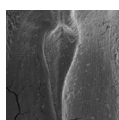


Lower-Middle Devonian (upper Emsian-Eifelian, *serotinus-kockelianus* zones) conodont faunas from the Prague Basin, the Czech Republic

STANISLAVA BERKYOVÁ



Lower-Middle Devonian conodonts (*serotinus-kockelianus* zones) from the Třebotov Limestone (Daleje-Třebotov Formation) and Choteč Limestone (Choteč Formation) were studied. The following sections in the Prague Basin were sampled in an attempt to refine the conodont biostratigraphy of this sequence: Barrandov road cut, Prastav quarry at Holyně, Jelínek mill quarry at Chýnice and Červený quarry near Suchomasty. Another aim was to collect new data from sections which have not been sampled before: Na Škrábku quarry at Choteč, U Němců section at Karlštejn and Na vyhlídce section at Hostím. The main focus was on clarifying ranges of individual conodont taxa and thus enabling more precise correlations to be made. Among the most important findings is the lower occurrence of *Polygnathus costatus partitus* Klapper, Ziegler & Mashkova (the defining species for the Lower-Middle Devonian boundary), recorded in its regional reference section (Prastav quarry) but 2.2 m below the previous boundary. The correlation between the onset of the Basal Choteč event, as well as the occurrence of *Polygnathus* sp. aff. *Polygnathus trigonicus*, with the base of the *costatus* Zone is supported by the results of this study. • Key words: Lower-Middle Devonian, conodont biostratigraphy, Prague Basin.

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Lower-Middle Devonian conodonts from the Prague Basin are the subject of the present research. The interval studied comprises the Třebotov Limestone (Daleje-Třebotov Formation, upper Emsian-lowermost Eifelian) and Choteč Limestone (Choteč Formation, Eifelian) and their shallow-water counterparts (Suchomasty and Acanthopyge limestones). The following sections were sampled (Fig. 1): Barrandov road cut, Prastav quarry at Holyně, Na Škrábku quarry at Choteč, Jelínek mill quarry at Chýnice, U Němců section at Karlštejn, Červený quarry near Suchomasty and Na vyhlídce section at Hostím. These sections were studied within the framework of the author's Ph.D. thesis, which deals with environmental changes that took place close to the Lower-Middle Devonian boundary, the Basal Choteč event. Detailed sampling for biostratigraphic purposes turned out to be a necessity in order to enable global correlations with this event, which has previously been correlated with the base of the *costatus* Zone, the entry of the goniatite *Pinacites jugleri* and the boundary of the *Nowakia holynensis*/*N. sulcata* zones (Chlupáč & Kukal 1986). There is a distinct basin-wide change in sedimentation patterns during this time interval with the deposition of light bioturbated skeletal wackstones (Třebotov Limestone) to

dark, well washed peloidal grainstones alternating with dark lime mudstone and gray, poorly bioturbated wackstones (Choteč Limestone). The above mentioned sections were sampled in order to refine the existing conodont zonal scheme and to provide new data for sections which have not been sampled previously.

History of conodont studies in the Prague Basin (Lower-Middle Devonian boundary interval)

The first conodont studies of Lower-Middle Devonian strata from the Prague Basin took place in the 1970s and were focused on sequences from the top of the Zlíchov Formation (Lower Emsian) to the top of the Choteč Limestone (Eifelian), with the emphasis on the position of the Lower-Middle Devonian boundary. The following sections in the Prague Basin had already been studied by preceding authors, especially with respect to Lower-Middle Devonian conodont taxonomy and biostratigraphy: Prastav quarry at Holyně, Jelínek mill quarry at Chýnice, Císařská roklo gorge at Srbsko, Hlubočepy-Vysoká quarry (Klapper

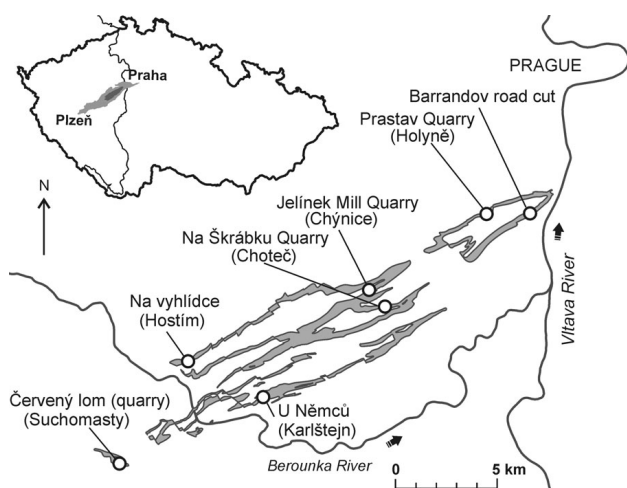


Figure 1. Schematic map showing location of the Prague Basin in the Czech Republic and distribution of the Daleje-Třebotov and Choteč formations with positions marked of sections sampled. Location plan of the Daleje-Třebotov and Choteč formations (marked in grey) is based on geological maps (1 : 25 000) published by the Czech Geological Survey.

1977a, Klapper *et al.* 1978), Hlubočepy-railway cut (Ziegler in Chlupáč *et al.* 1977), Červený quarry near Suchomasty (Klapper 1977a, Klapper *et al.* 1978, Weddige & Ziegler 1987, Kalvoda & Zikmundová in Galle & Hladil 1991), Barrandov road-cut section (Zusková 1991), Jirásek quarry (Kalvoda in Hladil & Kalvoda 1993, Kalvoda & Zikmundová in Galle & Hladil 1991) and Preisler quarry in the Koněprusy area (Kalvoda & Zikmundová in Galle & Hladil 1991).

Studied sections

Prastav quarry, Fig. 2A ($50^{\circ}02'05.6''N$, $14^{\circ}21'14.9''E$). – An abandoned quarry situated N of Prague-Holyně. Regional reference section of the Lower-Middle Devonian boundary. Třebotov and the base of the Choteč limestones are well exposed in this section. Relevant papers are: Chlupáč (1959), Klappper (1977), Klapper *et al.* (1978), Chlupáč *et al.* (1977), Chlupáč *et al.* (1979), Chlupáč (1982, 1985), Buggisch & Mann (2004), Ellwood *et al.* (2006) and Koptíková (accepted). The following conodont zones have been recognized: *serotinus*, *patulus*, *partitus*, *costatus* zones. Klapper (1977) and Klapper *et al.* (1978) provided a first conodont zonation. According to new data, the base of the *partitus* Zone (Lower-Middle Devonian boundary) lies 5 m below the base of the Choteč Limestone, which is 2.2 m lower than the previously reported lowest occurrence of *P. c. partitus*. The first *P. costatus patulus* in this study was found 4.5 m below the base of the Choteč Limestone, which is 1.5 m higher than that reported by Klapper (1977). For that reason, the base of the *patulus* Zone has been drawn according to previously

published data at this section. *P. c. costatus*, which has not been found previously, was recorded 2 m above the base of the Choteč Limestone. That is in agreement with Klapper *et al.*'s (1978) study in which *Polygnathus* sp. aff. *P. trigonicus* was reported 1.75–1.8 m above the base of the Choteč Limestone (for a discussion on correlation of occurrence of the latter mentioned taxon and the base of the *costatus* Zone see text below). A correlation between the *costatus* Zone and the presence of *P. sp.* aff. *P. trigonicus* had been suggested earlier (Klapper *et al.* 1978, p. 105).

Barrandov road cut, Fig. 2B ($50^{\circ}02'08''N$, $14^{\circ}23'33''E$). – The Třebotov Limestone and the base of the Choteč Limestone crop out in this section which was exposed during construction of the main road system in Prague, (Lukeš 1989 and Zusková 1991). Bases of the *patulus* and the *partitus* zones were drawn according to data published by Zusková (1991), as occurrences reported in this study are higher. The first occurrence of *P. c. costatus* (two specimens) was reported 1.25 m below the base of the Choteč Limestone in this study. This is the first record of this taxon below the base of the Choteč Limestone in the Prague Basin. The *australis* Zone is drawn at this section with a question mark on the basis of the lowest occurrence of *P. pseudofoliatus*. The overlap of the base of the *australis* Zone and the lowest occurrence of *P. pseudofoliatus* is not completely certain, as a lower range of this taxon cannot be ruled out (see text below). The thickness of rocks corresponding to the *costatus* Zone would be 3.5 m, which is in contrast to other sections in the Prague Basin; however, there is some evidence for condensed sedimentation in this section. Among these are intervals with hardgrounds and from which a higher number of conodont elements were recovered. Furthermore, in this section the Choteč Limestone is only 6 m thick, and is overlain by the Srbsko Formation, however, the contact itself is covered and therefore a physical unconformity cannot be ruled out.

Na Škrábku quarry, Fig. 3 ($49^{\circ}59'20''N$, $14^{\circ}16'45''E$). – An abandoned quarry situated at the foot of Škrábek hill in the village of Choteč and stratotype of the Choteč Limestone. The Třebotov and Choteč limestones both crop out in this section. Relevant papers are: Chlupáč (1959), Svoboda & Prantl (1948), Buggisch & Mann (2004) and Koptíková (accepted). The following conodont zones were recognized (this study): *serotinus*, *patulus*, *partitus*, *costatus*, *australis* Zone (the last mentioned zone with a question mark). The first occurrence of *P. c. partitus* (the Lower-Middle Devonian boundary) was documented 3.4 m below the base of the Choteč Limestone. *P. c. costatus* was found 5 m above the base of Choteč Limestone; however, the base of the *costatus* Zone was drawn according to the occurrence of *Polygnathus* sp. aff. *P. trigonicus*

