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RECENT DISCOVERIES OF TITHONIAN AMMONITES IN THE ŠTRAMBERK LIMESTONE (KOTOUČ QUARRY, OUTER WESTERN CARPATHIANS)

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Abstract: Recent discoveries of ammonites in the Štramberk Limestone in the type area of their occurrence near the town of Štramberk supplement existing data on the Tithonian age of the limestones. *Franconites* cf. *fascipartitus* occurs in the lower part of the Lower Tithonian (Neochetoceras mucronatum Zone). *Lemencia ciliata* has a zonal character in the upper part of the Lower Tithonian. *Richterella richteri* is a subzonal species of the upper part of the Lower Tithonian in the Mediterranean and Submediterranean areas (Semiformiceras fallauxi Zone). All of the new discoveries are referable to the faunal associations of the Submediterranean bioprovince, and are in agreement with existing knowledge of it. Sexual dimorphism was seen in the genus *Richterella*, with the recognition of both macroconchs and microconchs in the type species of *Richterella*, i.e. *R. richteri*. The stratigraphic position of these recent ammonite discoveries in the Štramberk Limestone at the Kotouč Quarry does not support the stratigraphy of the limestones based on the distribution of calpionellids, as previously assumed by other authors. The recent collection of ammonites confirms that the Štramberk Limestone belongs to the lower Tithonian and lower Berriasian and also represents the lower Tithonian as a shallow-water facies.

Key words: Ammonites, *Richterella*, Tithonian, Štramberk area, Silesian Unit, Czech Republic.

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INTRODUCTION

The fossil-rich Štramberk Limestone (possibly mainly Tithonian to early Berriasian in age) in the Outer Western Carpathians of Moravia (Czech Republic) has attracted the attention of palaeontologists since the first half of the nineteenth century. The term Štramberk Limestone for the light grey to whitish grey limestones was introduced by Hohenegger (1849). From approximately 1910 onwards, the quarry at Kotouč Hill has been the main source of material for palaeontological studies. A review of geological and palaeontological papers, addressing the Štramberk Limestone and associated deeper-water Lower Cretaceous deposits from Štramberk and the surrounding area, was presented by Vašíček and Skupien (2004, 2005).

With reference to the Štramberk Limestone, the Tithonian Stage was defined (see Oppel, 1865; von Zittel, 1870) as the uppermost unit of the Jurassic in the Tethyan Realm. Both of these classic works were based on material from the Hohenegger collection, which was taken almost exclusively from the type area at the Castle Hill (Zámecký vrch) Quarry (Schlossberg Steinbruch), where mining started in 1780. Therefore, this quarry was selected as the type area of the Štramberk Limestone (Houša, 1968). The part of the Štramberk Limestone forming Castle Hill was accessed in the Castle Hill Quarry at a stratigraphic level, which corresponded to the upper part of the lower Tithonian (Houša, 1975, 1990). The ammonite species, documenting this stratigraphic interval in the quarry, exhibits a uniform lower Tithonian character, The material in the Hohenegger collection also came from other sites. A small part of this collection was recovered from the Municipal Quarry (Obecní lom, Gemeinde Steinbruch), at Štramberk, which was still rather small in size at the time (opened in 1820). The younger Remeš Collection from the Štramberk Limestone shows a somewhat different faunal spectrum, compared to the older collections. This difference is explained by the fact that the Remeš collection was obtained later, between 1870 (when it was initiated by Remeš's father) and about 1930, and thus contains samples from quarries that were active at that time, as well as purchases from quarry workers. The Castle Hill Quarry had been almost completely abandoned at the end of 19th century, and the main sources of Štramberk Limestone were the quarry on Kotouč Hill and the Municipal Quarry

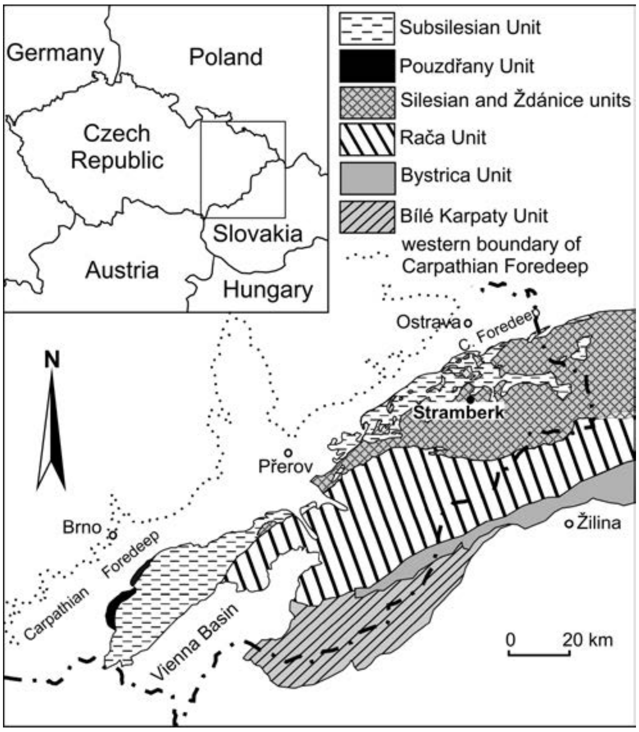

Fig. 1. Tectonic map of the Outer Western Carpathian area of the Czech Republic.

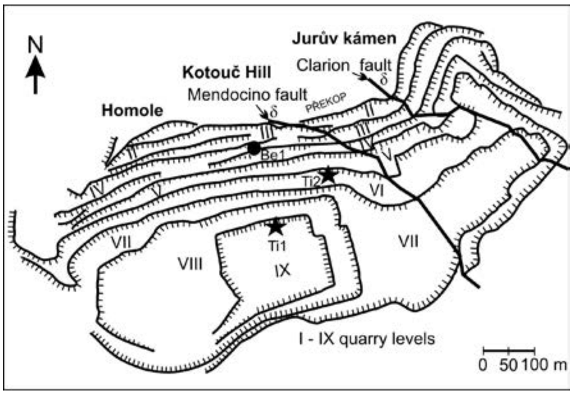

Fig. 2. Location of the discoveries of the Tithonian (marked with the asterisk) and Berriasian (marked with the circle) ammonites at the Kotouč Quarry. Ti1 – middle part of the lower Tithonian, Ti2 – higher part of the lower Tithonian, Be1 – Lower Berriasian.

