25th Czech – Slovak – Polish

PALEONTOLOGICAL CONFERENCE

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FIELD TRIP GUIDE

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Excursion 1

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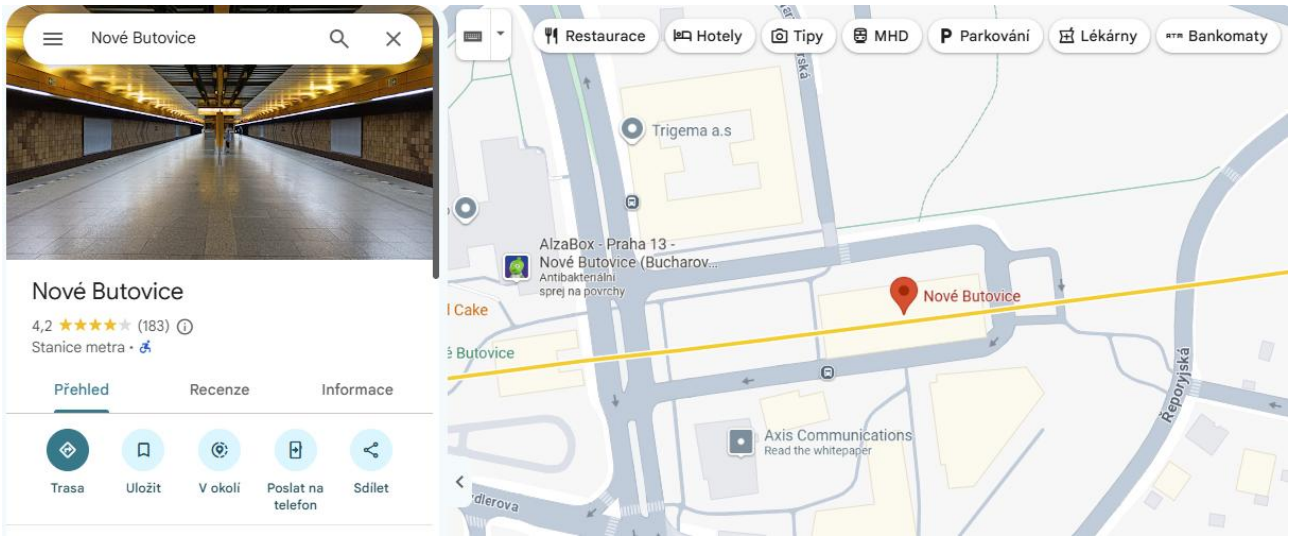
Excursion 2

Paleozoic of Prague – Schedule and Information

- **Meeting time:** 9:30

- **Meeting place:** Nové Butovice Metro B Station, Exit E1, next to the bakery Pekárna Kabát





- **What to expect:** A field trip focusing on some key paleontological sites. Along the roughly 8-km route, we will walk through scenic valleys, visit old limestone quarries and Hlubočepy Lake, and with a bit of luck, find some interesting fossil specimens. Make sure to wear proper outdoor shoes, as the terrain in Prokop Valley might be challenging.

Excursion 2

Paleozoic of Prague

Introduction

Prague Basin is a geological unit that, according to the regional geological division of the Bohemian Massif, forms part of the Teplá-Barrandian area (Chlupáč & Štorch, 1992). The infill of the Prague Basin preserves a continuous succession of marine sedimentary and volcanic rocks ranging in age from Lower Ordovician to Middle Devonian without any major interruptions. During the Variscan orogeny, the rocks of the Prague Basin were deformed into their present-day form of a complex synclinorium, for which the terms "Prague synclinorium" or "Prague synform" are frequently used (e.g.; Melichar, 2004; Vacek & Žák, 2019).

Silurian and Devonian of the Prague Basin

The Silurian and Devonian succession of the Prague Basin represents a classical area for stratigraphic and paleontological research. To date, it hosts four Global Stratotype Sections and Points. The bases for Aeronian stage, Přídolí series, Devonian system and Pragian stage are all defined here.

The earliest Silurian sediments in the Prague Basin deposited continuously on thick ordovician clastic sequences and are represented by pelitic graptolite shales. Starting in the Wenlock, carbonate admixture increased continuously and the Ludlovian and Přídolian sediments are predominantly carbonates (Kříž, 1992). Sedimentation during the mid-Wenlock to the mid-Ludlow was greatly influenced by volcanic activity and synsedimentary tectonic movements, resulting in variable topography and differentiated sedimentary succession between different parts of the Prague Basin. Some of the volcanic centres probably reached above sea level, creating volcanic islands, as evidenced by several gaps in sedimentation and discoveries of early land plants in the upper Wenlock and lower Přídolí (Kříž, 1992).

The Devonian sequence from the Lochkovian to the Eifelian is typified by carbonate development characterized by combinations of micritic and bioclastic facies. Changing relationships between these reflect changes in bathymetry and oceanic regimes (Chlupáč, 1998). The carbonate sedimentation is briefly interrupted in the lower part of the upper Emsian by the sedimentation of the siliciclastic Daleje Shale in some areas of the Prague Basin.

Rather distinct development can be observed in the area near Koněprusy, which is separated from the main part of the Prague Basin by a thrust fault. Here, a shallow water reef complex developed in the early Pragian, and the subsequent sedimentation during the Emsian and Eifelian typically reflects high-energy shallow environments (Chlupáč, 1998).

