GEOLOGICA CARPATHICA, DECEMBER 2017, 68, 6, 583–605 doi: 10.1515/geoca-2017-0038

Some perisphinctoid ammonites of the Štramberk Limestone and their dating with associated microfossils (Tithonian to Lower Berriasian, Outer Western Carpathians, Czech Republic)

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(Manuscript received June 5, 2017; accepted in revised form September 28, 2017)

Abstract: The present contribution deals with the taxonomy of seven species of perisphinctoid ammonite from the Štramberk Limestone (Outer Western Carpathians, Czech Republic) deposited in Moravian-Silesian museums. The age of these studied ammonites is compared with that of index microfossils contained in the matrix adhering to or infilling the studied specimens. The ammonites document a stratigraphic range from earliest Tithonian to early Berriasian. In addition to taxonomy and new ontogenetic data on some species, we also present data on their palaeogeographic distribution. The occurrence of Subboreal himalayitids in the Štramberk Limestone of an early Berriasian age is determined by both the microfauna and accompanying ammonites, which indicate connection of the Silesian-part of the Tethyan Carpathian area with the Subboreal Russian Platform Basin. These records also suggest an early Berriasian age (Jacobi Chron) for the lowermost part of the Ryazanian stage in its type area.

Keywords: Ammonoidea, Calpionellids, calcareous dinoflagellates, Upper Jurassic, Lower Cretaceous, biostratigraphy, Western Carpathians.

Introduction

The Moravian–Silesian museums (Ostrava, Opava, Nový Jičín) in the Czech Republic and the Naturhistorisches Museum in Vienna and Bayerische Staatssammlung für Paläontologie und Geologie in Munich hold large numbers of ammonites found in the Štramberk Limestone. The above-mentioned ammonites all come from old collections, some of which date from the nineteenth century. A common feature of these collections is the absence of detailed locality data for the specimens. On the original labels, only "Štramberk" or "Stramberg" are usually stated. Some of these specimens do not even come from the Štramberk area. These ammonite finds are associated with the occurrence of Štramberk-type limestones which occur in the form of so-called "exotic blocks" (term of Hohenegger 1861) in the Outer Western Carpathians in the north-eastern Czech Republic and south-western Poland.

The above-mentioned ammonite specimens held in foreign collections were initially studied by Zittel (1868, from the Zámecký lom — Castle Hill Quarry — and exotic blocks) and Blaschke (1911, Kotouč Quarry). They are often holotypes or lectotypes. Their precise stratigraphic positions, however, were not known. This was usually recognized later, on the basis of studies of profiles with ammonites, primarily at sites in Western and Central Europe.

The primary focus of the paper is to describe the perisphinctoid ammonites from old collections and discuss their taxonomy and age. We also try to precisely determine the age of some of the Štramberk ammonites deposited in Moravian–Silesian museums: we do this by studying the microfossil contents of thin sections of the rocks adhering to or infilling the ammonites, as in studies by Oloriz & Tavera (1982), Kaiser-Weidich & Schairer (1990). Where it was possible, we cut off pieces of rock for preparation of 38 thin sections from the rock matrix of 27 ammonite specimens. However, only 16 thin sections, from 10 ammonite specimens, contain stratigraphically important microfossils. Comparative thin sections come from the Kotouč Quarry at Štramberk, which recently yielded some new ammonite finds. Ammonite specimens with matrix lacking any index microfossils are not included in the taxonomic part of this paper.

Geological setting

The Štramberk Limestone is exposed at several quarries (Kotouč, Municipal, Horní Skalka and Castle Hill) in the immediate vicinity of the town of Štramberk (Figs. 1 and 2) in the form of carbonate megablocks (in a wide range of sizes), breccias and conglomerates. The Štramberk Limestone

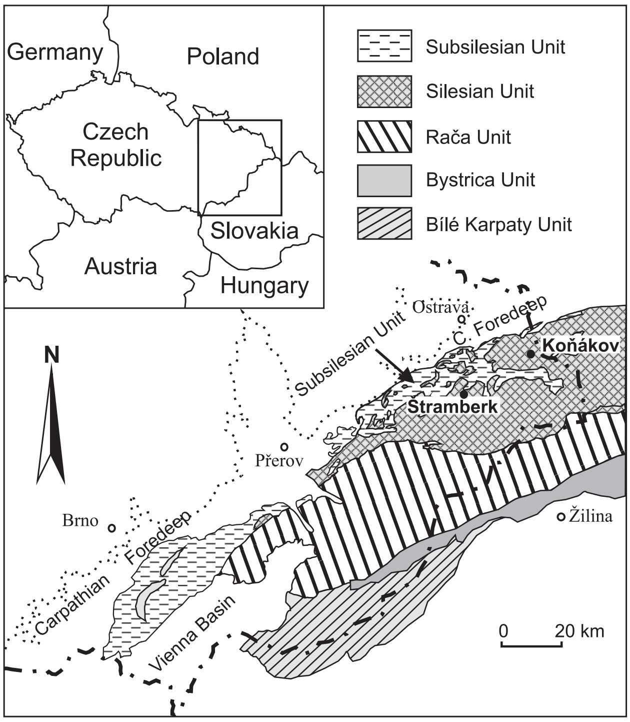

Fig. 1. Tectonic map of the Outer Western Carpathian area of the Czech Republic (after Skupien & Smaržová 2011).

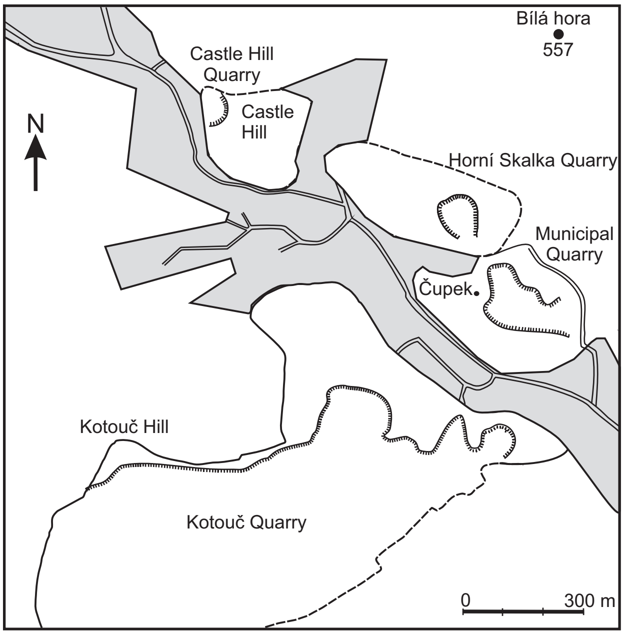

Fig. 2. Geographical situation of bodies of Štramberk Limestone in the vicinity of Štramberk.

represents a deposit that was formed during the latest Jurassic –earliest Cretaceous in a carbonate platform belt along the northern Tethyan margin in the area of the Outer Western Carpathians. Block accumulations of the Štramberk Limestone form part of the continental-rise sediments of the Baška Facies in the Silesian Unit, which were deposited in the flysch trough of the Baška Subunit (for more details, see Picha et al. 2006).

According to Picha et al. (2006), the Štramberk carbonate platform was rimmed by coral reefs, and these were the source of carbonate clasts. 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 (Neogene) tectonic thrusting of the Silesian nappe, large tectonic pieces of the carbonate platform were separated from the softer, less resistant rocks situated on the slopes of the platform. The result is a mélange, in which larger blocks from the carbonate platform appear to have the characteristics of klippen.

The age of the Štramberk Limestone was assumed to be, as the latest, Kimmeridgian and Tithonian (e.g., Houša 1990; Houša *in* Houša & Vašíček 2004). However, calpionellids (Houša *in* Houša & Vašíček 2004) and ammonites (Vašíček et al. 2013; Vašíček & Skupien 2013, 2014; 2016) from the limestone bodies are indicative of the higher part of the early Tithonian, the entire late Tithonian and the lowermost Berriasian (Vašíček et al. 2016).

Methods and Material

In the Štramberk Limestone, ammonites are generally favourably preserved, their moulds are usually undeformed. In the selected material, the specimens in which at least a half of the last whorl is preserved prevail. This makes it possible to measure all size parameters, to determine the whorl cross section, and to determine the half-whorl density of ribs. A usual problem is that in most of the studied specimens, juvenile whorls are not preserved. In addition to literary sources, the study of most ammonites was supported by examination of the original materials in Munich (Zittel 1868) and Vienna (Blaschke 1911) [as well].

The following abbreviations are used when citing museum ammonite collections:

AS III — von Zittel's collection, Bayerische Staatssammlung für Geologie, Munich

NHMW — Blaschke's collection, Naturhistorisches Museum, Vienna

PL — collections of the Nový Jičín Regional Museum

Z — collections of the Silesian Museum in Opava

B — collections of the Museum of Ostrava in Ostrava

UK — Remeš's collection, Charles University in Prague.

Our micropalaeontological study is based on 38 thin sections. Rock sampling for thin sections was performed perpendicularly to the presupposed bedding. The bedding was derived from the sagittal plane of an ammonite's shell symmetry, assuming that the specimen must have lain on the bottom of the sea parallel to this plane. In the other specimens, where such an above-mentioned cut was not possible, one was made parallel to the plane of symmetry of an ammonite. Thin sections were preferentially prepared from the finer parts of detrital limestone.

The thin sections are marked with 5-digit numbers and are stored in the thin section book at the Department of Laboratory Research on Geomaterials of the Institute of Geonics of the Czech Academy of Sciences in Ostrava-Poruba. The museum number of the ammonite is also stated in this book together with the number of the thin section. The thin sections were made in the laboratory of the Institute of Geonics, Academy of Sciences of the Czech Republic and during the time of their evaluation they are stored in the collections of the Department of Geology and Palaeontology (Faculty of Natural Sciences) in Bratislava.

Microfacies analysis focused on determination of stratigraphically important bio markers, and accompanying bioclasts were studied under a light microscope. Thin-sections have been evaluated under an optical microscope (LEICA DM 2500). The calpionellids and cysts of calcareous dinoflagellates were evaluated among spectra of further residual bioclasts. Together, they offered the information useful for stratigraphy and palaeoenvironmental interpretation. A LEICA DFC 290 HD camera was used for microfacies and microfossil documentation. The calpionellid zonation of Reháková and Michalík (1997), the dinoflagellate cyst zonation of Reháková (2000) and a limestone textural classification after Dunham (1962) were adopted. The definitions of microfacies types of Wilson (1975) were used.

Taxonomy of ammonites

At the supragenetic level, the ammonite taxonomy adopted here is conservative. As already noted by Donovan et al. (1981) and Cecca et al. (1989), the systematics of Tithonian families are in a state of chaos. For early Berriasian ammonites, we follow Klein (2005), albeit with a change in the taxonomic position of the genus *Riasanites.*

All the specimen dimensions are given in millimetres: D — diameter (Dmax — largest diameter measured), H — whorl height, B — whorl breadth, and U — umbilical diameter. The ratios of the parameters to shell diameter (H/D, B/D, U/D) are given in brackets. The whorl breadth to height ratio (B/H) is also indicated. Where possible, the number of inner (primary) ribs at the umbilicus (UR) and the number of ventrolateral ribs (VR) are given for a half whorl. If possible sexual dimorphism is recognized; the abbreviations *m* (microconchs) and *M* (macroconchs) are used, in brackets.

The stratigraphic position of Tithonian ammonite species within the ammonite zonal succession is derived from data presented by Zeiss (2001, 2003) and Scherzinger and Schweigert (2003, 2016). The Berriasian ammonite zones follow Reboulet et al. (2014).

Suborder: Ammonitina Fischer, 1882
Superfamily: Perisphinctoidea Steinmann, *in* Steinmann & Döderlein, 1890
Family: Ataxioceratidae Buckman, 1921
Subfamily: Lithacoceratinae Zeiss, 1968

Genus: *Lithacoceras* Hyatt, 1900

Type species: *Ammonites ulmensis* Oppel, 1858.

Remark: The taxonomy of the subfamily Lithacoceratinae Zeiss, 1968 was briefly dealt with by Zeiss et al. (1996). According to the latter authors, typical representatives of this subfamily are large or very large, and they have fascipartite branching of ribs in the middle stages of growth. The latest, adult, whorls bear rough, simple ribs.

Lithacoceras eigeltingense Ohmert and Zeiss, 1980 (M)
Fig. 3

1980 *Lithacoceras (Lithacoceras) eigeltingense* n. sp.; Ohmert and Zeiss, p. 12, pl. 1, figs 1–3.

Material: The only specimen, PL3228, is preserved as an internal mould. Juvenile whorls are only partially preserved and are not very clearly visible. The last half of the last whorl comprises a body chamber.

Description: Large semi-evolutely coiled macroconch with a wide umbilicus. The height of the last whorl exceeds the width. The low, rounded umbilical wall falls obliquely to the line of coiling. The sides of the whorl are moderately arched. The whorl reaches its greatest width at the level of the base of primary ribs. The flanks of the whorl then steadily fall and merge into a rounded, moderately wide ventral side.

