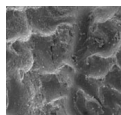


Post-Lau Event (late Ludfordian, Silurian) recovery of conodont faunas of Bohemia

LADISLAV SLAVÍK & PETER CARLS



The effects of the Lau Event on conodont faunas in shallow water environments of the Prague Synform were rather moderate in comparison with Gotland. The post-event restoration of conodont diversity following the characteristic post-*siluricus* faunas with diminished elements and dominated by a long-ranging stock of *Delotaxis* was gradual and not abrupt. This points to absence of such large gaps in the sedimentation like they had occurred below and had caused the lack of a large upper part of the *siluricus* Zone. Accordingly, the Bohemian conodont record of diversifying conodont faunas, starting with the entry of “slender spathognathodontids”, is comparably complete. Increased diversity and abundance of incoming conodont taxa has enabled a refinement of the regional zonal subdivision. This includes the succession of the *plodowskii*, *latialatus*, *parasnajdri* and *crispa* conodont biozones for the interval following the Lau Event in the late Ludfordian. The conodont data from Bohemia show that “*Oz.*” *snajdri* range is largely included in the overlap of *Pedavis latialatus* and “*Ozarkodina*” *crispa*. Accordingly, the use of the problematic stratigraphical unit – the *snajdri* Interval Zone as a base for the definition of a middle Ludfordian Stage Slice can be misleading. Conspicuous morphological changes in the “*Ozarkodina*” *snajdri*–“*Oz.*” *crispa* stocks and in the *Ozarkodina typica* lineage allow refined inter-regional correlations. • Key words: late Silurian, Ludfordian, post-Lau Event, conodont recovery, Lau Event, Prague Synform.

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Numerous studies on Jeppsson’s (1998) mid-Ludfordian conodont Lau Event and its effects on conodont faunas and other faunal groups have been presented in recent years (see e.g., Barrick *et al.* 2010, Manda *et al.* 2012, Tonarová *et al.* 2012). A reflection about the influence of the Lau Event on conodont faunas of Bohemia has been provided by Slavík *et al.* (2010), who interpreted the event as a rather moderate change observed in shallow-water environments and marked by presence of stratigraphic gaps in the vicinities of former volcanic elevations. The present paper refers to the continuation of detailed biostratigraphic studies of the late Silurian strata in the Prague Synform. It focuses on the post-event recovery of conodont faunas during the late Ludfordian.

The precision of global correlation often suffers from incomplete documentation of faunal distribution that is the basis for biostratigraphic framework. Inaccuracies in correlation and spatial image of the interval after the Lau Event on global scale are mostly due to poor biostratigraphic record (partly caused by the corresponding extinction) and/or sedimentological/environmental constraints

(e.g., incompleteness of sedimentary record). The lack of “fresh” biostratigraphic data is, however, the major weak point of some recent summarizing studies dealing with early-middle Palaeozoic bioevents and biozonations. The aim of the present paper is to improve the basis for correlation with conodont data from the latest Ludlow of Bohemia and to document the post-Lau Event recovery in conodont faunas. The conodont ranges obtained from sections in the Prague Synform are correlated with data from previous studies in the same region and with corresponding stratigraphic intervals in Gotland, Eastern Baltica, Sardinia and Carnic Alps. This paper is a result of a long-term study focused on the late Silurian conodont stratigraphy in the Prague Synform within the project “Late Silurian integrated stratigraphy”.

The first conodont zonation for the late Silurian, developed by Walliser (1964), has been modified subsequently by several authors (for review see Corradini 2009 and Corrigan *et al.* 2009). As regards the latest Ludlow (late Ludfordian), the zones treated in this paper, the *siluricus*, *latialatus* and *crispa* zones, have been changed only

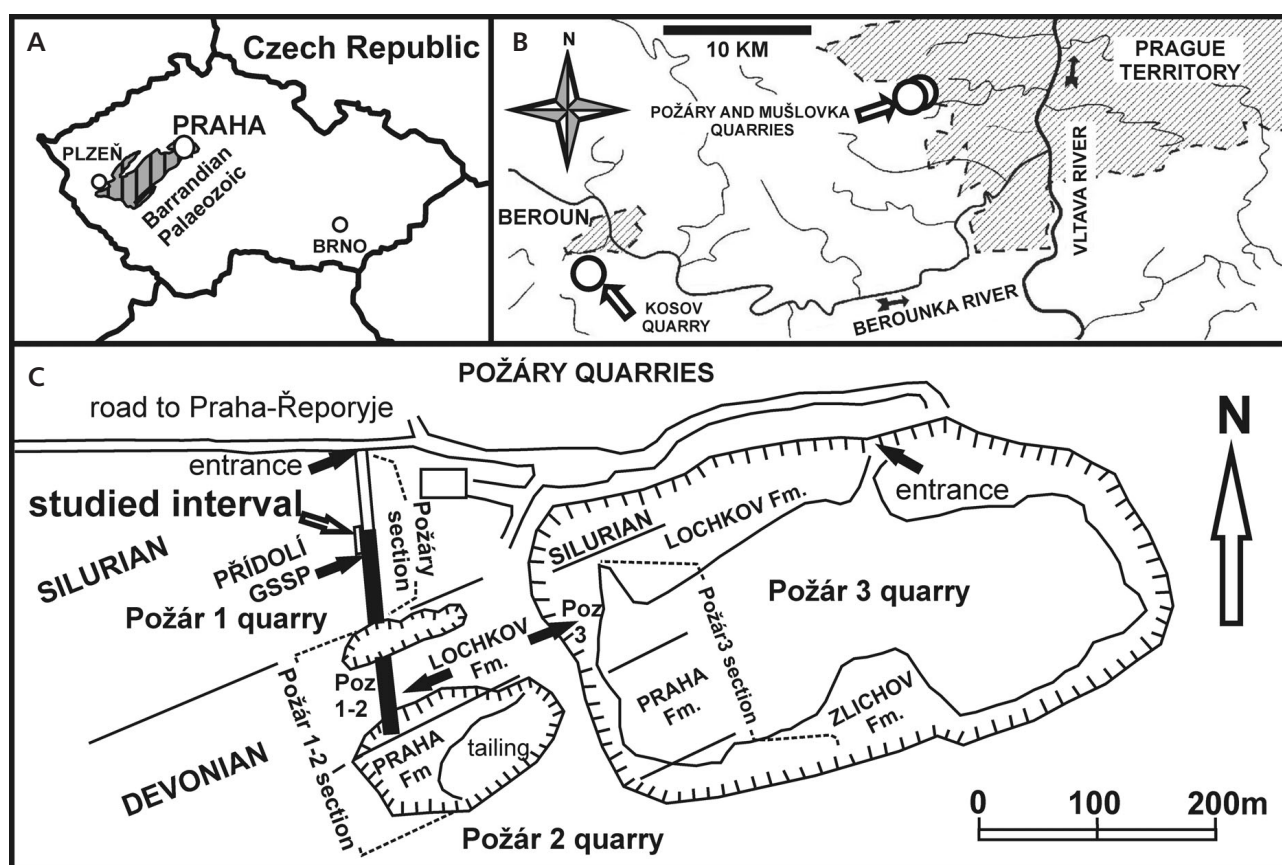


Figure 1. A, B – the position of studied sections within the Barrandian Paleozoic, in the vicinity of Prague. • C – detail of the Požáry Quarries with location of the studied interval near the Přídolí GSSP in the Požáry section.

slightly by including the *snajdri* Interval Zone as summarized by Corradini & Serpagli 1999 and by Corradini (2009). Corradini (2009) highlighted the major problems when searching for a globally acceptable late Silurian standard conodont zonation. Corradini & Barrick (2009) summarized the characteristics that every standard biozonation should possess. Particularly, the lack of “basic properties” of some “standard” zones is the main hindrance for their global application. Another condition that any standard zone should fulfil is its taxonomic and phylogenetic meaningfulness. Moreover, a rather slow progress in taxonomy has precluded substantial progress in the zonation that is almost fifty years old.

Conodont studies on the Ludfordian of Bohemia have been summarized by Slavík *et al.* (2010); the authors stated that the documentation of conodont data was rather scarce in past decades, although there existed extensive collections made by previous conodont workers (*e.g.*, Walliser & Schönlaub) and the present authors. Walliser (1964) was the first author who systematically studied conodonts from the Ludlow of the Prague Synform and the data he obtained were incorporated into his pioneer zonal framework. The conodont distribution and figures of specimens from the

Mušlovka and Koledník sections were presented by Schönlaub (*in* Chlupáč *et al.* 1980). Schönlaub (*in* Kříž *et al.* 1986) studied conodonts mostly from the Ludlow–Přídolí boundary interval in 10 stratigraphic sections (including *e.g.*, Požáry, Mušlovka, Hvíždalka, Koledník and Kosov). He reported the distribution of conodont indexes such as “*Ozarkodina*” *snajdri* and “*Oz.*” *crispa*, and some other common taxa including *Ozarkodina* “*confluens*” (= *Ozarkodina* *ex gr. typica*) and “*Ozarkodina*” *excavata* (= *Wurmiella* *excavata*). The present paper follows up the studies by Carls *et al.* (2005) and Slavík *et al.* (2010) in order to complete the conodont biostratigraphy in the late Ludfordian interval in Bohemia.

After several sections in the Prague Synform have been studied, the Požáry section has been found to be the most suitable one for detailed conodont research of the Ludfordian strata. This implies the good accessibility of late Silurian strata where the GSSP for the Přídolí has been defined, the almost continuous succession with high density of manifold studies on biostratigraphy (*e.g.*, Kříž *et al.* 1986), on bioevents (*e.g.*, Manda & Frýda 2010), on palaeoecology and palaeogeography (*e.g.*, Manda 2008). It benefits from diversity and abundance of conodont faunas.

Accordingly, the Požáry section (see Figs 1 and 2) may serve as a reference section for the conodont correlation of the Ludfordian in the Prague Synform.