At the base of the Givetian, the sedimentation changes abruptly with the onset of the siliciclastic Srbsko Formation. Sedimentation in the Prague Basin is then terminated during the Givetian by the onset of the Variscan orogeny (Kukal & Jaeger, 1988; Chlupáč, 1998).

Field excursion

During this excursion, we will explore some of the key geological outcrops of Prague's Palaeozoic bedrock. This roughly 8 km walk through the Prokop and Daleje Valleys Nature Reserves will reveal more than 50 million years of Earth's history, from the Upper Ordovician to the Middle Devonian – a time when this region was covered by shallow seas teeming with life. Along the way, we will visit classic paleontological localities, products of ancient submarine volcanism and observe beautiful landscape features formed by faulted limestones. The geological localities along the itinerary are outlined below (shown on the map in Fig.1; with stratigraphic sections of the sites in Fig.2):

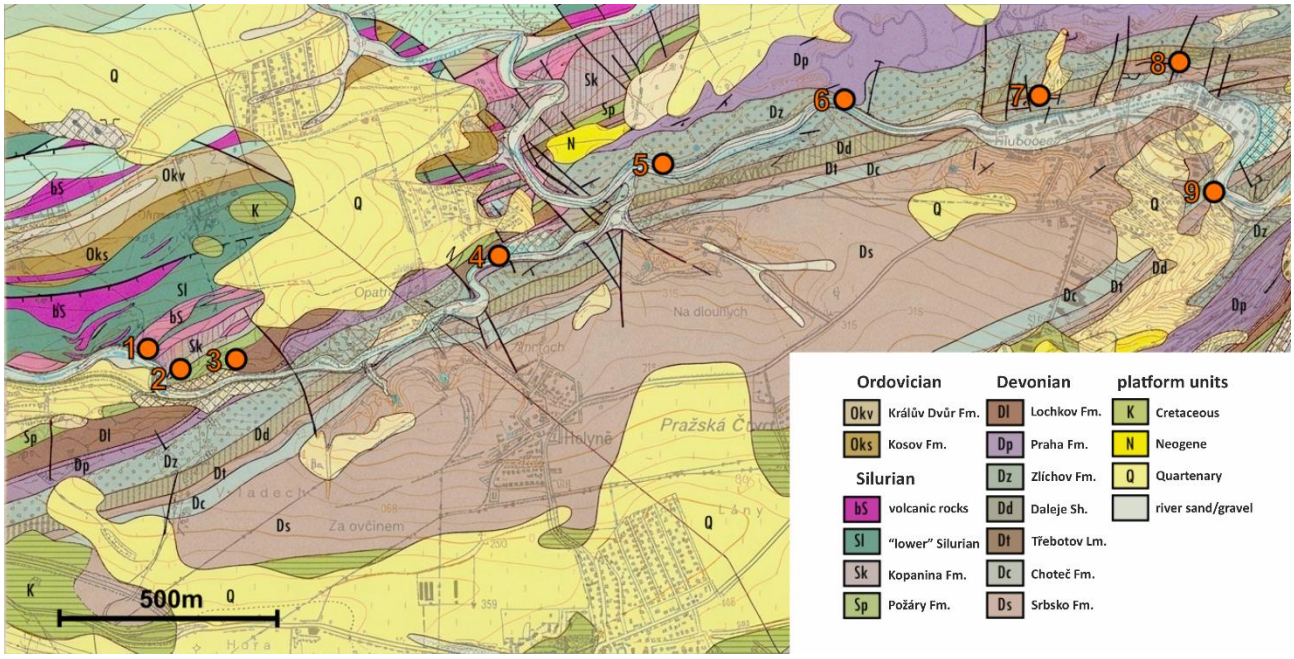


Fig. 1: Map of the excursion area with the localities highlighted; modified after Cháb, 1990**:** **1**) Arethusina Gorge; **2**) Mušlovka Quarry; **3**) Lobolith Hillside and Black Quarry; **4**) Opatřilka and Red Quarry; **5**) Klukovice Swimming Pool; **6**) Prokop Quarry; **7**) Hlubočepy Lake; **8**) Vysoká Quarry; **9**) Hlubočepy Railway Cutting.

Scan the QR code to view the route on the map:

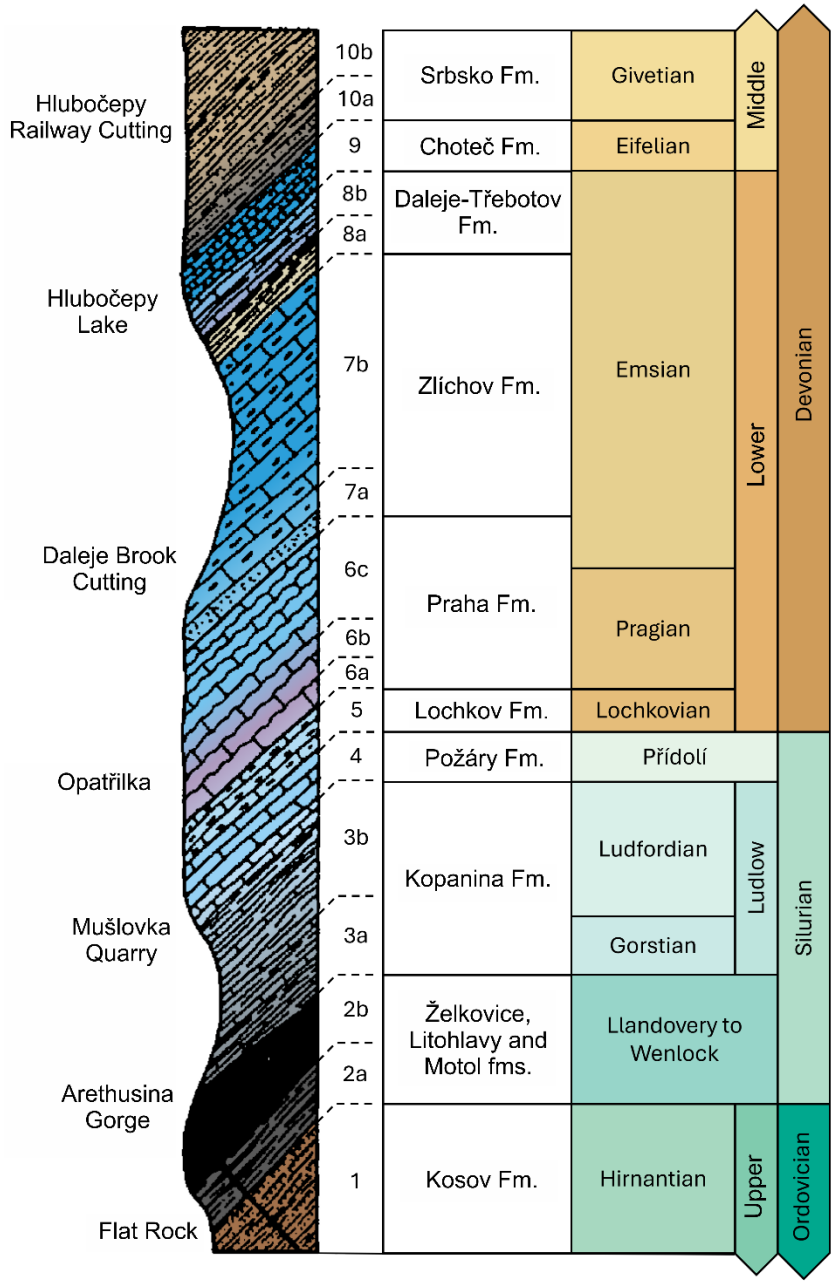


Fig. 2: Simplified stratigraphic section through the Daleje and Prokop Valleys; modified after Kubíková & Kříž, 1981: **1**) siltstones and sandstones; **2a**) graptolite shales; **2b**) basalts and tuffites; **3a**) tuffitic shales with limestones; **3b**): bioclastic limestones; **4**) platy bioclastic limestones; **5**) bioclastic Kotýs Limestone with cherts; **6a**) bioclastic Koněprusy and Slivenec limestones; **6b**) micritic nodular Řeporyje (red) and Loděnice (variegated) limestones; **6c**) grey micritic nodular Dvorce-Prokop Limestone; **7a**) bioclastic limestones of the Chapel Coral Horizon; **7b**) biomicritic grey Zlíchov Limestone with cherts; **8a**) dark greenish to red Daleje Shale; **8b**) red to light grey micritic Třebotov Limestone; **9**) dark grey platy Choteč Limestone with cherts; **10a**) dark grey shales and mudstones of the Kačák Member; **10b)** siltstones and sandstones of the Roblín Member.

Stop 1: Arethusina Gorge:

Lithostratigraphy: Motol and Kopanina Formations

Chronostratigraphy: uppermost Wenlock to lower Ludlow

At our first locality, we can observe a majestic outcrop of basalt volcanics with pillow lavas. The locality is named after the trilobite *Aulacopleura konincki* (formerly *Arethusina*), whose remains were found in shales underlying the basalt rocks. Today, the fossil-bearing rocks are no longer exposed and fossil collecting is unfortunately impossible here.

The basalts are of upper Wenlock to lower Ludlow in age and are part of the so-called Nová Ves volcanic centre, one of several volcanic centres that were active in the area of the Prague Basin from the mid-Llandovery to the lower Ludlow (Kříž, 1992)

Apart from the basalt rocks, we can observe an overlying succession of tuffites and tuffitic shales of the Kopanina Formation and their gradual transition to tuffaceous limestones at the top of the exposure. The succession then continues in the nearby Mušlovka Quarry.

Stop 2: Mušlovka Quarry

Lithostratigraphy: Kopanina and Požáry Formations

Chronostratigraphy: Ludlow to lower Přídolí

Mušlovka Quarry (Fig.3) is named after the very abundant brachiopod and bivalve remains found in the quarry ("mušle" = "shell" in Czech). Today, the quarry is often vsited by fossil collectors for its rich fossil assemblages mostly composed of brachiopods and cephalopods, followed by bivalves, gastropods and various species of trilobites.



Fig.3: View of the rock outcrop at the Mušlovka Quarry. *Photo by M. Uhlířová.*

Biotic communities as well as depositional environments changed rapidly during the deposition of the Kopanina Formation. Throughout the Prague Basin, we can observe deeper slope cephalopod-bivalve dominated communities, trilobite-brachiopod communities typical of intermediate depths and also shallow-water coral-crinoid-dominated communities. These changes reflect global eustatic movements and biotic events as well as local synsedimentary tectonics (Kříž, 1992; Manda & Frýda, 2014).

