Sbor. geol. věd	Geologie 41	Pages 69—103	1 fig.	2 tabs.	10 pls.	Praha 1986 ISSN 0581-9172

Ordovician-Silurian boundary in the Prague Basin (Barrandian area, Bohemia)

Hranice ordovik-silur v pražské pánvi (Barrandien)

Petr Štorch[1]

Received April 2, 1984

Štorch P. (1986): Ordovician—Silurian boundary in the Prague Basin (Barrandian area, Bohemia). — Sbor. geol. Věd. Geol., 41, *69—103*. Praha.

Abstract: The Ordovician—Silurian boundary in the Prague Basin is characterized by an uninterrupted sedimentation and abrupt increase of the organic matter content which is accompanied by a change of colour and texture of the sediments. Bioturbated mudstones of the uppermost Kosov Formation, with abundant Hirnantia fauna in the eastern part of the Basin, are followed by dark graptolitic shales at the base of the Silurian (in the Prague Basin the base of the A. ascensus Zone). The marked change of sedimentation manifested itself by a transition to sandy-micaceous laminites in the course of the Par. acuminatus Zone sedimentation. The change chronologically corresponds to the break in sedimentation in the north limb of the Basin and in the Pankrác area in which the break continues up to the Monocl. griestoniensis Zone. The sedimentary sequence and the succession of faunal communities indicate a gradual quieting of sedimentation in the deepening sedimentary area which originated already in the uppermost Kosov Formation. The paper surveys the fauna of the Kosov and the lower part of Želkovice Formations. The analysis of graptolite faunas permitted a detailed stratigraphic description of the boundary interval in the Prague Basin and its international correlation.

[1] *Ústřední ústav geologický, Malostranské nám. 19, 118 21 Praha 1*

Introduction

The Ordovician—Silurian boundary interval in the Prague Basin (Barrandian area) is characterized by a transition from the flysch type development of the Kosov Formation (upper Ashgill) into black graptolitic shales of the Želkovice Formation (lower Llandovery).

Opinions on the character of the Ordovician—Silurian boundary in the Prague Basin have been developing gradually. Researchers, originally influenced by Perner and Kodym (1919, 1922), recognized the stratigraphic gap on the base of the Silurian and considered it a chief evidence of the Taconic phase of the Caledonian orogeny in the Barrandian (Prague Basin). The existence of the so called emergent Taconic phase was evidenced also by a marked lithologic change on the boundary with the Silurian graptolitic shales.

Graptolites of the Silurian Akidograptus acuminatus Zone were for the first time documented by M a r e k (1951a) in an isolated occurrence of the Silurian strata near Běchovice. Therefore M a r e k (1951a) and B o u č e k (1953) already contradicted the boundary gap in the Úvaly region (Běchovice), however, they still admitted the existence of the gap for the very Barrandian as a mobile area.

H o r n ý (1956, 1960) found even lower Silurian graptolite zone of *Akidograptus ascensus* in the entire south limb of the Basin extending from Libomyšl through Želkovice up to Černošice and came to the conclusion that in the major part of the Barrandian (Prague Basin) the continuous sedimentation spanned from the Ordovician to the Silurian. This hypothesis was not corroborated namely in the north limb of the Basin. H o r n ý (1958, 1960) reported that the basal graptolite Silurian zones were absent locally and considered this phenomenon the evidence of epeirogenic movements which represented the aftermath of tectonic activity during sedimentation of the Kosov Formation. Recent synthetic papers of H a v l í č e k (1981, 1982) showed that the deformation of the linear sedimentary depression of the Prague Basin resulted in tectonically affected sedimentation and subsequent lithologic changes in the uppermost Ordovician. However, this intensive deformation of the Basin can be associated with the effect of the emergent Taconic phase of the Caledonian orogeny. The results of this work suggest that the weakening of tectonic activity took place as early as in the uppermost Ordovician and the sedimentation of the Ordovician—Silurian boundary beds was not affected by further tectonic movements.

The present research began in the south limb of the Basin (Š t o r c h 1980), continued on incidental exposures on the territory of Prague (Š t o r c h 1982) and was terminated by examination of the north limb of the Basin. Fourteen reference sections were studied in detail. We used the results of H o r n ý (1956, 1960) from the southwest closure of the Silurian syncline as well as unpublished results of exploratory drilling for the uranium industry and descriptions of additional localities (Prague: - Pankrác, Š t ě p á n e k 1974; - Řeporyje, B o u č e k 1937: - Řeporyje — a trench on the southeast periphery of the village. J. Kříž pers. comm.: - Nová Ves near Jinonice, M a r e k - H a v l í č e k 1967; - Velká Chuchle — turning of the road to Lochkov, J. Kříž pers. comm. Tachlovice — borehole, P r a n t l - P ř i b y l 1944 and other). The complex study of the Ordovician—Silurian boundary links up with the work of the preceeding authors, namely with the stratigraphic work of B o u č e k (1953) and H o r n ý (1956, 1960), papers on the Barrande's "colonies" (P ř i b y l 1940, K ř í ž - P o j e t a 1974), sedimentological studies of B o u č e k - P ř i b y l (1958) and K u k a l (1961a, 1963a,b) and communication on the fauna of the Kosov Formation (M a r e k 1954, 1963a and M a r e k - H a v l í č e k 1967). The conception of the geological development of the Prague Basin emanates from the theory that the Basin is a linear sedimentary depression (H a v l í č e k 1980, 1981, 1982).

The sedimentological and detailed stratigraphical research that has just been completed confirmed that the Ordovician—Silurian boundary in the Prague Basin belongs already to the period of the deepening of the sedimentary area which followed after the tectonic activity period (synsedimentary deformations of the Basin which can be associated with the Taconic phase). The research yielded, besides a detailed biostratigraphic description and correlation, also a model of the Basin development in the uppermost Ordovician and basal Silurian, which explains shifting of the apparently monotonous graptolitic shale facies as well as the local gaps.

The paper on the Ordovician—Silurian boundary in the Prague Basin contributes to the international discussion about a convenient boundary horizon and stratotype section. According to the international Subcommission for the Silurian stratigraphy in Kiev, May 1983, the section Dob's Linn in Scotland was selected as the stratotype locality of the Ordovician—Silurian boundary and the base of the Parakidograptus acuminatus Zone was chosen as the base of the Silurian. The Ordovician—Silurian boundary interval in the Prague Basin can be well compared with the proposed stratotype and with other important sections in the world (tab. 1).