Locality of Požáry Quarries, sedimentological overview and previous conodont work

The Požáry Quarries lie in the Prague Synform. In the sense of Melichar (2004) and Knížek *et al.* (2010) it is an asymmetric elliptical structural depression and erosional relic of unmetamorphosed Ordovician through Middle Devonian volcanic-sedimentary successions. The locality comprises the stratigraphic interval from Ludlow to Emsian. The Požáry Quarries are located E of Řeporyje village (Fig. 1), at the WSW margin of Prague (GPS location: 50°01' 43.92" and 14°19' 38.74" for the GSSP of the Přídolí Series). The area consists of several quarries and connecting tunnels. The section above the entrance tunnel is the GSSP locality of the Přídolí Series (described in detail by Kříž *et al.* 1986) and particularly known as the Požáry section. The abandoned quarries are known in literature as Požár 1 and Požár 2; the section exposed in the western part of the active quarry is Požár 3 (Slavík *et al.* 2010). The interval sampled for the present study is within the protected part of the locality; it begins just above the northern mouth of the entrance tunnel and ends at the base of the Přídolí (*i.e.* the GSSP boundary) above the middle of the tunnel.

The history of studies of various stratigraphic intervals in the Požáry Quarries dates back to the early half of the 20th century; it was briefly summarized in Slavík *et al.* (2010). The fundamental bed-by-bed study of the Ludlow-Přídolí interval was done by Kříž (1965, unpublished data). It includes detailed descriptions and numbering of beds. Data derived from it were the basis for the GSSP definition (Kříž *et al.* 1981, 1986); this numbering is applied also in this paper.

The Požáry section and the nearby very similar section at Mušlovka Quarry cover a part of the Řeporyje Volcanic Elevation, which is the WNW part of the Ludfordian isolated carbonate platform in the eastern part of the Prague Basin, as interpreted by Manda & Kříž (2006). The lithology of the Ludfordian from the upper part of the *siluricus* Zone to the base of the Přídolí including the newly sampled interval of the Požáry section is shown in Fig. 2. The lithology of the underlying interval of the Požáry section, including the equivalent of the Lau Event, was summarized by Slavík *et al.* (2010). Massive grainstones (beds Nos. 33 and 34) contain fauna coeval to the *N. kozlowskii* graptolite Biozone. They are followed by mostly crinoidal grainstones with the *Ananaspis fecunda* trilobite horizon which first appears in bed No. 37. Lehnert *et al.* (2007) observed signs of paleokarst in the bed No. 33 and above, up to bed

No. 41; accordingly, extreme shallowing or even stratigraphic gaps can be expected in this interval. Thick-bedded biotrititic limestones (beds Nos. 42, 44), that represent a major part of the Lau Event interval in the Požáry section, are overlain by thinner packstone beds with increasing contents of micrite. From the level of 19 m onward, the section consists of grey thin bedded packstones, subordinate siltstones and calcareous shales alternating with layers or lenses of grey lime-mudstones and packstones. Some limestone layers contain abundant trilobites (*e.g.*, beds Nos. 60, 73, 75). Graptolites *Pristiograptus dubius s.l.* and "*Mono-graptus*" aff. *kallimorphus* are reported from calcareous shales in beds Nos. 86 and 88, *Pristiograptus fragmentalis?* was obtained only from the base of bed No. 93 (Kříž *et al.* 1986). According to Kříž (1992), the massive bed No. 87 (so-called "cephalopod bank") is the top bed of the Kopanina Formation. It contains very rich fauna with cephalopods, bivalves, ostracods and chitinozoans. The Požáry Formation begins just above this bed in the final Ludlow with mainly unsorted grainstones, packstones and carbonate mudstones (Kříž *et al.* 1986). Sorting of bioclasts within the uppermost Ludfordian beds may indicate storm deposits. The lithology and the faunal contents of the entire Ludfordian in the Požáry section reflect considerable fluctuation in depth like in other Ludfordian sections in the Prague Synform (Manda & Kříž 2006, text-fig. 2).

Conodonts have been studied from several stratigraphical intervals of the Požáry Quarries (see summary by Slavík *et al.* 2012 *in press*). Conodonts from the post-Lau Event interval were included in the study by Mehrtens & Barnett (1976), who reported index taxa including *Pedavis latialatus* and "*Spathognathodus*" *snajdri*. Schönlaub (*in* Kříž *et al.* 1986) provided conodont data from the Ludlow-Přídolí boundary interval from several sections including the Požáry section. He found the index taxa "*Ozarkodina*" *snajdri* and "*Oz.*" *crispa*, the latter of which reached the base of the bed No. 91. Carls *et al.* (2005) showed further ranges of taxa in the late Ludfordian and discovered the innovative origin of alternating denticle size within Spathognathodontidae in *Parazieglerodina pldowskii* found in bed No. 62. Slavík *et al.* (2010) showed the conodont distribution around the Lau Event in the Požáry section. This paper continues the studies about the Lau Event in Bohemia based on additional conodont collections from the late Ludfordian.

Material and methods

The samples from the Požáry, Mušlovka and Kosov sections have been taken during campaigns in the last 10 years. They were collected in closely spaced intervals – mostly from the entire thickness of a solid carbonate bed (usually 15–20 cm thick) or from thicker intervals of thin beds

(composite samples) as seen in Fig. 2. Weights of samples vary from 4 to 15 kg. The rock was leached using standard techniques with formic or acetic acid in the laboratories of the Institute of Geology AS CR, v.v.i. and TU Braunschweig.

Voluminous residues (of up to 400 ml) dominated by siliceous particles were concentrated in tribrommethane. Residues with porous aggregates were treated with the up-graded magnetic susceptibility separation method (Carls & Slavík 2005), which avoids using heavy liquids. Conodonts were obtained from all samples (*i.e.* more than 3000 complete or slightly fragmented elements). The SEM images of selected conodont elements were made by using a Tescan Vega 3 SEM. The conodont material from the Požáry Quarries is temporarily kept in the collections of L. Slavík and P. Carls at the Institute of Geology AS CR, v.v.i. and at the TU Braunschweig, respectively.

Conodonts from the post-Lau Event interval in the Prague Synform

The generic affiliations of some conodont taxa mentioned in this paper have been changed repeatedly, and the inclusion of some in a genus is doubtful. The latter genera are set in quotation marks because no better generic affiliation is presently possible. This is particularly the case of the genus “*Ozarkodina*” *s.l.*; *e.g.*, taxa belonging to the *crispa* and *snajdri* stocks differ from the typical stock of the genus *Ozarkodina* Branson & Mehl, 1933 *s.s.*, but have only been quoted in it and have not yet been formally attributed to a convenient genus.

Mušlovka, Kosov, and Požáry sections, selected for the new sampling, partly confirmed previous data but also provided important new biostratigraphic information: Most samples from the Kosov section (for description and location see Kříž *et al.* 1986) furnished only few indeterminate fragments of conodonts; a fragment of P1 element of “*Ozarkodina*” *crispa* was found just below the Ludlow-Přídolí boundary (bed No. 19); it confirms the previous data of Schönlaub (*in* Kříž *et al.* 1986). Preliminary results obtained from 18 conodont samples from the Mušlovka section extended the previous knowledge provided by Schönlaub (*in* Chlupáč *et al.* 1980). The new samples were taken mostly from previously unsampled levels or parts of

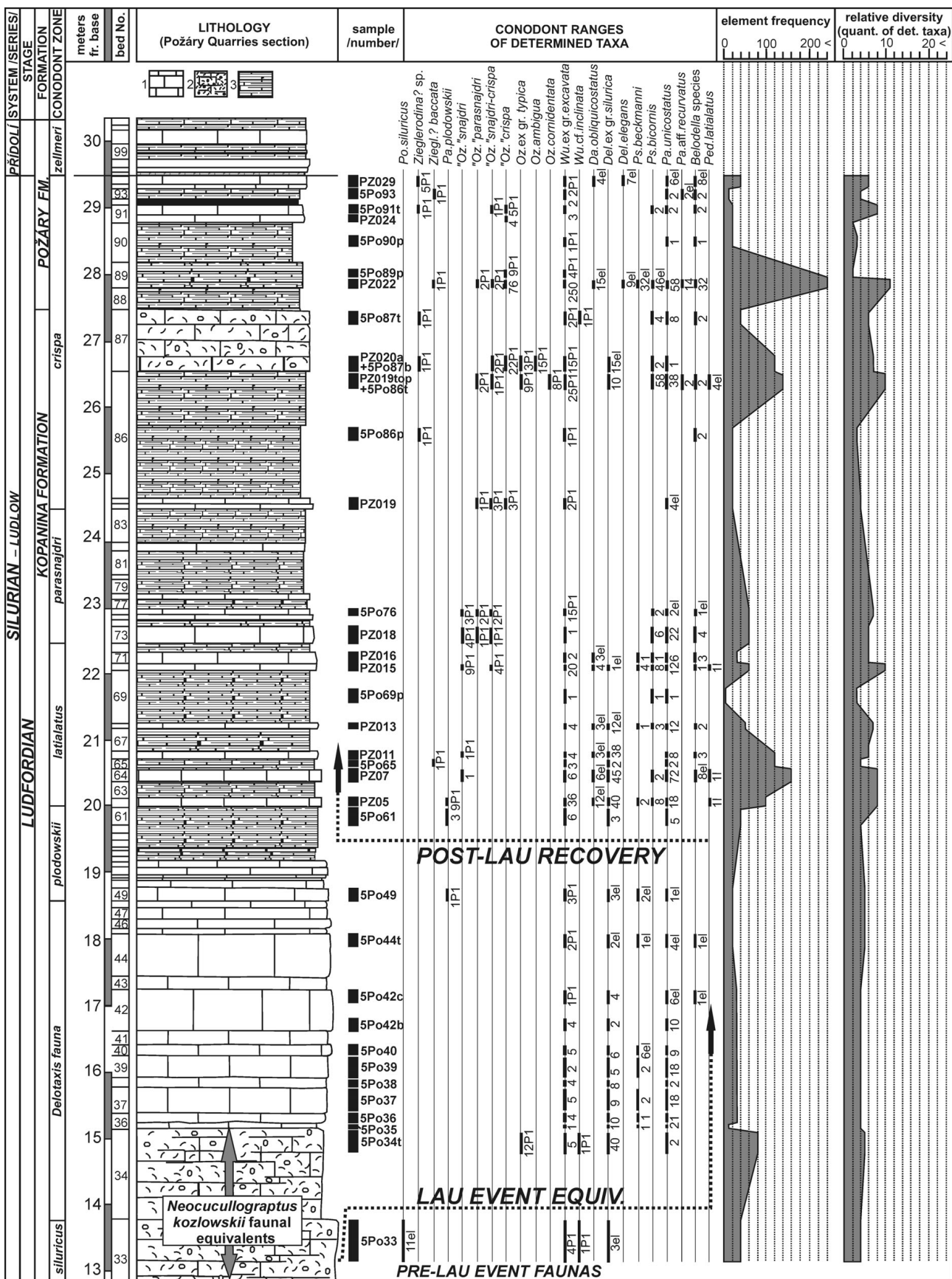
beds in order to complete the information on conodont ranges. The Mušlovka section lies about 700 m east from the Požáry section. Both sections have similar lithologies, however, the thicknesses of some horizons vary slightly. For a detailed description of the Mušlovka section see Kříž (*in* Chlupáč *et al.* 1980). The “traditional” stratigraphically important taxa as *Polygnathoides siluricus*, “*Ozarkodina*” *snajdri* and “*Oz.*” *crispa* were found in the Mušlovka section, and, most importantly, also *Parazieglerodina plodowskii* Carls *et al.*, 2005 was obtained. The conodont data from the repeated samplings of the late Ludfordian of the Požáry section is presented herein with special attention because it is considered the most representative set within the entire Prague Synform.

