Ber. Inst. Erdwiss. K.-F.-Univ. Graz	ISSN 1608-8166	Band 23	Valencia 2017
International Conodont Symposium 4	Valencia, 25-30th June 2017		

Lower Devonian conodonts from the Koněprusy area

Ladislav Slavík[1] & Jindřich Hladil[1]

[1]Institute of Geology of the CAS, v.v.i., Rozvojová 269, 16500 Praha 6, Czech Republic; slavik@gli.cas.cz

Locality *- The Koněprusy area (Fig. 1) includes several localities where conodonts from shallow-water reef facies have been studied. The main locality is the VČS - Velkolom Čertovy schody Quarry (Fig. 2). It is situated approximately 500 m S of the village Koněprusy (GPS positioning of the road junction at the upper entrance to quarried area: N 49°54'45'', E 14°04'09''). The other locality – Plešivec hill is aproximately 1 km E of village Měňany (N 49°54'20'', E 14°05'26'').*
Lithostratigraphic units *- Lochkov Formation (Kotýs Limestone), Praha Formation (Vinařice and Koněprusy Ls.), Daleje-Třebotov Formation (Suchomasty Ls.), Choteč Formation (Acanthopyge Ls.); underlying Požáry, Kopanina and Liteň formations. and overlying Srbsko Formation are nearby.*
Age *- Lochkovian to Eifelian; and closely adjacent parts of Wenlock – Přídolí and Givetian ages. The conodont zones included:* trigonicus-kutscheri, steinachensis beta-brunsvicensis *and* serotinus. *(in the sense of Slavík et al., 2012 and Valenzuela-Ríos et al., 2015).*
What to see *- The richly fossiliferous shallow-water feef facies of the Pragian age, large gaps in sedimentation documented by conodont faunas (between Lochkovian and Pragian; between Pragian and Emsian).*