The youngest juvenile whorls in their lower part, which is not covered with a subsequent whorl, bear relatively sparse, simple, moderately thick curved ribs, which are concave to the aperture. Other whorls are poorly preserved. On the penultimate whorl, there are simple, concave, curved, not very thick ribs, which suddenly become relatively sparser. As the umbilical wall changes into the flanks of the whorl, the primary ribs gradually intensify into the longitudinally-elongated thick bases of ones. A short, unfavourably preserved, portion on the last quarter of the penultimate whorl (at an umbilical width of approximately 140 mm) is followed by a change in the character of the ribs, in the form of sparsely distributed coarse and consequently blunt-shaped ribs. The strengthening, concavely curved ribs on the last whorl become more sparcely spaced and bare blunt umbilical tubercles. Just at the beginning of the last whorl, still on the phragmocone, it is possible to see (imperfectly) that the ridge-shaped ribs may branch into some more obscure, relatively thin fascipartite, gradually disappearing ribs at approximately 2/3 of the height of the whorl. These ribs are not closed and dense, but are rather sparsely distributed. In the next part of the shell, fascipartite ribs are no longer visible. In general, the ribs of the last whorl have a triangular shape. They are curved, and concave towards the aperture. Towards the ventral side, the ribs and inter-rib depressions disappear.

Measurements: At almost the maximum diameter of the specimen, with D=337 mm, H=98.0 (0.29), U=160.0 (0.47), B ca. 84.5 (0.25), and B/H ca. 0.86. At D'=287 mm, H'=86.0 (0.29) U'=135.0 (0.47), B'=71.5 (0.25) and B'/H'=0.83.

Fig. 3. *Lithacoceras eigeltingense* Ohmert and Zeiss, 1980, spec. PL 3228, Nový Jičín Regional Museum, Kotouč Quarry, lower part of the Early Tithonian. Scale bar equals 20 mm.

The end of the phragmocone occurs at a diameter of approximately 280 mm. When the umbilicus width is 110 mm, there are approximately 50 primary ribs on half of the internal whorl. On the last half-whorl, there are only 9–10 ridge-like ribs.

Remarks: The Štramberk specimen differs from other morphologically close species primarily by its large size, which places it in the macroconch category. In juvenile and adult specimens it is characterized by concave, curved ribs. The transition of the thinner ribs on the internal whorls into different, consequent thicker ribs is relatively abrupt and occurs at a shell diameter of approximately 150 mm.

Based on the preliminary investigation of morphologically related species in the literature, namely macroconchs, with large dimensions and relatively close dimensional parameters, only some representatives of the genera *Lithacoceras* Hyatt, 1900, *Ernstbrunnia* Zeiss, 2001 and *Usseliceras* Zeiss, 1968 are similar to the Štramberk specimen.

Data on the dimensions of the possibly close species, such as *Lithacoceras zeissi* Sapunov, 1979, *Lithacoceras eigeltingense* Ohmert and Zeiss, 1980, *Ernstbrunnia bachmayeri* Zeiss, 2001, or *Usseliceras franconicum* Zeiss, 1968, show that they are all characterized by close H/D (0.30 to 0.33) and U/D (0.44 to 0.45) ratios. On their body chambers, there are 9–10 ridge-shaped ribs on half a whorl.

The differences are only found by means of a detailed analysis of the ribbing of the above mentioned species. In the case of the genus *Lithacoceras*, some ribs that are concave and curved towards the aperture may bifurcate on the internal whorls near the umbilical seam. On the ventral side of the majority of the last whorl, there are uniform thin and dense ribs. The juvenile ribbing stage in *L. zeissi* changes to adult ribbing at an umbilicus width of approximately 85 mm.

In representatives of the genus *Ernstbrunnia* the ribs on the internal whorls are straight or nearly straight. They do not bifurcate near the umbilicus. On smaller paratypes of the robust species *E. bachmayeri* Zeiss, 2001 (pl. 11, figs. 1, 2), the initial section of relatively sparse and simple juvenile ribs are followed by very dense, thin ribs on the inner whorls. The transition from dense to adult ribbing is slow and roughly occurs approximately at an umbilicus width of 100 mm. The genus *Ernstbrunnia* , when preserved, shows dense, uniform ribs on the ventral side (see, e.g., *E. toriseri* Zeiss, 2001, pl. 14, fig. 4). These outer ribs resemble similar ribbing seen in the genus *Lithacoceras*.

Most likely, the only close to the discussed specimen (but not identical) species of the genus *Usseliceras* is *Usseliceras franconicum*. The Štramberk specimen, however, differs by its much larger size, and thus also it shows a much later changes from relatively long-lasting juvenile ribbing into adult blunt-shaped ribs (only when the umbilicus width is approximately 150 mm).

The overall analysis shows that with respect to the size parameters and overall morphology, the Štramberk specimen best corresponds to *Lithacoceras* Hyatt, 1900. The type species of that genus is *L. ulmense* (Oppel), first figured in Oppel, 1863 (pl. 74, fig. 1). The type specimen of this species differs from the Štramberk specimen by the higher number of ribs on the last half-whorl, and an earlier onset of strong ribbing, whereas the shell diameter is the same. The lower Tithonian species of the genus, namely *Lithacoceras eigeltingense* Ohmert and Zeiss, 1980, corresponds best, both morphologically and dimensionally, to *L. ulmense*. According to Ohmert and Zeiss (1980), the largest specimen of *L. eigeltingense* originating from the Eigeltingen locality reaches D=280 mm; the specimen has H=80.0 (0.29) and U=130.0 (0.46).

Zeiss et al. (1996) concluded that the genus (or subgenus) *Virgatolithacoceras* Olóriz, 1978 is synonymous with the genus (subgenus) *Lithacoceras*. That is why some species have not been considered to be *Virgatolithacoceras*. Zeiss et al. (1996) therefore defined the new genus *Euvirgalithacoceras* (type species *Virgatosphinctes supremus* Sutner in Schneid, 1914). Schweigert (1996) already classified *Lithacoceras eigeltingense* as *Euvirgalithacoceras*. The other species, *L. zeissi*, could also belong to *Euvirgatolithacoceras.* It is smaller in size, and the ribs on the living chamber are markedly concave and curved, as in *E. eigeltingense*.

Recently, the species *E. eigeltingense* has been attributed to the genus *Lithacoceras* by Parent et al., 2006, 2013. In accordance with the above-mentioned authors, we also classify the Štramberk specimen as belonging to the genus *Lithacoceras*.

Distribution: *L. eigeltingense* is known from the basal Tithonian of the Swabian Alb Hills. According to Schweigert and Scherzinger (1995) and others (e.g., Schweigert and Zeiss, 1998, Scherzinger and Schweigert, 2016), the "*eigeltingense*-horizon" is the basal horizon in the ammonite *Lithacoceras riedense* Subzone, namely in the basal part of the Tithonian (*Hybonoticeras hybonotum* Zone).

Associated microfossils: In thin sections nos. 14980 and 14981 of the rock from accompanying specimen PL3228 (deposited in Nový Jičín Museum), *Parastomiosphaera malmica* is abundant. This species provides evidence for the early part of the early Tithonian.

Subfamily: Sublithacoceratinae Zeiss, 1968
Genus: *Blaschkeiceras* Zeiss, 2001
Type species: *Perisphinctes (Aulacosphinctes) Schoepflini* Blaschke, 1911.

Blaschkeiceras schoepflini (Blaschke, 1911) (m)
Figs. 4A–E, 5

1911 *Perisphinctes (Aulacosphinctes) Schöpflini* n. sp; Blaschke, p. 158, pl. 4, fig. 1.
1911 *Perisphinctes (Virgatosphinctes) Kittli* n. sp.; Blaschke, p. 158, pl. 3, fig. 1.
?1984 *Dorsoplanitoides?* cf. *kittli* Blaschke; Vígh, p. 204, pl. 3, fig. 1.
2001 *Blaschkeiceras schoepflini* (Blaschke); Zeiss, p. 42, pl. 9, figs 1, 2, 4 (m), fig. 3 (?M), text-figs 3, 4.
?2001 *Blaschkeiceras* cf. *kittli* (Blaschke); Zeiss, p. 43, pl. 18, figs 1, 3.

Material: An incompletely preserved external mould (spec. PL4925), consisting of the last three whorls, with unpreserved internal whorls. The last half-whorl is sometimes incomplete. At least the terminal portion is part of the living chamber. The holotypes of *B. schoepflini* and *B. kittli*, deposited in Blaschke's collection in Vienna, were also studied.

Description: An evolute shell with slightly overlapping, slowly expanding whorls. The whorls are strongly arched and low. The low umbilical wall continually passes into the flanks. They also continue into the rounded venter. The width of the whorl is the same as its height. The greatest width of the whorl is in the lower third of the height of the whorl.

All the ribs on the inner whorl, up to a diameter of 80 mm, seem to be relatively simple and sparsely spaced. They are biplicate with a high rib furcation point. At approximately 2/3 of the height of the whorl on the last whorl (almost to the maximum of the preserved diameter), all the ribs are biplicate. Rib furcation point on the internal whorls lies high; it overlies the following whorl. The expressive ribs are substantially straight and slightly inclined towards the aperture. On the ventral side, the ribs are slightly arched, without interruption or weakening. Only at the end of the last whorl, triplicate ribs appear in addition to bifurcate ribs. In one case, approximately in the middle of the incomplete last whorl, a constriction cannot be excluded.

Measurements: Incomplete spec. PL4925 reaches a diameter of 104.5 mm. If D is 104.3 mm, H=32.1 (0.31), U=53.4 (0.51), B=32.2 (0.31); B/H=1.00. On the penultimate whorl

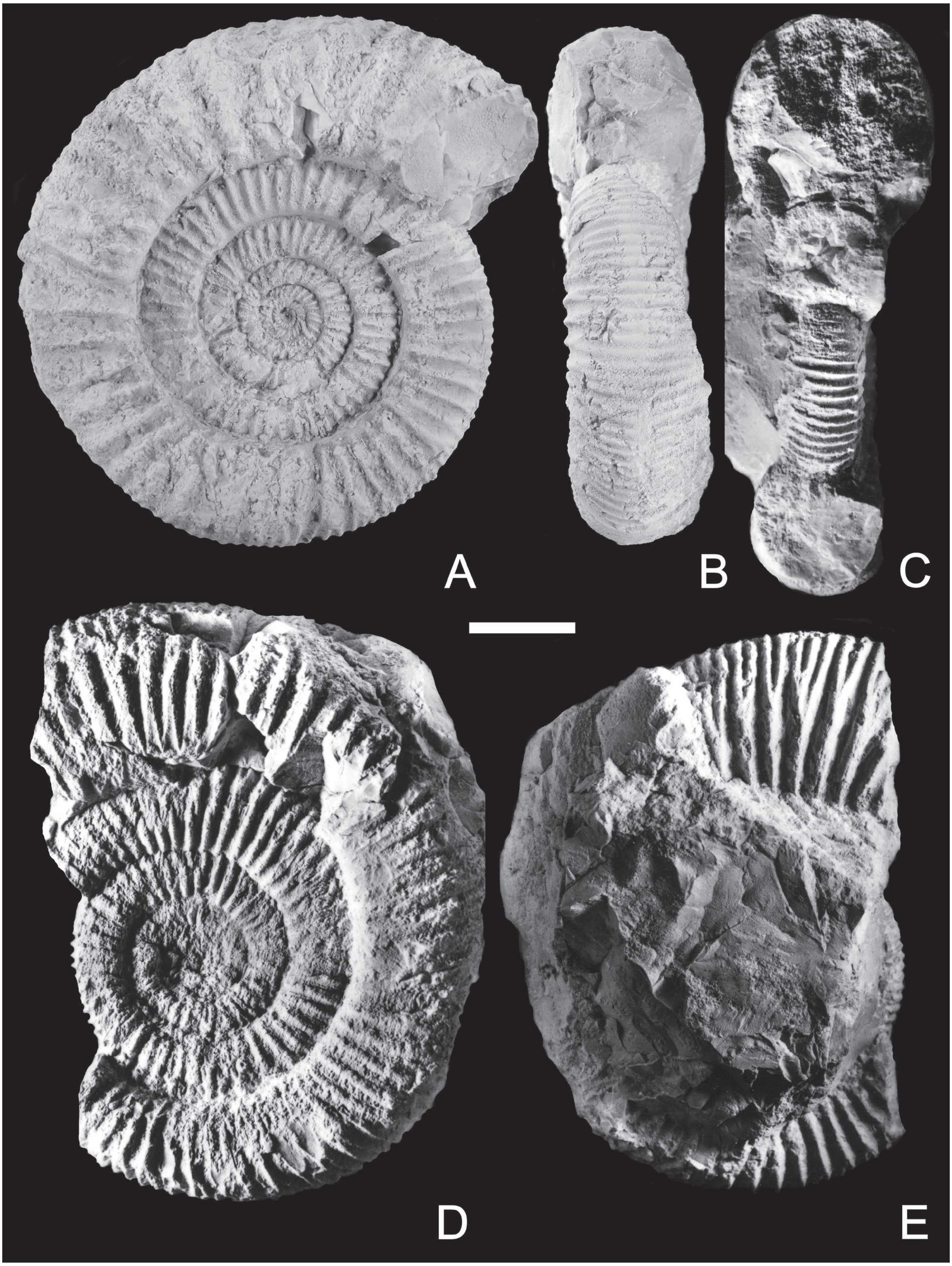

Fig. 4. A, B — *Blaschkeiceras schoepflini* (Blaschke, 1911), holotype deposited in the Naturhistorisches Museum in Vienna, in lateral and ventral views; **C–E:** *Blaschkeiceras schoepflini* (Blaschke, 1911), spec. PL4925 deposited in the Nový Jičín Regional Museum. **C** — ventral view; **D, E** — lateral views, debris on the 9th level of the Kotouč Quarry, Early Tithonian. Scale bar equals 20 mm.