(Remeš, 1899, 1904). However, the newly opened quarry on Kotouč Hill was the main source of fossils. Here, the Štramberk Limestone was extensively exposed and extracted during the 1900s, throughout nearly its entire stratigraphic range between the early Tithonian and early Berriasian. An early Tithonian age is documented by an ammonite assemblage (e.g., Blaschke, 1911) from the former Gutmann Quarry, opened in 1881 in the oldest, southwesterly portion of the Homole body of the Kotouč Hill complex. New discoveries of an ammonite fauna, indicative of the early Berriassian Beriasella jacobi Zone, were made in a block of Štramberk Limestone with conspicuous bedding, at the Kotouč Quarry, near Štramberk (Vašíček and Skupien, 2013). It is the youngest fauna reported so far from the Štramberk Limestone. This fauna thus permits the redefinition of the upper stratigraphic limit of this classic unit in its type area as lower Berriassian.

The main aim of the present paper is to present a description of the recently discovered ammonites, together with a determination of their age. These ammonites have revealed many ambiguities in the existing taxonomic position and interpretation of the genus *Richterella*, beginning with its type species. Therefore, the authors have revised *Richterella richteri* (Oppel in Zittel) in some detail, on the basis of both published information and the specimens from the Kotouč Quarry. In addition, the authors present here a detailed synonymy of the species and give their opinion on the sexual dimorphism of *R. richteri*. The detailed stratigraphy of particular rock bodies in the Štramberk Limestone is not known. For this reason, the stratigraphic position of three of the ammonites identified in the Štramberk Limestone was deduced, by analogy with occurrences of the same species at European localities, where the stratigraphy is well established.

These results provide new information about the taxonomy of *Richterella*. Two other ammonites, namely *Franconites* cf. *fascipartitus* (Zeiss) and *Lemencia ciliata* (Schneid), are described in detail. Moreover, the stratigraphic implications of the new ammonite discoveries are presented with a discussion of the main differences, with respect to previous opinions on the stratigraphy of the Štramberk Limestone at the Kotouč Quarry.

GEOLOGICAL SETTING

The Štramberk Limestone is exposed in several quarries (the Kotouč, Municipal, Horní skalka and Castle Hill Quarries) in the immediate vicinity of the town of Štramberk (Figs 1, 2), in the form of carbonate megablocks in a wide range of size, breccias and conglomerates. The Štramberk Limestone occurs within the Cretaceous flysch deposits of the Silesian Unit (Silesian Nappe, Baška Facies), in the Outer Western Carpathians (for more details, see Picha *et al*., 2006).

The geology of the Štramberk area and the nature of the megablocks are the subject of a long-standing controversy. Houša (1990) interpreted the carbonate blocks as tectonic klippen, which were separated from the carbonate platform during the Silesian Nappe overthrust movements. In his interpretation, the associated deeper-water Lower Cretaceous deposits represent material, which filled fissures or cavities of different origins in the Štramberk Limestone, or covered the original surfaces of the limestone bodies.

According to Eliáš and Stráník (1963), Eliáš (1970) and Eliáš and Eliášová (1986), the limestones are embedded in base-of-slope conglomerates and slump bodies within the Cretaceous part of the Hradiště Formation, constituting an extreme development of the Chlebovice Conglomerate. This accumulation was formed between the Tithonian and the Turonian (see Vašíček and Skupien, 2004; Svobodová *et al*., 2011).

According to Picha *et al*. (2006), the Štramberk carbonate platform, rimmed by coral reefs, was the source of the clastics and large fragments of the carbonate body, later created by a combination of mass movement and tectonic activity. Gravitational slides and turbidity currents transported both small and large blocks and fragments of limestones from the edge of the platform to the bottom of the adjacent basin. However, during the course of later tectonic thrusting of the nappe during the Neogene, large tectonic pieces of the carbonate platform were separated from the softer, less competent rocks, situated on the slopes of the platform. The result is a melange, in which larger blocks from the carbonate platform are reminiscent of the characteristics of klippes. The smaller blocks and debris correspond to clastic sediments at the foot of the platform. These developed in the Lower Cretaceous and the earliest part of the Upper Cretaceous, in particular.

The Štramberk Limestone is whitish-grey in colour and was deposited in different settings across the carbonate platform and reef complex, including reef buildups. The commonest types are biodetrital limestones. The limestones, found in some intervals, are very coarse to pebbly grained.

Traditionally, the Štramberk Limestone was believed to be Tithonian, which may be the correct age for the main stage of reef development. However, Houša supposed without any precise justification that the Štramberk Limestone had originated already during the latest Kimmeridgian (e.g., Houša, 1990; Houša in Houša and Vašíček, 2005; Vašíček *et al*., 2013; Vašíček and Skupien, 2013). The identified calpionellid zonation (Houša in Houša and Vašíček, 2005) in the limestone bodies, exposed in the Štramberk area, is indicative of the upper part of the Lower Tithonian, the entire Upper Tithonian and the earliest Berriasian.

The Štramberk Limestone represents sediments, formed on a carbonate platform during the Late Jurassic and earliest Cretaceous, along the northern Tethyan margin in the area of the Outer Western Carpathians. The block accumulations of the Štramberk Limestone form part of the continental-rise facies of the Baška Facies in the Silesian Unit, deposited in the flysch trough of the (hypothetical?) Baška Cordillera (Picha *et al.*, 2006). This uppermost Jurassic to Upper Cretaceous sedimentary succession includes slumps, slides, olistoliths and sporadic turbidites, which were fed from the uppermost Jurassic to the Coniacian carbonate platform on the Baška Cordillera and its slopes, including the Tithonian–Berriasian reef complex. The intervals between gravity flows usually are represented by hemipelagic sediments. The gradual lateral and vertical transition of the block accumulations into facies that are clearly the products of mass movement contradicts the classic theory, regarding the tectonic klippes in the Silesian Unit.

DESCRIPTION OF AMMONITE-BEARING LIMESTONES

The recently discovered ammonites, the subject of the present paper, come from two different mining levels of the Kotouč Quarry (Fig. 2). The first site is situated in the middle part of the northern slope of level 9 (GPS: 49°34'56.941"N, 18°6'58.088"E). The specimens were collected from debris formed by blasting in June, 2013 (Ti1 locality in Fig. 2). The sediments macroscopically consist of greyish, massive and finely detrital limestones. In one block of limestone, two ammonites were found. The accompanying fauna is composed of fine debris from corals and bivalves.

The second locality of ammonite occurrence is situated at level 6, on the northern slope of the block called "Homole" (GPS: 49°35'0.505"N, 18°6'57.107"E). The samples were found in debris formed by blasting in November, 2013 (Ti2 locality in Fig. 2). Macroscopically, the limestones are white, finely to coarsely detrital, and disintegrated. This locality is rich in associated fauna, in the form of mainly corals, bivalves, gastropods and crabs. There are visible signs of reworking and transportation of the coral colonies.