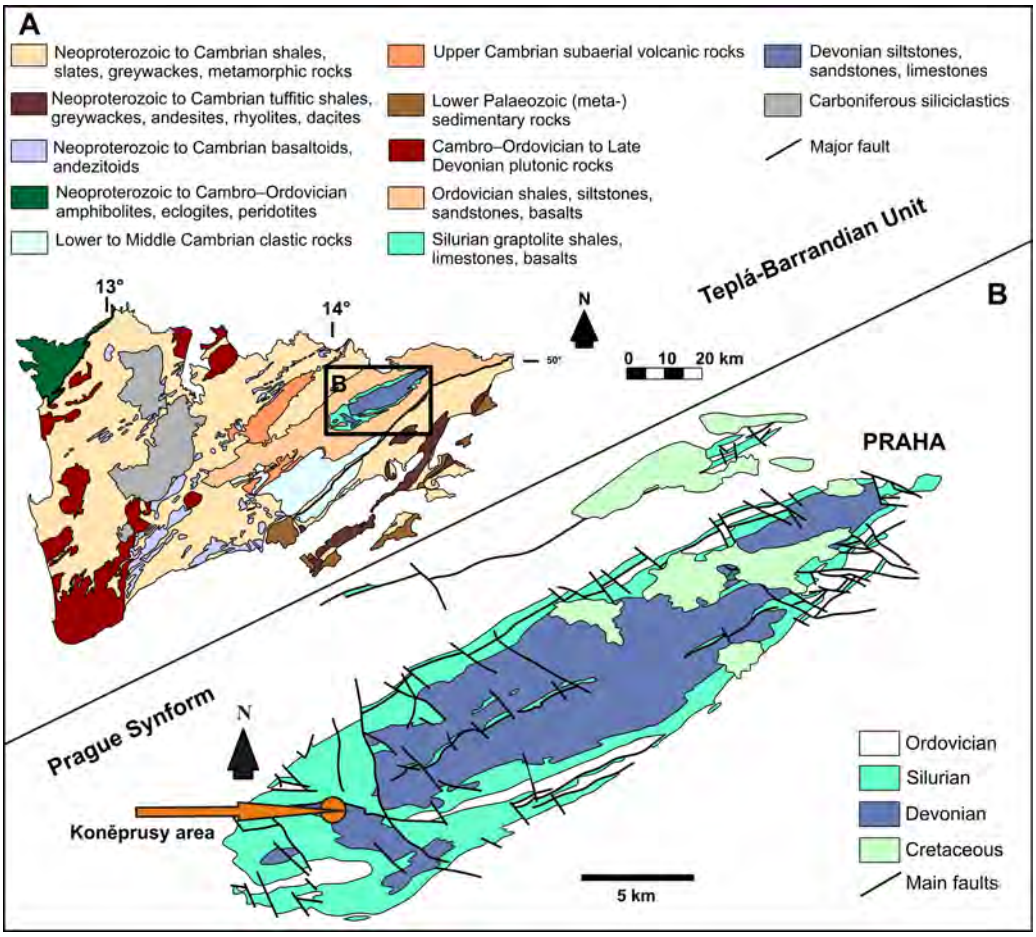

Figure 1. A location of the Koněprusy area in the Prague Synform (i.e a part of the Teplá-Barrandian Unit).

How to get there
The VČS quarry can be reached from the road from Koněprusy to Vinařice and Plešivec Hill is accessible from the road W of Měňany.

Figure 2. The view of the Velkolom Čertovy schody Quarry (VČS): **A.** Western part of the Quarry. **B.** Eastern part of the Quarry (Photo by J. Hladil, 2001).

Historical outline

Early Devonian sediments of Koněprusy area have become subjects of many studies during the last 50 years, mainly because of increasing research activity associated with still persisting questions about the stage boundaries in the Devonian (for summary, see e.g., Chlupáč et al., 1998). The

conodont studies of the Lower-Middle Devonian boundary started in seventies of the last century (Klapper, 1977) and the conodonts from the Lochkovian and Pragian at the end of the last century (Slavík, 1998).

Sedimentology, paleoenvironment and deformation

The Koněprusy skeletal accumulation represents a unique open-sea carbonate buildup of the Pragian age. For detailed information on facies see Hladil (in Čejchan et al., 1997). Both the sedimentary record and biocorrelation indicate the Devonian peri-Gondwanan affinity of the complex. The Devonian of the Koněprusy area is known world-wide for extremely rich, particularly reef faunas. The Koněprusy Limestone (Pragian) reach a thickness up to 200 m and the fauna includes more than 500 fossil species described which were found mostly in reef facies and their talus (crinoids, brachiopods, bryozoans, gastropods, corals, red algae, rostroconchs, etc.).

The late Lochkovian dextral transpression zone (striking WSW – ENE, forming meso- and mega-scale Riedel shear faults) pushed up the blocks of Kotýs Ls. (calciturbidites of a moderately deep plateau), forming a linear submarine elevation rising sharply above the surrounding sea floor. The tilted topmost parts of towering blocks reached sea level during the low-stand episodes, as evidenced by their truncated, mesa-shaped tops. After a period of low accumulation rate and hiatuses, the linear elevation was capped by skeletal limestones: starting with crinoid-bryozoan facies with brachiopods, first on the flanks and then also on the summits. The major volume of whitish