The rock wall in the Mušlovka Quarry is formed by a succession of various types of fossil-rich limestones of the upper Kopanina and lower Požáry Formations (Ludfordian to lower Přídolí), deposited on the shallow slopes of the volcanic archipelago (Fig. 4). The succession starts at the northern edge of the quarry with light grey bioclastic limestones and calcareous shales with abundant remains of trilobites *Diacalymene diademata, Diacanthaspis* minuta and Otarion *diffractum*, alongside the dominant *Encrinuraspis beaumonti* (Fig. 5), which marks a local biostratigraphic trilobite horizon.

Above these layers, we can observe light grey limestones dominated by brachiopods, especially *Atrypoidea linguata* (Fig. 5). These layers are overlain by a massive bank of cephalopod limestone with common bivalves followed higher up by a bank of brachiopod limestone with abundant pyrite aggregates. This succession is then terminated with a gap in sedimentation that is traceable in much of the Prague Basin and further emphasizes the instability of the environment during this time (Kříž, 1992).

The layers following the hiatus are part of the *Ananaspis fecunda* trilobite horizon and consist of light to pinkish grey crinoid limestones. They are then overlain by a succession of grey bioclastic limestones with shale intercalations belonging to the *Prionopeltis archiaci* trilobite horizon.

At the topmost part of the succession, the boundary between the Kopanina and Požáry Formations can be found, as well as the boundary between the two upper Silurian series, Ludlow and Přídolí. The GSSP of this boundary was established in the Požáry Quarry (Kříž et al., 1986), just about 500 m southwest from Mušlovka.

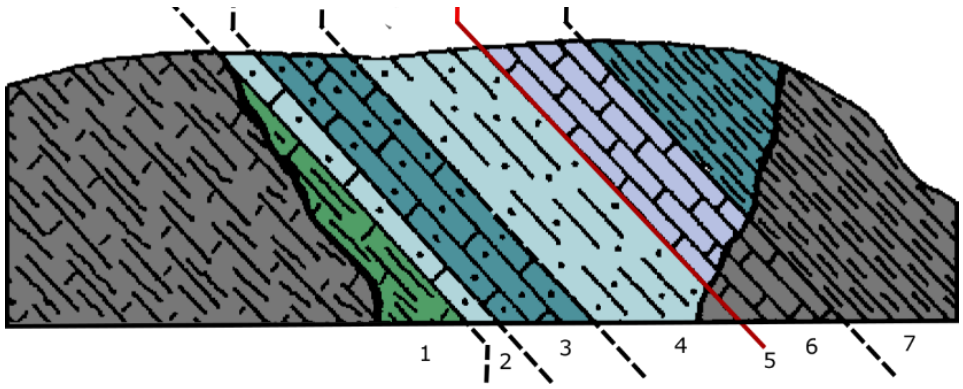


Fig. 4: Schematic section through the Mušlovka Quarry outcrop; modified after Chlupáč, 1999**:** **1**) Tuffites and tuffitic shales; **2**) Light grey bioclastic limestones with trilobite *Encrinuraspis beaumonti*; **3**) Dark grey bioclastic brachiopod limestones; **4**) Light grey cephalopod limestones with common bivalves; **5**) Hiatus; **6**) Light grey to pinkish grey crinoidal limestones of the *Ananaspis fecunda* trilobite horizon; **7**) Grey platy bioclastic limestones with typical trilobites *Prionopeltis archiaci* (uppermost Ludlow) and *Prionopeltis striata* (lower Přídolí).