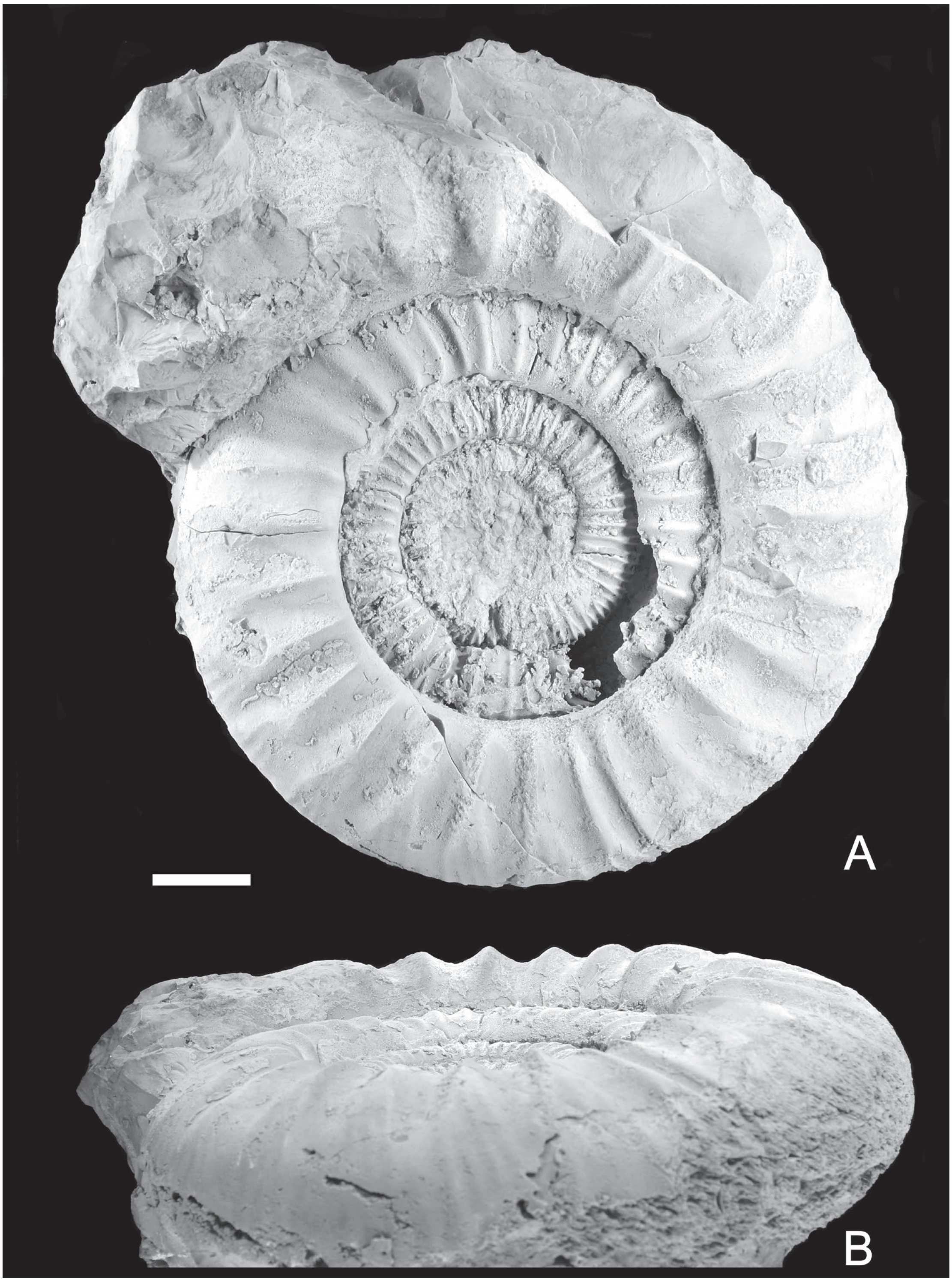

Fig. 5. A, B — *Blaschkeiceras kittli* (Blaschke, 1911), holotype deposited in the Naturhistorisches Museum in Vienna, in lateral and ventral views, Kotouč Quarry, Early Tithonian. Scale bar equals 20 mm.

(if D is approximately 65 mm), there are 46 primary ribs. On the last half-whorl, there are 28 ribs around the umbilicus.

On the *B. schoepflini* holotype, which is deposited in the Naturhistorisches Museum in Vienna (NHMW), one of us (Z. V.) made the following measurements: by D=94.5 mm, H=25.6 (0.28), U = 47.5 (0.50), B=30.0 (0.32); B/H=1.13. Dmax is 96 mm. The phragmocone end has a diameter of approximately 67 mm. The specimen has corroded ribbing, and carries approximately 20 primary ribs on the last half-whorl.

The measured data on the holotype for *B. kittli* (Fig. 5) are as follows: when D=159.5 mm, H=46.3 (0.29), U=79.5

(0.50), and B ca. 50.0 (0.31); B/H=8.1. Dmax is approximately 190 mm, and the phragmocone ends when the umbilicus width is 80 mm. By D=160 mm, 14 of the primary ribs fall on half of the whorl.

Remarks: *B. schoepflini* is characterized by an evolute coiling in medium-sized shells (U/D of approximately 0.50) and sparse ribs. Initially, all the ribs bifurcate at approximately 2/3 of the whorl height, and at the end, triple ribs also appear.

In addition to the holotype of *B. schoepflini*, Zeiss's specimens (2001) and the further specimen described here, larger similar specimens, called *Pseudovirgatites kittli* by Blaschke (1911) exist — see Zeiss, 2001, p. 43). The holotype of *Pseudovirgatites kittli* is deposited in the NHMW. The phragmocone of the holotype ends when the umbilical diameter is approximately 80 mm. Early whorls are ribbed similarly to those of *B. schoepflini*. Already at the beginning of the penultimate whorl, thicker ribs with bullate umbilical tubercles follow after the previous simple ribbing. On the last whorl, around the middle of the whorl height, fasciculate ribs (consisting of 3–4 ribs) join them. The width of the umbilicus and the ribbing of the inner ribs are similar to those in *B. schoepflini*. In view of these circumstances, in accordance with one of Zeiss's opinions (2001, p. 43), we can assume that *B. schoepflini* is the microconch while *Blaschkeiceras kittli* (Blaschke) could be considered as its macroconchiate counterpart. In addition to the different ribbing of the adult portion of *B. kittli*, *B. schoepflini* also differs in the fact that close to the umbilical seam on inner whorls, the points of bifurcation of ribs are not visible, whereas in *B. kittli* the ribs are visible. In *B. kittli*, the coarse ribbing begins only when the shell diameter is larger than that of specimens of *B. schoepflini*.

Distribution. In addition to further unlocalized finds in the area of Štramberk, *B. schoepflini* occurs in the area of Ernstbrunn (Lower Austria) in the upper part of the lower Tithonian and unspecified upper Tithonian (Zeiss, 2001) and in the Gerecse Mountains in Hungary (? the lower Tithonian).

Associated microfossils: The described specimen, PL4925, was found in the debris after several phases of blasting in the northeastern part of the Kotouč Quarry's eighth level. The thin section of the encasing limestone no. 13748 contains microfossils, including *Parastomiosphaera malmica*, from the lower Tithonian.

Genus: *Kutekiceras* Zeiss, 2001

Type species: *Perisphinctes pseudocolubrinus* Kilian, 1895.

Kutekiceras pseudocolubrinum (Kilian, 1895)
Fig. 6A–B

1870 *Ammonites colubrinus* Reinecke sp.; Zittel, p. 107, pl. 33 (9), figs. 6 a–c (lectotype in Donze & Enay, 1961, p. 181), pl. 34, ?figs 4–6.
1880 *Ammonites colubrinus* Rein.; Favre, p. 32, pl. 2, fig. 12.
1895 *Perisphinctes pseudocolubrinus* n. sp. (= *A. colubrinus* Zittel, Kilian, Toucas, non Reinecke); Kilian, p. 679.
1915 *Perisphinctes pseudocolubrinus* Kilian; Schneid, p. 326, pl. 2, figs 7, 7a.
1961 *Perisphinctes(?) pseudocolubrinus* Kilian; Donze & Enay, p. 180.
1978 *Subdichotomoceras pseudocolubrinus* (Kilian); Olóriz Saéz, p. 476, pl. 55, figs 8–10.
?1985 *Subdichotomoceras* cf. *pseudocolubrinum* (Kilian); Tavera Benitez, p. 56, pl. 5, fig. 3, text-fig. 5F.
1990 *Subdichotomoceras pseudocolubrinum* (Kilian); Főzy, p. 327, pl. 1, fig. 6.
2001 *Kutekiceras pseudocolubrinum* (Kilian); Zeiss, p. 45, pl. 10, figs 1–4,?8, text-fig. 6.
2013 *Kutekiceras pseudocolubrinum* (Kilian); Főzy & Scherzinger, p. 233, pl. 16, figs 1, 2, 6.

Material: A quite favourably preserved internal mould with somewhat corroded inner whorls with unfavourably preserved fragments of the suture lines (spec. Z-7349). The last 1/8 of the whorl is a part of the body chamber.

Description: An evolute specimen with low whorl heights. Whorls a little wider than high. The umbilicus is wide. The umbilical wall is low and declines obliquely to the umbilical seam. This wall passes through the curved zone into the vaulted flanks. The largest whorl width is at approximately half the whorl height. The flanks gradually pass into the rounded venter.

The sculpture consists of stronger, sparsely spaced and slightly proverse ribs. Primaries are straight in the lower half of the whorl. At approximately half the whorl height they bifurcate (on the inner whorls just below the umbilical seam). At the point of bifurcation, weak lateral tubercles are suggested. The front branch of the bifurcated ribs continues with the same direction as the primary ribs. The rear branch is backward inclined. The only simple ribs and intercalatories occur at the end of the last whorl. On the ventral side, there is a narrow and shallow siphonal belt with slightly weakened ribs. The bifurcate ribs on the opposite side mutually alternate, and the rear secondary rib on one side is the front rib on the opposite side.

Measurements: Dmax=59.8 mm, H=16.6 (0.28), U=31.0 (0.52), and B=18.3 (0.31); B/H=1.10. The phragmocone ends at a diameter of approximately 55 mm. On the last half-whorl, there are 25 primary ribs and 49 ribs on the ventral side.

Remarks: Our figured specimen corresponds well to the specimen depicted by Zeiss (2001, pl. 10, figs. 1, 2) and includes a shallow siphonal furrow and a zigzag arrangement of the bifurcated ribs on the outside. However, the above-mentioned species does not include Zeiss's specimens (2001, pl. 10, figs. 5–7) which he marked with an aff. or a cf.

Distribution: According to Főzy and Scherzinger (2013), the above-mentioned species is supposed to be abundant in the lower Tithonian of the Mediterranean bioprovince. However, there are usually no data on its detailed stratigraphic position. This is the case, for example, with the lectotype from Italy and finds from Hungary and Austria (Ernstbrunn). According to Olóriz Saéz (1978), it occurs in the *Haploceras verruciferum* and *Richterella richteri* zones (the upper part of the lower Tithonian) in Spain.

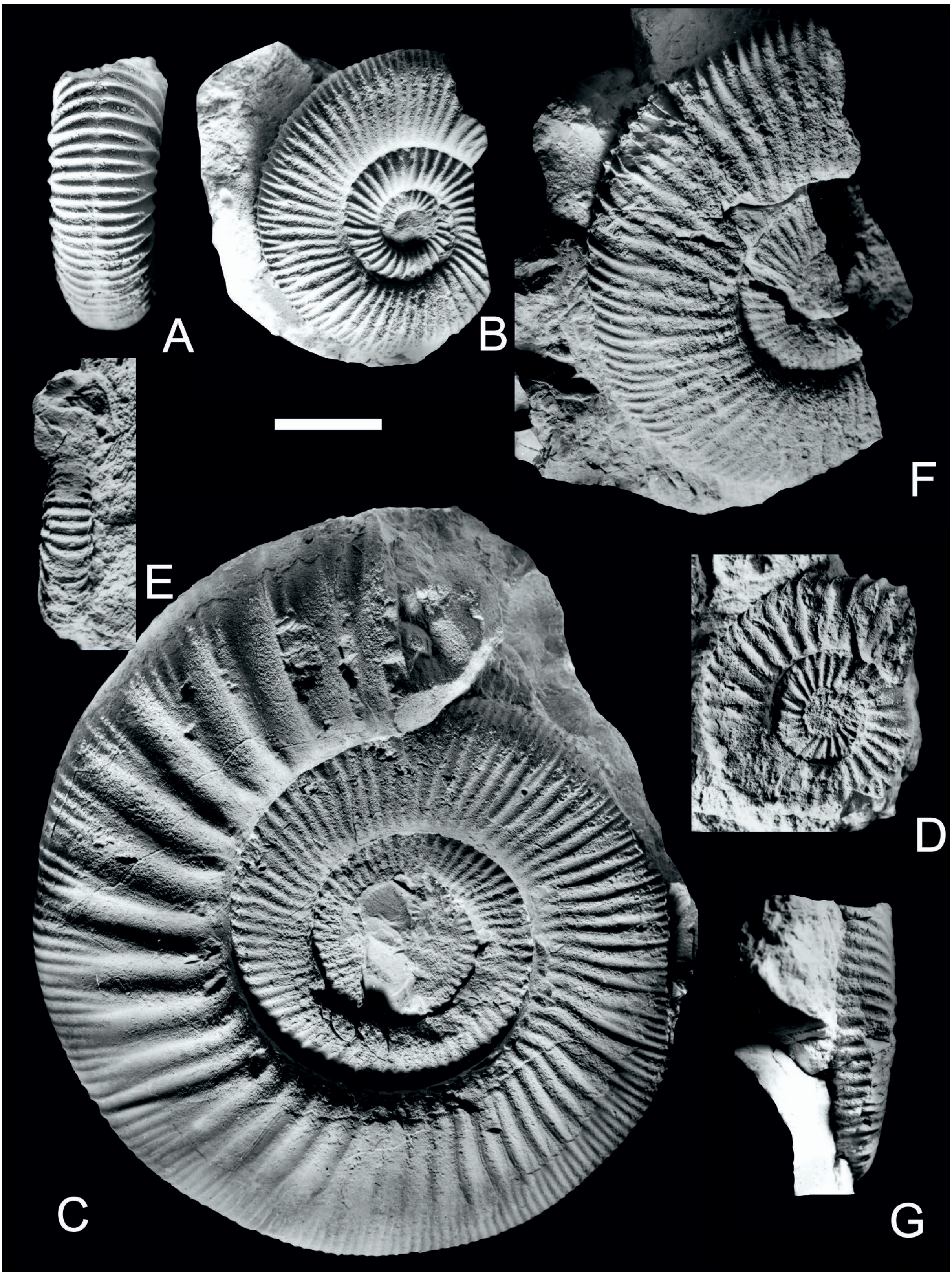

Fig. 6. A, B — *Kutekiceras pseudocolubrinum* (Kilian, 1895), spec. Z-7349 deposited in the Silesian Museum in Opava, in the ventral and lateral views, Early Tithonian; **C —** *Paraulacosphinctes transitorius* (Oppel, 1865), spec. 3232 deposited in the Nový Jičín Regional Museum, Kotouč Quarry, Late Tithonian; **D, E —** *Riasanites* cf. *swistowianus* (Nikitin, 1888), spec. B13303 deposited in the Museum of Ostrava in Ostrava in the lateral and ventral views, Kotouč Quarry, Early Berriasian; **F, G —** *Pseudargentiniceras abscissum* (Oppel, 1865), spec. Z-4604 deposited in the Silesian Museum in Opava, in the lateral and ventral views, Kotouč Quarry, Early Berriasian. Scale bar equals 20 mm.