Koněprusy limestone deposited in the middle of the 'Praha Fm.' time span. The limestones on slopes have often pink colours and some of them are also blackish, due to interactions with seeping formation water and hydrothermal vents. Reefs, capping this elevation and containing also colonial rugose corals, stromatoporoids and algae, are of lesser thickness than underlying skeletal accumulations. The upper part of the Praha Fm. and entire Zlíchov Fm. are missing here: approximately 7myr long hiatus encompasses much of the equivalent time. The prominent falling stage system tract, ending the Praha Fm. on the ridge, is marked by karstic phenomena, terraces, boulders, pebbles and oncoids. The first transgressive system tract, after the hiatus, contains the oceanward dipping, slope-to-outer ramp clinoforms (also stromatactis-containing skeletal lobes). This transgression roughly corresponds to the base of the Daleje-Třebotov Fm., but showing gradual onlaps of beds onto topographically higher areas; i.e. younger Emsian ages mark the drowning of these highs. The Eifelian Choteč Fm. is represented here by crinoidal Acanthopyge Ls. with three levels of coral – stromatoporoid faunas; these, together with conodonts and dacyoconarids, are indicative of open-sea platform edges and oceanward exposed slope. It should be noted that practically all the stratigraphic members of the Koněprusy Devonian show different facies, and have also different names compared to those which are used for the other structural belts in the Prague Synform. This is due to great effects of such ocean-ridge barriers on separation of the inner basins, which were, most likely, almost encircled by islands, and seafloor was there never deeper than several hundreds of meters. Before the Kačák Event, the area was tectonically bulged (paleosols and karst cavities). However, this area was flooded again, just before the Eifelian/Givetian boundary (blackish styliolinid limestones with conodonts and fragments of drowned land flora). These were overlaid by channelized breccia flows, giving us information about small Early Givetian reefs and slopes dissected by downslope directed channels. The last sediments were sporadically preserved clays, connected with sediment-starved deep-water conditions, and rapidly accumulated argillaceous flyschoid successions of Givetian age.