The preservation of conodont elements in the majority of the samples is fair. Only in the sample PZ015 all elements are thoroughly bleached and are of whitish colour. In contrast to the underlying *siluricus* Zone, the basal filling is not preserved in any conodont element. The following characterization of the conodont material does not only consider taxonomical affinity, but also looks out for possible relations between morphology and susceptibility for environmental effects on conodontophorid life.

Plain spathognathodontids

A group of taxa represented by rather delicate P1 elements, which are notably smaller than other late Ludfordian Spathognathodontidae, are herein informally addressed as “slender spathognathodontids” (see Figs 3–7). Most P1 elements can be attributed to the established taxa. Several specimens could not be classified with certainty, neither to specific nor to generic level; their distribution at Požáry is marked as *Zieglerodina*? sp. Apart from *Wurmiella*, the first spathognathodontid taxon that appears after a long interval with only monotonous conodont faunas around the Lau Event is *Parazieglerodina plodowskii* Carls *et al.*, 2005, which is characterized by incipient alternating denticulation in some ramiform elements. This morphological innovation probably reflects a new function of the ramiform elements in the post-Lau Event development of conodonts, which tested the new morphologies for feeding apparatuses. The entry of this taxon is found herein 1.3 m lower than it was found by Carls *et al.* (2005). In the Požáry

Figure 2. Stratigraphic section with sampled interval comprising the upper Ludfordian including the equivalents of the Lau Event and the post-Lau Event time in the Požáry Quarries. The figure shows the distribution of the most important conodont taxa and numbers of conodont elements (*e.g.*, “3P1” means 3P1 elements in the sample, “18el” means 18 conodont elements of different kinds belonging to the taxon in the sample). Element frequency in samples is based on the total number of conodont specimens, and relative conodont diversity is based on the quantity of determined taxa (undetermined elements were not considered in the graph). The bed numbers are adopted from Kříž *et al.* (1986) and Kříž (1965, unpublished part of the Požáry section). Lithology legend: 1 – grey lime-mudstones and biotrititic packstones; 2 – bioclastic grainstones with cephalopods, bivalves or brachiopods; 3 – thin-bedded packstones and subordinate siltstones and calcareous shales alternating with layers or lenses of grey lime-mudstones and packstones.



section it enters in bed No. 49 (sample 5Po49). In the Mušlovka section it was obtained only from bed No. 22 (sample 9MU). As the recorded range in the Požáry section shows (Fig. 2), *Parazieglerodina plodowskii* is a short range taxon that probably precedes the entry of “*Oz.*” *snajdri* and thus may be stratigraphically significant in the Barrandian.

Only three P1 elements of *Zieglerodina?* *baccata* (Miller & Aldridge, 1997) were obtained from three samples of the late Ludfordian in the Požáry section. The apparatus of *Z.?* *baccata* has not yet been reconstructed, but few associated fragments of ramiform elements with alternation from the Požáry section point to a similarity with the apparatus of *Zieglerodina* Murphy *et al.*, 2004. This taxon has been reported from the Upper Whitcliffe Formation from Wales (Miller & Aldridge 1997) and from the Kuressaare Stage in East Baltica (Viira 1999).

Ozarkodina s.s.

The characteristic species of *Ozarkodina* s.s. generally have unsteady distributions in many sections and regions. The representatives of the genus *Ozarkodina* Branson & Mehl, 1933 disappeared from the Prague Synform during the Lau Event and re-appeared thereafter. Following the revision by Murphy *et al.* (2004), only the taxa belonging to *Ozarkodina* ex gr. *typica* are considered herein to fall into *Ozarkodina*. The P1 elements of *Ozarkodina* are characterized by a high anterior cockscomb set off from the rest of the element; the basal cavity is centered very near the mid-length of the blade, the basal cavity and the platform lobes are very small. There is a very long interruption in the occurrence of *Ozarkodina* from the top of the bed No. 34 up to the top of bed No. 86, where it reappears and ranges in a very short interval. The same range of *Ozarkodina* can be seen in the equivalent section Mušlovka, where *Ozarkodina* is absent from 1 m above the last occurrence of *Polygnathoides siluricus* onward. Its massive re-appearance then starts from bed No. 33a which is the base of the “cephalopod bank” known from several sections around the Prague Synform (cf. Kříž *et al.* 1986). The new sampling did not furnish any occurrence of *Ozarkodina* s.s. between these levels. The material obtained from four samples taken around the boundary of beds Nos. 86 and 87 in the Požáry section shows certain variability, but the specimens are not variable to the high degree as during the *siluricus* Zone (cf. Slavík *et al.* 2010, fig. 5). Several P1 elements of *Ozarkodina* obtained from the top of bed No. 86 can be assigned to *Ozarkodina cornidentata* (Viira, 1983). This taxon has been described from the Paadla Stage in East Baltica and, according to Viira (1999), is characterized by 2–3 big posteriorly inclined denticles in the central-posterior part of the blade. The specimens vary in the inclination of denticles, which is not always so distinct as shown by Viira

(1999, pl. 2, figs 5, 6). Therefore some specimens are treated herein in open nomenclature. The specimen of Fig. 7B represents the typical morphology of *Ozarkodina cornidentata*; it was found only at the top of bed No. 86. *Ozarkodina ambigua* (Viira, 1983) occurs only just above, in the basal part of bed No. 87. This taxon from the Kuressaare Stage in East Baltica is characterized by a convex posterior part of the blade and a regular anterior cockscomb with at least three unfused denticles (see Fig. 7O). Similar morphology of the blade occurs also in other taxa and in other regions but are not identical: The specimen figured by Corriga & Corradini (2009, fig. 4L) from the *snajdri* Zone in the Carnic Alps seems to be very close to *Oz. ambigua* because of its irregular denticle sizes. The character of the cockscomb, degree of fusion of denticles and their inclination is also variable in our *Ozarkodina* s.s. and therefore, many specimens from the Požáry section cannot be unambiguously attributed to the species of *Ozarkodina* s.s. mentioned above. Accordingly, a number of specimens from both levels is here treated as *Ozarkodina* ex gr. *typica* – i.e. a group of taxa with general morphology of *Ozarkodina* s.s. According to Carls *et al.* (2007), in the Požáry section, *Ozarkodina typica* s.s. appears 20 cm above the base of Přídolí. The genus reached the very end of the Silurian, but did not cross the Silurian-Devonian boundary.

“*Ozarkodina*” of the *snajdri-crispa* group

As mentioned above, spathognathodontid taxa of the *crispa* and *snajdri* stocks cannot belong to the genus *Ozarkodina* s.s. This may be stated, although their apparatuses remain unknown. The morphological difference of their P1 elements from *Ozarkodina* is substantial: e.g., lack of anterior cockscomb, far posterior extension of basal lobes. These taxa were reported from many parts of the world including Australia (see review by Simpson 1995) as *Ozarkodina*. Following the discussion in Murphy *et al.* (2004), we maintain the traditional generic attribution to *Ozarkodina* in quotation marks, only because no other genus name is available. We suggest that a genus should be typified by a species whose apparatus could largely be characterized.

The material of the “*Ozarkodina*” *snajdri-crispa* group obtained from the Požáry and Mušlovka sections can be attributed to four taxa based on the P1 elements. The oldest “*Oz.*” *snajdri* enters just above the last *Parazieglerodina plodowskii* (sample PZ07, bed No. 64, Požáry section; sample 10MU, bed No. 23, Mušlovka section). The range of “*Oz.*” *snajdri* is relatively short in both sections (approximately 2.5 m interval). In the upper range it overlaps with “*Oz.*” *parasnajdri* Viira & Aldridge, 1998. According to its diagnosis, “*Oz.*” *parasnajdri* differs from “*Oz.*” *snajdri* by characteristic fusion of denticles above its platform. All of Walliser’s figured type specimens of *snajdri* have discrete