The author wishes to thank Dr. I. Chlupáč, J. Kříž, Z. Kukal and M. Šnajdr from the Geological Survey, Prague, for very helpfull discussions and for providing him with some important data. He also wishes to express his gratitude in the first place to dr. V. Havlíček (Geological Survey, Prague) for his expert criticism which was so important for analysing the problems.

Description of sections

The reference sections (pl. 1) served for measuring of thicknesses with $\pm$ 2 cm precision, collecting samples for thin sections and for X-ray examination of clay minerals. The content of organic matter in graptolitic shales was orientationally assessed and the sections were thoroughly exploited for fauna regardless, of its frequently insufficient preservation (especially in laminites).

P r a g u e - B ě c h o v i c e

This locality, at present inaccessible, was discovered by V. Havlíček in 1950, during mapping in the Úvaly area. North of Běchovice railway station gently inclined boundary beds of the Ordovician and Silurian were unearthed by construction works. Rich Hirnantia fauna was discovered in light-coloured siltstones and especially in concretions of muddy limestones of the uppermost layers of the Kosov Formation (M a r e k 1951, M a r e k - H a v l í č e k 1967). At Běchovice, graptolitic shales (clayey to silty shales) of the basal Silurian set on the uppermost layers of the Kosov Formation without any interruption. Their graptolite fauna was partially evaluated by B o u č e k (1953) but unfortunately the locality had been already almost destroyed by then. The present author studied the new section within the Par. acuminatus — Cyst. vesiculosus Zones (in the true thickness of 4.5 m).

The Silurian near Běchovice represents a denudational remainder and the highest preserved zone is Dem. pectinatus. Great thicknesses of the basal graptolite zones (pl. 1) with coarser silty sediments are characteristic. Silicites were not recorded. The onset of laminites occurs in the higher part of the Par. acuminatus Zone. The section is similar to that at the locality Prague - Řepy, as to sedimentology and biostratigraphy.

Prague - Řepy

Another temporarily accessible locality was described by S t o r c h (1982). Up to 6 m deep construction excavations exposed a sedimentary succession of the uppermost Ordovician and the lower Silurian. Excavation walls showed a gradual bleaching of dark shales and siltstones covered by thick ancient waste mantle. At the bottom of excavations, fresh rock exhibited perfectly preserved original sedimentary textures (bedding, pyrite clusters).

In the uppermost layers of the Kosov Formation Hirnatia fauna was discovered only 35 centimeters below the first graptolitic shales. The Ordovician—Silurian boundary is undoubtedly concordant, lithologic change occurs gradually within 10 cm thick transitional layer with first graptolites (see ? G. persculptus Zone). The typical assemblage of graptolites of the A. ascensus Zone occurs in dark graptolitic shales located even 10 cm higher. A. ascensus and Par. acuminatus Zones developed in greater thicknesses, usually in the form of silty shales and thin-bedded clayey to silty shales. Laminites appeared in the higher portion of the Par. acuminatus Zone and prevailed up to the Dem. convolutus Zone. Some graptolite faunas permit a correlation of the sections on an intrazonal level in the framework of the Prague Basin; on the boundary of the A. ascensus and Par. acuminatus Zones an assemblage with *Cl. trifilis* and in the higher portion of the Par. acuminatus Zone an assemblage with *D. diminutus apographon*. The position of the locality outside the Prague Fault is very important for geological interpretations.

Prague - Řeporyje (Velká Ohrada)

An interesting section was exposed by excavations near the northeast periphery of Řeporyje. The local Silurian pertains to a tectonic block neighbouring with the block from the locality of an abandoned kiln described by Prantl and Přibyl (1940). The new exposure furnished an unambigous image of the character of the Ordovician—Silurian boundary in this part of the Prague Basin north limb.

The uppermost layers of the Ordovician are formed as usually by silstones and claystones. The base of the Silurian displays 5 cm of grey clayey to silty shales with climacograptid fauna and rare *A. ascensus.* Sandy laminites and silty shales of the Demirastrites convolutus Zone with thickness reaching only 60 cm sharply set on the basal shales. They are followed by light-coloured bioturbated claystone from the base of Litohlavy Formation (Kříž 1975). The stratigraphic gap in this site is not situated on the base of graptolitic shales but inside the Silurian, between the A. ascensus and Dem. convolutus Zones. Above the bioturbated claystone the section is continued in its typical development by the Spirograptus turriculatus Zone. Between the Dem. convolutus Zone and basal claystone of the Litohlavy Formation occurs another sedimentary break ranging from the Monograptus sedgwickii to Rastrites linnaei Zone. In this place, a transitional type between the complete development of the lower Silurian and the development with a pronounced stratigraphical gap was observed. The most prominent sedimentary break (the whole of the Želkovice and a part of Litohlavy Formations) is known from the southern outskirts of Prague (Malá Chuchle, Pankrác).

Loděnice

The territory between Řeporyje and Mezouň is shaped by an old peneplain with a thick waste mantle. Further outcrops of the upper Ordovician and lower Silurian were observed as far as east of Loděnice (Kolo and Hačka hills). Northeast of the Loděnice lime-kiln construction works uncovered the Ordovician—Silurian boundary. Above a tectonically disturbed diabase sill with kneaded graptolitic shales a longitudinal fault follows. Above the fault the section encountered 30 cm of bioturbated siltstones and claystones of the topmost Kosov Formation followed by the basal Silurian graptolite zones of *A. ascensus* and *Par. acuminatus* in the form of light-coloured bleached clayey shales. Joint thickness of the both zones (incomplete) is 50 cm. Above these zones laminites of the Dem. triangulatus Zone abruptly set on. Again, a gap was observed, this time between the Par acuminatus (upper portion) and C. cyphus Zones. The section was terminated by siliceous shales of the Dem. pribyli Zone. The A.

ascensus and Par. acuminatus Zones near Loděnice were described for the first time from the north limb of the Prague Basin.

Sedlec

Another section of the Ordovician—Silurian boundary was studied northeast of Sedlec, near Loděnice. It is situated in the area of a direct influence of the Svatý Jan volcanic center; however, it seems that the sedimentation at the Ordovician—Silurian boundary has not been affected by the volcanism (it holds for the situation north of Tachlovice fault, the situation south of the fault is unknown).

The solid bioturbated siltstone of the uppermost layers of the Kosov Formation are overlaid by dark silty shales with graptolites corresponding to middle part of the Par. acuminatus Zone. Then follows 20 cm of tectonically disturbed shales with undeterminable graptolites and above them siliceous shales with sandy laminae, the Dem. pectinatus and Dem. pribyli Zones. The base probably lacks the A. ascensus Zone. the absence of the Cyst. vesiculosus, C. cyphus and Dem. triangulatus Zones may be associated with the break in sedimentation as well as with the tectonic fault.