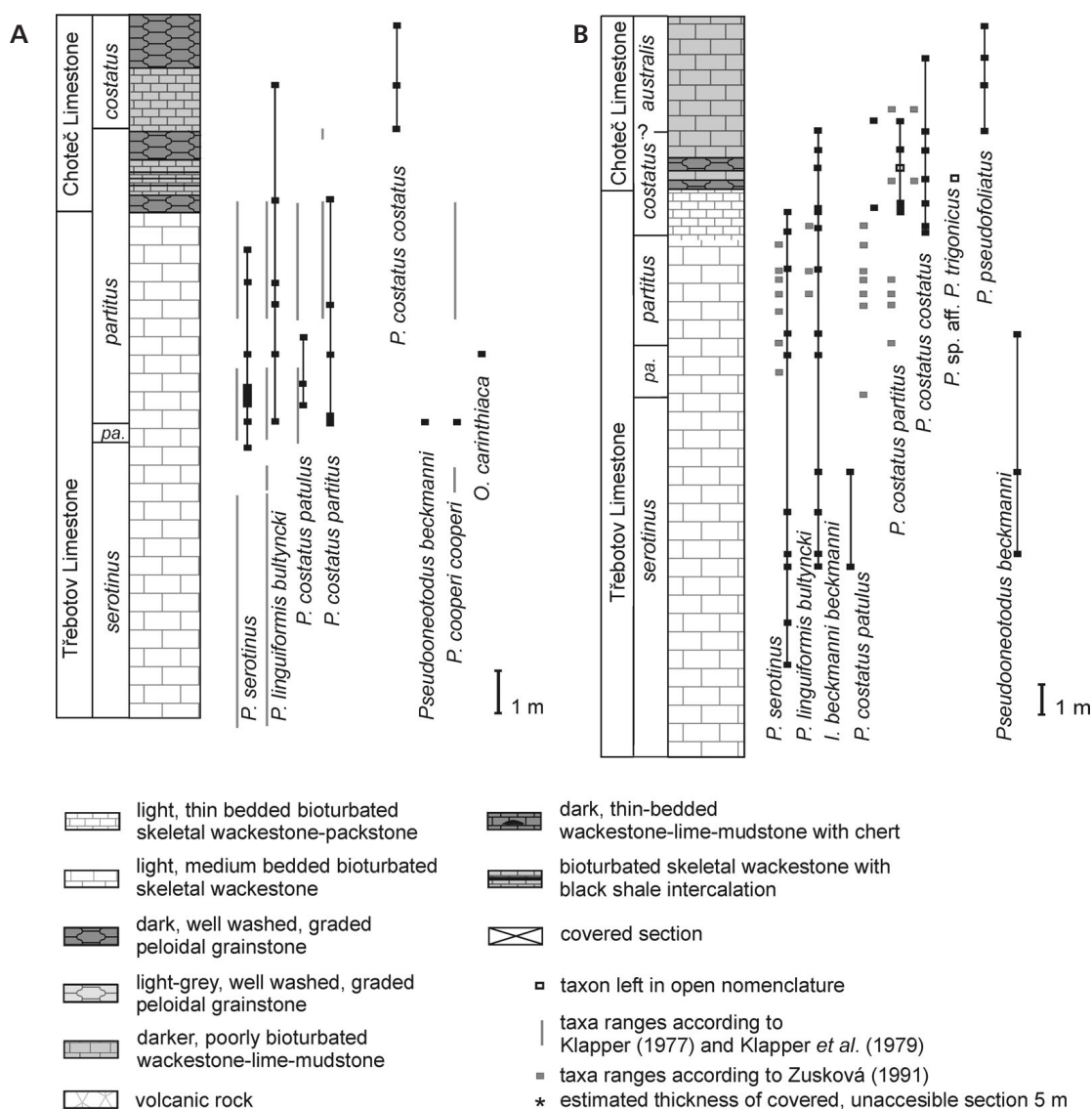


Figure 2. A – simplified lithological column of the Prastav quarry with conodont ranges. The bases of the *serotinus* and *patulus* zones are drawn according to data published by Klapper (1977a) (the lower part of the section was not sampled). • B – simplified lithological column of the Barrandov road cut section with conodont ranges. The bases of the *patulus* and *partitus* zones were drawn according to data published by Zusková (1991). Abbreviations: pa. – *patulus* Zone, au. – *australis* Zone, kockel. – *kockelianus* Zone.

(see text below) which was found 0.2 m above the base of the Choteč Limestone. According to previously compiled data (Weddige 1977, Klapper & Johnson 1980, Wang & Ziegler 1983, Bardashev 1992), the earliest occurrence of *P. trigonicus* is known from the *australis* Zone. Similarly, the lower stratigraphical range of *P. pseudofoliatus* was recorded in the *australis* Zone (Weddige 1977, Klapper & Johnson 1980, Wang & Ziegler 1983, Mawson & Talent 1989, Bardashev 1992) with the exception of its occurrence in the *costatus* Zone as recorded by Belka *et al.* (1997). Therefore, in this locality, the base of the *australis* Zone was drawn (with the question mark) on the basis of the occurrences of *P. pseudofoliatus* and *P. trigonicus*.

Na vyhlídce at Hostím, Fig. 4A (49°57'41,9" N, 14°07'48"E). – Exposures of the Třebotov Limestone and almost the whole succession of the Choteč Limestone occur in small, abandoned quarries and in the cutting of the path on the left bank of the Loděnice ("Kačák") brook. Close surroundings were studied by Svoboda & Prantl (1953), Chlupáč (1959) and Chlupáč *et al.* (1979). Conodont faunas are scarce in this section, thus more sampling associated with trenching (parts of the section are covered) is necessary. The following conodont zones have been recorded so far: *serotinus*, *partitus*, *costatus* and *kockelianus* zones, the base of the *australis* Zone is questioned here as it is drawn according to the occurrence of *P. pseudofoliatus*. However, as mentioned above, the occurrence

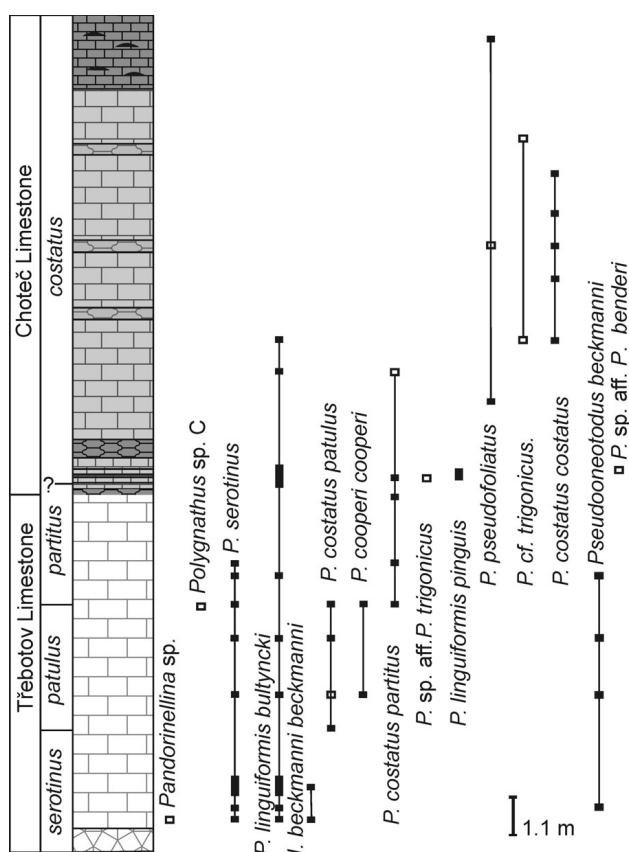


Figure 3. Simplified lithological column of the Na Škrábku quarry at Choteč with conodont ranges. See legend in Fig. 2. The base of the *costatus* Zone is drawn according to the occurrence of *P. sp. aff. P. trigonicus*.

of *P. pseudofolius* in the *costatus* Zone as recorded by Belka *et al.* (1997), should be taken into account.

Jelínek mill at Chýnice, Fig. 4B (49°59'50.6" N, 14°16'13.8" E). – An old quarry situated on the left bank of the Radotínský potok brook, E of the Chýnice village. Almost the whole succession of the Třebotov and Choteč limestones crop out here. This section was studied in detail by Chlupáč (1959), Klapper (1977), Klapper *et al.* (1978) and Chlupáč *et al.* (1979). Klapper (1977) provided the first conodont data from this section, recording *patulus*, *partitus* and *costatus* zones. The following zones have been recorded in this study: *serotinus*, *patulus*, *partitus*, *costatus*, *australis* and *kockelianus* zones. The first *P. c. patulus* was recorded 5.6 m below the base of the Choteč Limestone, the first *P. c. partitus* was recorded 4.7 m below that same datum, thus the thickness of rock corresponding to the *patulus* Zone would be approximately 1 m, which is comparable to the Prastav quarry, where it is even less – 0.5 m and the Barrandov road cut, where it is 1.8 m. However, more detailed sampling should be carried out to confirm this, as taphonomic and sampling biases cannot be ruled out. The first *P. c. costatus* was found

0.9 m above the base of the Choteč Limestone, which is in agreement with Klapper (1977), who recorded this taxon from the interval of 1.03–1.13 m above the base, together with *Polygnathus* sp. aff. *P. trigonicus*. This fact supports the possibility of a correlation between the last mentioned taxon with the base of the *costatus* Zone in the Prague Basin. *Polygnathus* sp. aff. *P. trigonicus* was recorded in this study 6 m above the base of the Choteč Limestone (5 m above FAD of *P. c. costatus*). The first appearance of *Tortodus kockelianus australis* was recorded approximately 30 m above the base of the Choteč Limestone in this study; an exact measurement cannot be given, as parts of the section are covered and inaccessible. The first *T. k. kockelianus* was found 3 m above the first appearance of *T. k. australis*.

U Němců section at Karlštejn (N 49°56'37.207", E 14°11'0.96"). – The whole succession of the Třebotov and Choteč limestones are exposed in this section in Karlštejn village, in the backyard (and surroundings) of a private house, opposite to the small hotel "Pod Dračí skálou". Svoboda & Prantl (1955), Chlupáč (1959), and Budil (1995) studied the immediate surroundings. The conodont fauna is very scarce here, especially in the Choteč Limestone. *P. serotinus*, *P. linguiformis bultyncki*, *P. c. partitus*, *P. c. costatus* and unidentifiable juveniles only were found. *P. c. partitus* was found 3 m below the base of the Choteč Limestone, represented by only one specimen. One specimen of *P. c. costatus* was found 10 meters above the base of the Choteč Limestone. This outcrop represents a very important section, with the whole succession of the Třebotov Limestone (graded from the Daleje shales) and the Choteč Limestone (overlain by the Srbsko Formation) being exposed and therefore the present author continues to seek more data and to construct a more precise conodont zonal scheme for this section.

Červený quarry near Suchomasty (49°54'37.54" N, 14°04'38.35" E). – A quarry situated SE of the Koněprusy village, near the road from Koněprusy to Suchomasty, the stratotype of the Suchomasty Limestone. The whole succession of the Suchomasty Limestone and the base of the Acanthopyge Limestone are exposed. The following authors considered the stratigraphy, paleontology and sedimentology of this section: Chlupáč (1959), Chlupáč *et al.* (1979), Klapper (1977), Klapper *et al.* (1978), Weddige & Ziegler (1987), Havlíček & Kukal (1990), Galle & Hladil (1991), Ellwood *et al.* (2006) and Koptíková (accepted). Conodont biostratigraphy of the Suchomasty Limestone was provided in detail by Klapper (1977), Klapper & Zikmundová in Chlupáč *et al.* (1977) and Klapper *et al.* (1978). The cited authors recorded the following conodont zones: *laticostatus*, *serotinus*, *patulus* and *partitus* zones. Only the very base of the Acanthopyge Limestone was for-