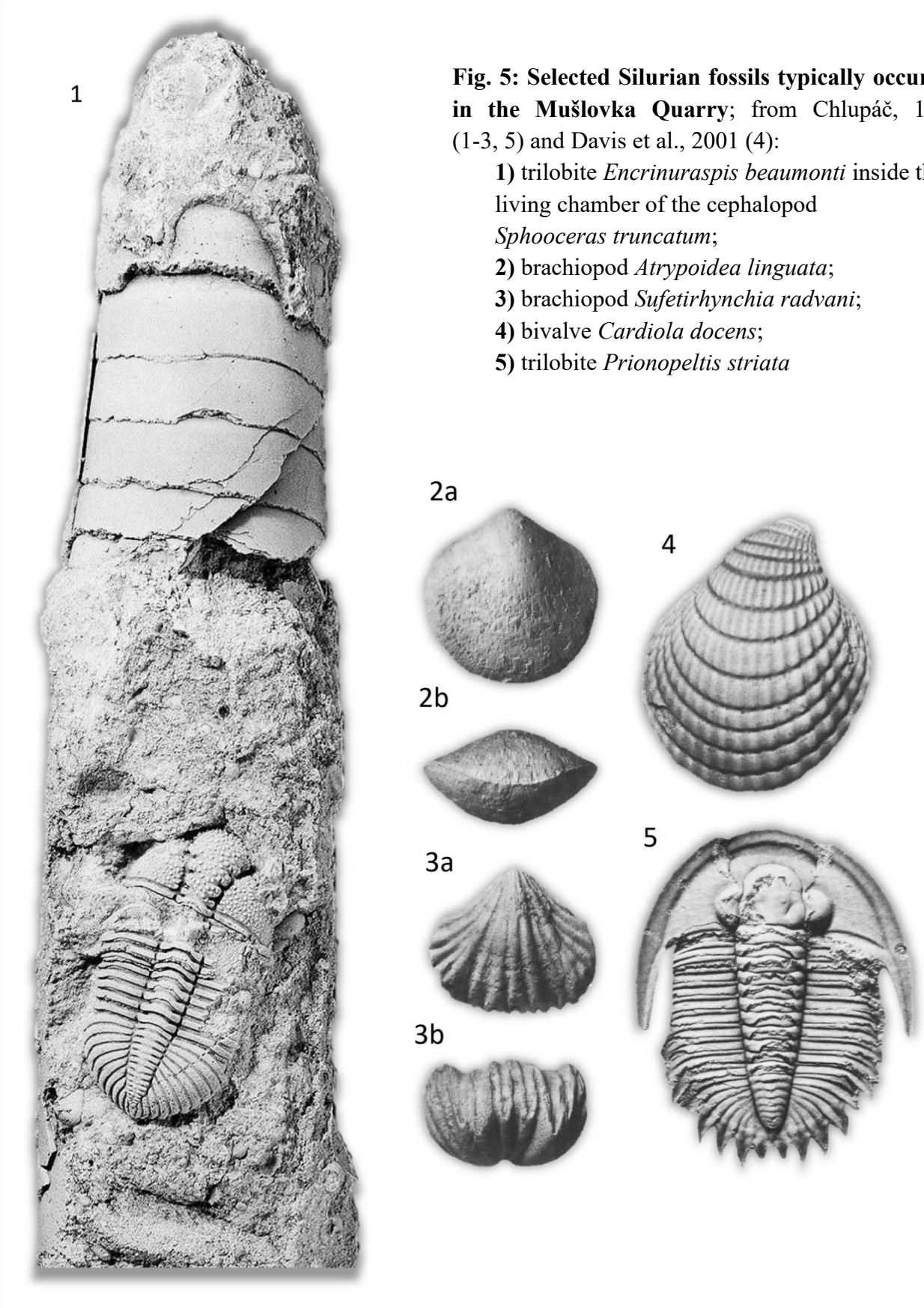


Fig. 5: Selected Silurian fossils typically occuring in the Mušlovka Quarry; from Chlupáč, 1998 (1-3, 5) and Davis et al., 2001 (4):

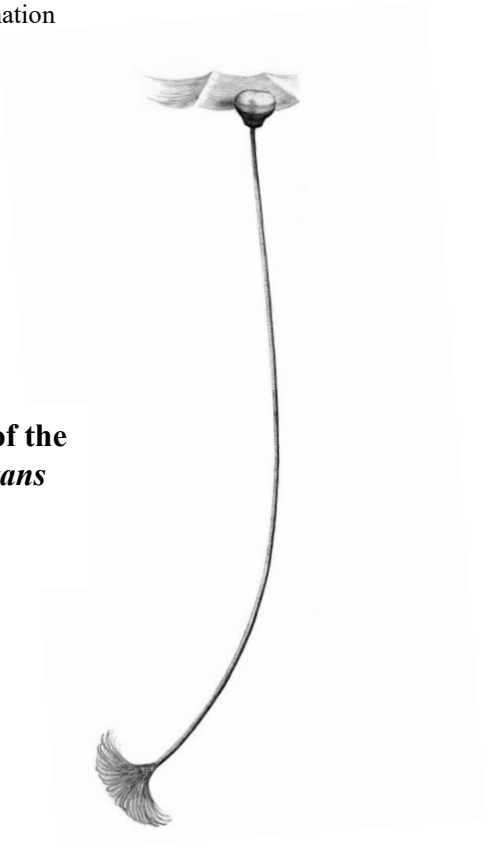
1) trilobite *Encrinuraspis beaumonti* inside the living chamber of the cephalopod *Sphooceras truncatum*;
2) brachiopod *Atrypoidea linguata*;
3) brachiopod *Sufetirhynchia radvani*;
4) bivalve *Cardiola docens*;
5) trilobite *Prionopeltis striata*

Stop 3: Lobolith Hillside and Black Quarry

Lithostratigraphy: Požáry Formation and Kotýs Limestone Member of the Lochkov Formation

Chronostratigraphy: Přídolí to lower Lochkovian

The Lobolith Hillside is named after loboliths, bulbous organs of crinoids of the genus *Scyphocrinites* (Fig. 6). These organs are mostly interpreted as buoyancy devices for a pelagic lifestyle (Ubaghs, 1978), although other possible interpretations have also been published (Gorzelak et al., 2020). Remains of these crinoids are very abundant in the youngest Silurian and oldest Devonian strata in the Prague Basin and, under favourable conditions, they can weather out from the rock wall and be found in the surrounding dirt alongside shells of the brachiopod *Dayia bohemica*.



► **Fig. 6: Reconstruction of the crinoid *Scyphocrinites elegans* as a pelagic animal**; from Gorzelak et al., 2020

In the nearby Black Quarry (Fig. 7), we can observe the Silurian-Devonian boundary and the transition between the grey bioclastic limestones containing *Scyphocrinites* of the uppermost Přídolí and light bioclastic chert-bearing Kotýs Limestone of the lowermost Lochkovian.



Fig. 7: View of the Black Quarry. *Photo by M. Uhlířová.*

Stop 4: Opatřilka and Červený lom („Red Quarry“)

Lithostratigraphy: Slivenec, Řeporyje, Loděnice and Dvorce-Prokop Limestone Members of the Praha Formation

Chronostratigraphy: lower Pragian to lowermost Emsian

In Opatřilka Quarry, we can once again observe the bioclastic limestones of the uppermost Přídolí series, this time in their unweathered state. Alongside abundant crinoids and brachiopods, remains of gastropods, phyllocarid crustaceans and trilobites can also occasionally be found.