There are not any suitable exposures for the study of the Ordovician—Silurian boundary between Sedlec and Kosov hill near Beroun. The southwest closures of the Prague Basin Silurian were studied using technical works by H o r n ý (1956, 1958, 1960) in the fifties. H o r n ý failed to document the basal graptolite zones of the Silurian in the north part of the area (Kosov, Koukolova hora Hill, Malkov, Lounín, Tmaň). H o r n ý (1960) explains this fact by lack of sedimentation on the very base of the Silurian in these parts of the sea bottom and by unfit fossilization environment. On the other hand, he described the lowermost Silurian graptolite zones (Želkovice, Bykoš, Liteň) from the entire southern part of the area.

Graptolitic shales set here abruptly but concordantly on claystones and siltstones of the uppermost layers of the Kosov Formation, without signs of sedimentary break.

Želkovice

H o r n ý (1956) described the sections of the Ordovician—Silurian boundary around Želkovice from test pits. I have extended his findings by the study of the section south of Želkovice. The uppermost Ordovician is formed by light-coloured bioturbated siltstones. On the base of the Silurian H o r n ý (l. c.) described gray clayey shales with climacograptids and rare glyptograptids, probably from the G. persculptus or G. bohemicus group (? G. persculptus Zone). Above them follow 40 cm of dark clayey shales and 30 cm of compact brown shales of the A. ascensus Zone. Then come 30 cm of laminites which I assign to the Par. acuminatus Zone and above the laminites I observed compact shales of the Cyst. vesiculosus and C. cyphus Zones with an increasing number of siliceous intercalations.

Běleč

At present, the Ordovician—Silurian boundary in the Prague Basin is best exposed in the roadcutting at the eastern periphery of Běleč. The uppermost Ordovician is represented by ochre bioturbated siltstones and claystones. Partially bleached clayey shales of the A. ascensus Zone sharply set on the bioturbated Ordovician sediments. Above them occur laminites which exhibited Par. acuminatus and Cyst. vesiculosus Zones within the thickness of less than 30 cm. In the lower portion (Par. acuminatus Zone) the sandy laminites are present, in the upper part they contain thin muddy intercalations with numerous graptolites (Cyst. vesiculosus Zone — an assemblage with dimorphograptids and *Atavograptus atavus).* The C. cyphus Zone is composed of light-coloured shales with frequent *Monograptus austerus,* above them is an assemblage with *Diplograptus fezzanensis.* Just below the basalt sill it is followed by shales which were compacted by contact metamorphism. A similar development as that at Běleč can be observed during the boundary interval in major part of the south limb of the Prague Basin.

Očkov

Another section was studied more northwards, on the slope of the Vočkov hill. In this site, the base of the Silurian is situated in the tectonic band separated from the Běleč outcrops by a longitudinal fault which forms one of the branches of the Vočkov overthrust. Above the light-coloured bioturbated claystones and siltstones of the uppermost Kosov Formation dark graptolitic shales with numerous climacograptids on the base (? G. perscuptus Zone) sharply set on. Above them *A. ascensus* and *D. modestus* were discovered. They are followed by 10 cm of sandy laminites with undeterminable graptolites. The section continues by 40 cm thick Cyst. vesiculosus Zone, in the lower part in the form of laminites and in the upper part in the form of dark compact shales with dimorphograptids and *A. atavus.* Then come 70 cm of silty shales of the C. cyphus Zone which exhibit frequent *D. fezzanensis* in their upper part. The section is terminated with dark shales of the Dem. triangulatus Zone compacted by contact metamorphism.

Zadní Třebaň

Another reference section of the Ordovician—Silurian boundary as a continuation of the tectonic band which we encountered already near Běleč was situated in the cutting of the Prague—Beroun railway, west of Zadní Třebaň. The uppermost Ordovician is represented by light-coloured bioturbated claystones and siltstones. On the base of the Silurian fine, dark, slightly micaceous shales of 15—20 cm thick A. ascensus Zone were observed. Soft sandy-micaceous laminites appear approximately in the middle of 30 cm thick Par. acuminatus Zone, extended throughout major part of the Cyst. vesiculosus Zone (50 cm) and gradually disappeared roughly in the middle of the C. cyphus Zone. They are substituted by black-grey compact, thin-bedded silty shales. In the underlying layer of 50 cm theik basalt ("diabase") apophysis the upper part of the C. cyphus Zone with an assemblage of *D. fezzanensis* has typically developed. Above the apophysis contactly metamorphosed shales of the Dem. triangulatus Zone and above them a thick basalt ("diabase") sill were observed.

Hlásná Třebaň

The locality on the slope overlooking the road from Hlásná Třebaň to Lety is the most easily accessible section of the lower part of the Želkovice Formation, stretching from the base up to the Dem. convolutus Zone.

The section begins with a thick basalt ("diabase") sill which forms a rock wall above the road between Hlásná Třebaň and Lety. In the overlying rock there are about 20 m of micaceous silty shales of the middle part of the Kosov Formation and above them laminated siliceous sandstones with shale intercalations which represent the upper part of the Kosov Formation. On the base of the flysch type sedimentation of sandstones and shales a bank of coarse-grained sandstone to conglomerate with capsular sedimentary structure (M a r e k 1951b, B o u č e k - P ř i b y l 1958) extending to the underlying shales was observed. The depression is filled with petromictic conglomerate which, besides quartz pebbles, contains fragments of earlier Ordovician sediments, Proterozoic shales and pebbles of granitic rocks (M a r e k 1951b, B o u č e k - P ř i b y l 1958 and K u k a l 1961b). In the course of the flysch type upper Kosov Formation deposition (thickness cca 25 m) smaller grain-size and more quiescent sedimentation was observed. The sedimentation resulted into 2 m thick layer of soft light-ochre clayey siltstones. The uppermost layer of the Kosov Formation is known already from the description of previous sections. Clayey shales of the A. ascensus basal Zone are very thin in the Hlásná Třebaň section. Their thickness is only 1 cm. Above them lay dark sandy-micaceous laminites with indistinct climacograptid graptolites. We failed to document the

Par. acuminatus Zone; the first graptolites of the Cyst. vesiculosus Zone were found 40 cm above the base of the Silurian. in the layer of silty shale. A rich fauna of graptolites of the C. cyphus Zone was found only in approximately 70 cm thick compact clayey shales with silty admixture. The onset of a new graptolite fauna on the base of the Dem. triangulatus Zone can be detailedly studied in the section.