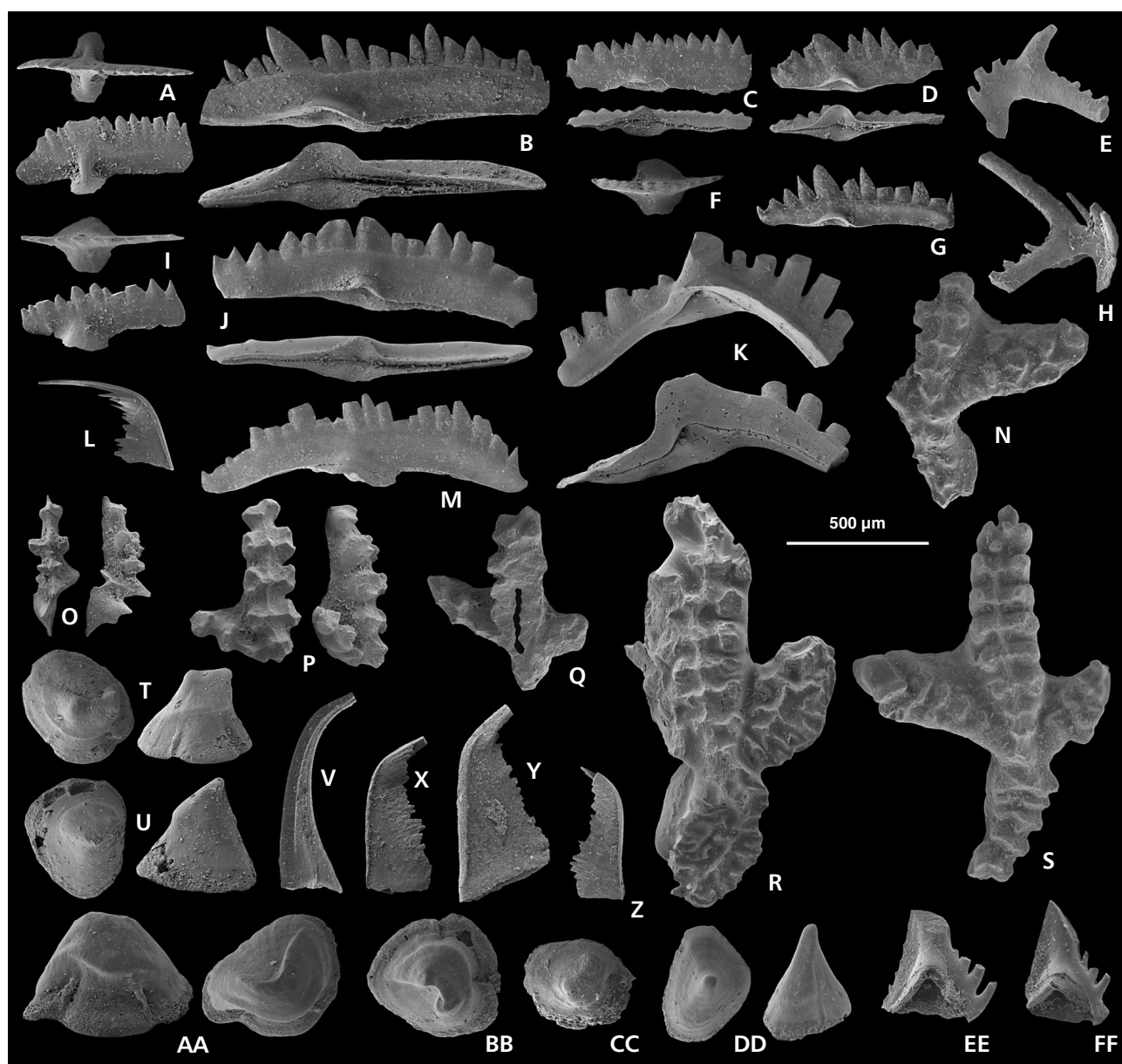


Figure 3. A – *Parazieglerodina plodowskii* Carls *et al.*, 2005; upper and lateral view of P1 element, sample 5Po61. • B, D, G, M – *Wurmiella excavata* (Branson & Mehl, 1933) *sensu lato*. • B – lateral and lower view of P1 element, sample 5Po61. • D – lateral and lower view of immature P1 element, sample PZ015. • G – lateral view of P1 element, sample PZ015. • M – lateral view of P1 element, sample 5Po93. • C – *Wurmiella* ex gr. *excavata* (aff. *alternata* Corradini & Corrigan, 2010); lateral and lower view of P1 element, sample 5Po93. • J – *Wurmiella* cf. *inclinata* (Rhodes, 1953); lateral and lower view of P1 element, sample 5Po87t. • E, H – *Delotaxis elegans* (Walliser, 1964), inner lateral views of S2 elements, sample PZ022. • F – *Zieglerodina*? cf. *baccata* (Miller & Aldridge, 1997), upper view of immature P1 element, sample 5Po93. • I – *Zieglerodina*? *baccata* (Miller & Aldridge, 1997), upper and lateral view of P1 element, sample 5Po65. • K – *Delotaxis* ex gr. *silurica* (Branson & Mehl, 1933), outer lateral and lower view of P2 element, sample PZ07. • L, Y – *Belodella* aff. *anomalis* Cooper, 1974. • L – lateral view, sample PZ019top. • Y – lateral view, sample 5Po87t. • N–S, EE, FF – *Pedavis latialatus* (Walliser, 1964). • N – upper view of incomplete I element, sample PZ019top. • O – upper and lateral view of immature I element, sample PZ05. • P – upper and lateral view of incomplete immature I element, sample PZ07. • Q – upper view of incomplete I element, sample PZ015. • R – upper view of incomplete I element, sample PZ019top. • S – upper view of I element, sample PZ019top. • EE – lateral view of uncertain element, sample PZ019top. • FF – lateral view of uncertain element, sample PZ019top. • T, AA–CC – *Pseudooneotodus bicornis* Drygant, 1974. • T – upper and lateral view, sample 5Po76. • AA – lateral and upper view, sample PZ019top. • BB – upper view, sample PZ019top. • CC – upper view, sample PZ016. • U, DD – *Pseudooneotodus beckmanni* (Bischoff & Sannemann, 1958). • U – upper and lateral view, sample 5Po61. • DD – upper and lateral view, sample PZ019top. • V – *Panderodus unicostatus* (Branson & Mehl, 1933); lateral view, sample 5Po61. • X, Z – *Belodella* cf. *resima* (Philip, 1965). • X – lateral view, sample 5Po65. • Z – lateral view, sample 5Po93. All specimens are deposited in the collections of Ladislav Slavík at the Institute of Geology AS CR, v.v.i. and Peter Carls at the Technische Universität Braunschweig. All figures are the same scale (scale bar equals 500 μm).

denticles throughout the blade. The platform of “Oz.” *parasnajdri* has a sub-quadrangular shape like in *snajdri* but unlike *crispa* where it is oblique. The taxon *parasnajdri* is treated herein on specific level (not as a subspecies) because of the difference in denticulation between *snajdri* and *parasnajdri*.

The entry of “Oz.” *crispa* was recorded in sample PZ019 (beds Nos. 84 and 85) in the Požáry section, *i.e.* 5 m below the base of the Přídolí. The new sampling revealed an earlier entry of “Oz.” *crispa* (sample 13MU, bed. No. 32) in the Mušlovka section than formerly reported by Schönlaub (*in* Chlupáč *et al.* 1980); this entry is equivalent to that in the Požáry section. The specimens of “Oz.” *crispa* obtained are highly variable (see Figs 4 and 5). Four morphotypes (alpha, beta, gamma and delta) of *crispa* were discriminated by Walliser & Wang (1989). Additionally, Viira & Aldridge (1998) further distinguished sub-morphotypes of the typical alpha morphotype, the only one that lacks a “sulcus” (furrow) on the oral margin of the blade. Similarly, like in Baltica, all obtained specimens from the Prague Synform can be attributed to the alpha group of morphotypes. According to Viira & Aldridge (1998), some specimens belong to morphotype alpha2 (see Fig. 5B, H–J) in which the basal cavity is sub-circular and the denticles of the blade above the basal cavity are fused. In morphotype alpha3 (see Fig. 5C, L, P) the denticles above the basal cavity are only partly fused or unfused. The stratigraphical ranges of these morphotypes overlap completely; in all samples they are present together. Therefore, the stratigraphic utility for a refined subdivision is not yet certain. The material attributed to the *snajdri-crispa* group contains many transitional forms. Accordingly, there are many specimens left in open nomenclature (*cf.* Figs 4 and 5): in “Ozarkodina” *cf.* *parasnajdri* and in “Oz.” *cf.* *snajdri* the denticles are only partly fused; “Ozarkodina” *snajdri-crispa* is the characteristic transitional form which has an undulated (wavy) platform like in typical *crispa*, but the end of the blade comes out like in *snajdri*. These transitional specimens are present in a thick interval starting from bed No. 70 in the Požáry section.

Icriodontids

Icriodontids are represented by *Pedavis latialatus* (Walliser, 1964). The new sampling confirmed its occurrence only in the Požáry section. Schönlaub (*in* Kříž *et al.* 1986) reported *Ped. latialatus* also from the sections of Koledník, Kosov, Marble Quarry, and Mušlovka. Although *Pedavis* is very scarce in the sections of the Prague Synform, in the Požáry section this stratigraphically important lineage has the longest range documented. Its stratigraphic range even exceeds the range of “Oz.” *snajdri*. It confirms that the conodont record in the Požáry section is the most complete

and representative in the Prague Synform. The oldest specimens are from bed No. 62 (sample PZ05). The material of *Pedavis* obtained from the Požáry section includes both mature and immature I elements. Classification of small I elements is not always unambiguous, however, the attribution to *Ped. latialatus* is likely because of the stratigraphic position of these oldest *Pedavis* for which only one species has been erected as yet. Apart from platform elements, some other associated elements of the *Pedavis* apparatus were found in sample PZ019top (see Fig. 3EE, FF), *i.e.* the youngest sample where this taxon occurs.

Wurmiella

The genus *Wurmiella* Murphy, Valenzuela-Ríos & Carls, 2004 is the most commonly represented one in the Ludfordian as regards P1 elements of Spathognathodontidae. Taxa belonging to *Wurmiella* are present in all samples in the Požáry and Mušlovka section. The genus shows maximum resistance against sea-level fluctuation and other palaeoenvironmental changes and whatsoever effects of the Lau Event. In *Wurmiella*, the post-Lau Event development consists in characteristic shortening of P1 elements and by decrease of the number of denticles. The post-Lau Event specimens have usually 4 to 5 denticles less than the adult P1 elements of *Wu. excavata* from the *siluricus* Zone. Diversity of P1 elements is also higher than in the preceding *siluricus* interval. Most of the specimens obtained from the new sampling belong to *Wurmiella excavata* (Branson & Mehl, 1933) *s.l.* We refer to this stock *sensu lato* because of marked differences in the angulation of the aboral margin and of the denticulation between the typical material from the Bainbridge Limestone (Branson & Mehl 1933) and the material obtained from the Požáry and Mušlovka sections. The concept of *Wurmiella* and the apparatus reconstruction herein agrees with that of Murphy *et al.* (2004); representative selections of elements of the apparatus of *Wurmiella* are figured on Figs 3 and 6. In the material from the Požáry section, a few specimens are similar to a taxon just recently established: *Wurmiella aff. alternata* Corradini & Corrigan, 2010 of Fig. 3C was obtained from bed No. 93 in the Požáry section. It is characterized by a straight aboral margin and intercalation of single small denticles between larger ones along the blade. The denticles are straight and without inclination that is typical for most other specimens of *Wurmiella*. The taxon *Wu. alternata* has been described from the Carnic Alps from the lower Přídolí. Four specimens obtained from the uppermost Ludlow of the Požáry section may represent the same taxon or its ancestor. The distribution of diverse forms of the *Wu. excavata* group from the Požáry section is indicated in Fig. 2 as *Wurmiella ex gr. excavata*. Only few P1 elements of *Wurmiella* were classified to *Wurmiella cf. inclinata* (Rhodes, 1953); their spacing of

