella hallstattensis (Mosher, 1968)

Pl. 3, Figs. 7, 8

1968 *Paragondolella navicula hallstattensis* n. subsp.—Mosher, p. 939, pl. 117, figs ?6–9, 10–12.

1980 *Gondolella hallstattensis* (Mosher)—Krystyn, pl. 11, fig. 12.

2003 *Norigondolella hallstattensis* (Mosher)—Channell et al., figs A3/21, 29, 87.

Material: 9 specimens in 1 sample

Description This species is characterized by a short and broad, leaf-shaped platform that leaves a short free blade composed of 1–2 denticles. The blade descends gradually into the carina that has well separated nodes. The cusp is the last denticle and it is surrounded by the rounded posterior platform. A constriction of the platform usually occurs at the level of the cusp. The pit is deeply excavated and terminally located. The keel end is rounded. In lateral view the profile of the element is arched.

Comparison Norigondolella navicula and *N. steinbergensis* are longer with sub-parallel margins. *Norigondolella kozuri* has a narrower platform.

Stratigraphical range From upper Lacian to lower (possibly middle?) Alaunian.

Norigondolella kozuri (Gedik, 1981)
Pl. 3, Fig. 4

1981 *Neogondolella kozuri* n. sp.—Gedik, p. 4, pl. 1, figs. 1–3.
2003 *Norigondolella kozuri* (Gedik)—Channell et al., figs A3/44–46, 55.
2014 *Norigondolella kozuri*—Muttoni et al., figure 3/K.

Material: 2 specimens in 1 sample

Description The platform occupies the entire length of the element and has sub-parallel margins. The blade is anteriorly high and it descends gradually in a carina composed of separated nodes. The cusp is large and it is the last denticle of the carina. It is surrounded by the posterior platform, however sometimes only by a short brim. The end of the platform can be rounded or blunt, as well as the keel termination surrounding the terminally located pit. In lateral view the element has an arched profile.

Comparison *Norigondolella hallstattensis* have a broader platform and a typical constriction at the posterior platform. *Norigondolella steinbergensis* is longer and has a cusp in a more posterior position. *Norigondolella navicula* is also longer, but the main difference is in the carina. In *N. kozuri* it is possible to distinguish separate nodes, whereas in *N. navicula* they are fused together (compare Pl. 3, Figs. 4, 5).

Stratigraphical range From Alaunian to Sevatian.

Norigondolella navicula (Huckriede, 1958)
Pl. 3, Figs. 5, 6

pars 1958 *Gondolella navicula* n. sp.—Huckriede, p. 147–148, pl. 12, fig. 10; non! pl. 11, figs. 1–4, 13–19, 27, 35; pl. 12, figs. 2–8, 15–22, 24–27.
1968 *Paragondolella navicula navicula* (Huckriede)–Mosher, p. 939, pl. 116, figs ?20–26, 27; pl. 117, figs ?1–3, 4, 5.
2003 *Norigondolella navicula* (Huckriede)—Channell et al., figs A2/7–10, 12, 13, 15, 21, 34, 35; fig. A3/11.
2014 *Norigondolella navicula*—Muttoni et al., fig. 3/G.

Material: 29 specimens in 10 samples

Description The platform has sub-parallel margins and it covers the entire length of the element. The blade is high in its anterior part and it descends quite rapidly in a low, ridge-like carina which is characterized by strongly fused nodes. The large cusp is in terminal position surrounded by the rounded or blunt posterior platform. The terminally located pit is surrounded by the broad keel. Depending on the shape of the posterior platform the keel end can be rounded or blunt. The element is arched in lateral view.

Comparison *Norigondolella hallstattensis* has a shorter and broader platform. The cusp of *N. steinbergensis* is on the posterior margin of the platform and strongly outwardly projected. *Norigondolella kozuri* is smaller and its carinal nodes are separated, not so strongly fused as in *N. navicula*.

Stratigraphical range From Lacian to Alaunian.

7 Conclusions

Large diversity, morphological variability and wide distribution of the Alaunian conodonts of the Tethyan Realm could have been only surmised previously, finding the scarce Tethyan illustrations of such species that were originally described from North America. The study of four new Upper Triassic sections from the Buda Hills (Hungary) allowed to conduct detailed investigations on 15 Alaunian conodont species, revealing instead that Middle Norian successions may display rich faunas and thus showing the inaccuracy of the conodont biostratigraphy until now. For instance: (1) the most commonly (but mostly erroneously) identified Middle Norian conodont, *Epigondolella abneptis* turned out to be absent in the investigated successions. (2) A great variety of previously unknown forms (*Epigondolella* aff. *vialovi*, *Mockina* aff. *matthewi*, *M.* aff. *spiculata*, *Mockina* sp. A and possibly also *M.* aff. *postera*) are present (Fig. 2), which clearly indicate that several new species have yet to be described. Despite this fact, no new species were introduced in the present study, because their presence needs to be proved also in other localities and the intraspecific variability of already established taxa must be revealed first. (3) First Tethyan documentation of *E. transitia* is also an important result since it is one of the transitional forms between Lower and Middle Norian faunas.

The Alaunian is a very important time interval in the evolution of conodonts, because it represents the evolutionary transition between the taxa that originated in the Late Carnian/Early Norian and the last representatives of conodonts of the Late Norian and Rhaetian. It is essential to precisely record the main features (forward shifting of the pit, prolongation of the keel and the posterior carina) of the Lacian/Alaunian turnover. This recognition is crucial for understanding the phylogenetic relationship of genus *Epigondolella* and genus *Mockina*.

Based on the presence of Middle Norian guide forms (*M. matthewi*, *M. medionorica*, *M. spiculata*), all four studied localities could be assigned to the Alaunian, however, the successions could not be unequivocally placed on a finer scale yet. Comparison of the fauna with that of different Tethyan areas was not possible either, due to the very few documented occurrences in other localities.

Investigation of well exposed, continuous successions throughout the Tethys can provide sufficient data to clarify the ranges of existing species and to describe new taxa in order to define the stratigraphically important ones. This effort emphasizes the necessity and great importance of proper figuration of conodonts, indication of their range charts together with the stratigraphic logs and the usage of modern systematics and nomenclature. This study is the initial phase of a complex attempt to enable a better comprehension of Norian conodont phylogenesis and thus, to improve and refine Middle Norian conodont biostratigraphy.

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