Karlík

On the wooded ridge northeast of Karlík the Barrande's locality "colony Karlík" is situated. Above light-coloured bioturbated claystones of the uppermost Kosov Formation concordantly lie dark clayey shales of the basal Silurian A. ascensus Zone. In the upper part of the A. ascensus Zone an assemblage with *Climacograptus trifilis* followed by the first laminites was observed. Above 40 cm thick A. ascensus Zone 20 cm thick Par. acuminatus Zone composed prevailingly of laminites is situated. Approximately in the middle of its bed succession there is 4 cm thick layer of light-coloured claystones without graptolites. The Par. acuminatus and Cyst. vesiculosus Zones repeat twice in the profile due to a minute longitudinal fault of an overthrust character. In the C cyphus Zone laminites disappear and thin-bedded compact dark shales prevail. Above 120 cm thick C. cyphus Zone the section continues by the Dem. triangulatus Zone in the form of dark siliceous shales.

Černošice

The locality is situated on the slope of Babka hill, above the Černošice—Solopysky road (B o u č e k 1953). The tectonic block of the Silurian originated by doubling of the bed succession behind the longitudinal fault.

The Ordovician—Silurian boundary beds are erect and mildly upturning. The uppermost Ordovician exhibits bioturbated claystones to siltstones. Then follows a break and above it approximately 15 cm of laminites of the Par. acuminatus Zone. H o r n ý (1956) described the section from a dug pit cca 300 m northeasterly. He describes the A. ascensus Zone as 80 cm thick, however he failed to document the Par. acuminatus Zone. The section on the slope of Babka hill is continued by laminites of the Cyst. vesiculosus Zone (30 cm) and C. cyphus Zone (50 cm). In the upper part of the C. cyphus Zone an assemblage with *D. fezzanensis* was found. The beds in the locality above the Dem. triangulatus Zone are folded.

Prague - Velká Chuchle

Southwesterly of Velká Chuchle, on the slope above the Praha—Beroun railway, in the middle of the Upper Ordovician formations, crops out another block of graptolitic shales (Barrande's "colony Haidinger"). Above the basalt ("diabase") sill 30 cm of light-coloured bioturbated claystones of the uppermost Kosov Formation, which were compacted by contact metamorphism, were preserved. They are covered with 30 cm of dark-grey clayey shales of the A. ascensus Zone. Clayey sedimentation continues into the lower part of the Par. acuminatus Zone and then is interchanged by sandy-micaceous laminites which continue upwards into the Cyst. vesiculosus Zone.

A completely different situation, according to the section provided by J. Kříž (pers. comm.), can be seen on the south edge of Velká Chuchle, not far from the described locality. The onset of graptolitic shales can be observed in the S. turriculatus Zone and perhaps already in the uppermost part of the R. linnaei Zone. There is a long break in sedimentation, the entire Želkovice Formation is absent, and in the uppermost Ordovician a layer of siliceous sandstone replacing the common bioturbated claystones occurs.

Prague - Malá Chuchle

Above the railway tunnel face in Malá Chuchle a remarkable bed succession was found. In the Kosov Formation the sandy sedimentation continues almost up to the boundary with the Silurian. The last several centimeters thick intercalations of fine-grained siliceous sandstones lay only 160 cm below the base of graptolite shales. Sandstones were succeeded by siltstones and 40—60 cm below the base was observed a sedimentary breccia in several layers formed by tiny (up to 5 mm) chips of brown-green claystones and siltstones. Immediately above the base of graptolitic shales light-coloured claystone resembling claystone intercalations in the overlying Litohlavy Formation was established. Here, bioturbations are infrequent and some parts are strongly limonitized. The Silurian begins with dark clayey shales of the Monoclimacis greistoniensis Zone with numerous intercalations of light-coloured claystones. In spite of the fact that probably the uppermost several tens of centimeters of the Kosov Formation and certainly the whole of Želkovice Formation and half of the Litohlavy Formation are missing, no influence was observed on the sedimentation type of the rest of the Litohlavy Formation. A similar situation occurs also in other places: in the area of Pankrác (Bouček 1946), Nová Ves near Jinonice (Marek - Havlíček 1967) and Tachlovice (Prantl - Přibyl 1944).

Sediments of the Ordovician—Silurian boundary interval

Claystones to siltstones of the uppermost Kosov Formation

The end of Kosov sedimentation (upper Ashgill) is characterized by a transition from psammitic sediments to aleurites and pelites. Light, yellow-grey, easily weathering, frequently bioturbated claystones and siltstones are typical of the uppermost layers. Bioturbations of Arenicolite type with corridors 1—4 mm in diameter are conspicuous. Vertical parts of the corridors are shorter than the middle horizontal part. Clastic mica flakes in the vicinity of the corridors are oriented parallelly with their walls. In the middle of the clayey matter of the rock well visible elongated clusters of clastic grains were observed. Except of the bioturbated portions the flakes of clastic muscovite in the rock are oriented according to the bedding. The incomplete, often chaotic stratification of the sediment results especially from heavy bioturbation. According to X-ray studies the basic clayey mass is formed by illite (Štorch 1980). The clastic component is composed of angular quartz grains 0.02—0.06 mm in size. Rounded quartz grains of about 0.1 mm are rare. Numerous muscovite flakes reach 0.2—0.3 mm in diameter. Lamellar plagioclases and zircon were rare. Association of heavy minerals from psammitic sediments of the Kosov Formation was described by Kukal (1961b). The content of disseminated organic matter is very low. Limonite impregnations originating from pyrite weathering are frequent. According to Horný (1960) the rocks in the fresh state are darker and rich in pyrite concentrated in irregular concretions and as bioturbation fillings.

Clayey shales of the base of the Silurian

The sediments change namely their colour on the base of the Silurian. The A. ascensus Zone, which represents the base of the Silurian in the Prague Basin, is in all sites developed in the form of dark-grey clayey shales with a variable silty admixture. From the granulometric point of view shales are very similar to the sediments from the uppermost layers of the Kosov Formation. They display similarly incomplete parallel orientation of clastic muscovite. Better orientation and horizontal bedding is known only from some localities (Prague-Řepy, Vočkov). In Řepy and Běchovice shales the number and size of clastic quartz grains increases and sediments get the character of silty shales to clayey siltstones. Illite is the absolutely prevailing clayey mineral in the rock, however, mixed structures of illite-montmorillonite and chlorite also occur. The content of organic matter in clayey shales of the A. ascensus Zone amounts to about 3.65—3.75 percent by weight (Štorch 1980). Marešová (1973) gives the mean content of organic carbon in graptolitic shales as 5.8 % and Kukal (1961a) 3.78 % (6.04 %).