All these Devonian structures were changed by early Variscan deformation, when the Očkov Thrust Fault with its overriding mass pushed the Lochkovian core of this linear elevation above the Pragian slope sediments to the south. A series of subvertical and north-dipping faults cuts the old contacts between the Lochkov Limestone and Koněprusy Limestone fills. The eo-Variscan thin-skinned structural style was found also in the direction to the S, reducing tectonically the former distances of facies (Bacín, Šámor – Vysoká skála hills/cuestas); this faulting and folding is parallel with the Borek Thrust Fault S of the Koněprusy area. Faults in weakened parts of allochthonous rigid limestones were also rejuvenated during the post-Palaeozoic and even geologically very recent times.

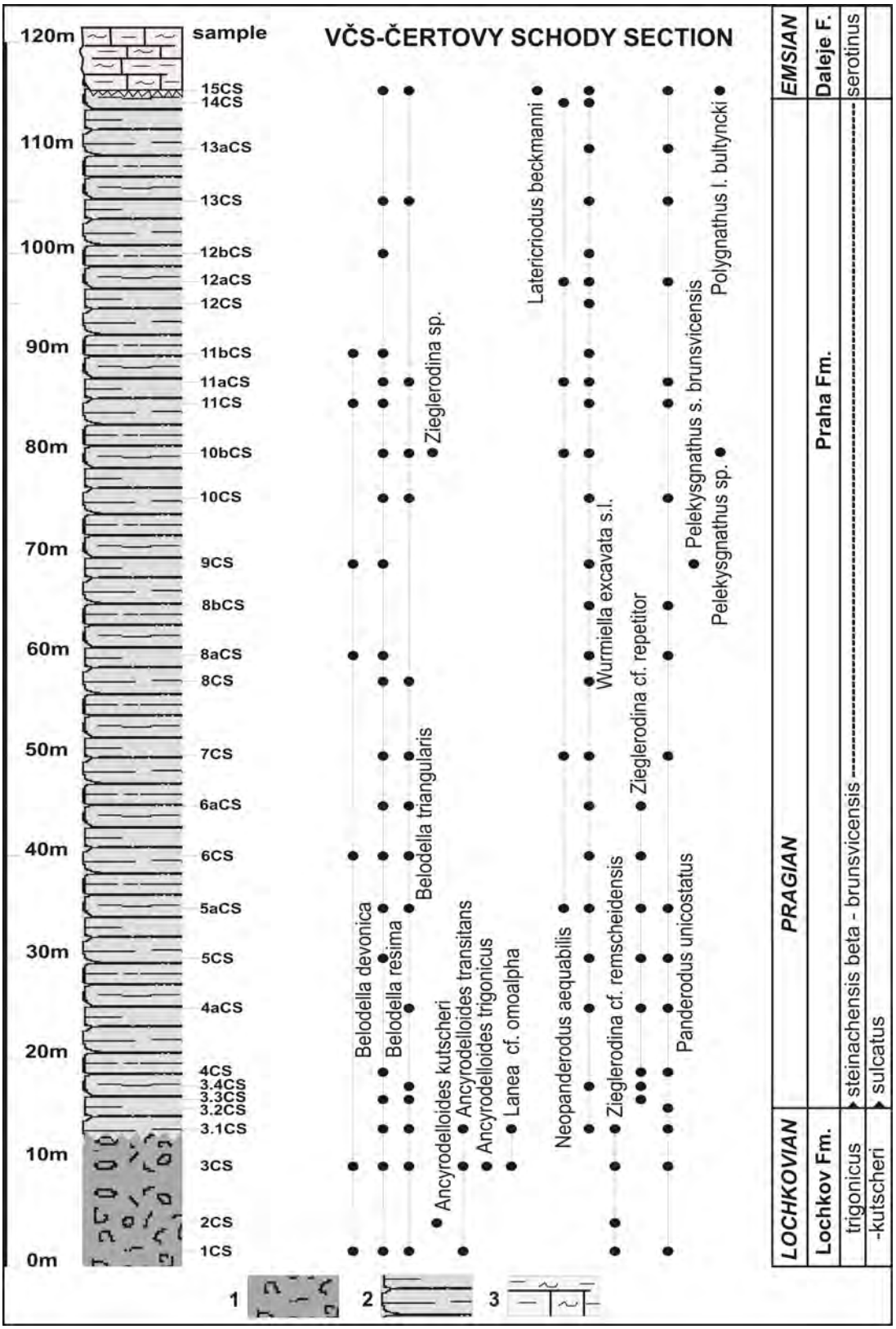

Figure 3. Conodont distribution in the Velkolom Čertovy schody section. Conodont data upgraded from Slavík (1998) and Slavík et al. (2007). Lithology: 1. Kotýs Ls. - dark grey micritic limestones with sedimentary breccia in uppermost parts. 2. Koněprusy Ls. - skeletal limestones of the reef complex with dominance of crinoid and bryozoan debris. 3. Suchomasty Ls. - well-bedded, scarlet-colored, coarse-grained, predominantly crinoidal limestones.

Conodont sudies in the Koněprusy area

The conodont studies of the Emsian-Eifelian boundary in Koněprusy area have been started by Klapper (1977) who described conodonts from the Červený lom (quarry) near Suchomasty. Klapper et al. (1978) then correlated conodont faunas from this locality with other Lower-Middle Devonian sections in the Prague Synform and established a new conodont zonation around this boundary. Conodonts were also reported by Weddige & Ziegler (1987) and by Kalvoda & Zikmundová (in Galle & Hladil, 1991). Berkyová (2009) reported *Polygnathus serotinus* Telford form Acantopyge Limestone of the Eifelian age; this occurrence in younger member is in contrast to other localities. Later, Klapper & Vodrážková (2013) studied ontogenetic and intraspecific variation of important polygnathid species around the Emsian-Eifelian boundary in the Prague Synform and Nevada. Conodont faunas from the early Devonian (Lochkovian, Pragian and Emsian) have been studied in the VČS – Velkolom Čertovy schody Quarry by Slavík (1998) who documented large gaps in sedimentation below and above the Koněprusy skeletal complex. Data from Lochkovian and Pragian from some other localities in the Koněprusy area (Bacín and Plešivec hills, Homolák quarry) have been reported by Slavík (2004). The data from Pragian of the VČS were used also for the new Early Pragian conodont correlation for peri-Gondwana and for alternative Pragian zonation (Slavík et al., 2007; Slavík et al., 2012). The conodont studies of other localities (e.g., Skalice near Měňany) are on-going.