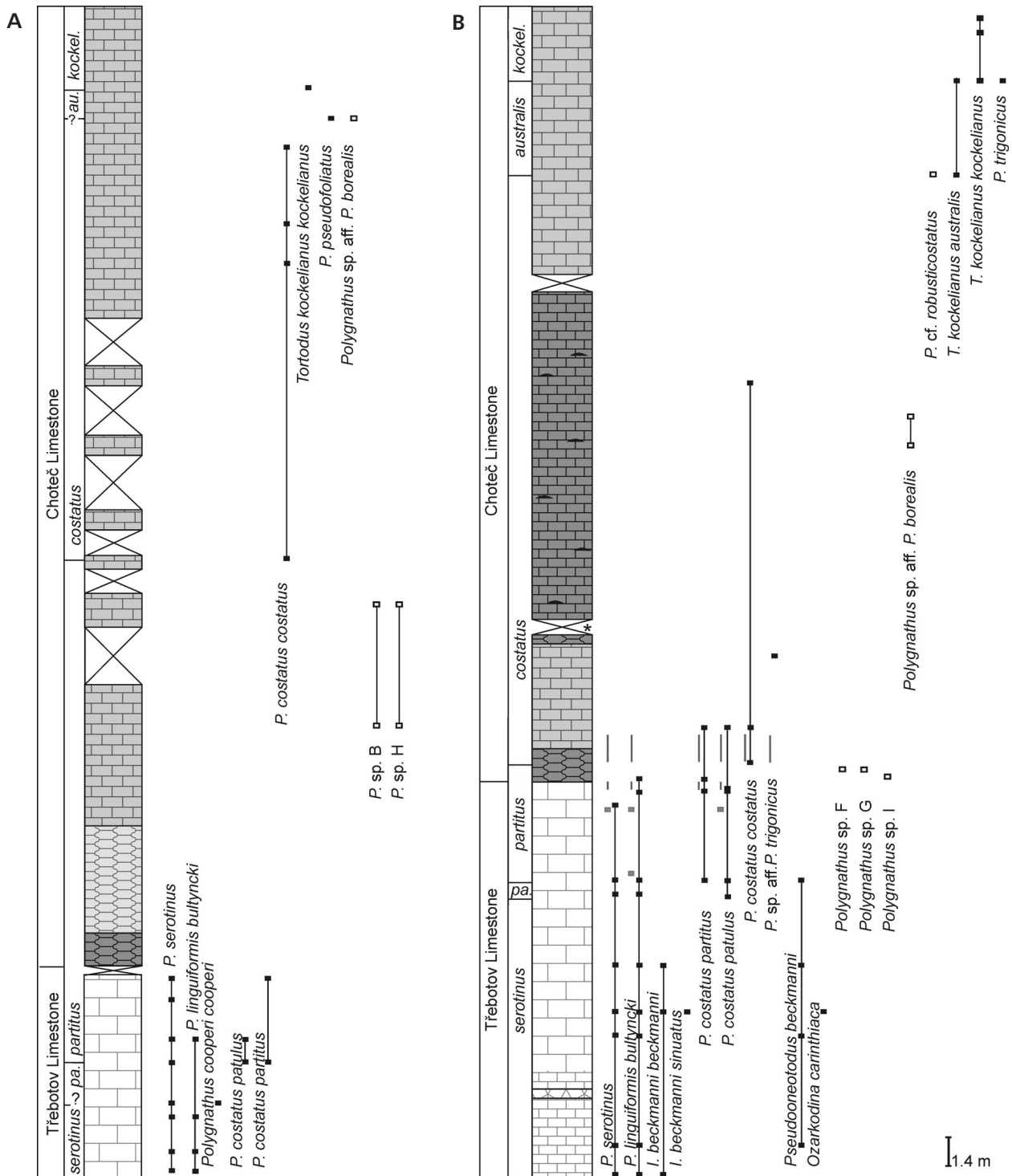


Figure 4. Simplified lithological columns of the Na vyhlídce section at Hostím (A) and Jelínek mill quarry at Chýnice (B) with conodont ranges. See legend in Fig. 2.

merly accessible at this quarry and thus this unit has not been sampled, except for its base, where Klapper *et al.* (1978) recorded *P. sp. aff. P. trigonicus*, *P. c. partitus* and *P. l. bultyncki*. Conodonts are more common in both the Suchomasty and Acanthopyge limestones in comparison to ot-

her studied sections; furthermore, adult specimens are better represented here. The occurrence of *P. serotinus* in the Acanthopyge Limestone was recorded, which is in contrast to other sections in the Prague Basin where elements of this taxon were not recorded from the Choteč Limestone.

Correlation of the *costatus* Zone, occurrence of *Polygnathus* sp. aff. *P. trigonicus* and the base of the Choteč Limestone

As mentioned previously, the onset of sedimentation of the Choteč Limestone reflected the effects of the Basal Choteč event, which has been roughly correlated with the base of the *costatus* Zone (Chlupáč & Kukal 1986). The appearance of *P. c. costatus* in this study was recorded at 1 m above the base of the Choteč Limestone in the Jelínek mill section, 5 m above the base of the Choteč Limestone in Na Škrábku quarry and 2 m above its base in the Prastav quarry. The exception is its occurrence at the Barrandov road-cut section, where its FAD was recorded 1.25 m below the base of the Choteč Limestone (below the first dark crinoidal grainstone). With respect to this, it is necessary to mention that a change in sedimentation had already been observed at the top of the Třebotov Limestone in this section, approximately at the level of the FAD of *P. c. costatus*. The sediments at this level are represented by skeletal wacke-packstones with intercalation of organic rich, bioturbated wackestone with prasinophytes (green algae). Similar algal blooms are also found at the base of the Choteč Limestone elsewhere in the Prague Basin (e.g. Na Škrábku quarry, U Němců section and also, to a lesser extent, Prastav quarry). The level with prasinophyte accumulation in this section is regarded as a first lithological manifestation of environmental changes that took place (the Basal Choteč event), therefore, it seems so far that the supposed correlation of the above mentioned event with the base of the *costatus* Zone can be supported.

The correlation of the base of the Choteč Limestone with the base of the *costatus* Zone (defined by the first appearance of *P. c. costatus*) may not be exactly coincident. As mentioned above, the base of the Choteč Limestone is in most sections represented by graded grainstones, the sedimentation of which may have been very fast. Furthermore, the rate and pattern of sedimentation may have been different in individual sections; therefore the first appearance of this taxon may have been affected by those circumstances. According to both new and previously published data (Klapper, personal communication, Klapper *et al.* 1978), it seems that the occurrence of *Polygnathus* sp. aff. *P. trigonicus* is characteristic for the base of the *costatus* Zone, not only in the Prague Basin but also elsewhere (Klapper 1971, Perry *et al.* 1974). For the above-mentioned reason, the base of the *costatus* Zone in the Na Škrábku quarry section is drawn according to the FAD of this taxon. Klapper *et al.* (1978) described *Polygnathus* sp. aff. *P. trigonicus* 1.75–1.8 m above the base of Choteč Limestone in the Prastav quarry, which is 20 cm below the FAD of *P. c. costatus* (this study). Similarly, in this study this taxon was found 30 cm above the base of the Choteč

Limestone at the Barrandov road-cut section (1.6 m above the bed with the first *P. c. costatus*). Klapper *et al.* (1978) also recorded *P. sp. aff. P. trigonicus* and *P. c. costatus* from the same sample approximately 1 m above the base of the Choteč Limestone in the Jelínek mill quarry. If this correlation proves to be valid, then it would have important implications for global correlation of the *costatus* Zone and consequently, the Basal Choteč event.

Conodont biostratigraphy

It should be remembered that the Lower-Middle Devonian conodont zonal concept does not mirror the total ranges of the zonally defining taxa. The persistence of a stratigraphically older taxon into a younger zone or zones is common. The principle of using a first appearance datum of a zonal taxon to define the base of a particular zone was followed (Weddige 1977, Weddige *et al.* 1979, Klapper 1977a). With the exception of *P. serotinus*, *T. kockelianus kockelianus* and *T. k. australis* the zonal scheme is based on the *P. costatus patulus*, *P. c. partitus* and *P. c. costatus* lineage, thus on taxa with close phylogenetic affinity. Because of that, certain problems in global correlations may arise as a consequence of different taxonomical approaches. Therefore, significant attention was paid in this paper to the description and photographic illustration of the “*costatus* group” from the Prague Basin, which represents the type area of one of the zonally defining subspecies (*P. c. partitus*). The conodont faunas studied are of very low diversity and also abundance, spanning six zones (*serotinus-kockelianus* zones). Representatives of juveniles in the offshore deposits prevail, which complicated the taxonomic and biostratigraphic assessment to a certain point, as juveniles cannot be identified to the species level with confidence. On the other hand, in the more shallow water settings (Červený quarry, Koněprusy area) adults prevail.

The ranges of zonally defining taxa found in the Prague Basin were as follows: *P. serotinus* (index taxon of the *serotinus* Zone) was recorded in the *serotinus*, *patulus*, *partitus* zones and at the very base of the *costatus* Zone (the last *P. serotinus* was found in the sample with the first *P. c. costatus*). *P. costatus patulus* (index taxon of the *patulus* Zone) was recorded in the *patulus*, *partitus* and the base of the *costatus* zones. *P. c. partitus* (index taxon of the *partitus* Zone) was recorded in the *partitus* and *costatus* zones. *P. c. costatus* (index taxon of the *costatus* Zone) was recorded in the *costatus* and *australis* zones. Representatives of *T. k. australis* (index taxon of the *australis* Zone) were not found in sufficient numbers to make a judgment about its stratigraphical range. Only two specimens were found, not however in the sample with *T. k. kockelianus* (index taxon for the *kockelianus* Zone). Only rocks corresponding to the base of the *kockelianus* Zone (upper part of the

Choteč Limestone) were sampled and thus the stratigraphical range of the last taxon cannot be discussed. The above-mentioned findings are in agreement with data published by Klapper *et al.* (1978) from the Prague Basin (with the exception that a higher range of *P. c. costatus* was recorded in this study) and also with data from Europe (*e.g.*, Ziegler 1977), N. Africa (*e.g.*, Belka *et al.* 1999), N. America (*e.g.*, Klapper & Johnson 1980), Australia (*e.g.*, Mawson & Talent 1989) and Asia (*e.g.*, Wang & Ziegler 1983). For discussion of the upper range of *P. serotinus* see below. On the basis of the authors' own observations and data already published, it seems so far, that only the *australis* Zone is defined by the total range of its defining taxon (but see also Klapper & Johnson 1980, p. 422, table 8 for recorded occurrence of *T. k. australis* in the *kockelianus* Zone in the Rhenish Slate Mts). Upper ranges of zonally defining taxa, which extend into a younger zone (zones), may represent a handicap for correlation, especially when only a limited number of elements are recovered. Therefore, the conodont zonation itself may not be a perfect correlation tool for this critical time interval (*serotinus-kockelianus* zones). If possible, the accompanying fauna should be taken into consideration, not only conodont taxa but also other fossil groups (*e.g.*, dacryoconarid tentaculites). In addition, the usage of other stratigraphical methods such as chemostratigraphy and magnetic susceptibility is very promising for regional as well as global correlations.

The following genera and species were recovered: *Polygnathus serotinus*, *P. linguiformis bultyncki*, *Icriodus beckmanni beckmanni*, *I. b. sinuatus*, *Ozarkodina carinthiaca*, *P. cooperi cooperi*, *P. costatus patulus*, *P. c. partitus*, *P. costatus costatus*, *P. sp. aff. P. trigonicus*, *P. linguiformis pinguis*, *P. trigonicus*, *Tortodus kockelianus australis*, *T. k. kockelianus*, *P. pseudofolius*, *Pelekysgnathus sp.*, *Pandorinellina sp.*, *Pseudooneotodus beckmanni*, *P. sp. aff. P. borealis* and several new species, which are not discussed in this paper. For conodont taxa ranges from selected sections, see Figs 2–4. All above mentioned taxa, except *P. sp. aff. P. borealis* and *Pandorinellina sp.*, are figured in Figs 5–10.

Serotinus Zone (Třebotov Limestone). – Weddige (1977) defined the lower boundary on the first appearance of *Polygnathus serotinus* and the upper boundary on the first appearance of *P. c. patulus*. Apart from *P. serotinus*, this zone marks the lowest appearance of *P. l. bultyncki* (together with *P. serotinus* being the most common taxa in the Třebotov Limestone, very often the only constituents). Other taxa occurring within this zone are: *Ozarkodina carinthiaca* (rare), *Pandorinellina sp.* (rare), *Pseudooneotodus beckmanni* (very abundant), *Icriodus beckmanni beckmanni* and *I. b. sinuatus* (not abundant).