Laminites

After deposition of clayey shales of the A. ascensus Zone there occurred a marked change in the character of sedimentation in major part of the sedimentation area in the lower half of the Par. acuminatus Zone. The difference is in many respects more pronounced than that between the sediments on the immediate Ordovician—Silurian boundary. There were observed sandy-micaceous laminated shales (laminites) termed varvitic shales by Horný (1956). Darker clayey laminites rich in organic matter interchange with light-coloured laminites with prevailing clastic silty and fine sandy material. The thickness of individual laminae is of tenth mm order. only exceptionally it exceeds 1 mm. Dark clayey laminae contain a great deal of disseminated organic matter. clastic laminae exhibit only rare structural organic remains (rhabdosomes of graptolites). In some sites were also observed circular particles of 0.1—0.2 mm in cross-section which probably pertain to microorganisms. The clastic component is formed especially by subangular quartz grains of 0.05—0.1 mm in size, rounded quartz grains of about 0.2 mm size were observed less frequently. Rare feldspars are represented by plagioclases with lamellae and sericitized potassium feldspars. Numerous muscovite flakes reach 0.2 (max. 0.4) mm in cross-section. Frequent limonite infiltrations and yellow coatings of sulphates result from weathering of disseminated pyrite. Sedimentation of laminites continues up to the Cyst. vesiculosus Zone and fades away in the course of the C. cyphus Zone in majority of localities (pl. 1). In the north limb of the Basin laminites were observed up to the Dem. pectinatus Zone and in the Řeporyje—Velká Ohrada section up to the Dem. convolutus Zone. In the section Prague - Řepy silty shales with laminite layers continue also up to the Dem. convolutus Zone.

Clayey to silty shales (thin-bedded mudstones)

Clayey to silty shales (thin-bedded mudstones) form a transitional element between clayey shales of the A. ascensus Zone and sandy micaceous laminites (pl. II, fig. 2). They exhibit perfect horizontal bedding, granulometrically correspond to some clayey siltstones of the uppermost Kosov Formation and altogether lack lamination. In localities with maximum thickness of basal Silurian graptolite zones (Běchovice, Řepy) they are developed in their most typical form and underlie laminites. In the south limb they occur sporadically in the layers overlying laminites, usually in the course of the C. cyphus Zone. The rocks are of very dark colour with well visible bedding and sometimes with microlamination. The thickness of the microlaminae is of a hundredth millimeter order. The differences between neighbouring microlaminae lie rather in the content of the disseminated organic matter than in the amount of the clastic component. Angular grains of clastic quartz reach the size of 0.01—0.03 (max. 0.06) mm. Lamellar plagioclases are rare, muscovite flakes have 0.01—0.15 in cross-section. Small clusters of light-coloured ("sericite") matter were observed locally. The main clayey minerals are formed by illite-montmorillonite mixed structures. Silica cement whose content increases towards the overlying strata is becoming more important.

Siliceous shales

First intercalations of shales with transverse fissility occurred in the area of southwest closures and in the western part of the south limb of the Silurian syncline of the Prague Basin already during sedimentation of the Cyst. vesiculosus Zone (pl. I. Želkovice section: see Horný 1956). In the Dem. triangulatus Zone the sedimentation of siliceous shales spreads over the whole south limb. The sections exhibit interchanging of thin-bedded more compact siliceous shales with fissile muddy silicites. Siliceous shales show perfectly horizontal bedding. The clastic component is composed namely of angular quartz grains of approximately 0.02 mm in size, thinly scattered semirounded grains of the size about 0.05 mm, rare feldspars, infrequent muscovite and lighter clusters of sericite. There was observed conspicuous number of siliceous skeletons of Radiolaria. Prantl (1949) reported 10—25 mm thick interlayers with 60—75 % of radiolaria skeletons of the spumellarian type from Hlásná Třebaň. He termed these siliceous shales phtanites. In the overlying beds above the Dem. triangulatus Zone the silica cement content further increases and finely bedded transversely splitted black-grey siliceous shale to muddy silicites gradually spread into the north limb of the Basin and into the Řepy—Běchovice area. A similar migration in the sedimentary area of the Prague Basin was noticed in all types of sediments of the Ordovician—Silurian boundary interval (fig. 1).

Faunal assemblage and sedimentological development of the uppermost Kosov Formation (uppermost Ashgill)

The Kosov Formation was detailedly studied by Bouček and Přibyl (1958), Kukal (1961b, 1963a,b) and Havlíček (1982). In their opinion, the formation represents a shallow-water sedimentation on tectonically active bottom. Kukal (1961b, 1963a,b) draws attention to the presence of turbidity currents and seismic activity in the Prague Basin during sedimentation of flysch-type deposits of the Kosov Formation. In his concept of the Prague Basin as a linear depression Havlíček (1981, 1982) presupposes particularly intensive synsedimentary deformations of the Basin during the Kosov Formation. Marginal segments outside the central graben-like segment ascended and were exposed to erosion. This was evidenced by numerous fragments of earlier Ordovician shales and sandstones exhibiting even fauna (H a v l í č e k 1982) in the conglomerate layers of the Kosov Formation. At the end of the Kosov Formation sedimentation (uppermost Ordovician) the tectonic activity connected with the enhanced deformation of the basin recedes. The sections exhibit a transition from interchanging of tabular bank-like quartz sandstones and shales to siltstones (see section Hlásná Třebaň).

The uppermost Ordovician developed in the form of very fine often heavily bioturbated siltstones to claystones. Calcareous admixture is present in various amounts either in the cement or it is concentrated in the form of lenses and flat concretions of clayey to silty limestones (Prague - Běchovice). In the topmost Ordovician of the Prague Basin area there could be expected a gradual and mild deepening of the sea (H a v l í č e k 1982), which, together with ceasing of the tectonic activity in the area, changed the character of sedimentation and permitted invasion of a new fauna in the place of the previous one which was destroyed by the abrupt change of the environment and living conditions at the base of the Kosov Formation.

The gradual deepening of the sedimentary area manifests itself in the sequence of new faunal assemblages. The first monotonous assemblage of infaunal lamellibranchs giving evidence of intertidal environment (H a v l í č e k 1982) occur already in the last layers of quartz sandstones. In the eastern half of the basin, in the higher level of siltstones and claystones (often calcareous) the assemblage is replaced by rich *Hirnantia sagittifera* Community testifying in favour of subtidal environment (according to H a v l í č e k 1982).