TAXONOMY

The systematic description of the new ammonites found in the Kotouč Quarry is based on the taxonomy established by Donovan *et al*. (1981), supplemented with the more recent concepts of Zeiss (2001). In accordance with the International Code of Zoological Nomenclature (International Commission on Zoological Nomenclature, 1999, p. 117), the authors use the suffix -oidea for the superfamily category.

When measuring the size parameters of the ammonite shells, the following international abbreviations were used: D – shell diameter (Dmax – maximum preserved diameter), H – whorl height, U – umbilicus width, B – whorl width. The values of the ratios of the measured parameters to the shell diameter (H/D, U/D, B/D) or the ratio of whorl width to whorl height (B/H) are indicated in brackets. Values of rib density near the umbilicus (UR) and ventrolaterally (VR) are given per half-whorl.

After the numbers of the figures in the synonymy and in the explanation for Fig. 3, symbol M in brackets indicates macroconch and m microconch.

The material under investigation is deposited in three museums: the Nový Jičín Regional Museum (the abbreviation PL accompanies specimen numbers), the Silesian Museum in Opava (with Z before each number), and Bayerische Staatssammlung für Paläontologie und historische Geologie of the University in Munich (with the abbreviation AS III).

Suborder AMMONITINA Hyatt, 1889
Superfamily PERISPHINCTOIDEA Steimann, 1890
Family LITHACOCERATIDAE Zeiss, 1968
Subfamily FRANCONITINAE Zeiss, 1968

Genus *Franconites* Zeiss, 1968

Type species: *Franconites vimineus* (Schneid, 1915) (Lower Tithonian, Franconian Jura, Germany) by original designation of Zeiss (1968).

Franconites cf. *fascipartitus* (Zeiss, 1968)
Fig. 3A–C

cf. 1968 *Usseliceras* (*Usseliceras*) *fascipartitum* n. sp. – Zeiss, p. 54, pl. 2, figs 1, 3, pl. 3, fig. 4, text-fig. 5.
cf. 2003 *Franconites fascipartitus* (Zeiss) – Scherzinger and Schweigert, p. 14.

Material: An external mould of a large specimen with fragments of the recrystallized original shell. Juvenile whorls are imperfectly

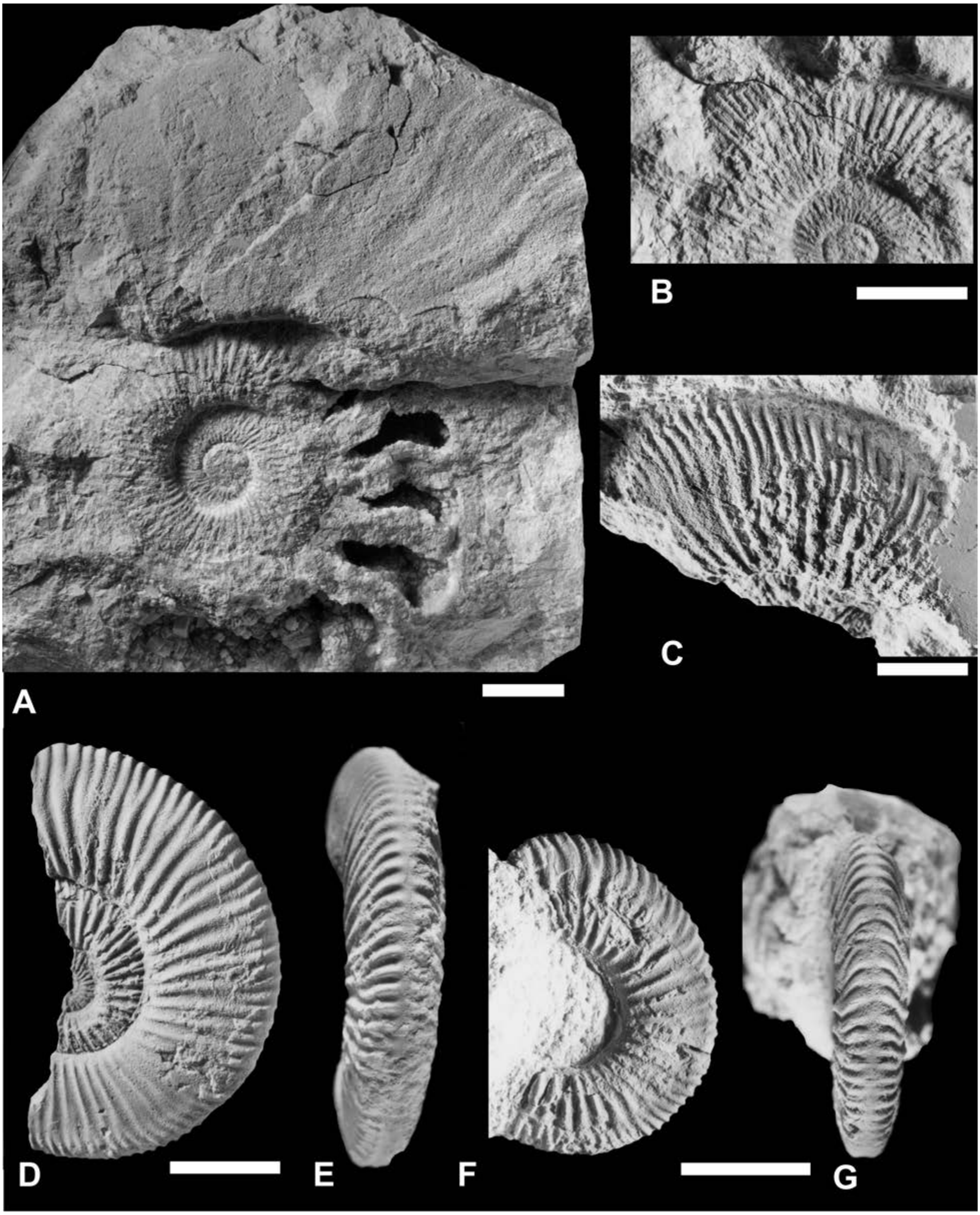

Fig. 3. Ammonites. Scale bars equal 10 mm. **A–C.** *Franconites* cf. *fascipartitus* (Zeiss). A. Lateral view of macroconch, specimen PL 4393. B. Inner whorls of the same specimen; C. Fragment of one of the inner whorls of specimen PL 4394. **D, E.** *Lemencia ciliata* (Schneid), specimen PL 4395. D. Lateral view. E. Ventral view showing siphonal furrow. **F, G.** *Richterella richteri* (Oppel), specimen PL 4396 (m). F. Lateral view; G. Ventral view.

and incompletely preserved. The preserved fragment of the ultimate whorl is part of the body chamber (specimen PL 4393). In the same piece of rock, a fragment of approximately one-quarter of a whorl of another smaller specimen, with a partly visible fragment of the preceding whorl and with the recrystallized original shell (specimen PL 4394), is also preserved. The umbilical area is corroded.