Patulus Zone (Třebotov Limestone). – Weddige (1977) defined the lower boundary on the first occurrence of *P. c. pa-*

tulus and the upper boundary by the appearance of *P. c. partitus*, (*P. c. costatus* in the original definition). *P. c. patulus* represents a rather rare taxon, most commonly found in the upper part of the Třebotov Limestone, together with *P. c. partitus*, thus already in the *partitus* Zone. Therefore, the base of the *patulus* Zone in the Prastav quarry and in the Barrandov road cut must be drawn according to previously published data by Klapper *et al.* (1978) and Zusková (1991). Other taxa present in this zone are: *P. c. cooperi* (rare), *P. serotinus* (very abundant), *P. l. bultyncki* (very abundant) and *Pseudooneotodus beckmanni* (abundant).

Partitus Zone (upper part of the Třebotov Limestone-lowermost Choteč Limestone). – Weddige *et al.* (1979) suggested this as a new name for the upper *patulus* Zone of Klapper *et al.* (1978). The base of this zone defines the Lower-Middle Devonian boundary. The lowermost occurrence of *P. c. partitus* was recorded 5 m below the top of the Třebotov Limestone in the Prastav quarry. This section represents the regional reference section for the Lower-Middle Devonian boundary; the previously published FAD of this taxon was at the level of 2.8 m below the top of the Třebotov Limestone (Klapper *et al.* 1978, Chlupáč *et al.* 1979). Other taxa occurring within this Zone are: *P. serotinus* (very abundant), *P. l. bultyncki* (very abundant) and *P. c. patulus* (rare).

Costatus Zone (uppermost part of the Třebotov Limestone and the majority of the Choteč Limestone). – Weddige (1977) defined the lower boundary of the zone on the first appearance of *P. c. costatus* and the upper boundary on the lowest appearance of *Tortodus kockelianus australis* (*T. k. kockelianus* in the original definition). The base of this zone roughly coincides with the main lithologic and faunistic changes, known as the Basal Choteč event which occurred in the Prague Basin and elsewhere (see Chlupáč & Kůral 1988 for additional references). The disappearance of *P. serotinus* from this area is characteristic for this time interval as no element of *P. serotinus* has been found in the Choteč Limestone within this study. The occurrence of *P. serotinus* together with *P. c. costatus* was recorded 1.25 m below the base of the Choteč Limestone in the Barrandov section. This finding represents the only record of *P. serotinus* in the *costatus* Zone in the Prague Basin within this study. According to Klapper (1977), Klapper *et al.* (1978) and Klapper (2009, personal communication), the last *P. serotinus* in the Prague Basin was found together with *P. c. costatus* from 2.28–2.33 m above the base of the Choteč Limestone in the Jelínek mill quarry. Thus, in contrast to other regions, where *P. serotinus* is common in the *costatus* Zone (*e.g.*, Klapper 1977b, Bardashev 1992), in the Prague Basin the occurrence of *P. serotinus* is limited just to the very base of the *costatus* Zone (the last specimen of *P. serotinus* was found together with first *P. c. costatus*). The occurrence of *Polygnathus sp. aff. P. trigonicus* seems to be

characteristic for the base of this zone. Other taxa within this zone comprise *P. c. patulus* (rare), *P. c. partitus* (relatively common in the lower part), *P. linguiformis bultyncki* (abundant), *P. l. pinguis* (rare) and *Pelekysgnathus* sp. (rare).

Australis Zone (upper part of the Choteč Limestone). – This zone was designated by Philip & Jackson (1973) as an assemblage and re-defined by Klapper (1977a) as a zone, the base of which coincides with the first appearance of *T. k. australis*, corresponding to the base of the *kockelianus* Zone *sensu* Weddige (1977). In this study, the base of this zone was drawn on the basis of the occurrence of two specimens in the Jelínek mill section. The *australis* Zone was identified also in the Barrandov road cut and in the Na Škrábku quarry, with a question on the basis of the presence of *P. pseudofolius* (Barrandov road cut) and *P. pseudofolius* and *P. trigonicus* (Na Škrábku quarry). For an explanation see the text above.

Kockelianus Zone. – Weddige (1977) defined the lower boundary of the zone on the first appearance of *T. k. kockelianus* and the upper boundary on the appearance of *Polygnathus xylus ensensis*. In this study the *kockelianus* Zone was identified only in the upper part of the Choteč Limestone in the Jelínek mill quarry in grey bioturbated wackestones. Also in the section situated on the road between Hostím and Srbsko villages, within the interval with tempestite sedimentation and in the Na vyhlídce section in Hostím within dark-grey lime mudstones and wackestones with silicites.

Conclusions

Conodonts from the Třebotov Limestone (Emsian-Eifelian) and the Choteč Limestone (Eifelian) of the Prague Basin were studied. Seven sections were sampled in order to refine the existing conodont zonal scheme and to provide new data for sections that have not been included in previous studies. The most important findings can be summarized as follows:

1. The zonal scheme was re-defined in the Jelínek mill quarry, where boundaries of the *partitus* and *patulus* zones are lower than in previous studies (Klapper *et al.* 1978); also the *australis* and *kockelianus* zones were newly recorded here. Furthermore, new data on the lower and/or upper ranges of other taxa were determined.

2. The supposed correlation of the Basal Choteč event with the base of the *costatus* Zone is supported. First representatives of *P. c. costatus* are, with the exception of Barrandov road cut section, always found at the base of the Choteč Limestone (the sedimentation of this unit reflects changes linked to the above mentioned event). In the Barrandov road cut, the base of the *costatus* Zone was recorded 1.25 m below the base of the Choteč Limestone,

which represents the first find of this taxon below the base of this unit. However, changes in sedimentation at this section (linked to the Basal Choteč event) have already been observed at this level (prasinophyte blooms recorded about 1 m below the base of the Choteč Limestone).

3. At the regional reference section for the Lower-Middle Devonian boundary, the Prastav quarry at Holyně, the first occurrence of *P. c. partitus* was recorded 5 m below the base of the Choteč Limestone. Thus the Lower-Middle Devonian boundary, which is drawn according to first occurrence of this taxon, is shifted 2.3 m lower. In addition, the *costatus* Zone was identified here on the basis of the nominal species for the first time, 2 m above the base of the Choteč Limestone.

4. The disappearance of *Polygnathus serotinus* at the very base of the *costatus* Zone from this area has been recorded. This taxon represents the most common species in the Třebotov Limestone; no single element of this taxon was found in the overlying unit, namely, the Choteč Limestone, in this study. This is in contrast with other regions, where it is quite common in the *costatus* Zone (*e.g.*, Klapper 1977b, Bardashev 1992).

5. According to new data and previously published data (Klapper 1977a, Klapper *et al.* 1978) it appears possible to correlate the occurrence of *Polygnathus* sp. aff. *P. trigonicus* with the lower part of the *costatus* Zone in the Prague Basin, as elsewhere (Klapper 1971, Perry *et al.* 1974). Both that species and *P. c. costatus* occur close to the base of the Choteč Limestone, which reflects the effect of the Basal Choteč event. Therefore, the occurrence of *P. sp. aff. P. trigonicus* may also have implications for global correlation of this event.

6. Based on data already published and also on the author's own observations on ranges of zonally defining taxa, the conclusion has been reached that global, as well as regional, correlations of the studied interval (*serotinus-kockelianus* zones) should not be, at best, based only on conodont zonation. Other fossils groups and also other stratigraphical methods (*e.g.*, chemostratigraphy, magnetic susceptibility) should be considered.

Systematic section

Conodont elements were extracted using standard techniques, which comprise dissolution of limestones in 6% acetic acid, sieving and drying the residues and handpicking the elements using a Carl Zeiss binocular microscope (magnification of 16–40×). Separation in a heavy liquid (sodium polytungstate) was carried out. SEM documentation was made at the Institute of Geology and Paleontology, Charles University, Prague, using the JEOL JSM-6380. Specimens studied are deposited in the collection of Stanislava Berkyová, at the Czech Geological Survey (SB2).

Genus *Polygnathus* Hinde, 1879

Type species. – *Polygnathus dubius* Hinde, 1879.

Polygnathus costatus* Klapper, 1971**Polygnathus costatus patulus* Klapper, 1971**

Figure 5A–C

- 1971 *Polygnathus costatus patulus* subsp. nov.; Klapper, pp. 62, 63, pl. 1, figs 1–9, 29; pl. 3, figs 16–18.
- 1977 *Polygnathus costatus patulus* Klapper 1971. – Weddige, pp. 310, 311, pl. 4, fig. 74.
- 1978 *Polygnathus costatus patulus* Klapper, 1971. – Klapper *et al.*, pl. 2, figs 6–9, 14–17, 19, 20, 25, 31.
- 1980 *Polygnathus costatus patulus* Klapper. – Johnson *et al.*, pl. 4, fig. 13.
- 1983 *Polygnathus costatus patulus* Klapper, 1971. – Wang & Ziegler, pl. 5, figs 11–14.
- 1984 *Polygnathus costatus patulus* Klapper. – Feist *et al.*, pl. 1, fig. ?8, pl. 2, fig. ?18, ?19, 21, ?22.
- 1986 *Polygnathus costatus patulus* Klapper, 1971. – Bultynck, p. 270, pl. 8, figs 1–6.
- 1986 *Polygnathus costatus patulus* Klapper. – Schönlaub, pl. 4, figs 4, 5, 8, ?6, ?7.
- 1986 *Polygnathus costatus patulus* Klapper, 1971. – Ziegler & Wang, pl. 1, figs 11, 12, ?13.
- 1986 *Polygnathus costatus patulus* Klapper. – Bardashev & Ziegler, pl. 1, fig. 1.
- non 1989 *Polygnathus costatus patulus* Klapper. – Mawson & Talent, pl. 3, fig. 3 [*P. linguiformis bultyncki*].
- 1992 *Polygnathus costatus patulus* Klapper, 1971. – Bardashev, pl. 1, fig. 11.
- 1992 *Polygnathus costatus patulus* Klapper, 1971. – Bardashev & Ziegler, pl. 6, figs 33–34.
- 1992 *Polygnathus costatus patulus* Klapper, 1971. – Boncheva, p. 36, pl. 2, figs ?4–8 (only lower views).
- 1994 *Polygnathus costatus patulus* Klapper. – Mawson & Talent, pl. 2, fig. 1.
- 1995 *Polygnathus costatus patulus* Klapper, 1971. – Mawson *et al.*, pp. 430–431, pl. 3, fig. 8.
- 2003 *Polygnathus costatus patulus* Klapper, 1971. – Benfrika & Bultynck, pl. 1, fig. 9.

Material. – 42 specimens.

Description. – Pa elements of *P. c. patulus* from the Prague Basin have an almost symmetrical (outer platform is slightly wider), broad platform. The anterior platform margins are slightly constricted. Upper view: the carina reaches the posterior end of the platform, at least in the form of nodes. Adcarinal grooves are relatively deep, mainly in the anterior part of the platform and wide-forming the characteristic shape of the platform, which is widest at about its

midlength. The platform of the Pa element bears short, but prominent transverse ridges (16–20 ridges on both sides of platform in mature specimens). Lower view: the centre of the small pit is situated at the border between the first and second quarter of the platform (in the anterior part of platform). The keel is straight or only slightly curved.

Remarks. – *P. c. patulus* is similar to *P. c. partitus* as they share some diagnostic features though they are distinguishable on the basis of the platform outline. However, this applies only to adult specimens. The platform of *P. c. patulus* is widest at about its midlength whereas the platform of *P. c. partitus* is narrow, and its anterior margins are almost parallel. *P. c. patulus* also resembles *P. cooperi cooperi* Klapper, 1971 (*serotinus-patulus* zones). The latter differs by the more asymmetrical development of the platform and especially by the development of a weak tongue, which usually bears two transverse ridges.