The world-wide *Hirnantia sagittifera* Community found in the sediments of the uppermost part of the Kosov Formation permits broad international correlations. It was recorded in the uppermost Ordovician of Britain, Sweden, Poland, Austria, Marocco, Kazakhstan, China, and according to K o r e n' et al. (1983) in the NE U.S.S.R. and according to L e s p é r a n c e - S h e e h a n (1981) in Canada. Its invasion into the Bohemian Lower Paleozoic sea brought entirely new faunal elements (brachiopods *Dalmanella, Aphanomena, Plectothyrella, Cryptothyrella, Zygospira,* cyrtodontid lamellibranchs and other organisms). In the Prague Basin *Hirnantia sagittifera* Community was first found near Prague - Běchovice (M a r e k 1963b, M a r e k - H a v l í č e k 1967) and in Nová Ves near Jinonice (M a r e k - H a v l í č e k 1967), and later in Prague - Pankrác (Š t ě p á n e k 1974) and Prague - Řepy (Š t o r c h 1982). Isolated findings were discovered in the borehole near Tachlovice (P r a n t l - P ř i b y l 1944) and in the test pit on the SE border of Řeporyje (J. Kříž pers. comm.). In the community prevail sessile elements represented namely by articulate brachiopods.

Intertidal community and **Hirnatia sagittifera** Community from the uppermost Ordovician of the Prague Basin

In the table, no. 1 designates the most abundant species, 2 — common species, 3 — rare species.

Polychaets	
Kettnerites sp.	
Inarticulate brachiopods	
"Lingulella" sp.	3
Trematis sp.	3
Orbiculoidea sp.	3
Paracraniops sp.	3
Philhedra (?) sp.	3
Articulate brachiopods	
Trucizetina subrotundata Havlíček	2
Giraldibella subsilurica (Marek et Havlíček)	3
Comatopoma sororium Marek et Havlíček	3
Ravozetina rava (Marek et Havlíček)	3
Dalmanella testudinaria (Dalman)	1
Dalmanella pectinoides Bergström	3
Hirnantia sagittifera (Mc Coy)	2
Kinella kielanae proclinis Havlíček	1
Draborthis caelebs Marek et Havlíček	2
Aegiromena ultima Marek et Havlíček	2
Aphanomena ultrix (Marek et Havlíček)	2
Aphanomena urbicola (Marek et Havlíček)	2
Eostropheodonta squamosa Havlíček	2
Leptaena rugosa Dalman	2
Bracteoleptaena polonica (Temple)	3
Leptaenopoma trifidum Marek et Havlíček	1
Fardenia comes Marek et Havlíček	3
Cliftonia oxoplecioides Wright	2
Plectothyrella crassicosta (Dalman)	2
Cryptothyrella sp.	3
Zygospira fallax Marek et Havlíček	2
Lamellibranchs (unrevised) of genera: *Cleidophorus, Ctenodonta, Goniophorina, Modiolopsis, Mytilarca, Praerca, Cyrtodonta.*	
Gastropods	
Sinuitopsis hornyi Marek	3
Grandostoma taconicum Marek	3
Temnodiscus evolvens (Perner)	3

Trilobites

Mucronaspis mucronata (Brongniart) 2
Brongniartella platynota (Dalman) 2
Primaspis (Bojokoralaspis) sp.n. 3
Duftonia sp. 3

Graptolites

Glyptograptus bohemicus Marek 2

There were also established remains of seaweeds (*Ischadites* sp.), unspecified conularids, trepostomate bryozoans, nautiloids, hyolitids, ostracodes (*Bollia* sp.n.), crinoid columnals, and blastoids (*Mespilocystites* sp.). Marek (1951b) mentions also scolecodonts and a mass occurrence of conodonts.

In none of the localities the Hirnantia fauna occurred just below the graptolitic shales. In addition, the section Prague - Řepy shows a layer of coarser bioturbated siltstone overlying the fossiliferous layers and in the section Nová Ves (Marek - Havlíček 1967) the sedimentary sequence of the uppermost Ordovician is terminated by a layer of nonfossiliferous sandy shale (layer no. 8). In the remaining localities the described layer probably corresponds to heavily bioturbated uppermost layers of claystones and siltstones.

The benthic Hirnantia fauna did not survive the dramatic change of living conditions accompanying the sedimentation of graptolitic shales. The sudden onset of graptolitic shales was not restricted to the central Bohemian Paleozoic only. Probably it was the result of more causes. The extensive and rapid transgression at the Ordovician—Silurian boundary and in the basal Silurian (Berry - Boucot 1973) was accompanied by facies changes, changes of sea currents, climatic changes and perhaps also by a decrease of salinity resulting from rapid thawing of the upper Ordovician glaciers.

Lowermost Silurian history of the Prague Basin

Formal differentiation of the Basin on the basis of sedimentological development

In accordance with the lithologic development of the basal Silurian the Prague Basin may be formally divided into five areas (pl. 2).

Pankrác area

The Pankrác area is characterized by a conspicuous, long break in sedimentation. Siltstones to claystones of the uppermost Ordovician are followed by graptolitic shales of the Litohlavy Formation. The longest gap was observed in Prague - Pankrác (Bouček 1946), Prague - Malá Chuchle and in Nová Ves (Marek - Havlíček 1967) with almost the entire Llandovery Series (approx. 10^6 years) absent. The sedimentation revives in the Monoclimacis griestoniensis Zone for the first time. At Prague - Velká Chuchle (the turn of the road to Lochkov) and in the borehole near Tachlovice (Prantl - Přibyl 1944) the sedimentation of the Silurian begins approximately at the level of the S. turriculatus Zone. Prantl and Přibyl (1944) presuppose tectonic border of the Ordovician—Silurian in this site but the character of the presumed thrust plane and occurrence of the Hirnantia fauna in the uppermost Ordovician give evidence for the presence of a gap.