Description: The shell is semi-evolute, with a whorl that is higher than wide. The umbilical wall is relatively low, rather vertical on the ultimate whorl. Flanks faintly arched, passing gradually into the venter, which is rounded and moderately wide.

The ribbing of the inner whorls of the large specimen is quite dense, thin and sharp. As the whorls overlap, only the lower part of the ribs can be seen and they have the form of simple ribs. In this area, the ribs are slightly concave and prosocline. As can be observed on the small area of this specimen, where the entire height (H = 28 mm) is visible, all ribs bifurcate narrowly just over the line of coiling. No tubercles can be distinguished on juvenile ribs.

The flanks of the last whorl of the smaller specimen (specimen PL 4394) are slightly vaulted. The vaults of the whorl are strengthened by the venter, which is not entirely visible. The ribs are dense, medium-strong and slightly sigmoidal. The basal part of the primary ribs appears to bear weak, short and longitudinally elongated umbilical tubercles. The ribs are quite straight and prorsiradiate. The primary ribs bifurcate at about two-thirds of the whorl height. The rib that is anterior with respect to a pair of ribs runs in the direction of the primary rib. The rib that is posterior with respect to a pair of ribs is initially deflected from the original direction; however, it remains subparallel with the primary rib elsewhere. The ribs become proverse again in the venter.

At the end of the whorl fragment, in the area of its mid-height, the sculpture weakens. Just before the whorl fragment ends (at a height of H = 34 mm), the only rib in triplet (polygyrate) occurs. The originally simple rib probably was split in the lower one-third of the whorl height.

The sculpture of the well-preserved part of the ultimate whorl of the large specimen (which is attached to the whorl fragment described above) is considerably weakened on the body chamber. It is formed by indistinct, rounded, S-shaped and stronger ribs, which are inclined to the aperture. Thinner, indistinct ribs, which are fascipartite, inserted between the stronger ribs. The ribbing gradually weakens towards the venter. Shallow constrictions can be distinguished on the front of the stronger ribs. Set of thinner fascipartite ribs limited by constrictions is thus subdivided in isolated segments. Stronger ribs at the area of transition of the umbilical wall to the flanks appear to bear unclear, rounded bases of tubercles. However, on one better preserved area, some weak umbilical tubercles that are densely distributed on the thinner ribs, located between the stronger ribs, remain distinct.

Approximate measurements of the specimen PL 4393: It has a maximum diameter of approximately 175.0 mm. At this diameter, H = c. 63.0 (0.36), U = 61.0 (0.35). When B = c. 36.0 and H = c. 66.0 mm, then H/B = 1.83 and B/H = 0.545.

In the penultimate whorl, i.e. the distinctly ribbed one, at the diameter of D = c. 65 mm, there are approximately 30 primary ribs per half-whorl.

Remarks: Zeiss (1968, p. 55) stated that *U. fascipartitum* differs from other *Usseliceras* in the thin ribbing of its inner whorls, narrow and elongated inner tubercles, as well as in the long persistence of the fascipartite sculpture on the body chamber. According to the characteristics mentioned and on the basis of the study of other materials from the type area in Germany, Scherzinger and Schweigert (2003) considered the species of *fascipartitum* to be members of *Franconites*. *Franconites* cf. *fascipartitus* differs from all other known *Franconites* in the special segmentation of the sculpture on the body chamber. Because of the incomplete preservation of the fossil, the exact classification is not certain.

Distribution: *F. fascipartitus* occurs in the Lower Tithonian in the Franconian Jura Upland in Germany. According to Enay and Geyssant (1975), *F. fascipartitus* is one of the species which occurs in the Darwini ammonite Zone of Spain.

Occurrence: Level 9 at the Kotouč Quarry (Ti1 locality in Fig. 2).

Subfamily SUBLITHACOCERATINAE Zeiss, 1968

Genus *Lemencia* Donze et Enay, 1961

Type species: *Lemencia pseudorichteri* Donze et Enay, 1961 (Tithonian, southeast France) by original designation of Donze and Enay, 1961, p. 162.

Lemencia ciliata (Schneid, 1915)
Figs 3D, E, 4

*1915 *Berriasella ciliata* n. sp. – Schneid, p. 67, pl. 7, figs 6, 6a, b.
1916 *Berriasella ciliata* Schn. – Schneid, pl. 4, figs 5, 5a, b.
?1939 *Berriasella ciliata* Schneid – Mazenot, p. 37, pl. 1, figs 1–3.
partim 1939 *Berriasella pergrata* Schneid – Mazenot, p. 38, pl. 1, fig. 4a, b, non fig. 5.
?1939 *Berriasella subcalisto* (Toucas) Gevrey – Mazenot, p. 53, pl. 3, fig. 13a, b.
1961 *Berriasella ciliata* Schneid – Donze and Enay, p. 164, text-figs 46, 47, pl. 22, figs 1–3.
2004 “*Lemencia*”*ciliata* (Schneid) – Schweigert and Scherzinger, pl. 2, fig. 2.

Material: One-half of a single specimen, well-preserved as an internal mould with fragments of the original shell on the body chamber (specimen PL 4395).

Description: The shell is semi-evolute. Low umbilical wall, slightly inclined to the line of coiling; it passes gradually to the flanks of the whorl, which are only weakly arched. Maximum width of the mid-high whorl occurs quite low, close to the umbilical shoulder. From this point, the flanks are inclined obliquely towards the venter. The venter is narrow and slightly flattened at its highest point. A narrow, rounded zone separates the venter from the flanks.

The ribbing of the last whorl has two styles. At the beginning, the ribs are mainly bifurcated with isolated simple ribs. The ribs start indistinctly in the area above the line of coiling. On the flanks of the whorl, the ribs are slightly S-shaped. In the basal part, there is a short section where the ribs are first curved slightly concavely towards the peristome. In the larger section of the flanks, the ribs are indistinctly convexly curved, with the centre of rib vaulting close to the mid-height of the whorl. Below a height of half of the whorl, most of the ribs bifurcate. They are distinctly inclined towards the peristome in the ventrolateral area.