Subfamily Paraulacosphinctinae Tavera, 1985
Genus *Paraulacosphinctes* Schindewolf, 1925

Type species: *Ammonites senex* (Oppel, 1865). Štramberk.

Paraulacosphinctes transitorius (Oppel, 1865 in Zittel, 1868)
Figs. 6C, 7A–B

1865 *Ammonites transitorius* Oppel, p. 554.
1868 *Ammonites transitorius* Opp.; Zittel, p. 103, pl. 22, figs. 1–4, 6 (m), fig. 5 (M).
1890 *Perisphinctes transitorius* Oppel; Toucas, p. 599, pl. 16, figs 5a,b, 6a,b (m).
1890 *Perisphinctes senex* Oppel sp.; Toucas, p. 599, pl. 16, fig. 7 (m),?8.
1936 *Perisphinctes (Aulacosphinctes) eudichotomus* Oppel; Roman, p. 15, pl. 1, figs 8, 8a, 10, 10a (m), non fig. 11 (= *?Zittelia algeriana* Tavera Benitez, 1985).
?1936 *Persisphinctes (Virgatosphinctes) transitorius* Oppel; Roman, p. 15, pl. 1, fig. 9 (m).
1965 *Virgatosphinctes transitorius* (Oppel); Houša in Špinar et al., p. 524, fig. VIII-272 (m).
1977 *Paraulacosphinctes transitorius* (Oppel) sensu Sapunov; Sapunov, pl. 5, fig. 2 (m).
?1978 *Virgatosphinctes transitorius* (Oppel); Řehoř et al., p. 85, pl. 36, fig. 2 (M).
1979 *Paraulacosphinctes transitorius* (Oppel); Sapunov, p. 127, pl. 36, fig. 2 (m), non fig. 1 (= *P. senoides?* Tavera Benitez, 1985).
1985 *Paraulacosphinctes transitorius* (Oppel); Tavera Benitez, p. 84, pl. 11, figs 1–5 (m), text-figs 7A, 7D.
2001 *Paraulacosphinctes transitorius* (Oppel); Zeiss, p. 62, pl. 19, figs 1, 1a (M),?text-fig. 22.
2011 *Paraulacosphinctes* cf. *transitorius* (Oppel); Arkadiev, p. 240, plate, figs 1–3 (m),?4.
2012 *Paraulacosphinctes* cf. *transitorius* (Oppel); Arkadiev & Bogdanova, p. 140, pl. 1, figs 1–3 (m), ?4 (= Arkadiev, 2011).

Material: Specimens AS III 235 to AS III 240 of von Zittel's type material (1868) are held in Munich. The specimens are partly preserved as internal moulds and partly as an external moulds. For the larger specimen III AS 236, which was labelled as a paratype by Zeiss (2001, p. 62=Zittel, 1868, pl. 22, fig. 5), only a fragment is depicted. Another part of this specimen, which was not illustrated by Zittel, is shown by Zeiss (2001, pl. 21, fig. 1). Specimen III AS 237 (in Zittel, 1868, pl. 22, figs. 1 a–c) represents the lectotype defined by Sapunov (1979, p. 127). Specimen AS III 240 has a well-preserved suture, which was depicted by Zittel (1868, pl. 22, fig. 3). In addition to the type material, a very favourably preserved specimen from the Nový Jičín Museum, PL3232, and less than half of an incomplete large specimen deposited in Remeš's collection at Charles University in Prague (spec. UK 2) have also been examined. The latter specimen has only partly and poorly preserved middle whorls, approximately half of the penultimate whorl, and more than a quarter of the last whorl. The internal whorls have a well-preserved recrystallized original shell. The last whorl, which as a whole belongs to the phragmocone, is preserved as an internal mould with partially preserved suture-lines. On its surface, remnants of the umbilical wall of the subsequent whorl are still visible. In the past, the ventral side of this specimen was partly and inappropriately affected by grinding.

Microconchs: Medium-size, semi-evolute shells with relatively wide umbilicus. Whorls are, with the possible exception of the earliest whorls, slightly higher than wide. The whorls are widest near the umbilicus. The whorl flanks are moderately arched and merge into the narrower, rounded ventral side.

The whorls have relatively thin and quite sparsely spaced ribs which closely bifurcate at the upper part of the whorl flank. The bifurcated ribs are close to each other. Near to base of the low umbilical wall, the ribs are concave and curved towards the aperture. On the flanks, the ribs are basically straight up or slightly S-shaped and slightly proverse. On the internal whorls, the furcation point of ribs is not visible. Occasionally, there may be simple ribs with intercalatories. In the type material, a siphonal furrow is always drawn (in Zittel, 1868, pl. 22). Instead of the furrow, in the type specimens, it is, in fact, usually a smooth strip or belt. On the lectotype (Zittel, pl. 22, fig. 1), which is represented by phragmocone, and on the specimen in pl. 22, fig. 2a, a very shallow depression occurs in places (especially near the aperture), with continuous ribbing that lacks deflection. Near the end of the last whorl, the above-mentioned smooth strip is already missing.

Macroconchs: Large semi-evolute shells. The rather low and rounded umbilical wall diagonally dipping towards the previous whorl. The whorl flanks are heavily arched. The largest arching is located around the base of the whorl. The ventral side is narrower and strongly arched. The whorl height is slightly greater than the width.

On the internal whorls, only simple, proverse, fairly straight and not very thick ribs are visible. At the beginning of the last whorl, it is obvious that the ribs above the umbilical seam closely bifurcate, and the furcation points therefore are concealed on the internal whorls. Eventually, bifurcate ribs are replaced with triplicate ribs, which are followed by fascipartite ribs. Short intercalatory ribs are also inserted there. The ribs gradually become thicker and more widely spaced. After approximately half of the last whorl, a constriction appears, accompanied by a rib with many branches along the rear side of the constriction and a simple rib along its front side. In the final quarter of the last whorl of specimen PL3232, in the lower part of the height of the whorl, there are thick, sparse simple ribs that bear umbilical bullae. At approximately half the whorl height, these primary ribs break down into a bundle of three to four thinner ribs. The bundles may be intercalated with one inserted rib. The ribs pass the ventral side without any hint of a siphonal furrow or interruptions; they are only slightly curved to the aperture. On the phragmocone's incompletely preserved penultimate whorl (not the terminal one) of spec. UK2, there are strong bulky-shaped ribs that begin with relatively blunt, massive umbilical tubercles. Above half the height of the whorl towards the venter, the ribs become thinner. The primary ribs at the preserved beginning

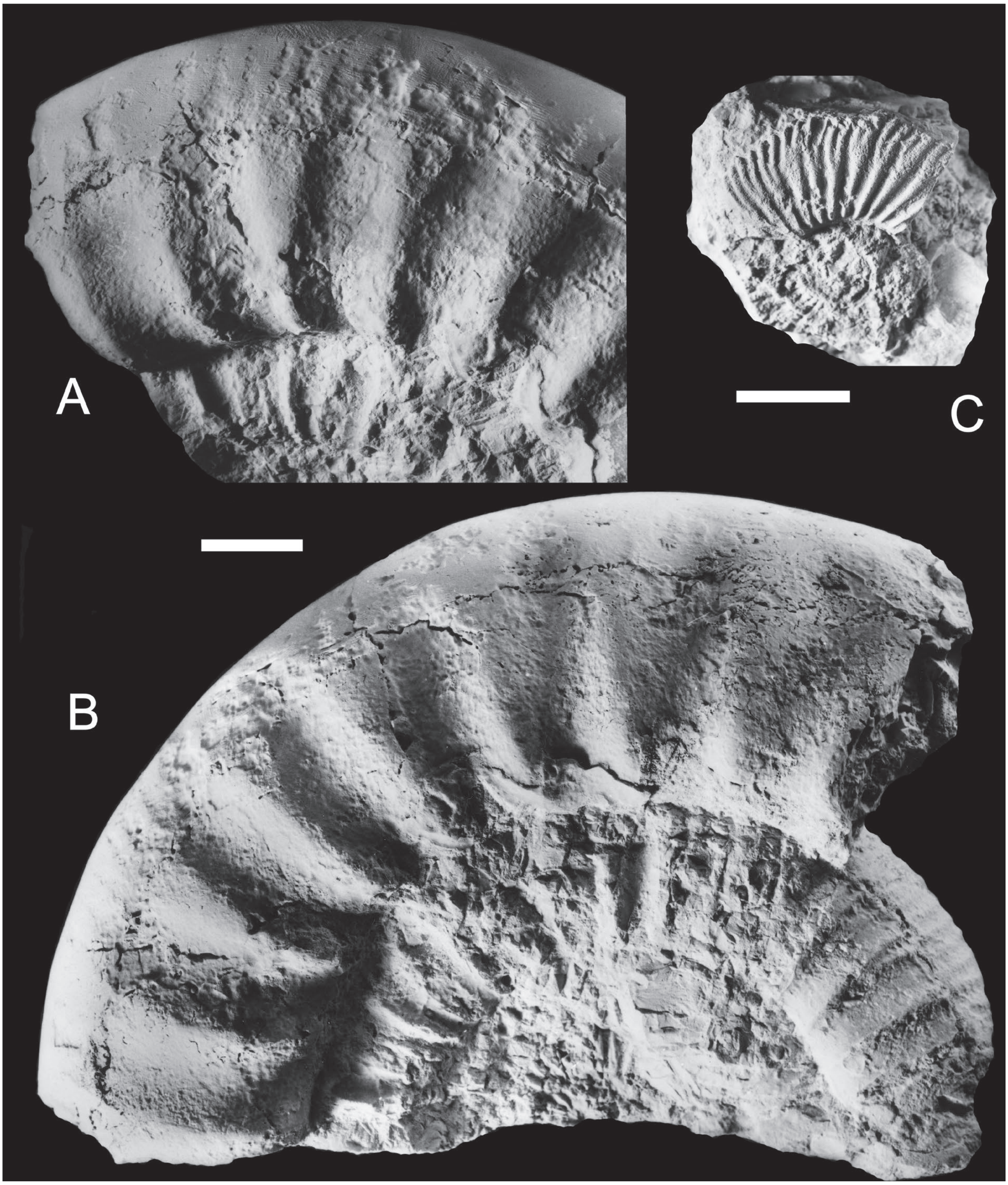

Fig. 7. A–B: *Paraulacosphinctes transitorius* (Oppel, 1865), spec. UK2 deposited in the Remeš collection, Charles University in Prague, Department of Palaeontology. A — detail view of ribbing on the beginning of the last whorl, B — whole view, Kotouč Quarry, Late Tithonian; **C —** *Pseudosubplanites lorioli* (Zittel, 1868), spec. PL 4927, deposited in the Nový Jičín Regional Museum. Kotouč Quarry, the 5th level, layer 021, Early Tithonian. Scale bar equals 20 mm.

of the last whorl are followed by bundles of ribs with three to four branches, which diminish to the ventral side. The ribs are concave and curved towards the aperture. The last preserved ribs on the side of the whorl have generally the shape of an asymmetrical triangle with a straighter rear side.

Measurements: Measurements of the *P. transitorius* are in the Table 1. At the end of the last quarter of the whorl (spec. PL3232), there are only 6 primary ribs. The whorl height is slightly greater than its width (at H=ca. 56.5 mm, B=53.5 mm, and B/H=0.95).

Table 1: Measurements (in mm) and ratios of *Paraulacosphinctes transitorius* (Oppel, 1865). AS III — Bayerische Staatssammlung in Munich, PL — Nový Jičín Regional Museum.