Stratigraphical range. – Late Emsian to early Eifelian (Lower-Middle Devonian), the first occurrence of this taxon defines the lower boundary of the *patulus* Zone. In the Prague Basin, the lowest occurrence is 7.3 m below the base of the Choteč Limestone in Na Škrábku quarry, the highest occurrence is 2.38 m above the base of the Choteč Limestone in the Jelínek mill section (the lower part of the *costatus* Zone).

***Polygnathus costatus partitus* Klapper, Ziegler & Mashkova, 1978**

Figure 5D–I

- 1978 *Polygnathus costatus partitus* subsp. nov.; Klapper *et al.*, p. 109, pl. 2, figs 1–5, 13.
- 1983 *Polygnathus costatus partitus* Klapper, Ziegler & Mashkova, 1978. – Wang & Ziegler, pl. 5, fig. 12.
- 1986 *Polygnathus c. partitus* Klapper, Ziegler & Mashkova. – Bardashev & Ziegler, pl. 1, figs 2, ?3.
- 1986 *Polygnathus costatus partitus* Klapper, Ziegler & Mashkova, 1978. – Bultynck, p. 270, pl. 8, figs 19, 20.
- 1986 *Polygnathus costatus partitus* Klapper, Ziegler & Mashkova. – Schönlaub, pl. 4, figs 9, 10.
- 1986 *Polygnathus costatus costatus* Klapper. – Schönlaub, pl. 4, fig. 11.
- 1986 *Polygnathus costatus partitus* Klapper, Ziegler & Mashkova, 1978. – Ziegler & Wang, pl. 1, fig. 14.
- 1989 *Polygnathus costatus partitus* Klapper, Ziegler & Mashkova. – Mawson & Talent, pl. 3, fig. 4.
- 1992 *Polygnathus costatus partitus* Klapper, Ziegler & Mashkova, 1978. – Bardashev, pl. 1, figs 14–17, 21–22, ?18–20.
- 1992 *Polygnathus costatus partitus* Klapper, Ziegler & Mashkova, 1978. – Boncheva, p. 36, pl. 2, figs ?2, ?3 [non fig. 1].

- 1994 *Polygnathus costatus partitus* Klapper, Ziegler & Mashkova. – Mawson & Talent, pl. 2, figs 2, ?3.
 1995 *Polygnathus costatus partitus* Klapper, Ziegler & Mashkova, 1978. – Sloan *et al.*, pl. 5, figs 15–19.

Material. – 74 specimens.

Description. – Pa elements of *P. c. partitus* from the Prague Basin have an almost symmetrical (outer platform is slightly wider), narrow platform, where the inner and outer posterior platform margins tend to be straight, meeting the posterior end of the platform to form a “sagittate” outline. The anterior platform margins are either parallel or only slightly constricted. Upper view: the carina reaches the posterior end of the platform, at least in the form of nodes. The platform of the Pa element bears short but prominent transverse ridges (16–20 ridges on both sides of the platform in mature specimens). Adcarinal grooves are relatively deep in the anterior part of the platform. Lower view: the centre of the small pit is situated on the border between the first and second quarter of the platform (in the anterior part of the platform). The keel is straight or only slightly curved.

Remarks. – *Polygnathus c. partitus* was described by Klapper *et al.* (1978) as a phyletic intermediate between *P. c. patulus* and *P. c. costatus* from which it can be distinguished essentially by the development of the platform margins, which are characteristically straight and by the narrow platform development. A comparison of all subspecies is given in the section on *P. c. costatus*.

Stratigraphical range. – Eifelian (early Middle Devonian), first occurrence of this taxon defines the lower boundary of the *partitus* Zone. In the Prague Basin, the first occurrence of this taxon falls in the upper part of the Třebotov Limestone. The lowest occurrence found is 5 m below the top of the Třebotov Limestone in the Prastav quarry (this study). The highest occurrence is 2.46 m above the base of the Choteč Limestone in the Barrandov road-cut (this study, lower part of the *costatus* Zone).

***Polygnathus costatus costatus* Klapper, 1971**

Figure 6I–L

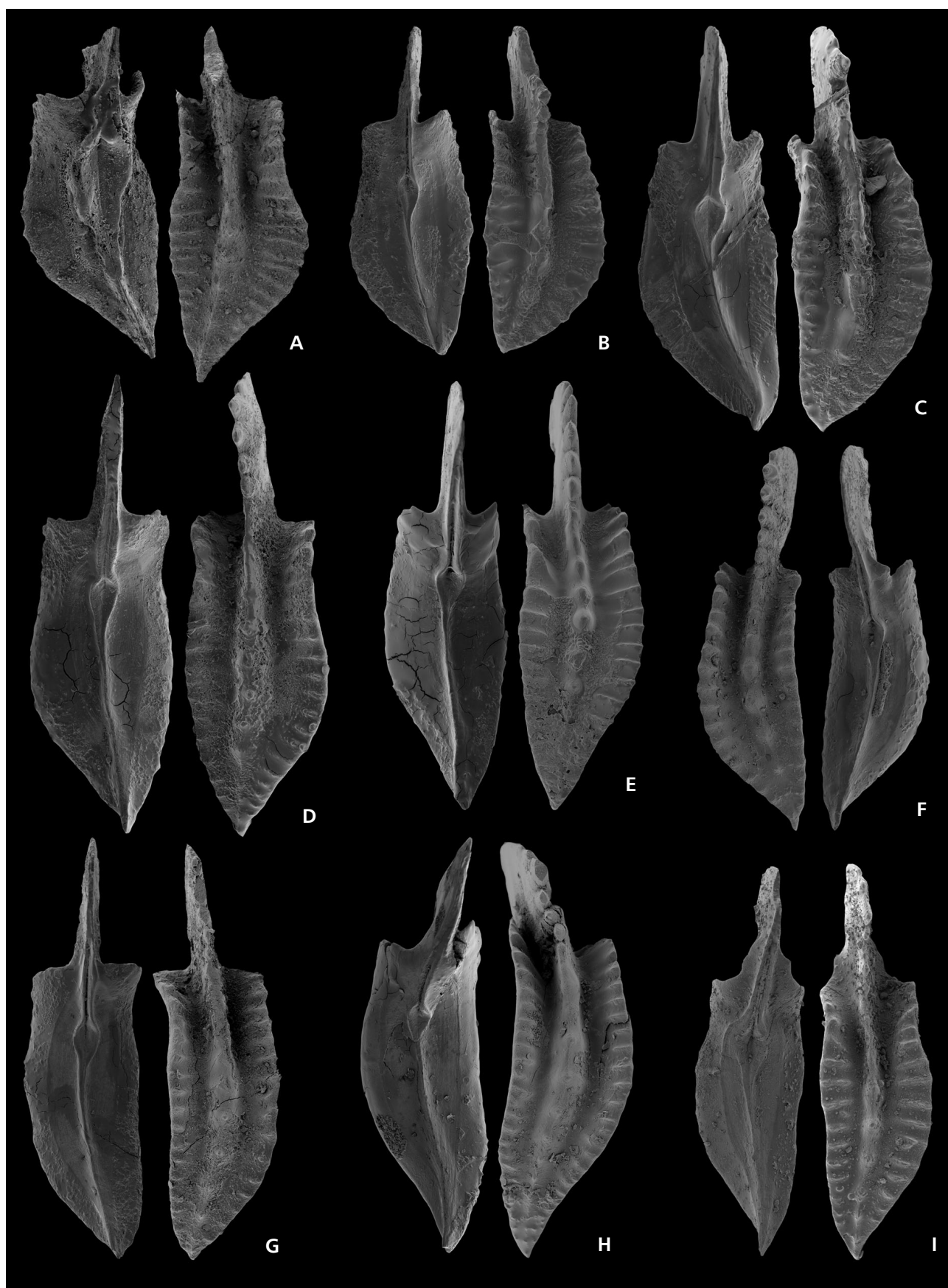
- 1971 *Polygnathus costatus costatus* subsp. nov.; Klapper, p. 64, pl. 1, figs 30–36, pl. 2, figs 1–7.

- 1974 *Polygnathus costatus costatus* Klapper 1971. – Perry *et al.*, p. 1087, pl. 7, figs 1, ?2, 3, 4, 5, ?6, ?7, ?10.
 1977 *Polygnathus costatus costatus* Klapper 1971. – Weddige, pp. 309, 310, pl. 4, figs 75–76.
 1978 *Polygnathus costatus costatus* Klapper, 1971. – Klapper *et al.*, pl. 2, figs ?10, ?11, 12.
 1980 *Polygnathus costatus costatus* Klapper. – Johnson *et al.*, pl. 4, figs 14, 15, 17.
 1983 *Polygnathus costatus costatus* Klapper, 1971. – Sparling, pl. 10, figs AB, AC; pl. 11, figs AB, AC, AF, AG.
 1985 *Polygnathus costatus costatus* Klapper. – Feist *et al.*, pl. 1, figs 2, ?3, ?4, 5, ?9., pl. 2, figs ?24, ?25, ?27, ?28.
 1986 *Polygnathus costatus costatus* Klapper. – Bardashev & Ziegler, pl. 1, figs 4, 5.
 1986 *Polygnathus costatus costatus* Klapper, 1971. – Bultynck, p. 270, pl. 8, figs 13–17.
 1986 *Polygnathus costatus costatus* Klapper. – Schönlaub, pl. 4, figs 12–15 [non fig. 11 = *P. costatus partitus*]
 1986 *Polygnathus costatus costatus* Klapper, 1971. – Ziegler & Wang, pl. 1, figs 17–19.
 ?1989 *Polygnathus costatus costatus* Klapper. – Mawson & Talent, pl. 3, fig. 5.
 non 1990 *Polygnathus costatus costatus* Klapper, 1971. – Lazreq, pl. 1, fig. 10.
 1992 *Polygnathus costatus costatus* Klapper, 1971. – Bardashev, pl. 1, figs 23–31.
 1994 *Polygnathus costatus costatus* Klapper. – Mawson & Talent, pl. 2, figs 9–12.
 1995 *Polygnathus costatus costatus* Klapper, 1971. – Savage, p. 545, pl. 8, fig. 3.
 1995 *Polygnathus costatus costatus* Klapper, 1971. – Sloan *et al.*, pl. 6, figs 1–6.
 2003 *Polygnathus costatus costatus* Klapper, 1971. – Benfrika & Bultynck, pl. 1, fig. 10
 2003 *Polygnathus costatus costatus* Klapper, 1971. – Pyle *et al.*, pl. 2, figs 1–2.

Material. – 53 specimens.

Description. – Pa elements of *P. c. costatus* from the Prague Basin have an almost symmetrical (outer platform is slightly wider), long, narrow platform. The anterior platform margins are slightly constricted. Upper view: the adcarinal grooves are relatively deep and narrow in the anterior part of platform. In the last third of the platform, grooves tend to be wider, thus forming the characteristic shape of the platform, which is

Figure 5. A–D – upper and lower views of *Polygnathus costatus patulus* Klapper, 1971. A – Na Škrábku quarry, 7.3 m below the base of the Choteč Limestone. B, D – Červený quarry, 2.3 m above the base of the Acanthopyge Limestone. C – Červený quarry, 0.35 m above the base of the Acanthopyge Limestone. • E–I – upper and lower views of *Polygnathus costatus partitus* Klapper, Ziegler & Mashkova, 1978. E – Červený quarry, 0.35 m above the base of the Acanthopyge Limestone. F–H – Červený quarry, 2.3 m above the base of the Acanthopyge Limestone. I – Barrandov road cut, 0.7 m below the Choteč Limestone. All magnifications are × 60.



widest in its final third (in the posterior part). The carina reaches the posterior end of the platform. The platform of the Pa element bears prominent, densely spaced transverse ridges (25–30 ridges on both sides of the platform in adult specimens). Lower view: the centre of the small pit is situated on the boundary between the first and second third of the platform. The keel may or may not be slightly curved.