Červený lom (=“Red Quarry“, Fig. 8) and surrounding quarries expose the various limestone facies of the Pragian to lower Emsian Praha Formation. Its succession starts with light pinkish bioclastic/biosparitic Slivenec Limestone with abundant crinoid remains. Above it we can observe biomicritic Řeporyje (dark red) and Loděnice (red-green variegated) limestones. The colour of these layers gave the quarry its name.

The succession continues in the next quarry with dark grey nodular micritic Dvorce-Prokop Limestone with abundant remains of trilobites, tentaculites, brachiopods, and bivalves (Fig. 9). Ichnofossils of the genus *Chondrites* are also frequent.

The transitions between the different limestone types are gradual and reflect changes in deposition shifting from a shallow-water, high-energy environment in the lower Pragian to a deeper-water, low-energy pelagic environment in the upper Pragian to lower Emsian (Chlupáč, 1998). It also records an upper Pragian period of pelagic iron oxide-rich sedimentation (see Bábek et al. 2018).



Fig. 8: View of the rock outcrop at Červený lom (“Red Quarry“). *Photo by M. Uhlířová.*

Stop 5: Klukovice Swimming Pool

Lithostratigraphy: Chapel Coral Horizon and Zlíchov Limestone Members of the Zlíchov Formation

Chronostratigraphy: lower Emsian (lower Zlíchovian regional stage)

At the base of the Zlíchov Formation, the sedimentation of the micritic Dvorce-Prokop Limestone is interrupted by the deposition of grey organodetritic limestones with layers of intraformational breccia containing a vast amount of coral, brachiopod, and bryozoan fauna (Fig. 9). These layers form the so-called Chapel Coral Horizon and represent the deposition of allochthonous material, most probably derived from an area southeast or east of the current distribution of the Devonian sediments of the Prague Basin (Chlupáč, 1957). The original source of the fauna, which was probably a reef-like environment similar to that found in the Koněprusy area, is therefore not preserved and the transported remains are the only available source of information about it.

At the location of the former outdoor swimming pool in Klukovice, layers of the Chapel Coral Horizon can be observed with transported remains of tabulate corals, rugose corals and crinoids.

Stop 6: Prokop Quarry

Lithostratigraphy: Dvorce-Prokop Limestone Member of the Praha Formation

Chronostratigraphy: upper Pragian to lowermost Emsian

The former Prokop Quarry exposes the upper Pragian to lower Emsian Dvorce-Prokop Limestone of the Praha Formation. At the locality, abundant remains of stromatoporoids were formerly discovered.

Beyond its geological significance, the limestone massif once contained a massive karst cave system reaching depths of up to 120 meters. Allegedly, this cave was discovered and inhabited in the 11th century by the famous Czech priest and hermit St Prokop. Centuries later, in the 18th century, a church dedicated to him was erected on the hilltop above the subterranean network. The landscape changed dramatically during the second half of the 19th century when the hill was exploited for its high-quality limestone, a process that ultimately and completely destroyed the cave system.

The site's purpose shifted again after the Second World War, when the quarry was repurposed into a high-security facility for the Czechoslovak Army, which demolished the hilltop church for security reasons. Today, the quarry remains an active military property and continues to serve as a high-security installation.

Just next to the facility, visitors can still see remnants of the area's industrial past: a long railway tunnel bored directly into the limestone wall, which was once used to transport quarried stone to nearby furnaces.