Spec.	D	H	U	B	H/D	U/D	B/D	B/H	UR	VR
AS III 238 (pl. 22/6)	42.6	15.0	16.7	15.7	0.32	0.39	0.37	1.05		
AS III 235 (pl. 22/2)	67.1	23.5	26.4	22.2	0.35	0.39	0.33	0.94	39	75
AS III 237 (lectotype)	90.5	30.4	38.0	27.5	0.335	0.42	0.30	0.90	45	
AS III 236 – 2nd part	126.0	37.7	60.0	34.0	0.30	0.48	0.27	0.90		
PL3232 (M)	144.0	43.3	65.0	c.41.0	0.30	0.45	0.28	0.95	32	96
Measurements based on the literature										
Sapunov (1979)	85.0	25.5	39.5		0.30	0.46				
Tavera (1985) – RR31	82.3	27.2	33.6	23.3	0.33	0.41	0.28	0.86	36	
spec. TMj.3.5	93.0	30.0	40.1	24.2	0.32	0.43	0.26	0.81	43	
Arkadiev (2011)	95.0	31.5	39.5		0.33	0.42			39	78

Remarks: From the above description, we therefore consider *P. transitorius* to be a dimorphic species. The dimorphic couple in this case have the same name for micro- and macroconchs. The microconchs reach a maximum diameter of approximately 130 mm. The whorl flanks are relatively flat. On the phragmocone, a ventral furrow or a smooth tape, which disappears towards the aperture, are evident. On the half whorl on specimens with diameters of approximately 90 mm, there are approximately 40 primary ribs and twice that amount on the ventral side.

The macroconchs reach up to a maximum diameter of 260 mm (e.g., the not illustrated specimen AS III 239 from Zittel's collection in Munich). The whorl flanks are arched, which declines to the ventral side. The adult whorl shape is shown in text-fig. 6B in Vašíček and Skupien (2016). The dense ribbing of the internal whorls up to diameters of approximately 120–130 mm is replaced by increasingly sparser and taller ribs. It is unclear whether a siphonal furrow is developed on early whorls because there is no specimen available that would properly expose the ventral side. On the last whorl of the largest available specimens, there are thick ribs with distinct blunt umbilical tubercles. Above half the height of the whorl, the thick ribs are followed by barely visible bundles of triple ribs or ribs with four branches. The primary ribs and the rib bundles diminish towards the ventral side, or bundle ribs are not visible (Zittel 1868, pl. 22, fig. 5). Akin to most microconchs, the B/H ratio for the macroconchs is close to 1 (typically 0.90 to 0.95). In their synonymies, Tavera Benitez (1985), Sapunov (1979), Arkadiev (2011), and Arkadiev & Bogdanova (2012) do not consider Zittel's specimen (1868, p. 22, fig. 5) to be *P. transitorius*.

A close species is *Paraulacosphinctes senex* (Oppel, 1865). A basic comparison with *P. transitorius* and the measured parameters of Munich macroconchs are listed in Vašíček and Skupien (2016, p. 20). When comparing both species in that contribution, however, there is misinformation; the lectotype *P. transitorius* is mistakenly stated as the paratype, i.e., spec. AS III 236 (a fragment of which is shown in Zittel (1868, pl. 22, Fig. 5). The lectotype is specimen AS III 237, as determined by Sapunov (1979).

Distribution: According to Zeiss (2001), *P. transitorius* occurs in the upper Tithonian at Štramberk and in Lower Austria. Furthermore, microconchs of the above-mentioned species are reported from the upper Tithonian of Spain, Algeria, Bulgaria and Crimea. Many specimens under this name are deposited in collections in Vienna and Munich.

Associated microfossils: The thin section of limestone (no. 14904) with *P. transitorius* from Remeš's collection (UK2) contains microfossils, including *Saccocoma* sp., which demonstrate the Tithonian.

Subfamily: Himalayitinae Spath, 1925
Genus: *Riasanites* Spath, 1925

Type species: *Hoplites rjasanensis* Nikitin, 1888. Ryazanian Stage of the Russian Platform (see Mitta, 2008, p. 251).

Remark: Mitta (2008, 2011) regarded the genus *Riasanites* as a member of the family Himalyitidae Spath, 1925 rather than family Neocomitidae as in previous concepts.

Riasanites* cf. *swistowianus (Nikitin, 1888)
Fig. 6 D–E

1888 *Hoplites swistowianus* Nikitin p. 93, pl. 1, figs 5–8.
2008 *Riasanites swistowianus* (Nikitin); Mitta, p. 258, pl. 5, figs 5, 10, pl. 6, figs 1–10 (cum syn.).

Material: A specimen with approximately the two last whorls with partially preserved recrystallized original shell (spec. B13303). The last whorl with two imperfectly preserved parts belongs to a slightly corroded internal mould with badly preserved fragments of suture-lines, except on the final segment. It is not completely clear whether the entire specimen belongs to the phragmocone or whether its end segment already represents the beginning of the body chamber.

Description: An evolute shell with relatively low, not very wide whorls and a wide umbilicus. The whorl height is about the same as the width. The umbilical wall is low, rounded and continually merges into the whorl flanks. The flanks are slightly arched. The greatest width of the whorl is in the lowest quarter of its height. The flanks with an indistinct shoulder merge into the slightly arched ventral side. The cross-section of the whorl is subquadrangular.

The shell is sparsely ribbed. Near the umbilical seam, simple, initially straight and then slightly S-shaped, relatively sharp, ribs begin, and are inclined to the aperture. On the last whorl, the bifurcate, widely open ribs diverge at different levels at approximately the middle of the whorl height. The front secondary rib is often proversely diverted from its original direction. Sparsely spaced ribs pass the ventral side without interruption; they are slightly curved towards the aperture. Places where the ribs bifurcate on the penultimate whorl are not overlain by the last whorl. Occasionally, there are simple ribs.

Measurements: The specimen reaches a diameter of 47 mm. By D=39.6 mm, H=13.5 (0.34), U=17.5 (0.44), and B ca. 12.0 (0.30). When Hmax=15.3 mm, Bmax is ca. 15.0 mm; B/H is ca. 0.98. By the shell diameter 47 mm, there are 7 primary ribs at the umbilicus and 14 ventrolateral ribs on the last quarter of the last whorl. One of the ribs is simple.

Remarks: Dimensional parameters, sparse ribs that pass the ventral side without interruption, and the whorl cross-section are close to those features in *R. swistowianus*. Because of the imperfect preservation of the specimen, the determination is given with a cf.

Distribution: *R. swistowianus* is species typical for the lower part of the Ryazanian Stage in Central Russia. After Mitta (2007) this is the index species of the swistowianus horizon, the lowermost *Riasanites*-bearing horizon of the Ryazanian.

Associated microfossils: The specimen deposited in the Museum of Ostrava has no precise locality data. In the thin section of accompanying limestone no. 13979, *inter alia*, *Calpionella alpina* and *Crassicollaria parvula* occur, demonstrating the lower Berriasian.

Family: Neocomitidae Salfeld, 1921
Subfamily: Pseudosubplanitinae Nikolov and Sapunov, 1977
Genus: *Pseudosubplanites* Le Hégarat, 1973

Type species: *Pseudosubplanites berriasensis* Le Hégarat, 1973.

Pseudosubplanites lorioli (Zittel, 1868)
Fig. 7 C

1868 *Ammonites Lorioli* Zitt.; Zittel, p. 103, pl. 20, figs 6 a – c, 8 (lectotype), non fig. 7 a, b.

?1880 *Ammonites (Phylloceras) Lorioli,* Zittel; Favre, p. 33, pl. 3, figs 1, 2.

?1889 *Perisphinctes Lorioli* Zitt.; Kilian, p. 652, pl. 28, fig. 3 a, b.

non 1890 *Perisphinctes Lorioli* Zittel sp.; Toucas, p. 589, pl. 16, fig. 2 a, b (= *?Pseudosubplanites* sp.).

?1939 *Beriasella euxina* (Retowski); Mazenot, p. 125, pl. 20, fig. 5a, b.

1939 *Berriasella Lorioli* (Zittel); Mazenot, p. 125, pl. 19, figs 3 a – d (lectotype), 4 a, b, 5 a, b, 6 a, b, 7 a,b.

1982 *Pseudosubplanites lorioli* (Zittel); Nikolov, p. 42, pl. 2, fig. 3, pl. 5, fig. 5, non fig. pl. 2, fig. 2 (= *Hegaratella crymensis* Bogdanova et Arkadiev, 2005), non pl. 5, fig. 6 (= *Pseudosubplanites fasciculatus* Bogdanova et Arkadiev, 2005), non pl. 5, fig. 7 (= *Berriasella jacobi* Mazenot, 1939), non pl. 5, fig. 8 (= *Beriasella oppeli* Kilian, 1889).

1985 *Berriasella (Pseudosubplanites) lorioli* (Zittel); Tavera Benitez, p. 261, fig. 20/I, pl. 36, fig. 10.

2012 *Pseudosubplanites lorioli* (von Zittel); Cecca et al., p. 111, fig. 5A,B.

?2013 *Pseudosubplanites lorioli* (Zittel); Szives & Fözy, p. 313, pl. 9, fig. 3.

2016 *Pseudosubplanites lorioli* (Zittel); Hoedemaeker et al., p. 120, pl. 2, figs 12 – 17 (m), pl. 3, figs 1 – 9 (M) - cum syn.

Material: Two incomplete specimens (PL 4927, PL 4928) from our new collection from the Kotouč Quarry. The more complete of these has less than a quarter of the last whorl preserved, as a deformed external mould, with a very imperfect imprint of the internal whorls and there is a poorly preserved counterpart of the same specimen. Furthermore, there are an imperfectly preserved fragment of approximately quarter of the last whorl, a corresponding whorl portion of the previous one and a plaster cast of the lectotype (spec. AS III 90).

Description: Semi-evolute specimens with relatively high, but quite narrow, whorls and moderately broad umbilicus. The cross section of the slightly arched last whorl is generally an elongate hexagon (leaving aside the low umbilical and subtrapezoidal wall). A low umbilical wall obliquely declines towards the umbilical seam. At the greatest whorl width, the umbilical wall quite suddenly passes into slightly arched high flanks. The flanks rather abruptly merge into a slightly arched and rather narrow ventral side.

The last whorl carries quite wide and not very densely spaced ribs. The ribs start above the umbilical seam as simple ribs. At approximately half way up the whorl, all the ribs (closely) bifurcate into secondary ribs. Overall, they are slightly S-shaped. The front secondary ribs continue in the direction of the primary rib. The rear secondary rib is diverted back and, when compared to the front one, is distinctly concave curved towards the aperture. All the ribs on the relatively flat venter are only slightly bent towards the aperture and are not interrupted. Slight thickening is indicated where the ribs bifurcate. In addition, a thickening of the short ribs is noticeable where the flanks merge into the venter.

Measurements: Accurate measurement and quantification of ribs on our material is not possible when there is not any measurable diameter. With a more complete specimen (PL 4927), it can be estimated that the shell reached a maximum diameter of approximately 49 mm. If the said diameter is H=19.2 (0.39), U=15.5 (0.32), and B is approximately 13.0 (0.265), then B/H=0.68. On a quarter of the whorl, there are approximately 10 ribs at the umbilicus and 19 ribs in the ventral area.

On the second fragment, B is approximately 11.5 mm, and H is 16.0 mm, and B/H=0.72.

Description of lectotype (Zittel's collection): A small semi-evolute specimen with whorls of medium height and moderately broad umbilicus. The umbilical wall is low and continuously gives way to slightly arched flanks. After the indicated edge, the flanks pass into the relatively narrow and slightly arched ventral side. The phragmocone ends occur at a diameter of 25 mm.

The sculpture consists of S-shaped ribs, all of which bifurcate at approximately the mid whorl or slightly above. The front bifurcation immediately follows the course of the primary rib, and the rear secondary rib is tilted backwards. The rear rib is concave and curved towards the aperture. The ribs cross the venter without interruption and in a nearly straight line.

Measurements: When D=34.5 mm (nearly max.), the lectotype has H=13.2 (0.38), U = 11.7 (0.34), B=10.5 (0.30), and B/H=0.795. On half of the whorl at this diameter, there are 18 primary ribs at the umbilicus and 35 ribs on the perimeter, whereas there are 32 to 33 primary ribs on the entire whorl.

Remarks: The lectotype of *P. lorioli* has been reinterpreted many times. In the second half of the last whorl of of Zittel's lectotype (D=34.5 mm), there are 18 primary ribs, whereas on the whole of the whorl, the number of ribs is 32–33. This means that in *P. lorioli* during the growth of the shell, the number of ribs changed significantly. After studying the lectotype cast at our disposal, a considerably more significant finding is that there are only bifurcated ribs on the last whorl. On his drawing of the lectotype, Le Hégarat (1973) (pl. 1, fig. 3) mistakenly depicts one triplicate rib. On the opposite side of the whorl as on the whole specimen, only bifurcate ribs are located. Le Hégarat's triple rib on the lectotype *P. lorioli* is mentioned again in later works. It must be added that Mazenot (1939) admits a very rare occurrence of triple ribs in *P. lorioli*, as demonstrated by some later pictures of the species. Mazenot (1939) also found that the body chamber on the lectotype begins at a diameter of approximately 25 mm (see the arrow in pl. 19, fig. 3b).

P. lorioli has been recently revised by Hoedemaeker et al. (2016), who supposes sexual dimorphism [of the male *P. lorioli*], distinguishing microconchs (m) and macroconchs (M).

Distribution: According to Hoedemaeker et al. (2016), *P. lorioli* occurs in the *Berriasella jacobi* Zone (the lower Berriasian) in France, Spain, Bulgaria and Iran. Zittel's lectotype came from the no longer existing site of the quarried out Koňákov quarry (Koniakau) near Český Těšín.