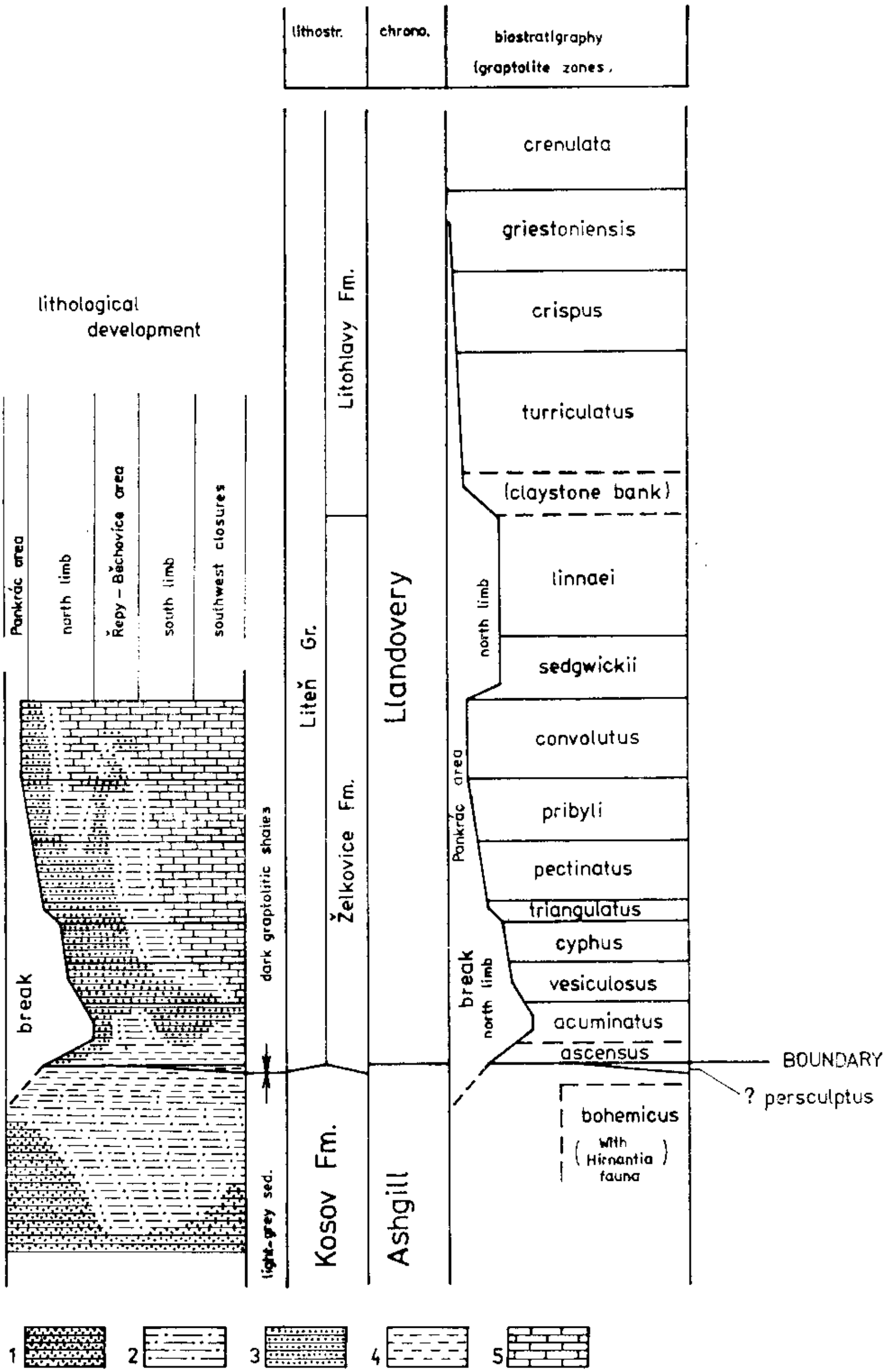
In the section Prague - Řeporyje (pl. 1), in the kiln near Stodůlky (Prantl - Přibyl 1940) and in the slope above the road between Řeporyje and Třebonice (Bouček 1937) the long break in sedimentation splits into two shorter gaps. The sections represent the transition to the sedimentation typical of the north limb of the Basin.

North limb area

The whole area exhibits only few outcrops. The Ordovician—Silurian boundary was studied near Loděnice and Sedlec (pls. 1, 2). Both localities are situated outside (to the north) the Tachlovice fault. The thicknesses of the basal Silurian graptolite zones are reduced. Sedimentation is interrupted in the course of the Par. acuminatus Zone and reappears in the form of silty shales to laminites of the Dem. triangulatus and Dem. pectinatus Zones.

Southwest closures area

The southwest closures area was studied by Horný (1958, 1960). Horný failed to document quide graptolites of the basal Silurian zones but he described approximately 50 cm of laminites (Kosov, Koukolova hora Hill, Tmaň, Lounín) below the C. cyphus Zone. Basal graptolite zones are developed in the form of laminites. According to Horný (1960) laminites originated by subaquatic redeposition of the uppermost layers of the Kosov Formation. From the degree of roundness of quartz grains we deduce a transfer of the sandy component grains in laminites from earlier sediments. We presume local subaquatic redeposition of the uppermost layers of the Kosov Formation by currents, however this statement is difficult to prove. Towards the south the character of the sediments changes and the thickness of the basal graptolite zones increases.



lithostr.
chrono.
biostratigraphy (graptolite zones)
lithological development
Pankrác area
north limb
Řepy – Běchovice area
south limb
southwest closures
break
dark graptolitic shales
light-grey sed.
Liteň Gr.
Litohlavy Fm.
Želkovice Fm.
Kosov Fm.
Llandovery
Ashgill
crenulata
griestoniensis
crispus
turriculatus
(claystone bank)
linnaei
sedgwickii
convolutus
pribyli
pectinatus
triangulatus
cyphus
vesiculosus
acuminatus
ascensus
BOUNDARY
? persculptus
bohemicus
(with Hirnantia fauna)
north limb
Pankrác area
break
north limb
1
2
3
4
5

South limb area

From several standpoints, the sections give evidence of the most quiescent sedimentation in probably the deepest part of the Basin. A complete sedimentary succession from the A. ascensus Zone to the Dem. triangulatus Zone (which was the uppermost detailedly studied zone) has been preserved in all localities (pls. 1, 2). From Želkovice Horný (1956) reports greenish clayey shales with climacograptids and rare glyptograptids present still in the base of the A. ascensus (G. persculptus ?) Zone. A similar assemblage was established on the immediate base of graptolitic shales at Vočkov section by the author. In the south limb of the basin the A. ascensus Zone developed in the form of clayey shales with variable silty admixture. Sandy-micaceous laminites set in the course of the Par. acuminatus Zone and temporarily correspond to the sedimentation break in the north limb of the Basin. Laminites disappear again in the westernmost part of the south limb (Želkovice, Bykoš) during the Cyst. vesiculosus Zone as well as towards the east in the C. cyphus Zone (Bělcč, Vočkov, Zadní Třebaň, Hlásná Třebaň, Karlík, Černošice). In the easternmost parts (Prague: Radotín - Klapice and Velká Chuchle — section in pl. 1) laminites reach up to the Dem. triangulatus Zone. Similarly to laminites, the onset of siliceous shales sedimentation migrates in the south limb. In Želkovice they occur in the Cyst. vesiculosus Zone (Horný 1956), further to the east in the Dem. triangulatus Zone and at Černošice and Velká Chuchle even higher.