Lithology and conodont distribution in the VČS Quarry

The base of a large active quarry uncovers the Kotýs Limestone of late Lochkovian age. This gray micritic to crinoidal limestone is overlain by mostly skeletal Koněprusy Limestone with dominance of crinoid and bryozoan debris. The uppermost parts of the Lochkovian deposits are represented by sedimentary breccia. The thickness of the Pragian exceeds one hundred meters. The upper boundary of the Koněprusy Limestone is preserved in the northern and eastern part of the quarried area. The Koněprusy Limestone displays a sharp, truncated contact with the overlying strata of well-bedded, biomicritic, predominantly crinoidal, scarlet-colored Suchomasty Limestone. These limestones were deposited during the late Emsian (Dalejan) which implies that a large break separates both members.

The conodont samples produced more than 400 elements. The *trigonicus-kutscheri* Zone of the late middle Lochkovian (in the sense of Valenzuela-Ríos et al., 2015) was documented close to the base of the active quarry. The younger Lochkovian zones are completely missing. The lower boundary of the Pragian sedimentary succession is transgressive and follows the eustatic fall and minimal eustatic sea-level during the upper Lochkovian. The boundary between the upper Lochkovian and early

Figure 4. Selected conodont specimens from Lower Devonian of the Koněprusy area (VČS section and Plešivec hill).

1, 8, 12. *Zieglerodina?* sp.; **1.** lateral view of Pa element, sp.No: 032CS, VČS section, sample 10bCS, **8.** lateral view of incomplete Sc? element, sp.No: 004Pl, Plešivec hill, sample Pl2, **12.** upper view of juvenile Pa element, sp.No: 033CS, VČS section, sample 10bCS. **2-5, 11, 14-15, 23.** *Wurmiella excavata sl.* (Branson & Mehl), **2.** lateral view of incomplete Sc? element, sp.No: 002Pl, Plešivec hill, sample Pl2, **3.** lateral view of incomplete Pb element, sp.No: 003Pl, Plešivec hill, sample Pl2, **4.** lateral view of large Pb element, sp.No: 001Pl, Plešivec hill, sample Pl2, **5.** lateral view of incomplete Sb element, sp.No: 031CS, VČS section, sample 10bCS, **11.** lateral view of Sb element, sp.No: 020CS, VČS section, sample 9CS, **14.** lateral view of M element, sp.No: 021CS, VČS section, sample 9CS, **15.** lateral view of incomplete Pb element, sp.No: 022CS, VČS section, sample 8aCS, **23.** lateral view of incomplete Sc element, sp.No: 017CS, VČS section, sample 9CS. **6, 17.** *Belodella devonica* (Stauffer), **6.** lateral view of sp.No: 005Pl, Plešivec hill, sample Pl2, **17.** lateral view of sp.No: 018CS, VČS section, sample 9CS. **7.** *Belodella triangularis* (Stauffer), lateral view of sp.No: 006Pl, Plešivec hill, sample Pl2. **9.** *Icriodus*? sp.; upper view of unidentified and incomplete I element, sp.No:007Pl, Plešivec hill, sample Pl2. **10.** *Belodella resima* (Philip), lateral view of sp.No: 008Pl, Plešivec hill, sample Pl2. **13.** *Ancyrodelloides transitans* (Bischoff & Sannemann); upper view of Pa element, sp.No:009Pl, Plešivec hill, sample Pl2.