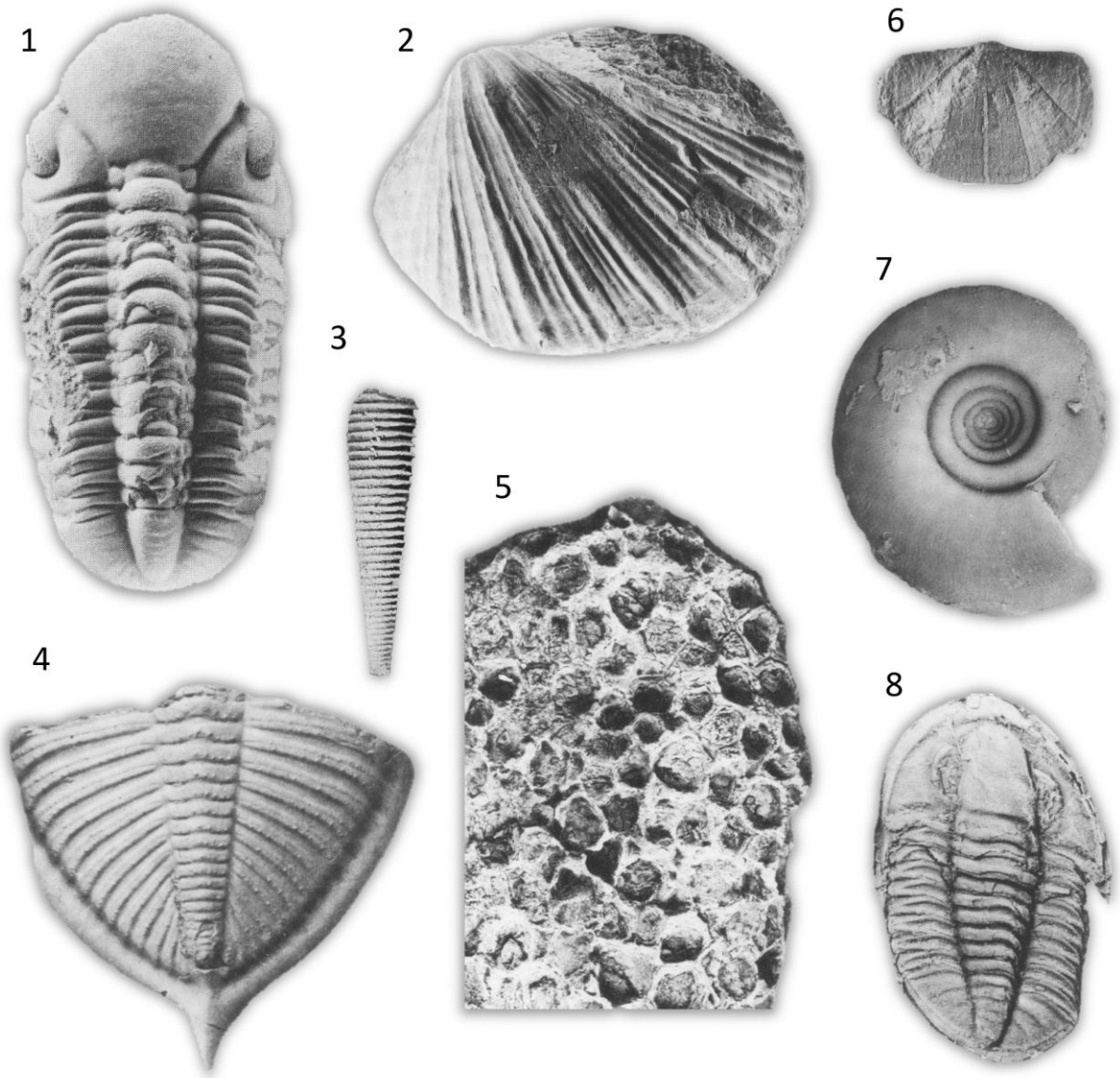


Fig. 9: Selected Lower Devonian fossils from the Barrandian area; from Chlupáč, 1999 (1); Chlupáč, 1998 (2, 4-8) and Bouček, 1964 (3):

1) bivalve *Kralovna* sp. (Praha Fm.);
2) trilobite *Reedops cephalotes* (Praha Fm.);
3) tentaculite *Nowakia acuaria* (Praha Fm.);
4) pygidium of the trilobite *Zlichovaspis auriculata* (Zlíchov Fm.);
5) tabulate coral *Squameofavosites svagercus* (Zlíchov Fm.);
6) trilobite *Macroblepharum perstes* (Daleje Sh.);
7) goniatite *Anarcestes simulans* (Třebotov Lm.);
8) brachiopod *Dalejodiscus comitans* (Třebotov Lm.)

Stop 7: Hlubočepy Lake

Lithostratigraphy: Daleje Shale and Třebotov Limestone Members of the Daleje-Třebotov Formation and the Choteč Limestone Member of the Choteč Formation

Chronostratigraphy: upper Emsian (Dalejan regional stage) to lower Eifelian

Hlubočepy Lake (Fig. 10) is situated in a former limestone quarry. There, and in the trench leading up to the lake, we can observe the upper Emsian and lower Eifelian rocks belonging to the Daleje-Třebotov and Choteč Formations. The Daleje-Třebotov Formation contains two distinct members (Chlupáč, 1959): the Daleje Shale is greenish-grey calcareous shale which interrupt the otherwise carbonate sequence of the Prague Basin and reflect the globally recognizable Daleje event (Chlupáč & Kukal, 2005). The Třebotov Limestone is a biomicritic greenish to light gray limestone overlying the Daleje Shale with a gradual transition which is better exposed in the next locality. They represent a low-energy deeper water environment with predominant pelagic sedimentation (Chlupáč, 1998; Bábek et al., 2018).

The Daleje Shale can be observed here only as a strongly weathered debris along the path leading up to the lake, while the Třebotov Limestone makes up the northern wall of the lake quarry.

The southern wall is made up of the overlying dark grey platy bioclastic to biomicritic Choteč Limestone of Eifelian age with abundant remains of the trilobite *Chotecops auspex* and tentaculites. The sharp transition between the two limestone types, reflecting the Choteč event (Chlupáč & Kukal, 2005) and the Emsian/Eifelian boundary, is not visible here, as the upper part of the Třebotov Limestone and the lowest part of the Choteč Limestone were the main focus of quarrying.



Fig. 10: View of Hlubočepy Lake with Třebotov (left) and Choteč (right) Limestone walls.
Photo by M. Uhlířová.

Stop 8: Vysoká Quarry

Lithostratigraphy: Daleje Shale and Třebotov Limestone Members of the Daleje-Třebotov Formation

Chronostratigraphy: upper Emsian (Dalejan regional stage)

In the trench leading up to the quarry itself, we can observe the well-exposed, although significantly weathered, lower parts of the Daleje Shale.

In the quarry itself (Fig. 11; with schematic section in Fig. 12), we can observe reddish upper layers of the Daleje Shale and their gradual transition to light grey pelitic Třebotov Limestone. The Třebotov Limestone layers and debris contain abundant and well-preserved fauna (Fig. 9) dominated by phacopid and proetid trilobites, tentaculites, nautiloids, ammonoids and crinoids with occasional occurrence of rugose corals. These fossils are, however, difficult to reach as the slope of the quarry is very steep.