The final part of the ultimate whorl shows mostly bifurcated ribs. There are two places on the body chamber, where polygyrate ribs occur. At one-third of the whorl height, the ribs start bifurcating. In the final portion, the points of rib bifurcation occur at different levels, in the interval of one-third to two-thirds of the whorl height. The rib that is posterior with respect to a pair of bifurcated

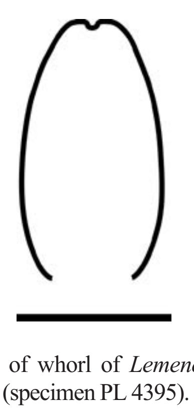

Fig. 4. Cross-section of whorl of *Lemencia ciliata* (Schneid) at whorl height of 17.0 mm (specimen PL 4395). Scale bar equal 10 mm.

ribs follows continuously the direction of the primary rib; the anterior rib is proverse. The polygyrate ribs bifurcate initially near the umbilicus. Approximately at the mid-height of the flank, the posterior rib of the pair of ribs bifurcates again. The points of bifurcation are also visible on the penultimate whorl, under the line of coiling.

All ribs, which occur on the ventral side in the entire preserved area of the ultimate whorl, are interrupted by a well marked siphonal smooth band.

Measurement: The specimen PL 4395 has a preserved diameter of the shell of 64.4 mm.

At the maximum diameter Dmax = 64.4 mm, H = 21.5 (0.33), U = 27.2 (0.42), B app. 14.5 (0.225), B/H = 0.67. When H = 20.2 mm, then B = 13.2 and B/H = 0.65.

At the maximum shell diameter, there are 27 primary ribs and 51 ventrolateral ribs per half whorl.

Remarks: The drawing by Schneid (1916) is not accompanied by a description of the species.

Distribution: According to Donze and Enay (1961), *L. ciliata* occurs at the upper part of the Lower Tithonian, in Germany (Neuburg in Bavaria) and in France (Saint-Concors).

Occurrence: This unique discovery comes from level 6 (Ti2 locality in Fig. 2).

Subfamily RICHTERELLINAE Sapunov, 1977

Genus *Richterella* Avram, 1974

Type species: *Ammonites Richteri* Oppel in Zittel, 1868 (Tithonian) by original designation of Avram (1974, p. 17).

Remarks: In the last decades, the genus *Richterella*, of which an objective synonym is *Richteria* Olóriz, 1978, has been studied by many specialists, such as Avram (1974), Sapunov (1977a), Olóriz (1978), Cecca (1986), Zeiss (2001). They concentrated in particular on the concept of this genus and its taxonomic rank. According to Sapunov (1977a) and on the basis of the other papers cited above, the authors assume that it is correct to separate *Richterella* from other lithacoceratids at the subfamily level, e.i. Richterellinae Sapunov, 1977.

According to Avram (1974) and Zeiss (2001), *Richterella* includes microconchs of the species of *Lemencia*. Both of the genera already mentioned should not have a siphonal furrow. But in fact, this is not true for *Lemencia* (see the diagnosis of the genus by Donze and Enay, 1961). Cecca (1986) assumed that *Lemencia praerichteri* Donze and Enay, 1961 is the macroconch of *Richterella richteri*. However, most of the other species, considered to be representatives of *Lemencia*, are not macroconchs, on the basis of their dimensions and the occurrence of lappets. According to Zeiss (1968), these specimens are microconchs of the genus *Sublithacoceras* Spath, 1925.

A important comment of Zeiss (2001) is based on the fact that the lectotype of *R. richteri* (in Zittel, 1868, pl. 20, fig. 9) with a shell diameter of more than 70 mm is too large to represent a microconch. Another specimen, described below, which comes from the Kotouč Quarry, even has a preserved diameter of 89 mm. What follows is that the macroconch of *L. praerichteri* should reach the same size as the microconch of *R. richteri*. According to what has been already stated and according to the specific cross-section of the holotype whorl and other specimens of *L. praerichteri* (see, for instance, Cecca, 1986), the statement that this species represents the macroconchs of *R. richteri* can be excluded.

The diagnosis of *Richterella*, which was characterized appropriately by Sapunov (1977a, p. 105), can be supplemented with the following information: dimorphic pairs occur within the genus *Richterella*. Macroconchs of the type species have a shell diameter of about 90 mm. Polygyrate and simple ribs also can occur on the body chambers of macroconchs.

The present authors assume in this study that the lectotype of *R. richteri* (see Zittel, 1868, pl. 20, fig. 9) and other representatives of this species, together with the specimens figured by Avram (1976) as *Lemencia* (*Richterella*) spp. aff. *richteri* (Oppel), and the authors' specimen of smaller dimensions from the Kotouč Quarry, described below, represent a dimorphic pair of *R. richteri*. The larger specimens of *R. richteri* are considered macroconchs. Specimens of Avram (1974, pl. 10, figs 3, 6, 7, 9) and the authors' recently discovered specimen are considered to be microconchs of *R. richteri* (m).

Richterella richteri (Oppel in Zittel, 1868)
Figs 3F, G, 5

*1865 *Ammonites Richteri* Opp. – Oppel, p. 556.

partim 1868 *Ammonites Richteri* Oppel – Zittel, p. 108–109, pl. 20, fig. 9 (M - lectotype), 11 (M), 12 (M), non fig. 10 [= *Lemencia pseudorichteri* Donze et Enay].

?non 1870 *Perisphinctes Richteri* Opp. sp. – Zittel, pl. 33, fig. 4 [= *Richterella striata* Olóriz], pl. 33, fig. 5 [very juvenile specimen of *R. richteri*].

1880 *Ammonites Richteri* Opp. – Favre, p. 33, pl. 3, figs 3a, b [?m], 4 [M].

1890 *Perisphinctes Richteri* Oppel sp. – Toucas, p. 580, pl. 14, fig. 2a, b [M].

non 1890 *Perisphinctes Richteri* Oppel sp. – Toucas, p. 597, pl. 16, fig. 1 [?m].

?1936 *Berriasella* (*Kossmatia*) *Richteri* Opp. in Zittel – Roman, p. 12, pl. 3, fig. 6a, b [= *Richterella striata* Olóriz].

partim 1939 *Perisphinctes Richteri* (Oppel in Zittel) – Mazenot, p. 129, pl. 21, figs 2 [M], 4a, b [refigured lectotype - M], 5 [M], non fig. 3 [= *Pseudosubplanites lorioli* Zittel].