Remarks. – *P. c. costatus* is easily distinguishable from *P. c. patulus* and *P. c. partitus* by its long, narrow platform, which is widest in the posterior third of the platform. The platform is longer and bears more densely spaced transverse ridges in comparison with the other two subspecies. The platform outline is regarded here as the most important diagnostic feature. The platform of *P. c. patulus* is broad and widest at midlength, the platform of *P. c. partitus* is narrow and the anterior margins of the platform are more or less parallel, the platform of *P. c. costatus* is long, narrow and expands in the posterior third. As the platform outline depends on the ontogenetic stage of development, it is possible to identify only the adult specimens with confidence.

P. c. costatus also resembles the stratigraphically younger *Polygnathus parawebbi* Chatterton, 1974; the latter has, however, deep adcarinal grooves and a sharply curved outer platform margin. For comparison with *P. pseudofolius* Wittekindt, 1966, see Klapper (1971).

Several morphotypes of this taxon were recognized in material from the Prague Basin and also from the Great Basin, Nevada (collections of M.A. Murphy at the University of California, Riverside).

Stratigraphical range. – Eifelian (early Middle Devonian). First occurrence of this taxon defines the lower boundary of the *costatus* Zone. The lowest occurrence of this taxon is 1.26 m below the base of the Choteč Limestone in the Barandov road cut; the highest occurrence is 22 m (only approximate, part of the section is covered) above the base of the Choteč Limestone in the Jelínek mill quarry.

***Polygnathus pseudofolius* Wittekindt, 1966**

Figure 8A–G

- 1966 *Polygnathus pseudofoliata* n. sp.; Wittekindt, pp. 637, 638, pl. 2, figs 20–23 [non fig. 19 = *P. eiflius*].
- 1971 *Polygnathus pseudofolius* Wittekindt. – Klapper, pp. 63, 64, pl. 2, figs 8–13.
- 1975 *Polygnathus pseudofolius* Wittekindt, 1966. – Telford, pp. 50, 51, pl. 9, figs 1–12.
- 1977 *Polygnathus pseudofolius* Wittekindt, 1966. – Weddige, pp. 317, 318, pl. 4, figs 68–70.
- 1983 *Polygnathus pseudofolius* Wittekindt, 1966. – Sparling, pp. 855, 856, pl. 11, figs ?S, ?T, AD, AE; pl. 12, figs K–M; pl. 13, figs X, Z, AK, AL.

- 1983 *Polygnathus pseudofolius* Wittekindt, 1966. – Wang & Ziegler, pl. 6, figs 14–15.
- 1985 *Polygnathus pseudofolius* Wittekindt. – Feist *et al.*, pl. 1, figs ?6, 11, 17–19, 21.
- 1986 *Polygnathus pseudofolius* Wittekindt, 1966. – Buldynck, pl. 7, fig. 13.
- 1986 *Polygnathus pseudofolius* Wittekindt. – Bardashev & Ziegler, pl. 1, figs 22–23.
- 1986 *Polygnathus pseudofolius* Wittekindt. – Schönlaub, pl. 5, figs 4–7, non fig. 8 [*P. angusticostatus*].
- 1989 *Polygnathus pseudofolius* Wittekindt. – Mawson & Talent, p. 237, pl. 4, figs 16–24.
- 1990 *Polygnathus pseudofolius* Wittekindt, 1965. – Lazreq, pl. 2, figs 10, 11, ?12, ?13 [= *P. eiflius*?].
- 1992 *Polygnathus pseudofolius* Wittekindt, 1966. – Bardashev, pl. 5, figs 1–3, 5, 6.
- 1994 *Polygnathus pseudofolius* Wittekindt. – Mawson & Talent, pl. 2, figs 19, 20.
- 1995 *Polygnathus pseudofolius* Wittekindt, 1966. – Savage, p. 546, pl. 3, figs ?12, ?13, ?14, 15–17.
- 1995 *Polygnathus pseudofolius* Wittekindt, 1966. – Sloan *et al.*, pl. 7, figs 11, 13, non fig. 12.
- 1995 *Polygnathus pseudofolius* Wittekindt, 1966. – Sparling, p. 1136, figs 2.1–2.4, ?2.5–2.8.
- 1998 *Polygnathus pseudofolius* Wittekindt. – Uyeno in Norris & Uyeno, pp. 164, 165, pl. 11, figs 11, 20; pl. 12, figs 5, 13–15; pl. 14, figs 19–21.
- 1999 *Polygnathus pseudofolius* Wittekindt, 1966. – Sparling, pl. 3, figs 17–19.
- 2003 *Polygnathus pseudofolius* Wittekindt, 1966. – Adhamian, p. 187, pl. 2, figs 9, 10.
- 2003 *Polygnathus pseudofolius* Wittekindt, 1966. – Morgan, pl. 3, figs 15, 16, 23.
- 2007 *Polygnathus pseudofolius* Wittekindt, 1965. – Benfrika *et al.*, pl. 9, fig. 1.

Material. – 16 specimens.

Description. – Pa elements of *P. pseudofolius* from the Prague Basin have a somewhat symmetrical (outer platform is slightly wider) platform; the anterior platform margins are slightly constricted. The free blade averages 37% of the total length of the platform. Upper view: the adcarinal grooves are relatively deep, mainly in the anterior part of the platform. The degree of ornamentation of the platform shows some variation. The anterior platform is either ornamented with transverse ridges, which become weaker towards the finely nodose posterior part (Fig. 9A, B, G), or only transverse ridges are present (Fig. 9C, E). The Pa element of this taxon is characterized by a significant expansion of the posterior outer platform. Lower view: the pit is of moderate size in mature specimens and is situated between the anterior end of platform and its midlength.

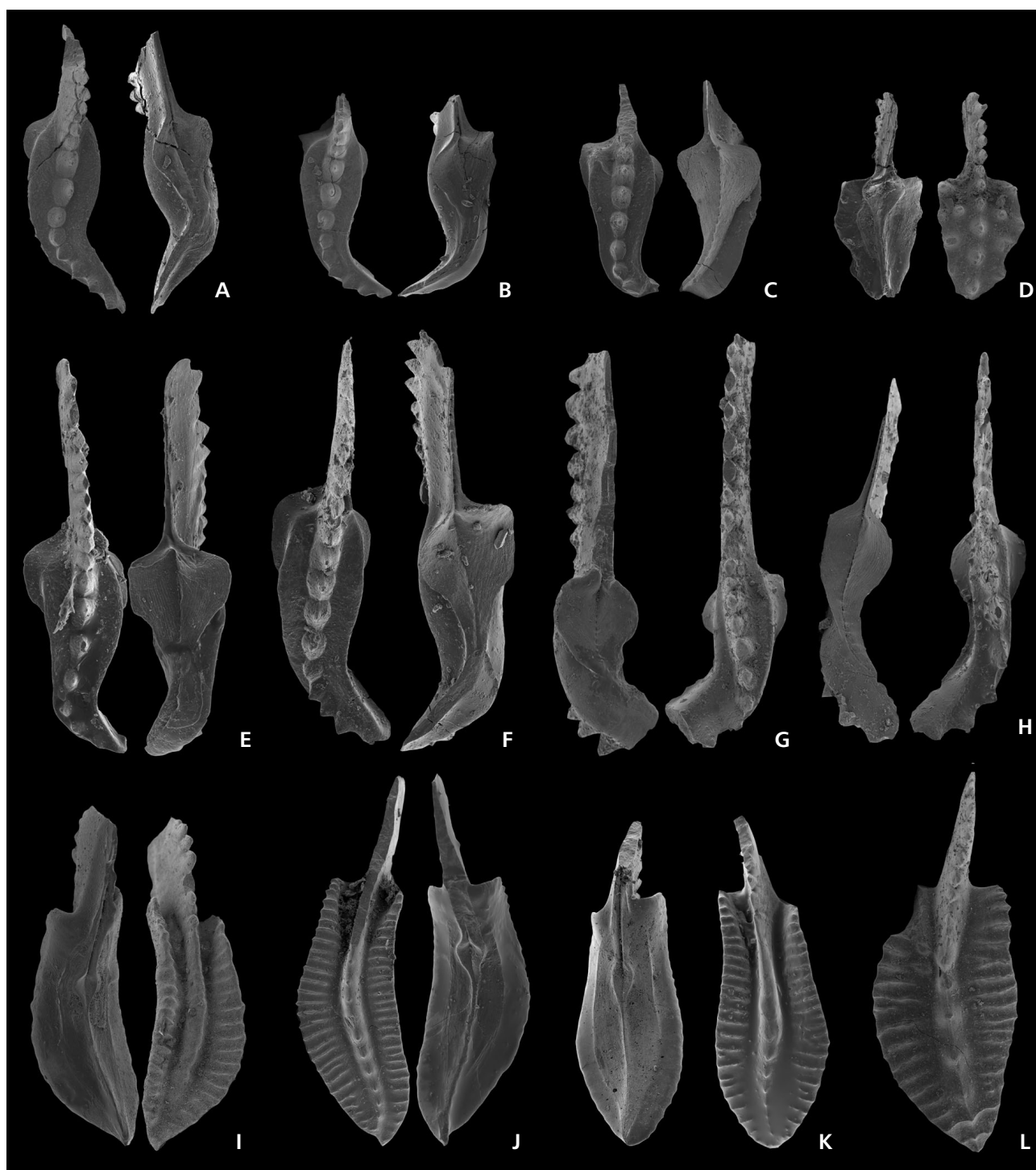


Figure 6. A–C, E–G – upper and lower views of *Tortodus kockelianus kockelianus* (Bischoff & Ziegler, 1957). • A–C, E–F – Jelínek mill quarry, 37 m above the base of the Choteč Limestone. G – Jelínek mill quarry, 35 m above the base of the Choteč Limestone. D – upper and lower view of *Polygnathus trigonicus* Bischoff & Ziegler, 1957, Jelínek mill quarry, 35 m above the base of the Choteč Limestone. • H – upper and lower view of *Tortodus kockelianus australis* (Jackson in Pedder *et al.*, 1970), Jelínek mill quarry, 35 m above the base of the Choteč Limestone. • I–K – upper and lower views of *Polygnathus costatus costatus* Klapper, 1971. I – Na Škrábku quarry, 5 m above the base of the Choteč Limestone. J, K – Na Škrábku quarry, 8 m above the base of the Choteč Limestone. • L – upper view of *Polygnathus* sp. aff. *P. trigonicus* Bischoff & Ziegler, 1957, Na Škrábku quarry, 0.4 m above the base of the Choteč Limestone. All magnifications are $\times 65$.