Below the quarry, along the Ke Hřbitovu Street, lies a classic paleontological locality where we can finally observe the Daleje Shale *in situ* in its almost unweathered state. Here it contains abundant fauna consisting mainly of trilobites, brachiopods, bivalves and tentaculites.

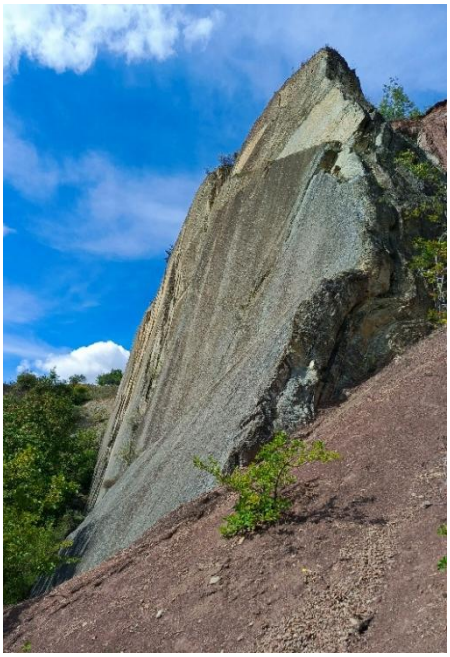
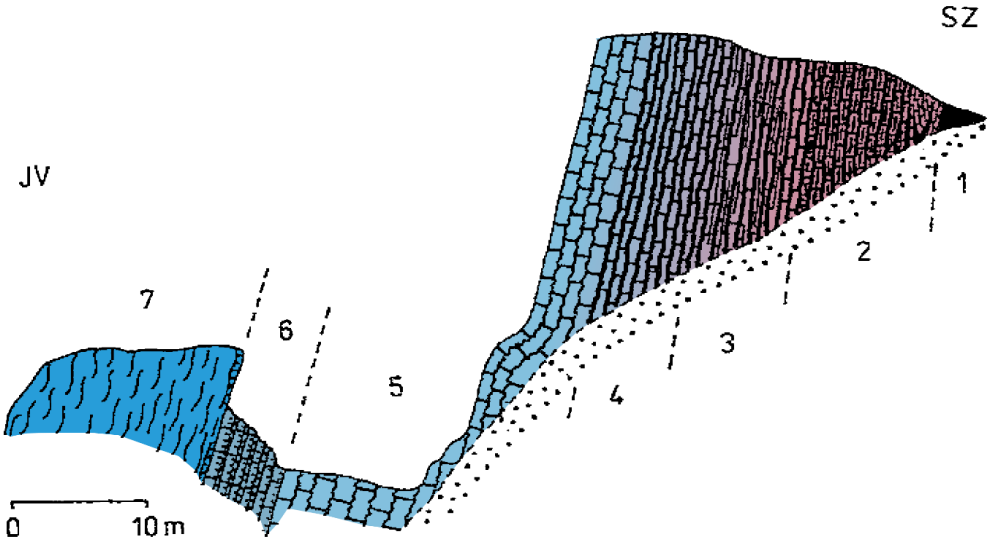


Fig. 11: Rock face at Vysoká Quarry.
Photo by M. Uhlířová.



▲ Fig. 12: Schematic section through the Vysoká Quarry outcrop; modified after Chlupáč, 1959: **1**) topmost Daleje Shale; **2**) red calcareous shales with limestone nodules and intercalations; the transition between the Daleje Shale and Třebotov Limestone; **3**) reddish nodular Třebotov Limestone with shale intercalations; **4**) light grey and greenish Třebotov Limestone with shale intercalations; **5**) light grey platy Třebotov Limestone; **6**) grey platy Choteč Limestone; **7**) dark platy Choteč Limestone with cherts.

Stop 9: Hlubočepy Railway Cutting

Lithostratigraphy: Choteč Limestone Member of the Choteč Formation and Kačák and Roblín Members of the Srbsko Formation

Chronostratigraphy: uppermost Eifelian to lower Givetian

Hlubočepy Railway Cutting (Fig. 13) exposes some of the youngest fossiliferous Devonian strata in the Prague Basin.

Dark, platy Choteč Limestone with silicites (Eifelian age) are overlain here by bituminous dark-grey shales with silicites. According to Chlupáč (1959), these layers belong to the Kačák Member of the Srbsko Formation, which were formed during the Kačák event. This event is tied to a globally recognizable marine transgression and minor extinction event at the base of the Givetian (Chlupáč & Kukal, 1986) and represents a definitive termination of carbonate sedimentation in the Prague Basin.

Above the Kačák Member, the second unit of the Srbsko Formation is found, the Roblín Member. It comprises greenish silty shales with rhythmic irregular sandstone intercalations. The greenish shales and siltstones at this locality contain abundant remains of early land plants, dominated by *Protopteridium hostimense*, alongside occasional cephalopods and very rare trilobites.

The Roblín Member is the youngest stratigraphical unit in the Prague Basin. It represents a flysch-like sequence influenced by tectonic activity reflecting the onset of the early stages of the Variscan orogeny which terminated the deposition of marine sediments in the Barrandian area (Kukal & Jaeger, 1988; Chlupáč, 1998).



Fig. 13: View of the Hlubočepy Railway Cutting. *Photo by M. Uhlířová.*

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