1966 *Berriasella richteri* (Oppel) – Houša, fig. VIII-280 [M].

non 1970 *„Berriasella“ richteri* (Oppel) – Patrulius, Avram and Matei, p. 143, text-figs 4, 5, pl. 3, figs 12–14 [= *Lemencia* (*Lemencia*) *pseudorichteri doftanensis* Avram].

1973 *Berriasella richteri* (Oppel in Zittel) – Le Hégarat, p. 63, pl. 6, figs 1, 2 [drawing of lectotype].

1974 *Richterella richteri* Oppel – Avram, p. 17.

1976 *Lemencia* (*Richterella*) spp. aff. *richteri* (Oppel) – Avram, p. 43, pl. 10, figs 3, 6, 7, 9 [all m].

1977a *Richterella richteri* (Oppel) – Sapunov, p. 105.

1977b *Richterella richteri* (Oppel) – Sapunov, pl. 4, fig. 3 [?m].

?partim 1978 *Richteria richteri* (Oppel in Zittel) s. str. – Olóriz, p. 595, pl. 51, figs 8 [M], 9 [?m], 10 [M], ?non fig. 11.

1978 *Richteria richteri* ssp. *toucasi* n. ssp. – Olóriz, p. 595, pl. 51, fig. 7 [M].

1979 *Richterella richteri* (Oppel) – Sapunov, p. 137, pl. 40, fig. 7 [?m].

1986 *Ammonites richteri* (Oppel) – Cecca, p. 34.

1986 *Richterella richteri* (Oppel) – Cecca, pl. 1, figs 1 [M], 2 [m], ?4, 5 [M], 7 [?m], 8 [m], 9 [?m], 10 [m], 11 [m], 12 [M].

partim 1991 *Richterella* aff. *richteri* (Oppel) – Cecca and Enay, p. 72, pl. 10, fig. 6 [?m], non fig. 5 [=? *Richterella striata* Olóriz].

2001 *Richterella richteri* (Oppel) – Zeiss, p. 47, text-fig. 8, pl. 14, fig. 3 [?m].

partim 2013 *Richterella richteri* (Oppel) – Főzy and Scherzinger, p. 235, pl. 11, fig 5 [M], pl. 12 fig. 4 [?m], ?non pl. 15, fig. 13, non pl. 23, fig. 5.

Lectotype: *Ammonites Richteri* Oppel in Zittel, 1868, pl. 20, fig. 9a-c (refigured by Mazenot, 1939, pl. 21, fig. 4a, b and Cecca, 1986, pl. 1, fig. 1).

Material: A microconch; last whorl preserved as an external mould with fragments of recrystallized calcite shell (specimen PL 4396). The side photographed is better preserved than the reverse side. A macroconch preserved with a recrystallized calcite shell (Silesian Museum in Opava, specimen Z-5541); the last half-whorl belongs to the body chamber, as indicated by remains of the septal suture lines.

Description: Microconch: small, semi-evolute shell with slender whorls. Umbilical wall is low and inclined. It passes gradually into a moderately high, slightly vaulted flank. The whorl reaches its greatest width near the lower quarter of its height. From there, the flanks incline slightly to the venter. The venter is narrow and rounded, undifferentiated from the flanks.

The ribs are on the umbilical seam. They are proverse and quite straight. At different levels, between one- and two-thirds of the flank, all ribs bifurcate. The anterior secondary runs in the direction of the primary. The posterior secondary ribs are initially bent retroversely. The ribs become prorsiradiate again on the venter. The ribs running across the venter are not interrupted and are very strongly arched towards the peristome. In the line of bifurcation, the ribs appear to be slightly thickened. The ribs are slightly sigmoidal on the flanks. The line of coiling of previous whorls occurs probably in the vicinity of the point, where the ribs bifurcate.

Macroconch: Semi-evolute shell, with slender and moderately high whorls. The low umbilical wall declines obliquely towards the preceding whorl. The umbilical wall is only indistinctly separated from the flanks, which are slightly vaulted. The flanks pass indistinctly into a narrow arched venter. The maximum width of the whorl is near the lower third of the flank.

The ribs of the last whorl begin at the umbilical seam. In a short section near the umbilicus, they are curved concavely to the peristome. On the flanks, slightly sigmoidal ribs occur. The primary ribs are nearly straight and somewhat proverse, between one-third and one-half of the flank. There, most ribs bifurcate close to the mid-height of the whorl, but not at the same point. The posterior secondary follows the direction of the primary rib, initially concave. Near the venter, it becomes strongly prosocline. The anterior secondary is noticeably sigmoidal. Its end is subparallel with the posterior rib. All ribs cross the venter without interruption and they are acutely arched towards the peristome, but not forming a chevron. One polygyrate rib occurs near the end of the last whorl. In addition to bifurcated ribs, primary ribs with short inserted ribs behind primary ones appear only rarely. The ribbing in the venter is dense. On the penultimate whorl, in the vicinity of the line of coiling, the points of rib bifurcation are visible.

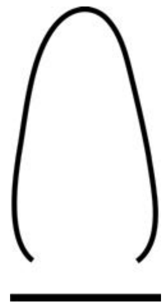

Fig. 5. Cross-section of whorl of *Richterella richteri* (m) at whorl height of 16.3 mm (specimen PL 4396). Scale bar equal 10 mm.

Measurement: See Table 1.

Remarks: Several authors (Mazenot, 1939; Le Hégarat, 1973; Olóriz, 1978; Sapunov, 1979) based their diagnosis of *R. richteri* on the fact that the species is characterised only by bifurcate ribs. However, apart from bifurcate ribs, a polygyrate rib and some sporadic simple ribs occur on the body chamber, as shown by Cecca (1986), and this is evident from the original specimen of the lectotype *R. richteri*, but not from the original illustration of it (in Zittel, 1868, pl. 20, fig. 9b).

The micro- and macroconchs of *R. richteri* described are very similar in morphology. This is supported by their nearly identical ratios of their measured parameters, H/D, U/D and B/D. Similar parameters were measured on the lectotype, as well. Macroconchs and microconchs certainly differ in the sizes of their shells. Macroconchs can reach 90 mm in diameter, microconchs 60 mm (see the specimen of Cecca, 1986, pl. 1, figs 2, 8, with the aperture preserved). The ribbing of both dimorphs, with a dominance of bifurcate ribs, is very similar in style. In the macroconchs, there are some extra sporadic polygyrate ribs on the body chamber, which Cecca (1986, pl. 1, fig. 1) already pointed out. Nevertheless, this feature was disregarded in the poor illustration of the lectotype by Le Hégarat (1973, pl. 6, fig. 2), as well as on the idealized figure, published by Zittel (1868, pl. 20, fig. 9). Dimorphic pairs differ more significantly in the density of ribbing. In the microconchs, which are more sparsely ribbed, there are approximately 19–22 primary ribs and 40–43 ventrolateral ribs per half-whorl (see also Avram, 1976). In the macroconchs, there are approximately 30–33 primary ribs and 65–70 ventrolateral ribs per half-whorl.