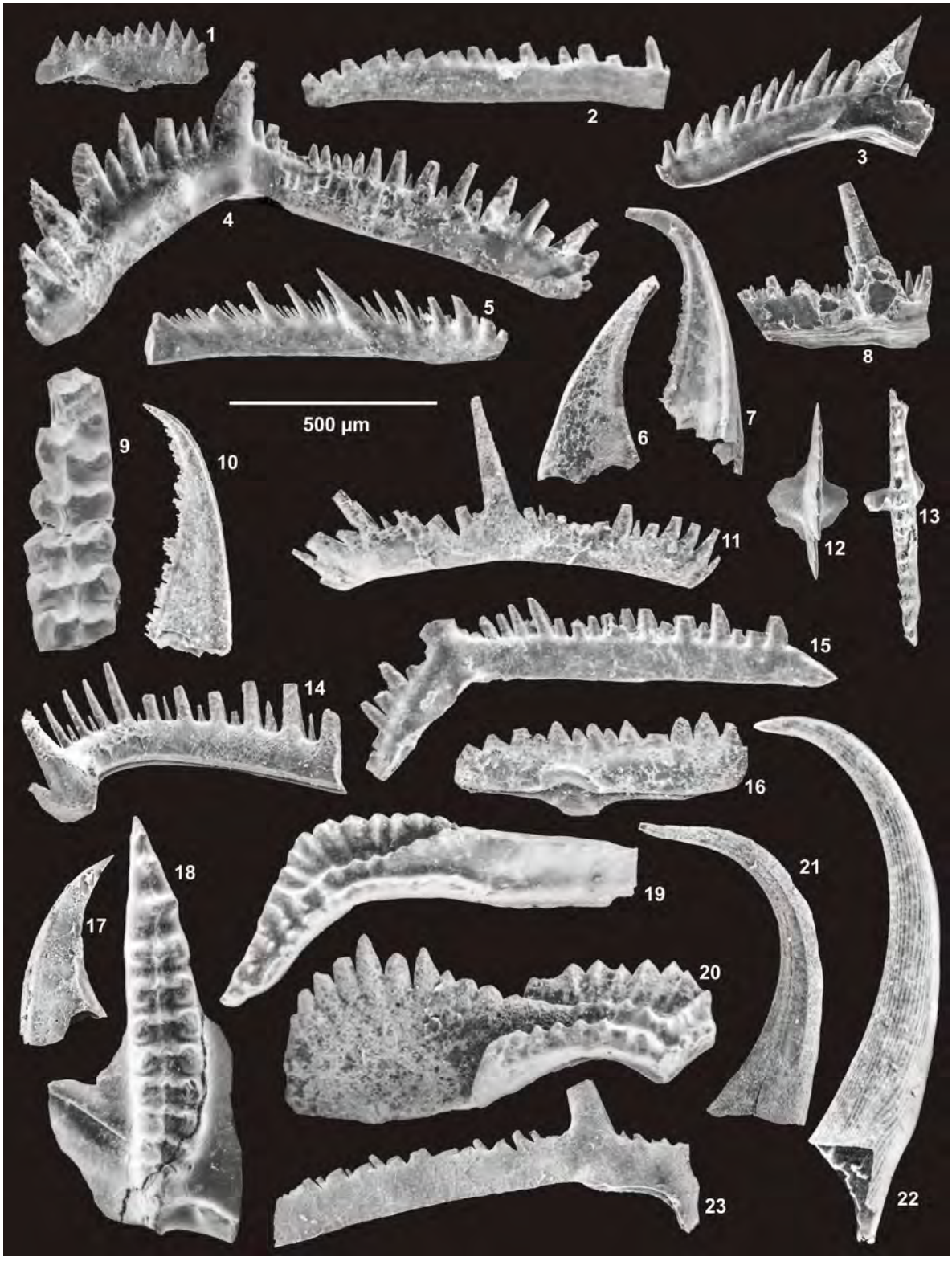

Figure 4. continued.
16. *Zieglerodina* cf. *repetitor* (Carls & Gandl), lateral view of Pa element, sp.No: 023CS, VČS section, sample 4CS. **18.** *Latericriodus beckmanni* (Ziegler), upper view of I element, sp.No: 026CS, VČS section, sample 15CS. **19-20.** *Polygnathus linguiformis bultyncki* Weddige, **19.** incomplete Pa element, sp.No: 025CS, VČS section, sample 15CS, **20.** incomplete Pa element, sp.No: 024CS, VČS section, sample 15CS. **22.** *Neopanderodus aequabilis* Telford, lateral view of sp.No: 027CS, VČS section, sample 14CS. **21.** *Panderodus* sp., lateral view of sp.No: 019CS, VČS section, sample 9CS.