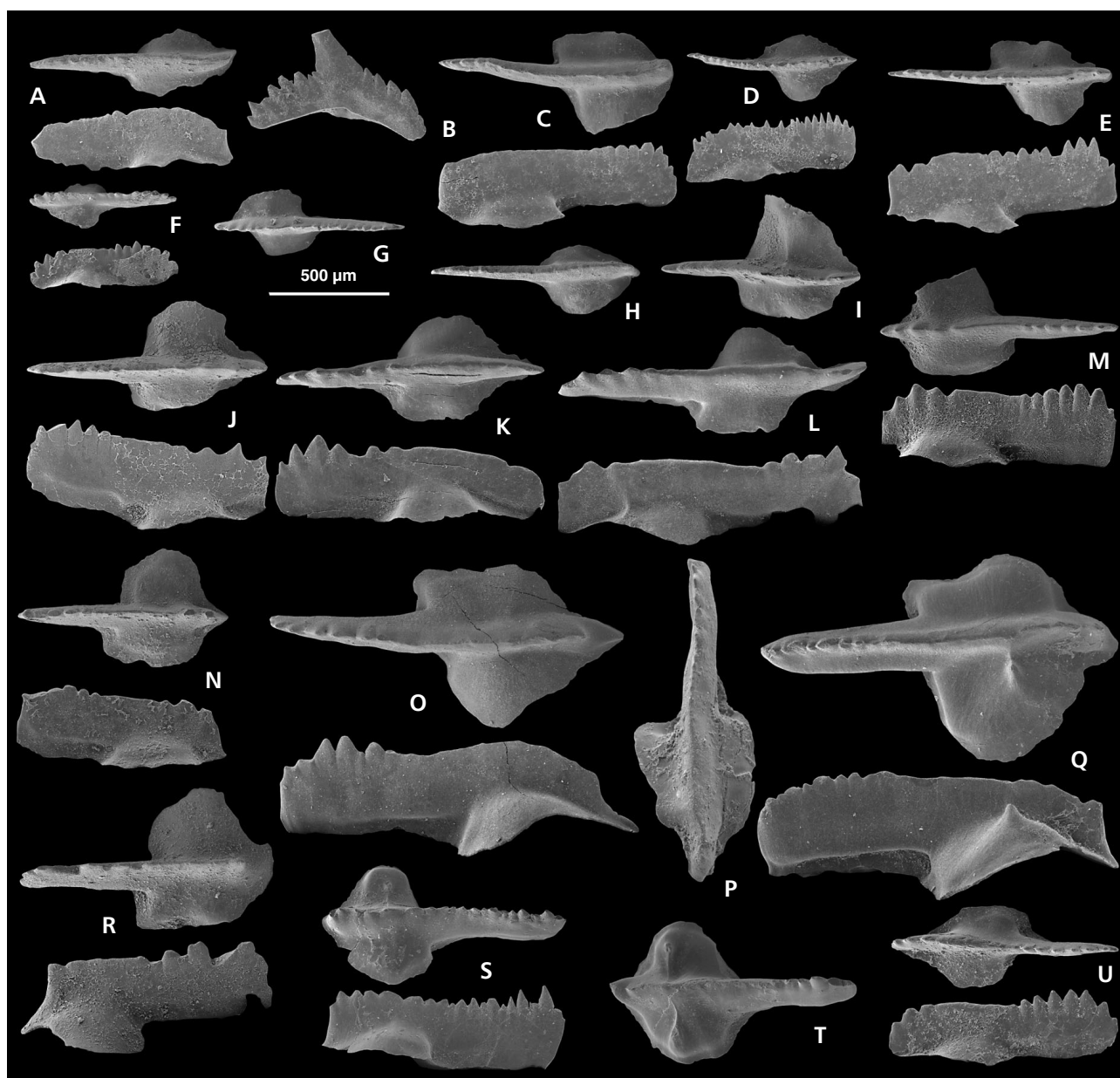


Figure 4. A, B, D, F, G, H, J, M – “*Ozarkodina*” *snajdri* (Walliser, 1964). • A – upper and lateral view of P1 element, sample PZ07. • B – lateral view of P2 element, sample PZ07. • D – upper and lateral view of P1 element, sample PZ015. • F – upper and lateral view of small P1 element, sample PZ07. • G – upper view of P1 element, sample PZ015. • H – upper view of P1 element, sample PZ015. • J – upper and lateral view of P1 element, sample PZ018. • M – upper and lateral view of P1 element, sample PZ018. • E, N – “*Ozarkodina*” cf. *snajdri* (Walliser, 1964). • E – upper and lateral view of P1 element, sample PZ015. • N – upper and lateral view of P1 element, sample PZ018. • C, I, O, Q, S – “*Ozarkodina*” *snajdri-crispa*. • C – upper and lateral view of P1 element, sample PZ015. • I – upper view of P1 element, sample PZ015. • O – upper and lateral view of P1 element, sample 5Po076. • Q – upper and lateral view of P1 element, sample PZ019. • S – upper and lateral view of P1 element, sample PZ019top. • K, L, U – “*Ozarkodina*” *parasnajdri* Viira & Aldridge, 1998. • K – upper and lateral view of P1 element, sample PZ018. • L – upper and lateral view of P1 element, sample PZ018. • U – upper and lateral view of P1 element, sample PZ019top. • P – “*Ozarkodina*” cf. *parasnajdri* Viira & Aldridge, 1998, upper view of P1 element, sample PZ019top. • R – “*Ozarkodina*” *crispa* (Walliser, 1964), upper and lateral view of P1 element, sample PZ019. • T – “*Ozarkodina*” aff. *crispa* (Walliser, 1964), upper view of P1 element, sample PZ019top. All specimens are deposited in the collections of Ladislav Slavík at the Institute of Geology AS CR, v.v.i. and Peter Carls at the Technische Universität Braunschweig. All figures are the same scale (scale bar equals 500 µm).

denticles is similar to that of the specimen figured by Rexroad & Craig (1971, pl. 80, fig. 25), which was designated as the neotype of *Wu. inclinata* by Murphy *et al.* (2004,

p. 10). The specimen figured in Slavík *et al.* (2010, fig. 6U) from the *siluricus* Zone is immature, but the specimen from the younger top of bed No. 87 (Fig. 3J herein) is mature.

These specimens are treated in open nomenclature because their lower margins are almost even, which differs from *Wu. inclinata*.

Delotaxis

The populations of *Delotaxis* Klapper & Philip, 1971 were very successful components of conodont faunas during the Lau Event. Following the discussion in Slavík *et al.* (2010), the use of the genus name *Delotaxis* for the late Silurian-early Devonian group of prioniodinid taxa is preferred herein rather than the name “*Oulodus* Branson & Mehl, 1933”. The distribution of *Delotaxis* in the Mušlovka section is similar to that in the Požáry section shown in Fig. 2. Elements of *Delotaxis* ex gr. *silurica* were found together with *Po. siluricus* and were frequent already during the early post-Lau Event time, when there were no other apparatuses of composite elements besides *Wurmiella*. Then they co-occurred only briefly with the just originating new spathognathodontids (*i.e.* *Pa. plodowskii*, *Z. ? baccata* and “*Oz.*” *snajdri*). Suddenly *Delotaxis* showed, however, a marked decrease at the massive entry of the “*Oz.*” *snajdri* stock, *i.e.* the interval between samples PZ015 and 5Po76 (see Fig. 2). From this level onward, the elements of *Delotaxis* disappear for a long interval, probably as a result of dominance of spathognathodontid competitors. The re-appearance of *Delotaxis* was found in the top of bed No. 86 in the Požáry section (Fig. 2). The material from the post-Lau Event interval is in general rather poor and often fragmented. Accordingly, the specific determination is difficult. Most of the specimens probably belong to *Delotaxis* ex gr. *silurica* (Branson & Mehl, 1933; see Fig. 3K). Close to the end of the Ludlow the *silurica* group is replaced by *Delotaxis elegans* (Walliser, 1964). Only few complete specimens of *D. elegans* were obtained (Fig. 3E, H). Also in the East Baltic erratics the *elegans* stock begins to abound in the late Ludfordian.

Coniform elements

Simple cone elements were much more abundant during the Lau Event and post-Lau Event interval than during the *siluricus* Zone. The increasing presence of coniform elements is the dominating success of conodont faunas and it corresponds with their recovery after the Lau Event. Three genera abound first: *Pseudooneotodus*, *Panderosus* and *Belodella*; *Dapsilodus* joins them in the *plodowskii* Zone. Selected coniform elements are figured in Fig. 3. The specific identifications (*cf.* Figs 2 and 3), however, are still more or less tentative. *Belodella* from the Mušlovka and Požáry sections includes several taxa close to *B. anomalis* Cooper, 1974 and *B. resima* (Philip, 1965).

Pseudooneotodus start to occur in higher numbers in the late Ludfordian as shown by Corradini (2007, fig. 2); the same is the case in the Prague Synform. *Pseudooneotodus bicornis* Drygant, 1974 occurs from bed No. 62 onward and is the most frequent coniform element in the late Ludfordian. The stratigraphic significance of some delicate simple cone elements (*e.g.*, *Belodella*) is, in general, rather low; as their frequency in samples may largely depend on depositional conditions (*e.g.*, hydrodynamic sorting of sediment particles).

Summary of biostratigraphic data from the late Ludfordian in the Prague Synform

To summarize, the conodont data from the late Ludlow in the Prague Synform provide an image of stepwise increase of conodont diversity that starts already below the recorded entry of *Pedavis latialatus*. It corresponds also to the restoration of benthic and nektobenthic faunas correlated with the upper part of the *Pseudomonoclimacis latilobus-Slovinograptus balticus* graptolite Biozone Zone and is connected with a moderate sea-level rise (*cf.* Manda & Kříž 2006, Manda *et al.* 2012). After an interval of low diversity with long-ranging ubiquists the entry of slender spathognathodontids (*e.g.*, *Parazieglerodina plodowskii*) is the dawn of conodont proliferation in the Požáry and Mušlovka sections. These localities belonged to the former volcanic elevation during the mid-Ludfordian and were affected by fluctuations of sea-level that also could reduce the completeness of the biostratigraphical record. The index taxon *Pedavis latialatus* is, as usual, very rare and it has been recorded by new sampling only in the Požáry section. Accordingly, in other sections the *latialatus* time is correlated indirectly – using the *snajdri* and *crispa* stocks. Schönlaub (*in* Chlupáč *et al.* 1980 and *in* Kříž *et al.* 1986) provided already basic conodont information (the ranges of the taxa *snajdri*, *crispa*, *typica* and *excavata*) of the Ludlow-Přídolí boundary interval from sections in the Prague Synform. According to the former and the new data, “*Ozarkodina*” *crispa* was documented to disappear closely below the Ludlow-Přídolí boundary.