A species close to *R. richteri* is *R. striata* Olóriz, 1978, which differs in its denser ribbing.

The specimens of *Lemencia praerichteri*, which Cecca (1986, pl. 1, figs 3, 6) considers as macroconch *R. richteri*, differ mark-

Table 1

Measurements (in mm) and ratios of *Richterella richteri* (Oppel in Zittel, 1868)

Specimen	D	H	U	B	B/H	UR	VR
PL 4396 (m)	46.5	17.0 (0.37)	17.4 (0.38)	c. 11.0 (0.24)	0.63	19	38
		16.3		10.3			
Z 5541 (M)	89.0	33.0 (0.38)	31.5 (0.36)	c. 19.0 (0.22)	0.58	33	c. 70
	84.5	32.0 (0.38)	30.5 (0.36)	18.5 (0.22)			
	78.0	30.0 (0.38)	30.0 (0.38)				
AS III 129 lectotype (M) (casts)	72.5	27.0 (0.37)	27.4 (0.38)	16.7 (0.23)	0.62	30	65

PL – Nový Jičín Regional Museum, Czech Republic, Z – Silesian Museum in Opava, Czech Republic, AS III – Bayerische Staatssammlung für Paläontologie und historische Geologie of University in Munich, Germany. m – microconch, M – macroconch. Parameters explained in the text (chapter Taxonomy).

edly in the cross-section of adult whorls (see also Donze and Enay, 1961, text-fig. 44). Since the shell diameter of the holotype of *L. praerichteri* and the size of adult specimens of *R. richteri* are almost the same, it is improbable that they should represent dimorphic pairs. The pointed cross-sections of the whorls in *L. praerichteri* differ from the cross-sections of other representatives of *Lemencia*. It is therefore unlikely that the specimens mentioned above belong to *Lemencia*.

Distribution: Sapunov (1977a) described in detail the stratigraphic position of *R. richteri*. On the basis of his data, which cannot be verified at our localities, *Richterella* should occur between the upper part of Lower Tithonian and the base of the Upper Tithonian (where the Tithonian is subdivided into two parts). According to Zeiss (2001), *R. richteri* is the index species of the Lower Tithonian Richteri Subzone, which can be correlated with the lower part of the Fallauxi Zone.

The type material of *R. richteri* comes from the Outer Western Carpathians, from an undated part of Štramberk-type limestones, from the locality Wilamowice in Poland, and from Štramberk Limestone in the Czech Republic (previous discoveries from Koňákov locality, recent discoveries from the Kotouč Quarry). The species also occurs (see the synonymics) in the upper part of the Lower Tithonian of Germany, Switzerland, France, Spain, Hungary, Bulgaria and Romania; information about the stratigraphic position of the Romanian and Outer Carpathians occurrences is missing.

Occurrence: The microconch (specimen PL 4396) was found at level 6 (Ti2 locality in Fig. 2). The macroconch (specimen Z-5541) comes from older collections from an unspecified site in the Kotouč Quarry.

DISCUSSION

Of the three species of ammonites described above, two have not yet been determined in the Štramberk Limestone. The third species, *Richterella richteri*, originally was determined in Štramberk-type limestones at the locality of Wilamowice, Poland, by Oppel (in Zittel, 1868); in the original paper the German name Willamowitz was used. Wilamowice is situated more than 50 km as the crow flies from Štramberk, where the Štramberk Limestone was defined. However, the mode of occurrence of the bodies of Štramberk Limestone in Wilamowice is different, as they are exotic blocks (sensu Hohenegger, 1861). These blocks are incorporated to sediments of the Lower Cretaceous of the Silesian Unit, Outer Western Carpathians. Nevertheless, a typical *R. richteri* also occurs in the Kotouč Quarry at Štramberk and is documented as the specimen, described in this paper from old collections in the Silesian Museum in Opava.

The maximal diameter of 89 mm of the specimen from the Silesian Museum in Opava should not be the maximum size of a macroconch. Its ribbing and measured parameters are completely similar to the lectotype from Wilamowice, of which the authors have a plaster cast, 72.5 mm in diameter.

In the opinion of the authors, in contrast to existing opinions (e.g. Cecca, 1986), it is not justified to consider *Lemencia praerichteri* Donze et Enay, 1961 to be a macroconch of *R. richteri,* even though the size of the adult whorls of *L. praerichteri* reaches the size of the adult whorls of *R. richteri*. The cross-section of the whorls of *L. praerichteri* is not similar to those of other *Lemencia,* or to that of *Richterella*.

The authors consider *R. richteri* to be dimorphic. Its type material (Zittel, 1868, pl. 20, figs 9, 11, 12) belongs to the category of macroconchs. Smaller specimens described by Avram (1976) as *Lemencia* (*Richterella*) spp. aff. *richteri*, with similar morphology as to macroconchs, but different sparser ribbing, should represent microconchs of *R. richteri*.

The stratigraphic evaluation by the authors of the species from the Kotouč Quarry relies on Zeiss (2001, 2003) and the revised zonation of Scherzinger and Schweigert (2003) for Southern Germany. The stratigraphy of the Štramberk area is based on the correlation chart for the Tithonian (Zeiss, 2003, fig. 5). According to this last mentioned chart and Figure 24 of Zeiss (2001), the Štramberk area belonged to the Submediterranean and Mediterranean provinces during the Late Jurassic (see Cecca and Enay, 1991). The nearest areas with sedimentary successions, containing similar ammonite associations, are Eastern Austria and the Southern Germany.

From the palaeogeographic point of view, it is evident that during the Early Tithonian the Štramberk area was connected with the autochthonous Tithonian in Southern Germany across the Pavlov-Waschberg Zone (eastern Austria).

Franconites cf. *fascipartitus* and *Lemencia ciliata* were hitherto unknown in the Štramberk Limestone. *Franconites* mainly occurs in the southern Germany in the lower part of the Lower Tithonian of the Mucronatum Zone (Zeiss, 1968, 2001, 2003, see Fig. 6). Enay and Geyssant (1975) mention the occurrence of *Franconites* cf. *fascipartitus* in the lower part of the Lower Tithonian of Spain (ammonite zone of Darwini). According to Sapunov (1979), the genus was recorded in the Lower Tithonian of Bulgaria.