Associated microfossils: We found two fragments of *P. lorioli* in 2016 in the Štramberk Limestone in the Kotouč Quarry in Štramberk, on the fifth level of the section B, layer 021. The micropalaeontological contents of calpionellids *Calpionella alpina* Lorenz, *Crassicollaria massutiniana* (Colom), *Crassicollaria parvula* Remane, *Crassicollaria brevis* Remane of the accompanying rock indicate the lower Berriasian (the *Calpionella alpina* Subzone).

Subfamily: Neocomitinae Salfeld, 1921
Genus: *Pseudargentiniceras* Spath, 1925

Type species: *Ammonites abscissus* Oppel, 1865.

Pseudargentiniceras abscissum (Oppel in von Zittel, 1868)
Fig. 6F, G

1865 *Ammonites abscissus* Oppel, p. 556.
1868 *Ammonites abscissus* Oppel in von Zittel, p. 97, pl. 19, figs 1a,b, 2, 4a–c, ?3a, b.
2005 *Pseudargentiniceras abscissum* (Oppel); Klein, p. 232 (cum syn.).
2013 *Pseudargentiniceras abscissum* (Oppel); Szives & Főzy, p. 320, pl. 5, fig. 3.

Material: Less than half of the specimen with an incomplete last and penultimate whorl with only one side of a poorly preserved internal mould (spec. Z4606). The entire specimen belongs to the phragmocone.

Description: A semi-involute shell with medium-height whorls, which are relatively narrow. The umbilical wall is low and declines very steeply towards the umbilical seam. The umbilical wall continuously changes into slightly arched flanks. The last whorl reaches its greatest width in the lower third of the height of the whorl. The flanks then clearly incline to the venter. The flanks are not sharply separated from venter side. The ventral side is narrow and relatively flat.

The ribbing is moderately dense and of a uniform type. Simple primary ribs begin in the upper part of the umbilical wall and, are not initially sharp. Overall, the ribs are slightly S-shaped. At the bottom part, the ribs are almost straight and proverse. At approximately half of the whorl height, they are slightly convex towards the aperture. At 2/3 of the whorl height, all the ribs closely bifurcate and incline towards the aperture. In the ventral region, they have a concave curvature. The rear branch of the bifurcated pair follows the course of the primary rib. The front branch proversely diverts. All the ribs cross the venter without interruption and deflection. At the beginning of the last whorl, preserved as an internal mould, a narrow furrow is indicated in the siphonal area. At one point near the end of the specimen, despite a poorly preserved umbilical area, umbilical tubercles are visible on two ribs. Furcation points on the penultimate whorl are overlapped by the last whorl.

Measurements: Specimen no. Z4606 reached approximately 87 mm in diameter. At the estimated D=84.5 mm, H=31.0 (0.37), U=32.8 (0.39), and B=21.0 (0.25). When Bmax=21.5 mm, Hmax=29.3 mm; B/H=0.73. At the estimated Dmax, the estimated number of ribs on the last whorl is 26 at the umbilicus, and 52 ventrolateral ribs.

Remarks: The last half of the last whorl of the largest specimens [of that species] deposited in Zittel's collection in Munich (pl. 19, fig. 1b) has no contact with the previous whorl. However, this anomaly could be the result of the specific mode of preservation. Characteristic umbilical tubercles on the lectotype (Zittel, 1868, pl. 19, fig. 4 a–c) occur only above a diameter of ca. 70 mm.

Distribution: In addition to finds at Štramberk, *P. abscissum* occurs in the lower Berriasian (*Berriasella jacobi* Zone) in south-eastern France, Spain and Hungary.

Associated microfossils: According to the collection label, the old find by V. Houša originated from the second level of the Kotouč Quarry in the Štramberk Limestone boulder in the Plaňava Formation. In thin section no. 13714, the small forms of *Calpionella alpina* dominate over loricas of *Crassicollaria parvula*, *C. brevis*, *Tintinnopsella carpathica* and other microfaunistic remnants. This is the evidence of the lower Berriasian age.

Results of microfacies analysis

Some of samples studied yielded stratigraphically important bio markers which make it possible to divide them into three biozones (see Figs. 8–11). The first group (represented by thin sections 13748, 14980, 14981 from limestones with ammonite species *Lithacoceras eigeltingense, Blaschkeiceras schoepflini, B. kittli,* and *Kutekiceras pseudocolubrinum*), belong to pelbiointraclastic, pelbioclastic wackestones, packstones to grainstones (Fig. 8A–C) in which fragments of bivalves, crinoids (also planktonic *Saccocoma* sp. Fig. 8F, G, H), echinoid ossicles, aptychi, ooids, sponges, sponge spicules, corals, gastropods, ostracods, brachiopods, bryozoans, fragments of miliolid foraminifera, benthic foraminifera (*Pseudocyclammina lituus* (Yokoyama) (Fig. 8D), *Mohlerina basiliensis* (Mohler), *Protomarssonella* sp., *Lenticulina* sp., *Trocholina* sp., *Pseudogaudryina* sp., *Andersenolina* sp., *Nodosaria* sp., *Lenticulina* sp.), dasycladalean algae (*Salpingoporella annulata* Carozzi, Fig. 8E), red algae, microencrusters of *Crescentiella morronenis* (Crescenti), tubes of *Aeolisacus* sp., *Terebella lapilloides* Münster (Fig. 8G), algal microproblematicum of *Muranella* sp., and cysts of calcareous dinoflagellates — common *Parastomiosphaera malmica* (Borza) (Fig. 8I, J), *Colomisphaera minutissima* (Colom) (Fig. 8K) and *Colomisphaera misolensis* (Vogler). The age of this part of the Štramberk Limestone is earliest early Tithonian, on the basis of the presence of the dinoflagellate *Parastomiosphaera malmica,* the biomarker of the Malmica Zone (*sensu* Reháková, 2000). According to morphological varieties of saccocomid skeletal elements observed in thin sections the early Tithonian Sc6 Saccocomid Zone proposed by Benzaggagh et al. (2015) can be confirmed . Authors have correlated this zone with the "*Micracanthoceras*" *ponti* ammonite Zone.

In the second group of samples (thin sections 14904, 14905, 14982, 14983 and 15119/B, from limestones with *Paraulacosphinctes transitorius, P. senex* and *Boughdiriella choutensis*) pelbiooncoidal wackestones to grainstones, bioclastic-intraclastic wackestones, packstones, grainstones to rudstones were identified (Fig. 9A–D). The limestones studied contain ooids, irregular algal nodules surrounding small bioclasts and micritized rounded clasts with fragments of bivalves, crinoids, echinoids, ophiuroids, spicules, ostracods, bryozoans, brachiopods, fragments of dasycladalean algae (*Salpingoporella annulata* Carozzi, *Macroporella praturloni* Dragastan, *Clypeina* sp., also microproblematicum of *Muranella* sp.), worm tubes of *Terebella* sp., calcimicrobes of *Girvanella* type, miliolids (*Rumanoloculina verbizhiensis* (Dulub), *Quinqueloculina* sp., *Istroloculina* sp.), benthic foraminifera — *Labyrinthina mirabilis* Weynschenk, *Paalzowella* sp., *Redmondoides lugeoni* (Septfontaine) (Fig. 9E), *Andresenolina* sp., *Pseudogaudryina* sp., *Protomarssonella* sp., *Protopeneroplis striata* Weynscheck, *Pseudocyclammina* sp., *Neotrocholina molesta* (Gorbatchik), *Lenticulina* sp., *Trocholina* sp., *Valvulina* sp., *Textularia* sp., *Spirillina* sp., microencrusters of *Crescentiella morronensis*, *Koskinobullina socialis* Cherchi and Schroeder, and structures of "Bacinella". The calpionellids *Tintinnopsella remanei* Borza (Fig. 9I), *Calpionella alpina* Lorenz, *Calpionella grandalpina* Nagy, *Crassicollaria massutiniana* (Colom) (Fig. 9J), *Crassicollaria parvula* Remane (Fig. 9K, L) were identified. Bioclasts are locally rimmed by micrite borders. Oncoids contain[s] bivalves, ostracods, brachiopods, crinoids, *Saccocoma* sp. (Fig. 9F, G, H), foraminifera and algal fragments. Elements of *Saccocoma* sp. were also observed in both matrix and in clasts of biomicrite mudstones.

In general *Crescentiella morronensis* dominates among microencrusters. This represents a slightly deeper environment showing less water energy and lower oxygenation (Chiocchini et al. 1994). Locally, voids filled by two types of calcite were identified in the bioclastic-intraclastic limestones. Interparticle pores are filled by fibrous Mg-calcite cement, and secondary solution pores are filled by blocky sparry calcite cement. Such type of cement formed on the slope and a distally steepened ramp (Flügel 2004). The calpionellid associations observed are of the Late Tithonian standard Crassicollaria Zone (Reháková & Michalík 1997). On the basis of saccocomid skeletal elements present in thin sections, the late Tithonian Sc7 Saccocomid Zone (*sensu* Benzaggagh et al., 2015) coinciding with the *Micracanthoceras microcanthum* ammonite Zone can be identified. The third group is represented by thin sections 13714, 13979, 14815, 14984, 14986–14988, 14987 and 15842 from limestones with *Pseudargentiniceras abscissum, Delphinella* cf. *janus, Pseudosubplanites lorioli, Riasanites* cf. *swistowianus* and *Riasanella* cf. *rausingi.* This group can be characterized as biomicrite wackestones, peloidal-bioclastic-intraclastic wackestones, packestones to grainstones, bioclastic-intraclastic rudstones (some of the rudstone layers are rich in organic matter, dispersed in the matrix**).** Voids filled by blocky calcite were also locally observed. Their matrix is locally recrystallized and there are vadose silt accumulations around coral clasts. Some of the bioclasts are micritized (requiring subaerial exposure and restrictive facies). Limestones contain calpionellids — small forms of *Calpionella alpina* (Fig. 10G, H, I, J) dominating over *Crassicollaria parvula* (Fig. 10K, L), *Crassicollaria brevis* Remane, *Tintinnopsella carpathica* (Murgeanu and Filipescu) (Fig. 10M, N), cysts of *Stomiosphaerina proxima* Řehánek, *Cadosina* sp., spores of *Globochaete alpina* Lombard, foraminifera *Pseudogaudryina* sp., *Epistomina* sp., *Andersenolina alpina* (Leupold) (Fig. 10A), *Andersenolina cherchiae* (Arnaud-Vanneau, Boisseau and Darsac) (Fig. 10A), *Andresenolina* sp., *Haplophragmoides joukowskyi* Charrolais, Brönnimann and Zaninetti (Fig. 10B), *Protopeneroplis ultragranulata* (Gorbachik) (Fig. 10C), *Pseudomarssonella* sp., (Fig. 10D), *Uvigerinammina uvigeriniformis* (Seibold and Seibold) (Fig. 10E), *Trocholina odukpaniensis* Dessauvagie,

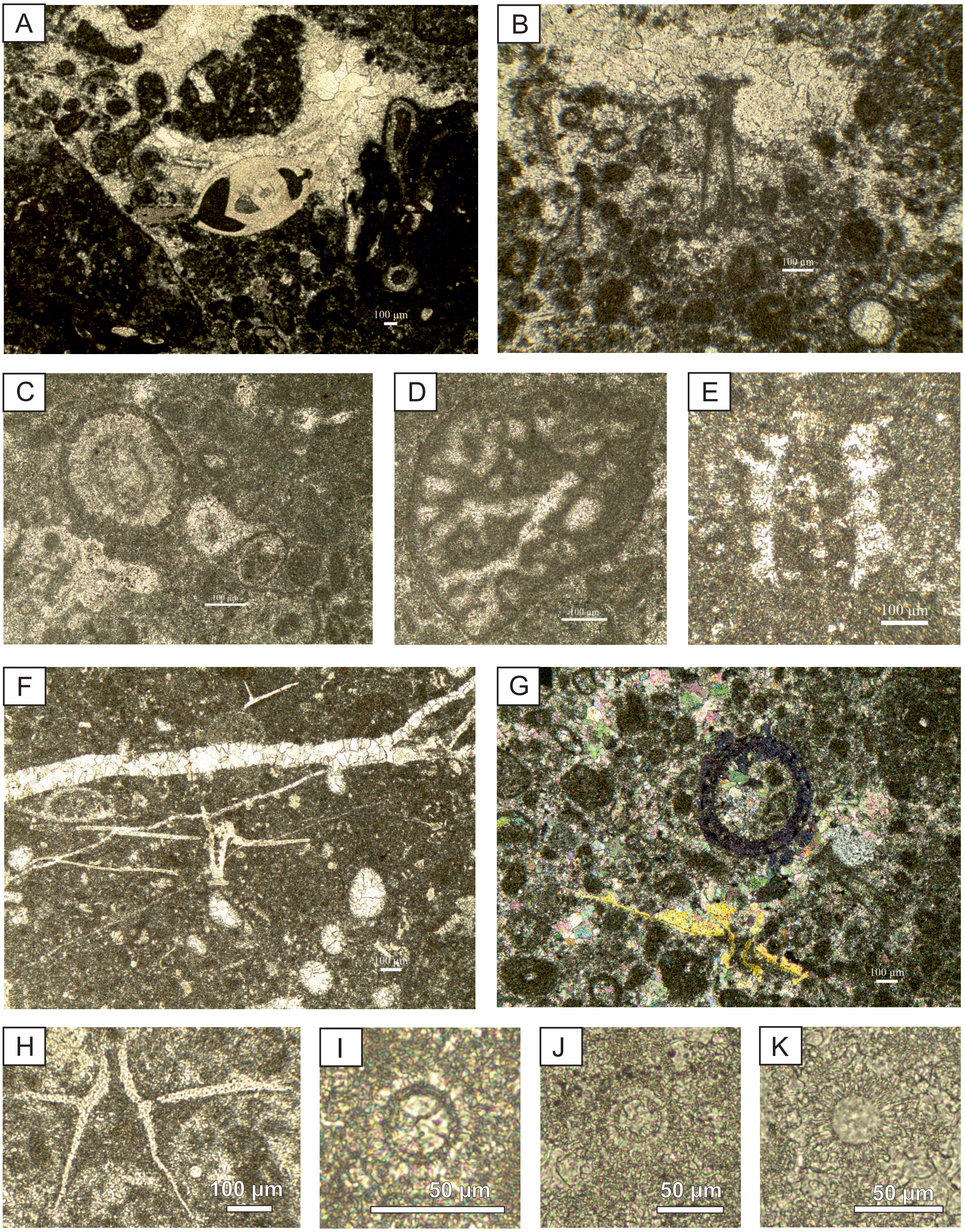

Fig. 8. Early Tithonian microfacies and microfossils. **A** — *Lenticulina* sp. in pelbiointraclastic packstone to grainstone, thin section 14981; **B** — *Mercierella dacica* Dragastan in pelbioclastic wackestone, thin section 14981; **C** — Fragments of dasycladacean algae, ooids and microproblematicum of *Muranella* sp. in bioclastic wackestone, thin section 14980; **D** — Fragment of *Pseudocyclammina lituus* (Yokoyama), thin section 14 980; **E** — *Salpingoporella annulata* Carozzi, thin section 14980; **F**–**H** — *Saccocoma* sp., thin sections 14980; 14981; **G** — *Terebella lapilloides* Münster, *Saccocoma* sp., in pelbiomicrosparite wackestone, thin section 14981; **I**, **J** — *Parastomiosphaera malmica* (Borza), thin sections 14980, 14981; **K** — *Colomisphaera minutissima* (Colom), thin section 14981.