Remarks. – Specimens figured as Fig. 8C and E may resemble *P. c. costatus*, however, the platform outline is more typical of *P. pseudofolius* and also the free blade to total length ratio corresponds more with *P. pseudofolius*. Furthermore, the transverse ridges in *P. c. costatus* are more densely spaced. Specimens figured as Fig. 8A, B and G, are similar to *P. pseudofolius* subsp. A *sensu* Sparkling (1995) with respect to the platform ornamentation; however, conodonts from the Prague Basin are not so constricted anteriorly, and also have better developed transverse ridges. The specimen illustrated by Sparkling (1995) in fig. 3.8, p. 1128 (*P. pseudofolius* subsp. D) is similar to the specimen from the Prague Basin figured as Fig. 8F (single specimen from Holyně locality, 11.9 m above the base of the Choteč Limestone) with respect to the anterior platform, which seems to slope upwards towards the free blade.

Stratigraphical range. – Late Eifelian-early Givetian (Middle Devonian). In the Prague Basin, this taxon occurs together with *P. c. costatus* and *P. trigonicus*. As mentioned previously, the base of the *australis* Zone was drawn with question mark on the basis of the presence of this taxon.

***Polygnathus cooperi* Klapper, 1971**

***Polygnathus cooperi cooperi* Klapper, 1971**

Figure 7A–D

- 1971 *Polygnathus linguiformis cooperi* subsp. nov.; Klapper, p. 64, pl. 1, figs 12–22; pl. 2, fig. 21.
- 1975 *Polygnathus linguiformis cooperi* Klapper, 1971. – Telford, pp. 44–48, pl. 8, figs 6–15.
- 1977 *Polygnathus linguiformis cooperi* Klapper 1971. – Weddige, pp. 314, 315, pl. 5, figs 93, 94.
- 1978 *Polygnathus cooperi cooperi* Klapper, 1971. – Klapper *et al.*, p. 108, pl. 2, figs 21, 22, 29, 30.
- 1986 *Polygnathus cooperi cooperi* Klapper. – Schönlaub, pl. 3, fig. 22.
- 1989 *Polygnathus cooperi cooperi* Klapper. – Mawson & Talent, pl. 3, fig. 8
- 1992 *Polygnathus cooperi cooperi* Klapper, 1971. – Bardashev, pl. 1, fig. 2, non figs 6–10.
- 1992 *Polygnathus cooperi cooperi* Klapper, 1971. – Bardashev & Ziegler, pl. 6, fig. ?29, non fig. 26.
- 1994 *Polygnathus cooperi cooperi* Klapper. – Mawson & Talent, pl. 2, fig. ?4; pl. 3, fig. 6.
- ?1994 *Polygnathus cooperi cooperi* Klapper. – Talent & Mawson, pl. 2, fig. ?18.

Material. – 8 specimens.

Description. – Pa elements of *P. c. cooperi* from the Prague Basin have a slightly asymmetrical platform (the carina is

situated closer to the inner margin). The adcarinal grooves are relatively shallow and broad, thus creating the characteristic broad, flat (mainly in the posterior part) appearance of the platform. The short free blade averages 18% of the total length of the platform. Upper view: widely spaced, prominent transverse ridges cover the platform, with a range of 16–20 ridges (in adult specimens). Neither the carina nor the adcarinal grooves reach the posterior end, where weak transverse ridges cross the tongue of the platform (usually only one or two ridges). Lower view: the centre of the moderate sized pit is situated at the border between the first and second quarter of the platform (in the anterior part of the platform). The keel is only slightly curved.

Remarks. – *P. cooperi cooperi* most closely resembles *P. c. patulus*; however, the latter can be distinguished from *P. c. cooperi* by having a more symmetrical development of the platform and by the absence of a tongue (the carina continues to the posterior end of the platform in *P. c. patulus*, at least in the form of nodes). The material from the Prague Basin is similar to material from New York which was assigned to a transitional form between *P. c. patulus* and *P. c. cooperi*, figured by Klapper 1971 on Pl. 1, figs 10–16. However, the platform is more asymmetrical in the latter.

Stratigraphic range. – *Serotinus*-lower *partitus* zones, late Emsian-early Eifelian (Lower-Middle Devonian). In the Prague Basin, the lowest occurrence of this taxon is 5.44 m below the base of the Choteč Limestone in the Na Škrábku quarry, the highest occurrence is 3.4 m below the base of the Choteč Limestone in the same quarry.

***Polygnathus trigonicus* Bischoff & Ziegler, 1957**

Figure 6D

- 1957 *Polygnathus trigonica* n. sp.; Bischoff & Ziegler, pp. 97, 98, pl. 5, figs 1–6.
- ?1977 *Polygnathus trigonicus* Bischoff & Ziegler 1957. – Weddige, pp. 320, 321, pl. 6, figs ?98, ?99.
- ?1980 *Polygnathus trigonicus* Bischoff & Ziegler. – Johnson *et al.*, pl. 4, fig. ?11.
- ?1983 *Polygnathus trigonicus* Bischoff & Ziegler, 1959. – Wang & Ziegler, pl. 7, figs ?19, ?20.
- ?1992 *Polygnathus trigonicus* Bischoff & Ziegler, 1957. – Bardashev, pl. 2, figs ?37– ?40.
- 1995 *Polygnathus trigonicus* Bischoff & Ziegler, 1957. – Savage, p. 550, pl. 2, figs 10–15.
- 2003 *Polygnathus trigonicus* Bischoff & Ziegler 1957. – Morgan, pl. 3, figs ?5, ?6, 13, 14.
- 2003 *Polygnathus trigonicus* Bischoff & Ziegler, 1957. – Pyle *et al.*, p. 105, pl. 2, fig. 18.

Material. – 4 specimens.



Figure 7. A–D – upper and lower views of *Polygnathus cooperi cooperi* Klapper, 1971. A, C–D – Prastav quarry, 4.4 m below the base of the Choteč Limestone. B – Na Škrábku quarry, 6.4 m below the base of the Choteč Limestone. • E – upper and lower view of *Icriodus beckmanni sinuatus* Klapper, Ziegler & Mashkova, 1978, Jelinek mill quarry, 9.7 m below the base of the Choteč Limestone. • F – upper view of *Icriodus beckmanni beckmanni* Ziegler, 1956, Jelinek mill quarry, 9.7 m below the base of the Choteč Limestone. All magnifications are $\times 80$.

Descriptions. – Pa elements of *P. trigonicus* from the Prague Basin have an approximately triangular platform outline. The anterior end of the platform meets the free blade at almost a right angle. The free blade averages 45% of the total length. Upper view: Diagonal rows of nodes cover the anterior part of the platform. The adcarinal grooves are broad and very shallow. The carina is formed by a row of distinct denticles and terminates at the posterior end. Lower view: the relatively large pit with rims is located anteriorly, close to the junction of the anterior end of the platform and the free blade.

Remarks. – *P. trigonicus* may resemble *P. sp. aff. P. trigonicus* Klapper, 1971 in platform outline; however, the latter differs mainly by the position of the pit, which is situated

closer to the midlength of the platform. The occurrence of *P. sp. aff. P. trigonicus* in the Prague Basin has been recently re-investigated.

Polygnathus linguiformis Hinde, 1879

Polygnathus linguiformis cf. pinguis Weddige, 1977
Figure 9B–C

[cf.] 1977 *Polygnathus linguiformis pinguis* n. ssp.; Weddige, p. 316, pl. 5, figs 88, 89.

[cf.] 1978 *Polygnathus linguiformis pinguis* Weddige, 1977. – Klapper *et al.*, pl. 2, fig. 34.

- [?] 1986 *Polygnathus l. pinguis* Weddige. – Bardashev & Ziegler, pl. 1, fig. ?16.
 [cf.] 1986 *Polygnathus linguiformis pinguis* Weddige, 1977. – Bultynck, pl. 7, figs 7–9.
 [cf.] 1986 *Polygnathus linguiformis pinguis* Weddige 1977. – Ziegler & Wang, pl. 2, fig. 7.
 [cf.] 1995 *Polygnathus linguiformis pinguis* Weddige, 1977. – Mawson *et al.*, p. 432, pl. 3, fig. 17.

Material. – 2 specimens.

Description. – Pa elements of *P. l. cf. pinguis* have an expanded and somewhat flattened central part of the platform. Upper view: short, transverse ridges, which in the posterior third of the platform cross the tongue, ornamenting the platform. The adcarinal groove of the outer platform is deeper and wider, thus causing a flange-like development from the margin. Only one specimen preserved the free blade, which constituted 36% of the total length. Lower view: the centre of the moderate sized pit is situated just between the first and second quarter of the platform.

Remarks. – The specimens found differ from the holotype of this taxon in having a longer free blade and lacking the noded ornamentation of the platform described by Weddige (1977). Only two specimens were found, one of them incomplete; therefore further comparisons could not be made.

Stratigraphical range. – Lower-Middle Devonian, late Emsian (upper *patulus* Zone)-early Eifelian (lower *costatus* Zone). In the Prague Basin this taxon was found in Na Škrábku quarry, 0.17 m above the bed that yielded *Polygnathus* sp. aff. *P. trigonicus*.

Genus *Tortodus* Weddige, 1977

Type species. – *Tortodus kockelianus* (Bischoff & Ziegler, 1957).

Tortodus kockelianus (Bischoff & Ziegler, 1957)

Diagnosis. – See original diagnosis in Bischoff & Ziegler (1957).

Tortodus kockelianus kockelianus (Bischoff & Ziegler, 1957)