The correlation of conodont and graptolite faunas within the late Ludfordian of the Prague Synform would be welcome, but it is difficult due to the facies-control of occurrences and absences of graptolites in limestone dominated sections. Reference to graptolite ranges is mostly indirect, being based on the distribution of benthic and nektobenthic faunas (*e.g.*, Kříž 1991, Manda & Kříž 2006). According to Kříž *et al.* (1986) graptolite data from the predominately carbonatic successions of the late Ludfordian are extremely scarce; this is in contrast to the Přídolí where

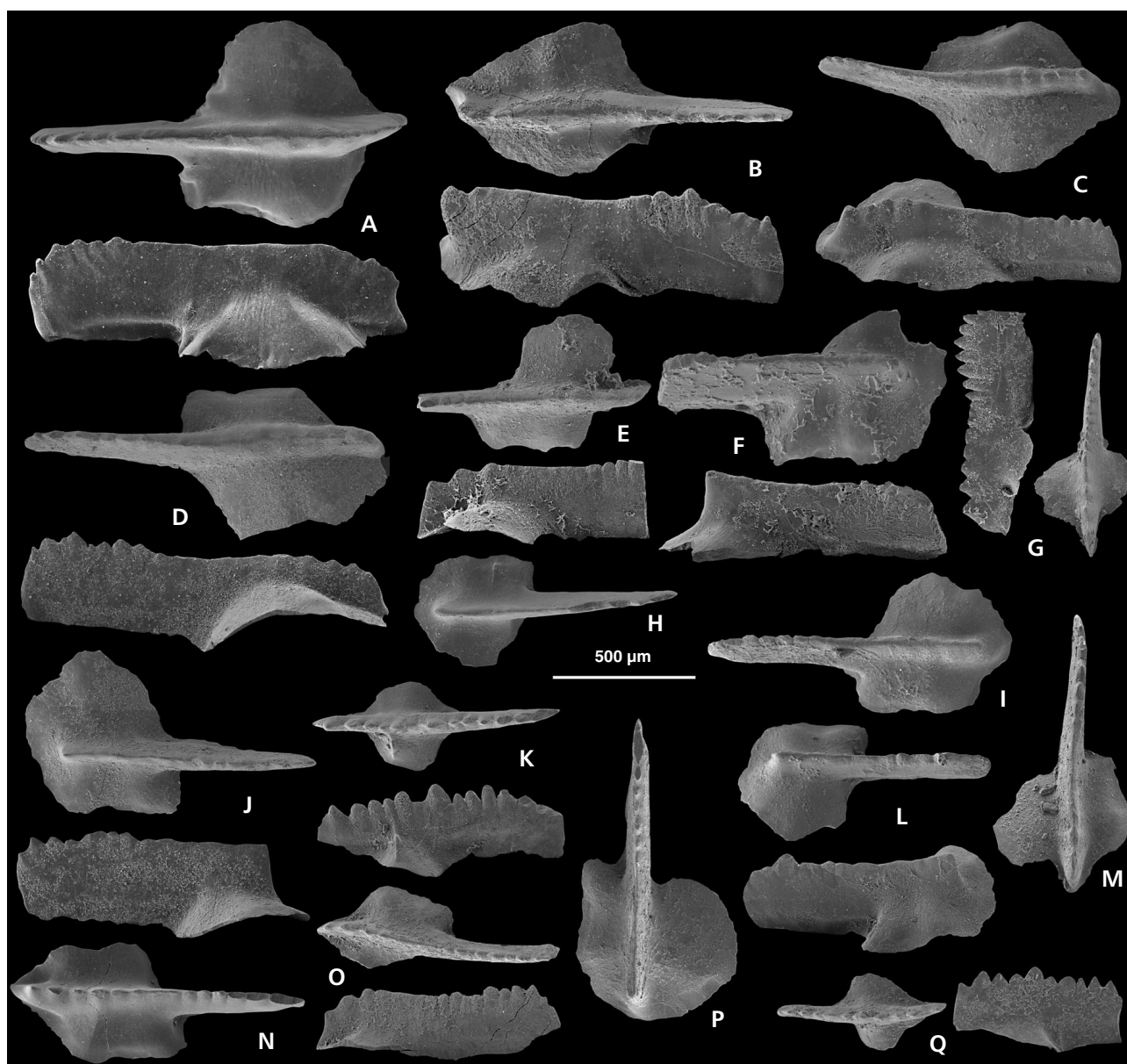


Figure 5. A, D, M, N – “*Ozarkodina*” *snajdri-crispa*. • A – upper and lateral view of P1 element, sample PZ019top. • D – upper and lateral view of P1 element, sample PZ020a. • M – upper view of P1 element, sample PZ022. • N – upper view of P1 element, sample PZ022. • B, C, F, H, I, J, P, L – “*Ozarkodina*” *crispa* (Walliser, 1964); B – alpha2 morph *sensu* Viira & Aldridge, 1998, upper and lateral view of P1 element, sample PZ020a. • C – alpha3 morph *sensu* Viira & Aldridge, 1998, upper and obliquely lateral view of P1 element, sample PZ020a. • F – alpha1 morph *sensu* Viira & Aldridge, 1998, upper and lateral view of P1 element, sample PZ022. • H – alpha2 morph *sensu* Viira & Aldridge, 1998, upper view of P1 element, sample PZ022. • I – alpha2 morph *sensu* Viira & Aldridge, 1998, upper view of P1 element, sample PZ022. • J – alpha2 morph *sensu* Viira & Aldridge, 1998, upper and lateral view of P1 element, sample PZ022. • P – alpha3 morph *sensu* Viira & Aldridge, 1998, upper view of P1 element, sample PZ022. • L – alpha3 morph *sensu* Viira & Aldridge, 1998, upper and lateral view of P1 element, sample PZ022. • E, O – “*Ozarkodina*” *parasnajdri* Viira & Aldridge, 1998. • E – upper and lateral view of incomplete P1 element, sample PZ022. • O – upper and lateral view of P1 element, sample PZ022. • G, Q – “*Ozarkodina*” cf. *parasnajdri* Viira & Aldridge, 1998. • G – lateral and upper view of P1 element, sample PZ022. • Q – upper and lateral view of small P1 element, sample PZ022. • K – *Zieglerodina*? *baccata* (Miller & Aldridge, 1997), upper and lateral view of P1 element, sample PZ022. All specimens are deposited in the collections of Ladislav Slavík at the Institute of Geology AS CR, v.v.i. and Peter Carls at the Technische Universität Braunschweig. All figures are the same scale (scale bar equals 500 μm).

a fine graptolite zonation has been developed. In the Požáry section the sole latest Ludfordian index graptolite *Pristiograptus fragmentalis*? (sic with question mark) was

documented from only one bed (base of bed No. 93, Kříž *et al.* 1986, fig. 8). This occurrence is problematic, as it seems to be rather delayed, if one considers the following

relations: Manda & Frýda (2010) subdivided the late Silurian–early Devonian interval in the Prague Synform into several “time slices”. With respect to the late Ludlow, their “Time slice A” corresponds to the *Monograptus fragmentalis* graptolite Zone of Kříž (1998) which can be approximated with the *Prionopeltis archiaci* trilobite Horizon of Horný (1955). At Mušlovka, the Time slice A can be indirectly correlated with the late Ludfordian interval from bed No. 28 (Kříž 1992); in the Požáry section, the corresponding interval begins from bed No. 75 (J. Kříž, pers. comm.). This boundary corresponds roughly to the base of the *parasnajdri* Zone. Although data on graptolites and chitinozoans are excellent for the identification of the base of the Přídolí, the finer subdivision of the post-*siluricus* interval that includes the rest of the Ludfordian time can be, however, made in the meantime only by conodonts.

Conodont biostratigraphy

There were several attempts to subdivide the Ludfordian. However, very conservative conodont taxonomy resulted in a slow progress of biostratigraphic subdivision. As regards the late Silurian, the recent introduction of “Stage slices” by Cramer *et al.* (2011) cannot be always considered as a step forward in knowledge because it only recycles and combines the outdated concepts and implies errors (e.g., including the entire *ploeckensis* Zone into the Ludfordian, problematic use of the *snajdri* Interval Zone to define the middle Ludfordian or even placing the origin of the Devonian genus *Icriodus* into the Silurian). As already mentioned in the introduction, since the pioneer Silurian conodont framework by Walliser (1964), there have been only slight modifications for the late Silurian, including the problematic *snajdri* Interval Zone (Nowlan 1995) that has been later included in the proposal for the global standard (Corradini & Serpagli 1999, p. 266).