Pragian *sulcatus* Zone in the Euroamerican Devonian sea-level curve (Johnson & Sandberg, 1989) well corresponds to the boundary of transgressive-regressive cycles pre-Ia and Ia. The conodonts from the reef facies of the Praha Fm. are relatively scarce. The early Pragian *steinachensis beta-brunsvicensis* Zone (roughly corresponding to the *sulcatus* Zone) can be documented, even if taxon *Icriodus steinachensis* has not been reported yet. The occurrences of pelekysgnathids in the upper parts of the preserved Koněprusy Ls. (Fig. 3) show that a substantial part (more than two thirds) of the Praha Fm. is missing. Also a substantial part of the Emsian (entire Zlichovian) is missing in this section. The next transgression extended over the documented area as late as during the *serotinus* Zone (Late Emsian, Dalejan age). This zone is documented only indirectly by means of characteristic taxa *Polygnathus linguiformis bultyncki* Weddige and *Latericriodus beckmanni* (Ziegler) (Fig. 4).

Interresting fenomena to observe

Neptunian dykes

The well-cemented skeletal accumulations of the Praha Fm. (buildups, reef, talus, fore-reef, drowned-terrace facies, etc.) were resting on relatively 'plastic' basement, where clayey-argillaceous rocks of Silurian and older ages were compacted. The rigid carbonate body of the Koněprusy Ls. was, therefore, subjected to tensional forces, and crevasses originated like in a glacier; it was as early as during the Early and Middle Devonian. This situation was particularly relevant to the major hiatus between the uppermost regressive system tract of the Koněprusy Ls. and transgressive system tract of the Suchomasty Ls., when, particularly before and after this hiatus, swarms of these fissures/crevasses were filled by the latest Koněprusy Ls., and then again by the first Suchomasty Ls. (and then also by the first Acanthopyge Ls.). The opening/infilling of these structures was, however, typically polyphase and very complex process; the formation of various granular or soft-flocculated sedimentary infills was closely combined with bacterially mediated precipitation of marine cements on the walls, gravitationally driven brecciation, etc. Other structures, drilled and sampled by numerous boreholes, even resemble chasms and blue-holes. Some fills are rich in shells of hyoliths or other organisms living in darkness of deep-seated marine caves. Many neptunian dykes are striking W – E or WSW – NEN, but some follows sub-perpendicular or irregularly shaped wrench-fault systems. The major karstification episodes reflect the emergence of islands during the major hiatus. Another one, connected rather with tectonic bulging of this area than gravitational extension, developed concurrently with the early Kačák sea level lowering and the holes of that age were filled until the Early Givetian; some of the holes and leaks in limestones were also re-opened and injected by argillaceous flyschoid rocks. It is worthy of note that these neptunian dykes were often combined with hydrothermal venting or leakage of deep formation waters. A few of them developed at intersections with halocline caves or other types of deeper-seated solution holes. For more detailed info about neptunian dykes see Chlupáč (1996).

Bitumens

Dark-coloured, solid bitumens and waxy or semi-liquid to liquid residual oils were precipitated from ascending condensates; most of them are blackish or coloured in darker/lighter shades of brown, orange and green. They belong to many phases of organic matter maturation and migration, as the Lower Palaeozoic source rocks were (and even are) almost continuously seated around 'the oil window' (Franců et al., 2001). The nests and inclusions are of pre-orogenic, but mainly of early post-orogenic ages. Live (gas saturated) oil occurs with rising distance from the faulted zone. Some hydrated liquid varieties contain light aliphatic fractions, showing various cerulean or pale opalescent shades; their origin is still subject to speculation, as they occur in the old (Carboniferous – Permian), but also very young (Cenozoic) aggregates of calcite crystals.

Acknowledgements

The study was supported by the research plan RVO67985831 of the Institute of Geology of the CAS, v.v.i.

References

BERKYOVÁ, S. (2009): Lower-Middle Devonian (upper Emsian-Eifelian, serotinus-kockelianus zones) conodont faunas from the Prague Basin, the Czech Republic. - Bulletin of Geosciences, 84(4): 667-686.

CHLUPÁČ, I. (1996): Neptunian dykes in the Koněprusy Devonian: geological and palaeontological observations. - Bulletin of the Czech Geological Survey, 71(3): 193-208.