Figure 6 A–C, E–G

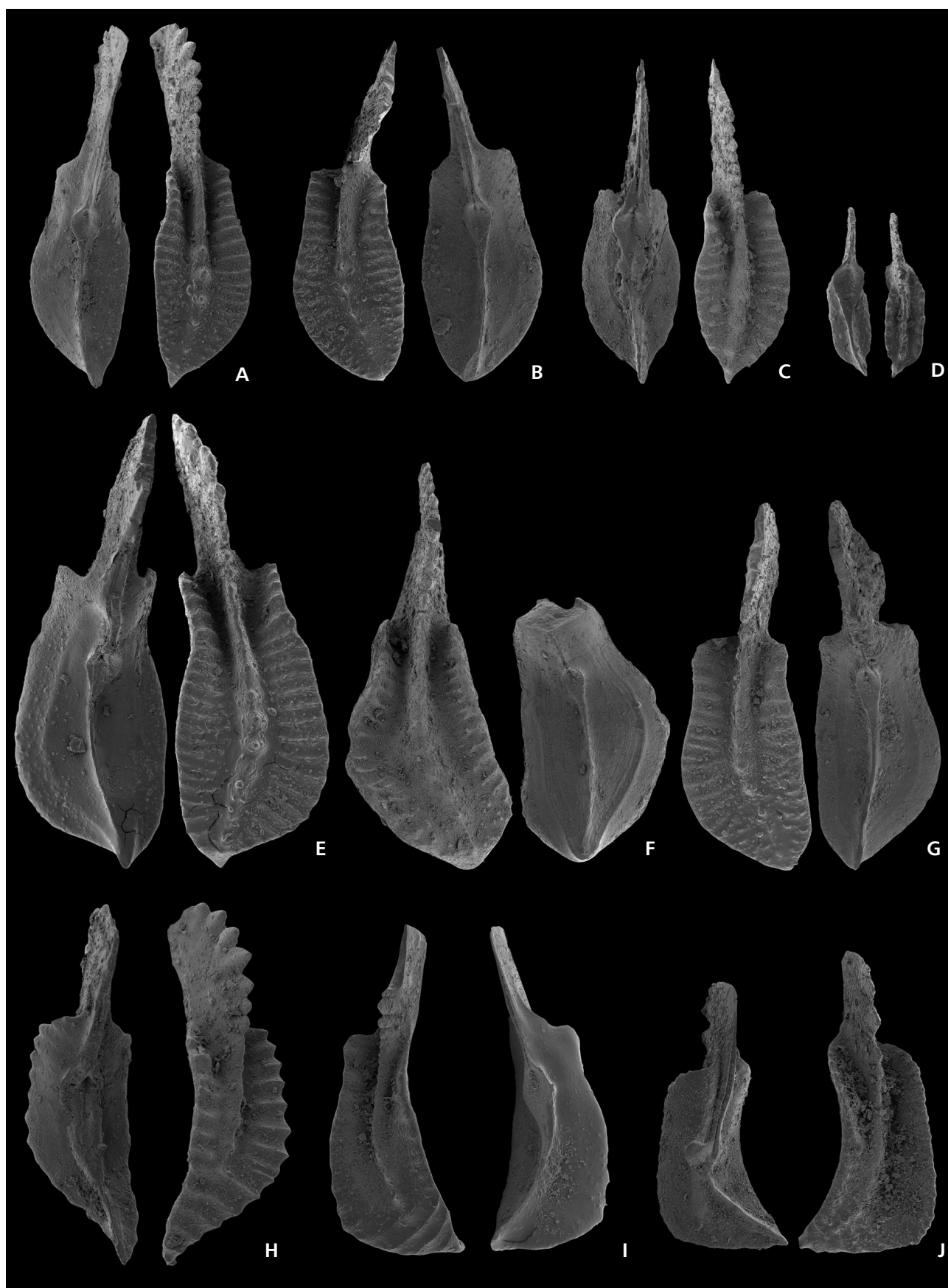
- 1957 *Polygnathus kockeliana* n. sp.; Bischoff & Ziegler, p. 91, pl. 2, figs 1–8, non 9–12 [= *T. k. australis*].
 1977 *Tortodus kockelianus kockelianus* (Bischoff & Ziegler, 1957). – Weddige, pp. 328, 329, pl. 3, fig. 52.
 1983 *Tortodus kockelianus kockelianus* (Bischoff & Ziegler, 1957). – Wang & Ziegler, pl. 8, figs 12, 13.
 1985 *Tortodus kockelianus kockelianus* (Bischoff & Ziegler). – Feist *et al.*, pl. 1, figs ?10, 26.
 1986 *Tortodus kockelianus kockelianus* (Bischoff & Ziegler). – Bultynck, pl. 7, fig. 19.
 1986 *Tortodus kockelianus kockelianus* (Bischoff & Ziegler). – Schönlaub, pl. 5, figs 20–23.
 1986 *Tortodus kockelianus kockelianus* (Bischoff & Ziegler, 1957). – Ziegler & Wang, pl. 1, figs 20, 21.
 ?1989 *Tortodus kockelianus kockelianus* (Bischoff & Ziegler). – Mawson & Talent, pl. 6, fig. ?19.
 1990 *Tortodus kockelianus kockelianus* (Bischoff & Ziegler, 1957). – Lazreq, pl. 2, figs 1–3, ?4.
 1992 *Tortodus kockelianus kockelianus* (Bischoff & Ziegler, 1957). – Bardashev, pl. 4, figs 18, 22, 23, 27, 28, 29, 32.
 1995 *Tortodus kockelianus kockelianus* (Bischoff & Ziegler, 1957). – Savage, pp. 552, 553, pl. 6, figs 1–6.
 2003 *Tortodus kockelianus kockelianus* (Bischoff & Ziegler 1957). – Morgan, pl. 2, figs 13–24.
 2003 *Tortodus kockelianus kockelianus* Bischoff & Ziegler 1957. – Pyle *et al.*, p. 105, pl. 2, figs 21, 22.

Material. – 11 specimens.

Description. – The Pa elements of *T. k. kockelianus* from the Prague Basin have a posteriorly twisted, smooth platform, which bears only one row of denticles, which are discrete and conical shaped. The free blade averages 40% of the total length. The platform gradually widens towards the anterior end. The flared basal cavity is situated in the anterior part, close to the junction of the platform and the free blade.

Remarks. – *T. k. kockelianus* is similar to *T. k. australis* (see Jackson in Pedder *et al.* 1970); however, the latter can be distinguished by the more restricted platform development

Figure 8. A–G – upper and lower views of *Polygnathus pseudofoliatus* Wittekindt, 1966. A, B, D, E – Barrandov road cut section, 5 m above the base of the Choteč Limestone. C – Holyně section, 12.2 m above the base of the Choteč Limestone. F – Holyně section, 11.9 m above the base of the Choteč Limestone. G – Barrandov road cut, 4.5 m above the base of the Choteč Limestone. • H, I – upper and lower views of *Polygnathus linguiformis bultyncki* Weddige, 1977. H – Jelínek mill quarry, 4.7 m below the base of the Choteč Limestone. I – Jelínek mill quarry, 9.7 m below the base of the Choteč Limestone. • J – upper and lower view of *Polygnathus serotinus* Telford, 1975, Jelínek mill quarry, 9.7 m below the base of the Choteč Limestone. All magnifications are $\times 57$.



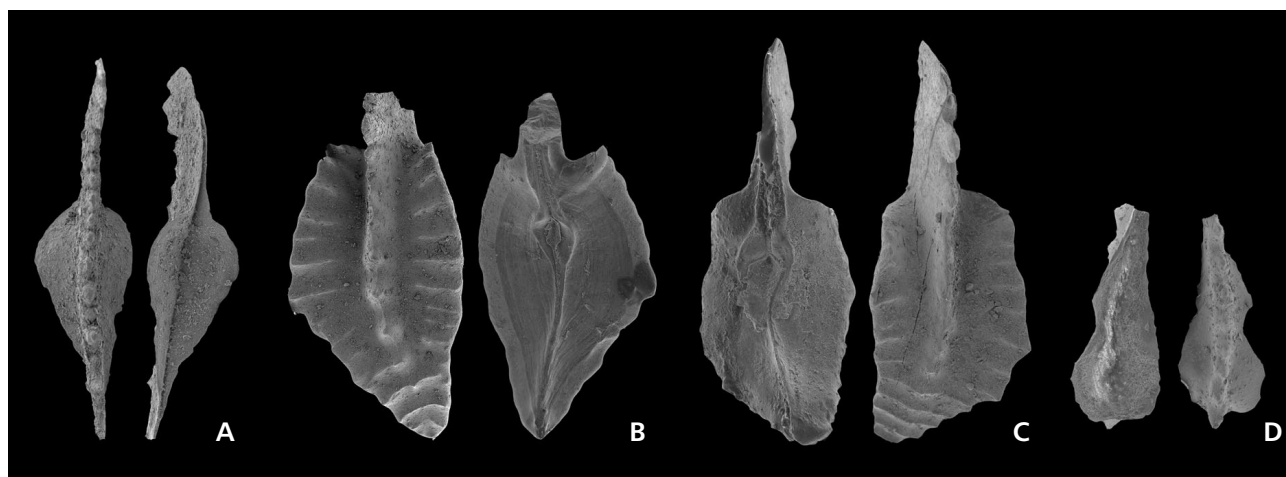


Figure 9. A – upper and lower view of *Ozarkodina carinthiaca* (Schulze, 1968), Jelínek mill quarry, 9.7 m below the base of the Choteč Limestone. • B, C – upper and lower views of *Polygnathus linguiformis pinguis* Weddige, 1977. B – Na Škrábku quarry, 0.65 m above the base of the Choteč Limestone. C – Na Škrábku quarry, 0.6 m above the base of the Choteč Limestone. • D – upper and lower view of *Pelekysgnathus* sp., Na Škrábku quarry, 0.65 m above the base of the Choteč Limestone. All magnifications are $\times 56$.

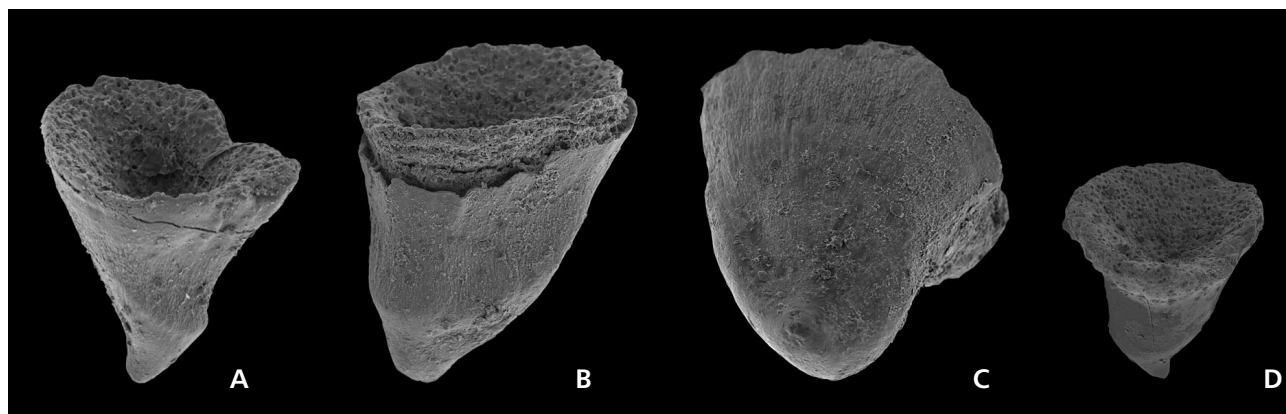


Figure 10. A–D – lateral views of *Pseudooneotodus beckmanni* (Bischoff & Sannemann, 1958). A – Na Škrábku quarry, 4.5 m below the base of the Choteč Limestone. B – Barrandov road cut, 12 m below the base of the Choteč Limestone. C – Jelínek mill quarry, 7.7 m below the base of the Choteč Limestone. D – Jelínek mill quarry, 9.7 m below the base of the Choteč Limestone. All magnifications are $\times 144$.

(the platform is much narrower in *T. k. australis*). Transitional forms between these two subspecies have been observed. The limited material available from the Prague Basin did not allow further comparison between these subspecies.

Stratigraphical range. – *Kockelianus* Zone, Eifelian (Middle Devonian). In the Prague Basin this taxon occurs together with *P. trigonicus*.

***Tortodus kockelianus australis* (Jackson in Pedder et al., 1970)**

Figure 6H

- 1977 *Tortodus kockelianus australis* (Jackson, 1970). – Weddige, p. 328, pl. 3, fig. 52.
- 1983 *Tortodus kockelianus australis* (Jackson, 1970). – Wang & Ziegler, pl. 8, figs 17–18.

1986 *Tortodus kockelianus australis* Weddige. – Schönlaub, pl. 5, figs 15–19.

1986 *Tortodus kockelianus australis* (Jackson, 1970). – Ziegler & Wang, pl. 1, fig. 22.

?1989 *Tortodus kockelianus australis* (Jackson). – Mawson & Talent, pl. 6, fig. ?18.

1992 *Tortodus kockelianus australis* (Jackson, 1970). – Bardashev, pl. 4, figs ?26, ?30, 31?, ?17, 16, 24.

1995 *Tortodus kockelianus australis* (Jackson in Pedder et al., 1970). – Savage, p. 554, pl. 6, figs 7–9.

2003 *Tortodus kockelianus* Bischoff & Ziegler. – Pyle et al., pl. 2, figs 19, 20.

Material. – 2 specimens.

Stratigraphical range. – *Australis* Zone, Eifelian (Middle Devonian). In the Prague Basin this taxon occurs together with *P. trigonicus*.

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