According to Slavík *et al.* (2010) only the younger part of the Lau Event is represented in the shallow water environment of the former Řeporyje Volcanic Elevation. The immediate post-*siluricus* interval is characterized by rather poor conodont faunas dominated by *Delotaxis* and *Wurmiella* that do not allow establish a useful biostratigraphical unit, that might be correlated positively elsewhere. It is because that the ranges of the poorly delimited taxonomic groups are too long for this purpose. The conditions improve, however, 5 m above the range of *Po. siluricus* in the Požáry section. The detailed documentation of the post-Lau Event conodont recovery from the Požáry section, with support through data from other sections, enables the delimitation and positive characterization of the following conodont biozones in the late Ludfordian that have, at least, a regional significance:

The *plodowskii* Bizone

Parazieglerodina plodowskii Carls *et al.*, 2005 is the index for the beginning of the regional conodont biozone as introduced herein. The base of the Zone is defined by the entry of the nominate taxon and the end is defined by the entry of *Pedavis latialatus* (Walliser, 1964). The wider geographic distribution of the taxon *Pa. plodowskii* and its range in other areas has still to be proven; in the meantime, this zone serves only for intra-regional correlation. The index taxon enters before the recorded range of “*Ozarkodina*” *snajdri*. Possible gaps in sedimentation mentioned by Slavík *et al.* (2010) above the recorded *siluricus* range might suggest a possibly earlier entry. But this is not likely: the long interval with the *P. siluricus* Zone within the presumed *N. kozłowski* graptolite Zone on Gotland (Jeppsson *et al.* 2006, text-fig. 1) and the short range of *siluricus* without *Kockelella* in Bohemia (in contrast to Gotland) rather indicates the absence of a long upper part of the *P. siluricus* Zone in the Požáry and Mušlovka sections. On the other hand, the absence of substantial parts of the ranges of *Pa. plodowskii*, “*Oz.*” *snajdri* or *Ped. latialatus* is not likely because these taxa entered when the sea-level was already rising (see discussion in Slavík *et al.* 2010, p. 410). Accordingly, the recorded entries of these taxa which are well above the interval affected with gaps thus may be close to their real origins. The earlier entry of “*Oz.*” *snajdri* reported by Schönlaub (in Chlupáč *et al.* 1980) from the Mušlovka section cannot be verified neither by the new sampling nor by study of the original material deposited in the Geological Survey of Austria (L. Slavík). On the other hand, the new sampling confirmed the entry of “*Oz.*” *snajdri* approximately at the same level (about 7 m above the last occurrence of *Polygnathoides siluricus*) in both equivalent sections (Mušlovka and Požáry). Until new (contrasting) data are available, the entry of *Pa. plodowskii* is considered older than the entries of “*Oz.*” *snajdri* and *Ped. latialatus*.

The *latialatus* Biozone

The zone is delimited by the entry of the nominate index taxon and its upper limit is the entry of “*Ozarkodina*” *parasnajdri* Viira & Aldridge, 1998. The relation between the entries of *Pedavis latialatus* and “*Oz.*” *snajdri* was discussed by Schönlaub (in Kříž *et al.* 1986) who documented the co-occurrence of both taxa in their early range. He reported *P. latialatus* from the Marble Quarry to appear below “*Oz.*” *snajdri*. Also in the Požáry section, *Pedavis latialatus* was documented to enter earlier. Like in the Cellon section, the fauna with *Pedavis latialatus* can be correlated with the Icriodontid Subzone on

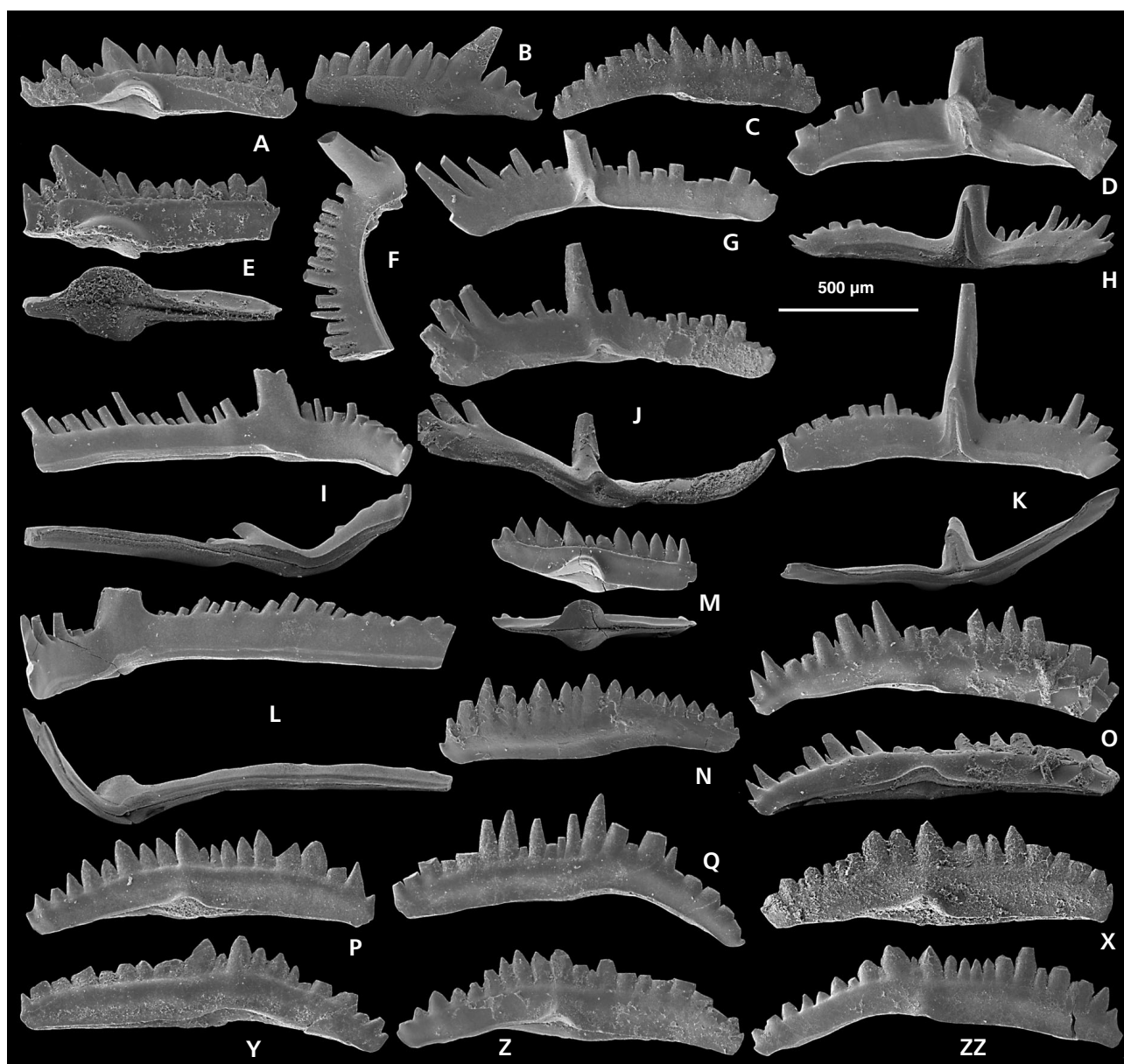


Figure 6. *Wurmia excavata* (Branson & Mehl, 1933) *sensu lato*. • A – lateral view of P1 element with large basal lobes, sample PZ019. • B – lateral view of paucidentate P1 element, sample PZ016. • C – lateral view of P1 element, sample PZ019top. • D – postero-lateral view of S0 element, sample PZ019top. • E – lateral and lower view of incomplete P1 element, sample PZ019top. • F – lateral view of M element, sample PZ019top. • G – lateral view of S1 element with short basal cavity, sample PZ019top. • H – lower view of S0 element, sample PZ019top. • I – inner-lateral and lower view of S2 element, sample PZ019top. • J – lateral and lower view of S1 element, sample PZ019top. • K – postero-lateral and lower view of S0 element, sample PZ019top. • L – inner lateral and lower view of S2 element, sample PZ019top. • M – lateral and lower view of short paucidentate P1 element with large basal lobes, sample PZ019top. • N – lateral view of P1 element, sample PZ022. • O – lateral and lower-lateral view of P1 element, sample PZ019top. • P – lateral view of P1 element, sample PZ019top. • Q – lateral view of P1 element, sample PZ019top. • X – lateral view of P1 element, sample PZ022. • Y – lateral view of P1 element, sample PZ019top. • Z – lateral view of P1 element, sample PZ022. • ZZ – lateral view of P1 element, sample PZ022. All specimens are deposited in the collections of Ladislav Slavík at the Institute of Geology AS CR, v.v.i. and Peter Carls at the Technische Universität Braunschweig. All figures are the same scale (scale bar equals 500 µm).

Gotland that is regarded older than the *snajdri* Interval Zone. In Sardinia (Corriga *et al.* 2009), the LAD of *Ped. latialatus* is approximated to the FAD of “Oz.” *snajdri*. As listed above, there exist more indices pointing to the earlier entry of *Ped. latialatus*. In spite of its scarcity the

range of *Ped. latialatus* also in the Cellon section is relatively long. In the Požáry section, the most representative specimens were obtained from the last sample of its occurrence well above the entry of “Oz.” *crispa* (see Fig. 3R, S).

The *parasnajdri* Biozone

The beginning of the zone is defined herein by the entry of “*Ozarkodina*” *parasnajdri* Viira & Aldridge, 1998 and its end by the entry of “*Oz.*” *crispa* (Walliser, 1964). The range of this morphology is comparatively long and its entry is younger than that of “*Oz.*” *snajdri* but older than that of “*Oz.*” *crispa*. In Bohemia, the overlap with “*Oz.*” *crispa* is long. Elsewhere, there are other age relations: The taxon *parasnajdri* was reported by Viira (1999, text-fig. 3) from the Kuressaare and early Kaugatuma Regional Stages. There it co-occurs with *Zieglerodina? baccata*, which locally brackets it, and it survives or even entirely ranges above “*Oz.*” *crispa*. According to Miller & Aldridge (1997), *Z.? baccata* occurs throughout the Upper Whitcliffe Formation and it roughly corresponds to the range of “*Oz.*” *snajdri* in Gotland (cf. correlation in Jeppsson & Aldridge 2000 and Jeppsson *et al.* 2006). Apparently, the upper range of “*Oz.*” *parasnajdri* recorded in the Eastern Baltica is longer than that in Bohemia. The *snajdri* Interval Zone is not used in the Prague Synform because the conodont record allows a more detailed subdivision. The *snajdri* Interval Zone, according to Corradini & Serpagli (1999), is limited below by the last occurrence of *Ped. latialatus* and above by the first occurrence of *Oz. crispa*. But as seen in Bohemia and mentioned above, *Ped. latialatus* brackets the range of “*Oz.*” *snajdri*. Nevertheless, for correlations the taxon *snajdri* offers a distinct morphology that can serve as a biostratigraphic tool. The entry of the early appearing taxon *parasnajdri* is a morphological step towards the subsequent origin of “*Oz.*” *crispa*, but this step does not yet reach “*Oz.*” *crispa*. There is a parallel taxon herein informally addressed as “*Oz.*” *snajdri-crispa* (cf. Fig. 4O). The formalistic application of a *snajdri* Interval Zone in a zonation scale would be useless because there is no space for it (see the overlap of LAD of *Ped. latialatus* and of the FAD of “*Oz.*” *crispa* in Fig. 2).