CHLUPÁČ, I., HAVLÍČEK, V., KŘÍŽ, J., KUKAL, Z. & ŠTORCH, P. (1998): - Palaeozoic of the Barrandian (Cambrian to Devonian). Czech Geological Survey, 183 pp.

FRANCŮ, J., FRANCŮ, E., BOHÁČEK, Z., HLADIL, J. & BOSÁK, P. (2001): Analýza organické hmoty z tmavě zbarvených vápenců Velkolomu Čertovy schody-západ (The analysis of organic matter from dark coloured limestones in the quarries of Velkolom Čertovy schody-západ). - Český kras, 27: 30-33.

GALLE, A. & HLADIL, J. (1991): Lower Palaeozoic corals of Bohemia and Moravia. - 6th Fossil Cnidaria Guidebooks to Field Trips B3, 1-83.

HLADIL, J. (1997): Lower Devonian open-sea elevation of Koněprusy: evolution of reef facies. - In: ČEJCHAN, P., HLADIL, J. & ŠTORCH, P. (eds): Field Trip Book of the Final Conference Biotic Recoveries after Mass Extinctions, 54 pp., Eurocongress Centre & Malák Press, Praha: 31-36.

JOHNSON, J.G. & SANDBERG, C.A. (1988): Devonian eustatic events in the Western United States and their biostratigraphic responses. - In: McMillan, N.J., Embry, A.F. & Glass, D.J. (eds): Devonian of the World. - Canadian Society of Petroleum Geologist, Memoir, 14(3): 171-178.

KLAPPER, G. & VODRÁŽKOVÁ, S. (2013): Ontogenetic and intraspecific variation in the late Emsian - Eifelian (Devonian) conodonts *Polygnathus serotinus* and *P. bultyncki* in the Prague Basin (Czech Republic) and Nevada (western U.S.). - Acta Geologica Polonica, 63(2): 153-174.

KLAPPER, G. (1977): Lower-Middle Devonian boundary conodont sequence in the Barrandian area of Czechoslovakia. - Časopis pro mineralogii a geologii, 22(4): 401-406.

KLAPPER, G., ZIEGLER, W. & MASHKOVA, T.V. (1978): Conodonts and correlation of Lower Middle Devonian boundary beds in the Barrandian area of Czechoslovakia. - Geologica et Palaeontologica, 12: 102-116.

SLAVÍK, L. (1998): Early Devonian conodont succession from the section of the Čertovy schody Quarry (Koněprusy, Barrandian, Czech Republic). - Bulletin of the Czech Geological Survey, 73(2): 157-172.

SLAVÍK, L. (2004): A new conodont zonation of the Pragian in the Stratotype area (Barrandian, central Bohemia). - Newsletters on Stratigraphy, 40/1,2: 39-71.

SLAVÍK, L., CARLS, P., HLADIL, J. & KOPTÍKOVÁ, L. (2012): Subdivision of the Lochkovian Stage based on conodont faunas from the stratotype area (Prague Synform, Czech Republic). - Geological Journal, 47: 616-631.

SLAVÍK, L., VALENZUELA-RÍOS, J.I., HLADIL, J. & CARLS, P. (2007): Early Pragian conodont-based correlations between the Barrandian area and the Spanish Central Pyrenees. - Geological Journal, 42: 499-512.

VALENZUELA-RÍOS, J.I., SLAVÍK, L., LIAO, J.-C., CALVO, H., HUŠKOVÁ, A. & CHADIMOVÁ, L. (2015): The middle and upper Lochkovian (Lower Devonian) conodont successions in key peri-Gondwana localities (Spanish Central Pyrenees and Prague Synform) and their relevance for global correlations. - Terra Nova, 27: 409–415.

WEDDIGE, K. & ZIEGLER, W. (1987): Lithic and faunistic ratios of conodont sample data as facial indicators. - In: AUSTIN, R. (ed.): Conodonts: Investigative Techniques and Applications. British Micropalaeontological Society Series, London, 333-340.