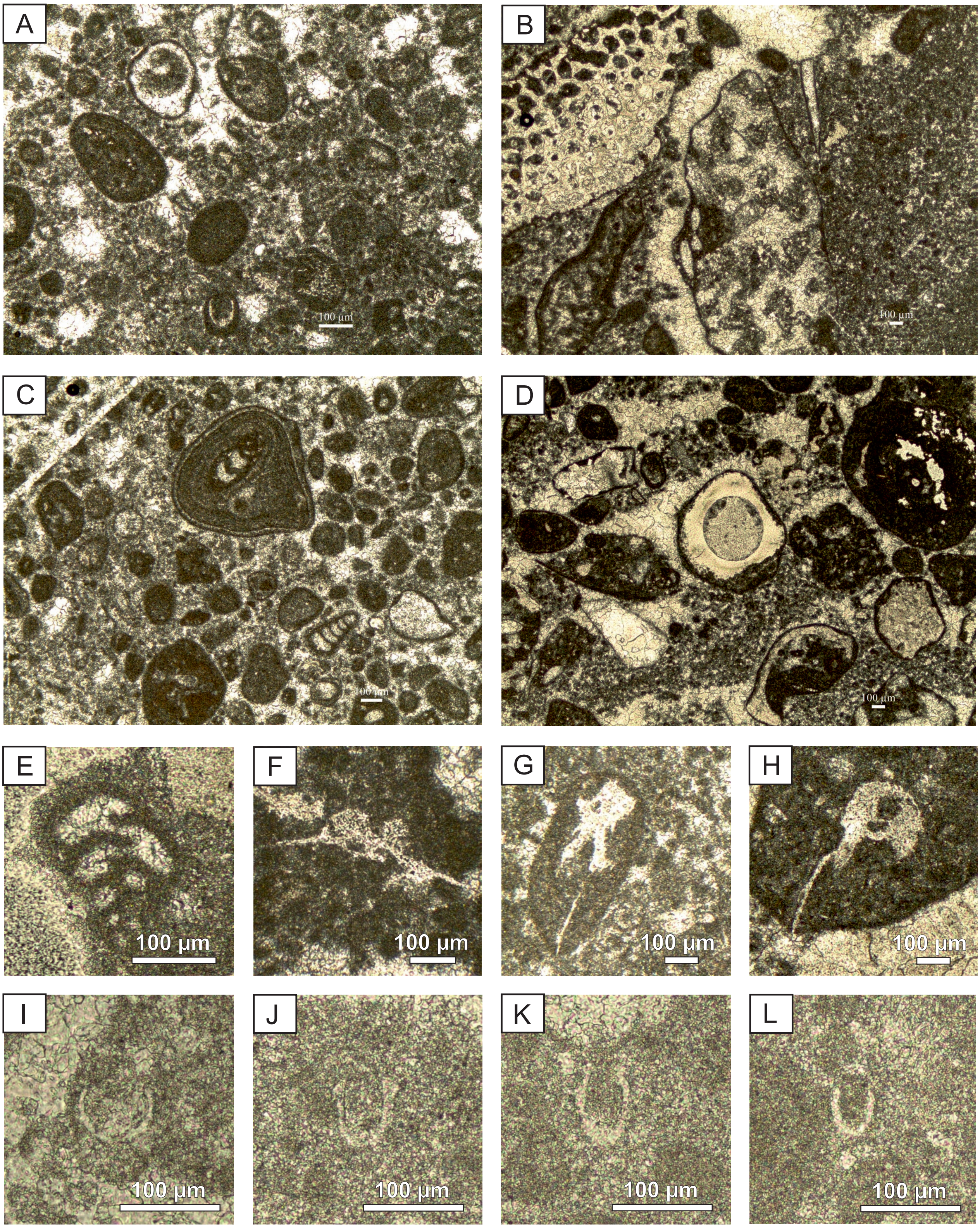

Fig. 9. Late Tithonian microfacies and microfossils. **A** — *Crescentiella morronensis* (Crescenti), gastropod shell and ?*Calpionella grandalpina* Nagy (lower middle part of the picture), in pelbiomicrosparite wackestone to packstone,thin section 14904; **B** — Fragments of bryozoa and sponges with encrusting foraminifera (*Nubecularia* sp.) in pelbioclastic wackestone, thin section 14982; **C** — Oncoids, foraminifera in pelbiooncoidal partially microsparite wackestone, thin section 14983; **D** — *Carpathocancer triangulates* (Mišík, Soták and Ziegler), microencrusters of *Crescentiella morronensis* (Crescenti), in pelbio intraclastic wackestone to packstone, thin section 14982; **E** — *Redmondoides lugeoni* (Septfontaine), thin section 14987; **F**–**H** — *Saccocoma* Aggasiz, thin section 14904; **I** — *Tintinnopsella remanei* Borza, thin section 14983; **J** — *Crassicollaria massutiniana* (Colom), thin section 14905; **K**–**L** — *Crassicollaria parvula* Remane, thin section 14905.

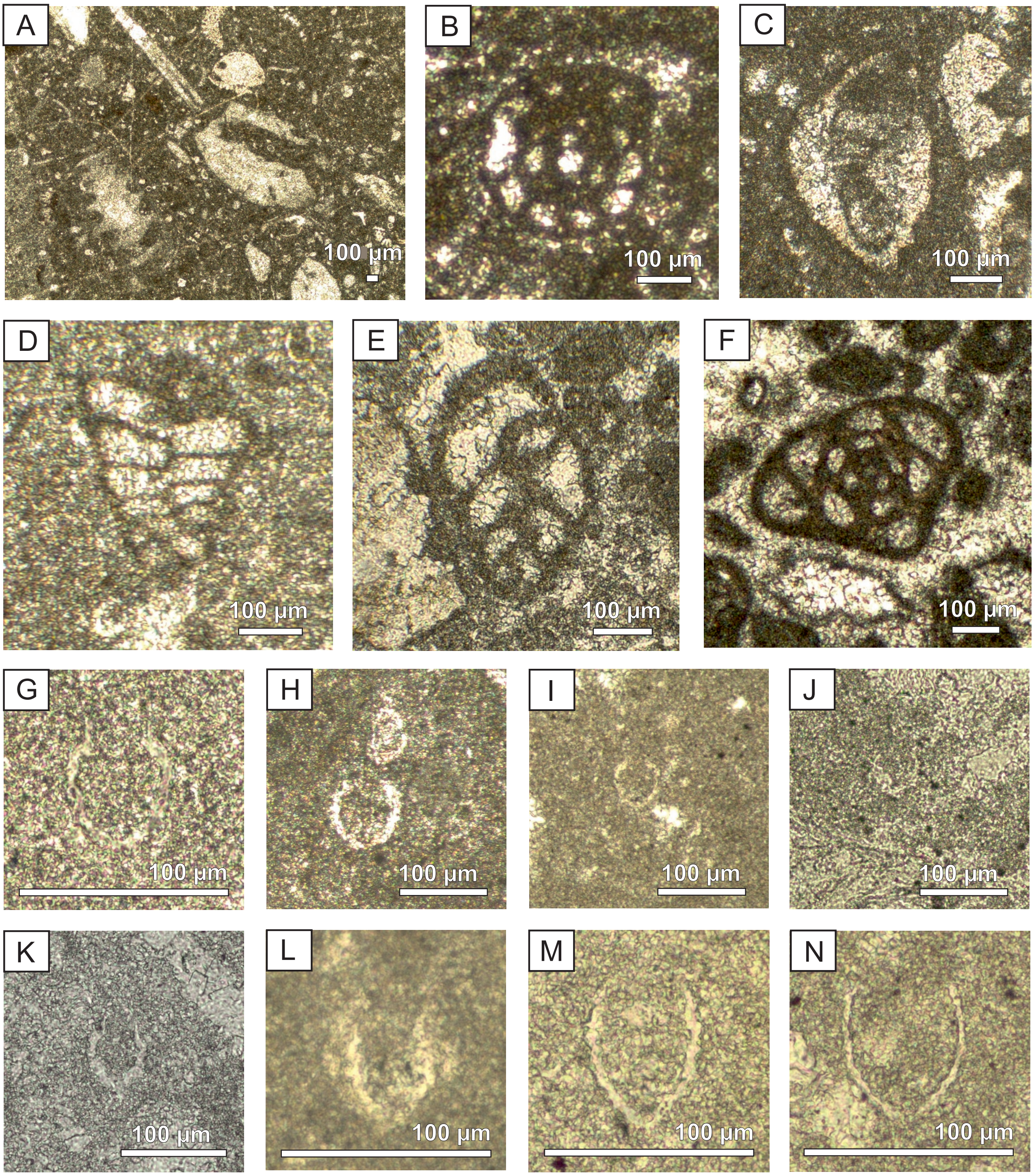

Fig. 10. Early Berriasian microfacies and microfossils. **A** — Bioclastic wackestone. There are *Andersenolina alpina* (Leupold), *Andersenolina cherchiae* (Arnaud-Vanneau, Boisseau and Darsac), crinoids, echinoids and calpionellids in micrite matrix, thin section 13714; **B** — *Haplophragmoides joukowskyi* Charrolais, Brönnimann and Zaninetti, thin section 14815; **C** — *Protopeneroplis ultragranulata* (Gorbachik), thin section 14986; **D** — *Pseudomarssonella* sp., thin section 13714; **E** — *Uvigerinammina uvigeriniformis* (Seibold and Seibold), thin section 14986. **F** — *Quinqueloculina verbizhiensis* Dulub, thin section 14815; **G–J** — *Calpionella alpina* Lorenz, thin sections 13714, 14815, 14987; **K–L** — *Crassicollaria parvula* Remane, thin sections 15842, 14984; **M–N** — *Tintinnopsella carpathica* (Murgeanu and Filipescu), thin section 13714.

Trocholina sp., *Ichnusella burlini* (Gorbatchik), miliolids (*Quinqueloculina verbizhiensis* Dulub; Fig. 10F), *Quinqueloculina frumenta* Asbel and Danitsch), microencrusters of *Crescentiella morronenis*, worm tubes of *Terebella lapilloides* Münster, calcimicrobes of *Girvanella* type, incertae sedis *Labes atramentosa* Eliášová, fragments of crinoids, echinoids, ophiuroids, corals, bryozoans, hydrozoa, dasycladacean algae, *Muranella* sp., brachiopods, ostracods, gastropods, bivalves, sponge spicules, juvenile ammonites and lithoclasts of biomicrite and pelbiomicrite wackestones (signalling synsedimentary erosion). Some of the bioclasts are silicified. On the basis of the calpionellid association early Berriasian Alpina Subzone of the standard Calpionella Zone can be established (Reháková & Michalík 1997). The presence of the foraminiferan species *Haplophragmoides joukowskyi* should also indicate a Berriasian age. Microfacies and the variable spectra of fossiliferous sediments mentioned above indicate that they were deposited in a rimmed platform environment (the external subtidal shallow marine conditions) with bioclastic shoal facies (Wilson 1975).

Discussion

The ammonite species that are described in the taxonomic part, deposited in several Moravian-Silesian museums and in Vienna, together with three species recently found in the Kotouč Quarry (as stated in Vašíček & Skupien 2016), represent, according to data in the literature and according to microfossils (calpionellids and cysts of calcareous dinoflagellates) found in thin sections, intervals of three different ages (see Fig. 11). The oldest belongs to the early Tithonian (thin sections Nos. 13748, 14980, 14981 and 15865), the second to the Late Tithonian (thin sections Nos. 14904, 14905, 14982, 14983 and 15119B) and the last to the early Berriasian (thin sections Nos. 13714, 13979, 14984, 14986 — 14988 and 15842).