The *crispa* Biozone

The *crispa* Zone starts with the entry of “*Oz.*” *crispa* in bed No. 84, 1 m below the end of the Kopanina Formation in the late Ludfordian. In the Prague Synform, no specimens of *crispa* straddle the graptolite-defined Ludlow-Přídolí boundary. According to the revision of conodont data (by Schönlaub in Kříž *et al.*, 1986, p. 336 and in this paper), the taxon *crispa* ends usually closely below or just below the

base of the Přídolí (*i.e.* below the entry of *Pseudomonoclimacis parultimus*). Its range up to the very top of the Ludfordian is not certain because the sea-level fluctuation just below the base of the Přídolí caused gaps in several sections (*e.g.*, Kosov Quarry). The absolute completeness of the sedimentary record at the very end of the Ludfordian in the Požáry and Mušlovka sections cannot be proven, but it seems that the extinction of “*Oz.*” *crispa* can be traced just below the Ludlow-Přídolí limit. Also the last occurrence of “*Oz.*” *crispa* just below the interbed with *Ps. parultimus* in the Cellon section confirms this concept (Carnic Alps, Schönlaub in Kříž *et al.* 1986, p. 336). The LAD of “*Oz.*” *crispa* is also used as a marker for the end of the Ludlow (*e.g.*, Sardinia, Corriga *et al.* 2009).

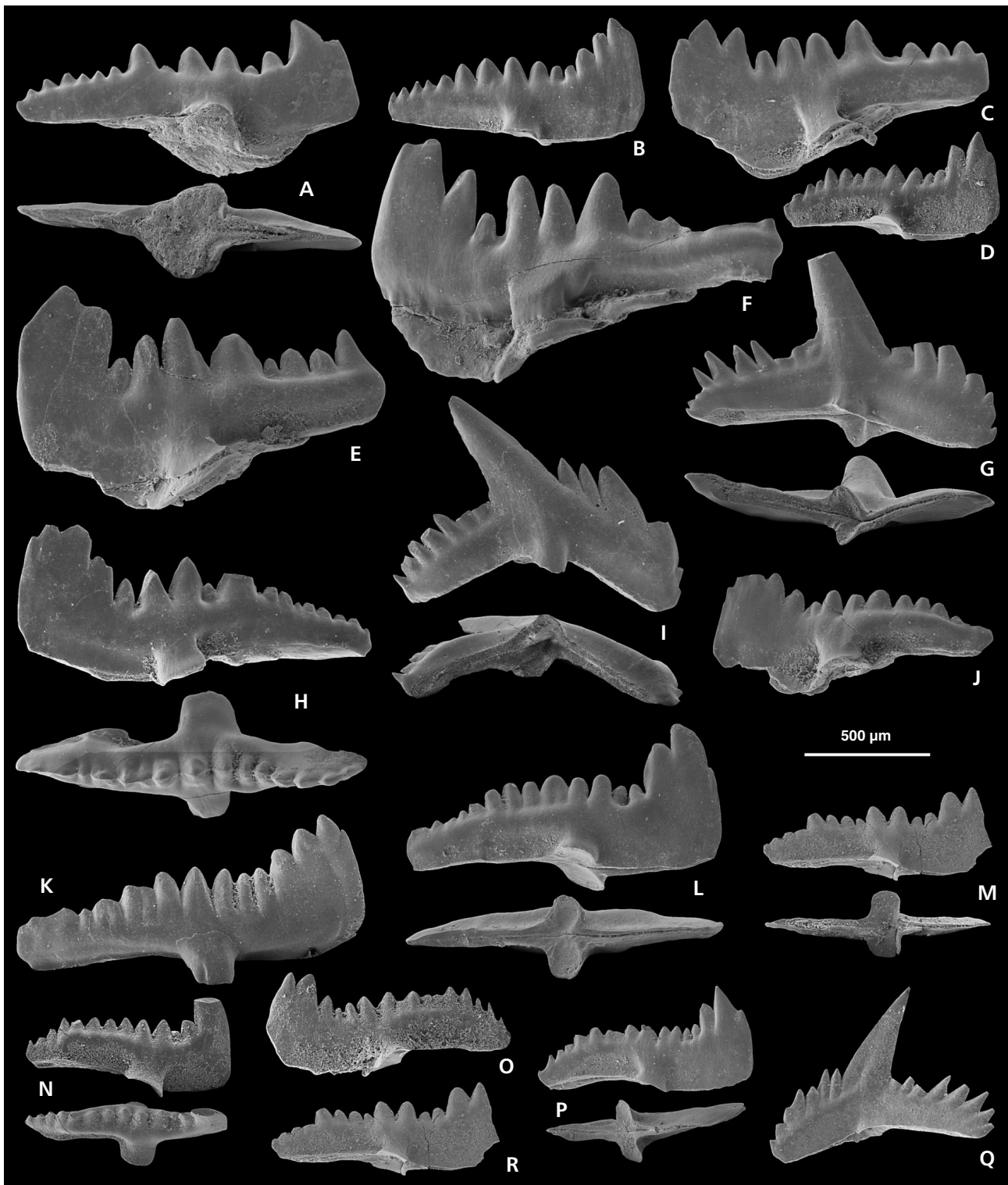
Jeppsson & Aldridge (2000) introduced the Klev Event that starts at or closely below the extinction of “*Oz.*” *crispa* and ends in the earliest Přídolí. According to data from the Prague Synform (cf. Kříž *et al.* 1986), the correlation with the base of *P. fragmentalis* graptolite Zone cannot be accurate because its entry in the Prague Synform is not exactly known. The effect of the local Klev Event from Gotland cannot be reproduced in Bohemia, because there is practically no sedimentary record available for it in the topmost Ludfordian (*i.e.* above the disappearance of “*Oz.*” *crispa*). The correlation of the upper limit of the Klev Event is also uncertain and the frequent records of changes in various faunal groups are provoked by the discussion concerning the Ludlow-Přídolí boundary.

Thus, the upper limit of the *crispa* Zone is formally independent of the base of the Přídolí as that is defined by the entry of the graptolite *Ps. parultimus*. As a Bohemian conodont marker near this base *Zieglerodina zellmeri* Carls *et al.*, 2007 may serve; it enters in the basal Přídolí bed (Carls *et al.* 2007). This taxon has been recently reported also from the Carnic Alps and Sardinia to enter close to the base of the Přídolí (Corradini & Corriga 2012).

Conclusions

The post-Lau Event diversity increase of conodont faunas in the Prague Synform (Barrandian area in Bohemia) starts with the appearance of slender spathognathodontid taxa in which the oldest is probably *Parazieglerodina plodowskii* Carls *et al.*, 2005. Our review of the Bohemian conodont faunal succession exposes its potential for the characterization of a succession of seven time intervals from the Ludfordian *siluricus* Zone to the *zellmeri* range in the Přídolí.

Figure 7. A, D, G, H, I, K, M, N, P, Q – *Ozarkodina* ex gr. *typica* Branson & Mehl, 1933. • A – lateral and lower view of P1 element, sample PZ019top. • D – lateral view of P1 element, sample PZ020a. • G – lateral and lower view of P2 element, sample PZ019top. • H – lateral and upper view of P1 element, sample PZ020a. • I – lateral and lower view of P2 element, sample PZ019top. • K – lateral view of P1 element, sample PZ020a. • M – lateral and lower



view of P1 element, sample PZ020a. • N – lateral and upper view of P1 element, sample PZ020a. • P – lateral and lower view of P1 element, sample PZ020a. • Q – lateral view of P2 element, sample PZ019top. • B – *Ozarkodina cornidentata* (Viira, 1983), lateral view of P1 element, sample PZ019top. • C, E, F – *Ozarkodina cf. cornidentata* (Viira, 1983). • C – lateral view of P1 element, sample PZ019top. • E – lateral view of P1 element, sample PZ019top. • F – lateral view of P1 element, sample PZ019top. • J, L, R – *Ozarkodina cf. ambigua* (Viira, 1983). • J – lateral view of P1 element, sample PZ020a. • L – lateral and lower view of P1 element, sample PZ020a. • R – lateral view of P1 element, sample PZ020a. • O – *Ozarkodina ambigua* (Viira, 1983), lateral view of P1 element, sample PZ020a. All specimens are deposited in the collections of Ladislav Slavík at the Institute of Geology AS CR, v.v.i. and Peter Carls at the Technische Universität Braunschweig. All figures are the same scale (scale bar equals 500 μm).

The conodont faunas increased in diversity and abundance enable a refined conodont subdivision of the post-Lau Event interval in the Ludfordian. It includes the *plodowskii*, *latialatus*, *parasnajdri* and *crispa* biozones. The presented regional conodont zonation for the post-siluricus interval in the late Ludfordian of Bohemia is not intended as a global standard, because for that purpose it would have to be carefully tested in other regions in order to fulfil the general characteristics for global biozonation (cf. Corradini & Barrick 2009). The data from Bohemia show that the use of a *snajdri* Interval Zone is useless, because its index enters quite shortly after *Ped. latialatus*. The use of *snajdri* interval as a basis for the definition of the Lu2 Stage Slice (i.e. approximately middle Ludfordian, Cramer *et al.* 2011) should be avoided. In the present paper the use of a distinct morphological change in the *snajdri-crispa* group is suggested that enables the refinement of the biozonal subdivision. The sum of *plodowskii*, *latialatus* and *parasnajdri* zones roughly corresponds to the time of a moderate sea-level rise in the upper part of the *Pseudomonoclimacis latilobus-Slovinograptus balticus* graptolite Zone (cf. Manda & Kříž 2006, Manda *et al.* 2012). The “Icriodontid” Zone of Jeppsson (2005) delimited on Gotland cannot be correlated with any of the regional zones in the Prague Synform because of extreme scarcity of icriodontids on Gotland. The recognition of the Klev Event near the beginning of the Přídolí is not possible in Bohemia, probably due to the more complete ranges of “Oz.” *crispa* and its associates in Bohemia, which were not affected by this rather local event. A good correlation with Eastern Baltica is enabled by the sharp change from *Ozarkodina cornidentata* (Viira, 1983) to *Ozarkodina ambigua* (Viira, 1983) within the *Ozarkodina typica* lineage. It may represent stratigraphically important level approximately amid the *crispa* Zone. According to Viira (1999), *Oz. cornidentata* is limited to the Paadla Stage, whereas its younger descendant, *Oz. ambigua*, occurs only in the Kuressaare Stage. The morphological variability in *Oz. ex gr. typica* is, however, relatively high and the stratigraphic value of this change still has to be tested in more regions.

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