Lemencia ciliata in Germany is an index species for the upper part of the Lower Tithonian Fallauxi or Ciliata Zone (Zeiss, 2001, 2003; Scherzinger and Schweigert, 2003). This species occurs in France, as well (Mazenot, 1939; Donze and Enay, 1961).

Richterella richteri has been recorded in the Submediterranean and Mediterranean domain, in the upper part of the Lower Tithonian. In the both of the areas mentioned, it is the index species of the Richteri Subzone, Fallauxi Zone (see Zeiss, 2001, 2003). *Richterella* occurs throughout a belt from eastern Europe to southern Africa (see Cecca, 1999, fig. 7).

According to Zeiss (2001, 2003), the three species described in this paper do not occur associated with calpionellids.

This information is not in agreement with the distribution of calpionellids and the stratification of the Štramberk Limestone in the Kotouč Quarry, which Houša interpreted accordingly (in Menčík *et al*., 1983; Houša in Houša and Vašíček, 2005). According to these latter papers, the new discoveries of the Tithonian ammonites should be associated with calpionellids in the Chitinoidella and Crassicollaria zones.

The discoveries of Lower Berriasian ammonites at level 4 (Vašíček and Skupien, 2013) do not support Houša´s assumed subdivision of the Štramberk Limestone at the Kotouč Quarry.

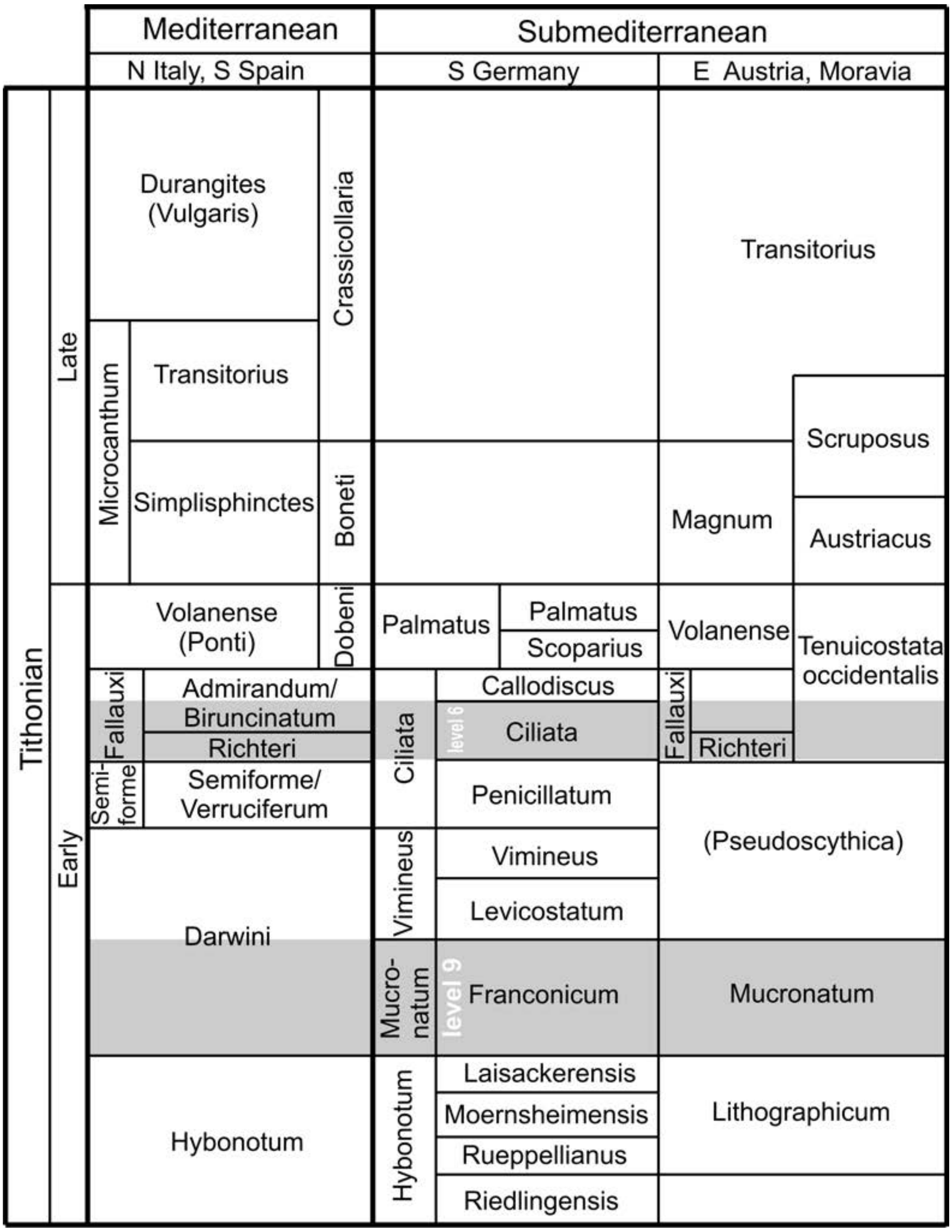

Fig. 6. Correlation scheme of the Tithonian ammonite and calpionellid zonations in the Mediterranean and Submediterranean bioprovinces (modified after Zeiss, 2001, 2003; Scherzinger and Schweigert, 2003). Stratigraphical ranges of described ammonites are signed by gray straps.

CONCLUSIONS

Recent discoveries of ammonites in the Štramberk Limestone at the Kotouč Quarry were assigned to the following species: *Franconites* cf. *fascipartitus*, *Lemencia ciliata* and *Richterella richteri,* all of them known in the Submediterranean province/domain. The ammonite-bearing limestones always contain the debris of corals.

Franconites cf. *fascipartitu*s should be the oldest species in the samples, Mucronatum Zone in age. In the southern Germany *Lemencia ciliata* is an index species typical of the upper part of the Lower Tithonian. *Richterella richteri*, occurring over a large geographic area within Submediterranean bioprovince, is the most significant species for biostratigraphy, as the index species of the Richteri Subzone (Fallauxi Zone). Macro- and microconchs can be differentiated in *R. richteri*. On the basis of the specific features of representatives of *Richterella*, the authors regard it as referable to the subfamily Richterellinae Sapunov, 1977.

The stratigraphic position, inferred for the ammonites described from the Štramberk Limestone in the Kotouč Quarry, does not agree with the interpretation of Houša (in Houša and Vašíček, 2005), based on the distribution of calpionellids.

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