The stratigraphically oldest assemblage of ammonites and microfossils are early Tithonian in age. It includes ammonites *Lithacoceras eigeltingense* (thin sections 14980–14981), *Blaschkeiceras schoepflini* (thin section 13748), *B. kittli* and *Kutekiceras pseudocolubrinum* (thin section 15685). The second assemblage of the late Tithonian ammonites includes *Paraulacosphinctes transitorius* (thin section 14904), relative species *P. senex* — thin sections 14905, 14982–14983 and *Boughdiriella chouetense* (nom. corr. in Frau et al. 2016),

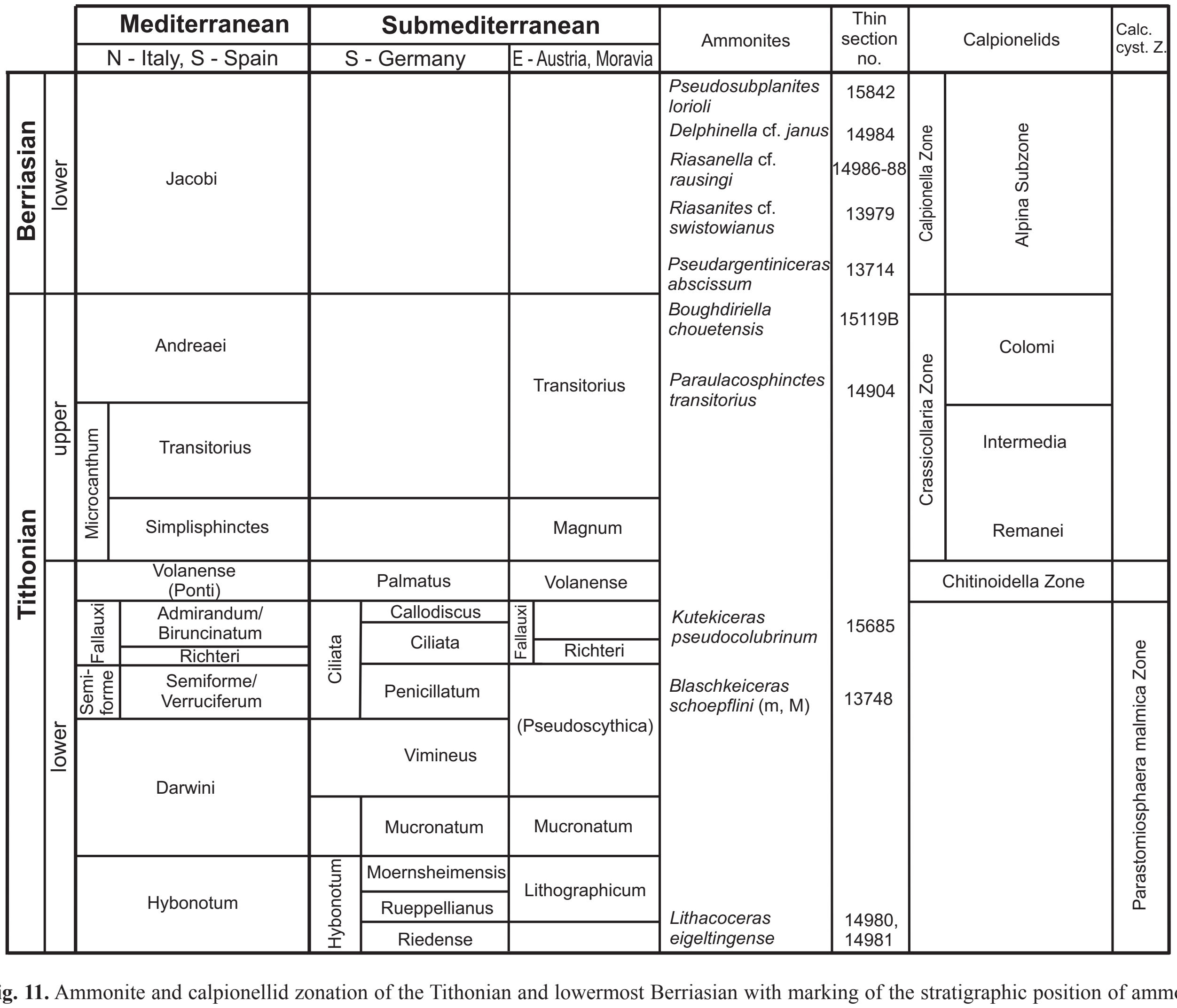

Fig. 11. Ammonite and calpionellid zonation of the Tithonian and lowermost Berriasian with marking of the stratigraphic position of ammonites and microfossils.

in thin section 15119B. The last assemblage contains the early Berriasian ammonites *Pseudargentiniceras abscissum* (thin section 13714), *Delphinella* cf. *janus* (thin section 14984), *Pseudosubplanites lorioli* (thin section 15842), *Riasanites* cf. *swistowianus* (thin section 13979) and *Riasanella* cf. *rausingi* (thin sections 14986–14988).

The large-sized specimen from the category of the entire processed set belongs to *Lithacoceras eigeltingense* Ohmert and Zeiss, 1980. *Parastomiosphaera malmica*, the marker of the early Tithonian calcareous dinoflagellate Malmica cysts Zone (Lakova et al. 1999; Reháková 2000), occurs abundantly in its rock matrix. According to the literature, this ammonite species occurs in the lower Tithonian in the *Hybonoticeras hybonotum* ammonite Zone, in the basal *Lithacoceras riedense* Subzone.

The second representative of the early Tithonian is *Blaschkeiceras schoepflini* (Blaschke, 1911), which belongs to the subfamily Sublithacoceratinae. Based on the study of the type material in Vienna, we have concluded that *B. schoepflini* (m) together with *Blaschkeiceras kittli* (M) form a dimorphic pair. In one of the derived thin sections from the associated rocks, *P. malmica* also occurs.

The late Tithonian is represented by *Paraulacosphinctes transitorius* (Oppel, 1865) and *Boughdiriella chouetense* Frau, Bulot and Wimbledon, 2015. *P. transitorius* is a rather problematic species. It is usually confused with *P. senex* (Oppel, 1868); as in the discussion in Vašíček & Skupien (2016). Based on the study of the type material in Munich, we have concluded that microconchs and macroconchs of *P. transitorius* were included in the type series. The shell size of the microconchs is less than about 130 mm, whereas that of the macroconchs is less than 260 mm. In one of the associated rocks (thin section 14904) the calpionellid associations are those of the lower part of the Crassicollaria Zone (Intermedia or Massutiniana subzones *sensu* Reháková & Michalík 1997; Lakova & Petrova 2013), which corresponds to the lower part of the upper Tithonian (*Paraulocosphinctes transitorius* ammonite Zone).

The late Tithonian species *B. chouetense,* as recently collected in France and found by us in the Kotouč Quarry (described in Vašíček & Skupien 2016), is a significant novelty for the Štramberk Limestone, both in the sense of the geographical distribution of the species and especially from a stratigraphic perspective. According to the authors of the species, *B. chouetense* occurs in the uppermost Tithonian in the *Protacanthodiscus andreaei* Zone. The spectra of calpionellids observed in the thin section No. 15 119B belong to upper part of the late Tithonian Crassicollaria Zone. The content of microfossils corresponds to the stratigraphic position of the mentioned species in Kotouč.

Five early Berriasian ammonite species and corresponding guide microfossils typical for the Alpina Subzone of the Calpionella Zone were identified in associated rock matrix. They are *Pseudosubplanites lorioli* (Zittel, 1870), *Delphinella* cf. *janus* (Retowski, 1893), *Pseudargentiniceras abscissum* (Oppel, 1865), *Riasanites* cf. *swistowianus* (Nikitin, 1888) and *Riasanella* cf. *rausingi* Mitta, 2011. With the exception of *P. lorioli*, all the above-mentioned species have already been illustrated and described in Vašíček & Skupien (2016). Our recent find of *P. lorioli* in the Kotouč Quarry also represents a novelty for the area of Štramberk because the mentioned species was not previously known from the Štramberk Limestone in that area. The lectotype of this species comes from the no longer existing locality of a worked out limestone quarry at Koňákov near Český Těšín, from a differently coloured grey limestone. The determined early Berriasian species correspond to a level in the *Berriasella jacobi* ammonite Zone.

From a palaeogeographic perspective, all the species described here are characteristic of the Mediterranean to Black Sea Tethyan area, but *Riasanites* and *Riasanella* belong to the Subboreal elements.

To classify stratigraphically the studied specimens and samples more accurately we have tried, based on current data in the literature, to compile a suitable ammonite and calpionellid zonation, as given in Fig. 11. It is the Tithonian deposits of the Pavlov Hills in southern Moravia and their continuation in the so-called Waschberg Zone of Lower Austria that are geologically the closest to Štramberk. The above mentioned Austrian region together with Štramberk was proposed by Zeiss (2001, 2003) as an ammonite zonation correlated with the zonation of the Mediterranean area (N. Italy, S. Spain and S. Germany). The ammonite zonation for southern Germany has been somewhat modified by Scherzinger & Schweigert (2003). Recently, Wimbledon et al. (2013) modified the upper Tithonian zonation, when in the uppermost Tithonian they defined the *Protacanthodiscus andreaei* Zone instead of the former *Durangites* (i.e. *Durangites vulgaris*) Zone. We have thus applied the mentioned changes in the Tithonian stage to our scheme in Fig. 11. In the recently most used ammonite zonation for the Lower Cretaceous, in the Berriasian stage, ammonite zones are placed according to Reboulet et al. (2014). Calpionellid zones follow the paper by Reháková & Michalík (1977) and the dinoflagellate cyst zonation is used after Reháková (2000). The ammonites of the youngest part of the Štramberk Limestone in the thin sections are accompanied by *Calpionella alpina.*

In the now used ammonite zonation (Fig. 11) based on both data in the literature and the accompanying guide microfossils in the ammonite matrices, we placed the derived stratigraphic position of the ammonite species under study coming from the Štramberk Limestone in the Kotouč Quarry. In accordance with Zeiss (2001) we regard the area of Štramberk in the Outer Western Carpathians as part of the ammonite Submediterranean bioprovince.

Conclusions

The occurrence of rare but stratigraphically important calcareous microfossils (dinoflagellates and calpionellids) in the Štramberk Limestone matrix filling and surrounding ammonite specimens has allowed us to identify the early Tithonian Malmica cyst Zone, the late Tithonian Crassicollaria Zone and the early Berriasian Calpionella alpina Subzone of the standard Calpionella Zone. This brings more light to the age of unlocalized ammonite specimens collected in the past and residing in museum collections without their exact localization.

From the perspective of taxonomy, the finding of sexual dimorphism in the species *Blaschkeiceras schoepflini* (m), forming a dimorphic pair with *B. kittli* (M), and the finding of two shell size groups in the case of *Paraulacosphinctes transitorius* (without different species names), are of importance to the studied ammonites. Smaller shells belong to microconchs (m), and shells that are up to twice as large belong to macroconchs (M).

The most significant new stratigraphic information is the determination of *Lithacoceras eigeltingense.* This species occurs in the basal part of the lower Tithonian, in the *Hybonoticeras hybonotum* ammonite Zone. This circumstance moves the previously stated stratigraphic range of the Štramberk Limestone (also according to the microfossil data), one ammonite zone lower. In the data given by Oloriz and Tavera (1982), coming from Zámek Hill Quarry, the basal part of the Tithonian in the Štramberk Limestone was unknown. The recent find of an exactly localized *Boughdiriella chouetense* in the Kotouč Quarry is also of substantial importance. According to data in the literature, this species occurs in the upper part of the *Protacanthodiscus andreaei* ammonite Zone, which means in the uppermost Tithonian. Other ammonites that unambiguously indicate the uppermost Tithonian not yet known in the area around Štramberk.

On the other hand, our results confirm that the youngest part of the Štramberk Limestone belongs to the early Berriasian, to the *Berriasella jacobi* ammonite Zone (or Berriasella jacobi *auctorum* Zone according to Frau et al. 2016 b) or to the *Calpionella alpina* Subzone.

The occurrence of *Riasanites* and *Riasanella* in the Štramberk Limestone is remarkable and indicates early Berriasian communication of the Silesian Unit with the Subboreal region of the Russian Platform. Moreover, the fact that both microfauna and accompanying ammonites prove the early Berriasian for both species of *Riasanites* and *Riasanella* determined herein is also of stratigraphic significance.

Acknowledgements: For access to or loans of collection material we are obliged to Dr. O. Frühbauerová (Nový Jičín Regional Museum), Dr. L. Jarošová (Silesian Museum of Opava) and Prof. Dr. H. Immel (University Munich). For consultations and advice in the identification of some species we are grateful to Dr. G. Schweigert (Staatliches Museum für Naturkunde, Stuttgart). We thank M.A. Rogov (Russian Academy of Sciences) A. Wierzbowski (University of Warsaw) and W. Wimbledon (University of Bristol) for review with constructive remarks and suggestions, We also thank K. Mezihoráková (Ostrava) for taking the majority of the photographs, Assoc.-Prof. Ing. J. Ščučka Ph D. for supplying photographs of macroconchs and Dr. M. Hyžný (Comenius University in Bratislava) for taking photographs of *Blaschkeiceras schoepflini* and *B. kittli* deposited in Blaschke's collection in Vienna. We also express our thanks to the management of Kotouč Quarry for allowing access to their grounds. The present paper has been supported by the Project for Long-Term Strategic Development of the Institute of Geonics, Czech Academy of Sciences and project GACR 16-09979S. The research of D. Reháková was supported by the APVV-14-0118 project, as well as by the VEGA Projects 2/0034/16 and 2/0057/16.

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