Řepy—Běchovice area

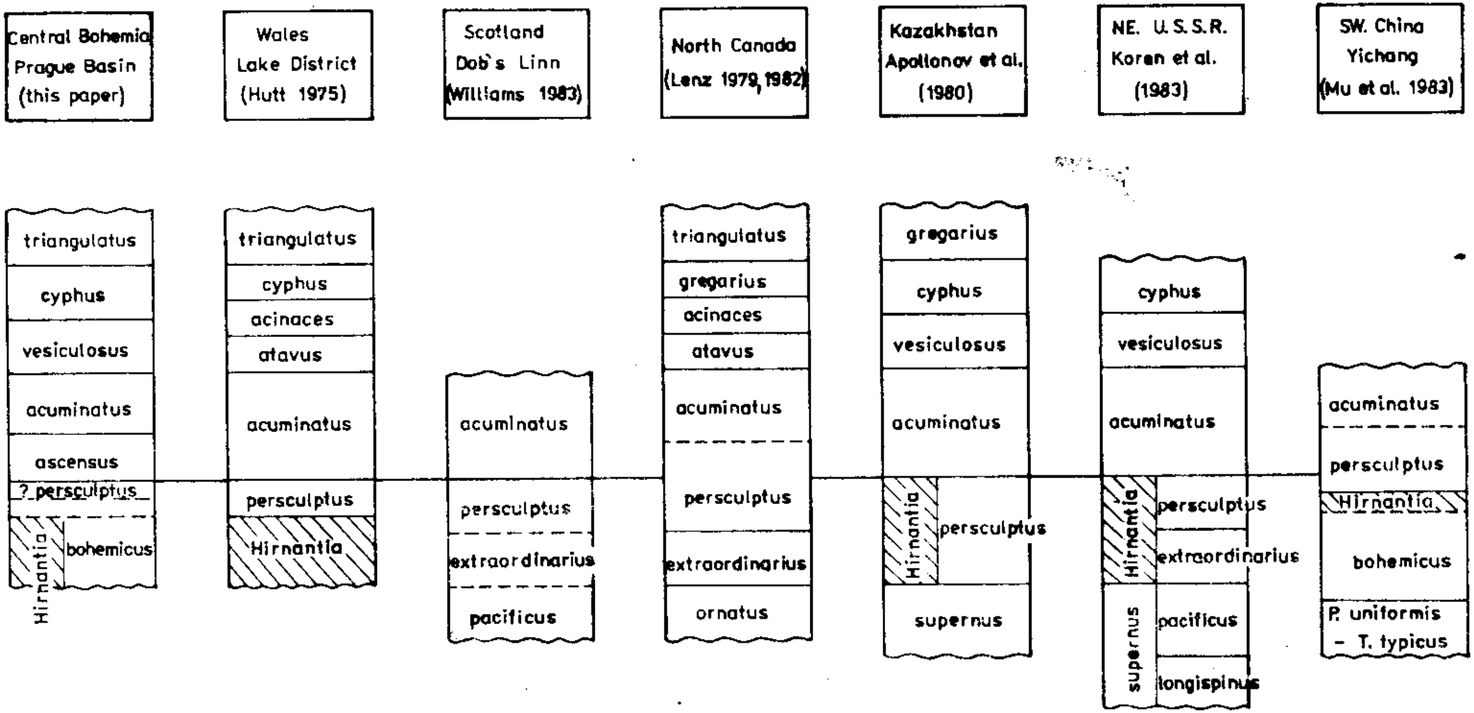
The Řepy—Běchovice area exhibits a complete sedimentary succession, more rapid sedimentation (with a higher content of silty component) and larger thicknesses of graptolite zones. Together with the Pankrác area it is characterized also by the occurrence of the Hirnantia fauna in the uppermost Ordovician. In Řepy below the base of the A. ascensus Zone occurs approximately 20 cm thick transient layer with graptolites corresponding most probably to the G. persculpus Zone. I suppose that the layer is authentical with that described by Horný (1956) from Želkovice. Laminites appear in the middle of the Par. acuminatus Zone; in the course of the C. cyphus Zone they pass into thin-bedded mudstones and continue up to the Dem. convolutus Zone.

---

1. Lithological (facial) development and relationships within biostratigraphy, chronostratigraphy and lithostratigraphy of the Ordovician—Silurian boundary interval in the Prague Basin (Barrandian area)
   1 — siltstone to fine-grained quartz sandstone; *2* — siltstone and silty shale; *3* — laminite; *4* — claystone and clayey shale; *5* — siliceous shale to muddy silicite. Columns with lithological development and biostratigraphy show time span interval and areal distribution of sedimentary break. Also diachronous base of graptolitic shales (Želkovice Formation) is depicted

Table 1

Correlation chart of the Ordovician—Silurian boundary interval biostratigraphy



Remarks: The occurrence of widespread Hirnantia fauna is restricted to G. persculptus — Cl. extraordinarius ? (G. bohemicus) Zones; G. persculptus Zone represents rather different time interval in different places in the world (as was shown by different graptolite assemblages)

Biostratigraphy and correlation

Uppermost Ordovician

Biostratigraphical subdivision of the uppermost Ordovician of the Prague Basin (Kosov Series) is very problematic. The highest established graptolite zone of international validity in the upper part of the Králův Dvůr Formation (Králodvor Series) is the Dicellograptus anceps Zone (Chlupáč 1953, Havlíček - Marek 1973). The fauna is unknown from the overlying, usually coarsely clastic flysch-type sediments of the Kosov Formation. Only the uppermost layers of the Kosov Formation contain rich fauna permitting broad correlations.

Hirnantia sagittifera Community referes the uppermost part of the Kosov Formation to the uppermost Ashgill (Hirnantian Stage). The graptolite *Glyptograptus bohemicus* Marek accompanying the *Hirnantia sagittifera* Community in the Prague Basin enables even more precise correlations. In Europe, *G. bohemicus* was established by Jaeger (1977) in Saxony (GDR), similar forms were reported from Kazakhstan (Apollonov - Bandaletov - Nikitin eds., 1980). It has been recorded as the guide fossil from the uppermost Ordovician of China (Mu et al. 1983, Li-Qian-Zhang 1983).

Glyptograptus bohemicus Zone: In the Prague Basin I assign to the G. bohemicus Zone the uppermost layers of the Kosov Formation which in many sites exhibit a simultaneous occurrence of the guide graptolite and benthic community of the Hirnantia fauna. Since this association is evidently dependent on the type of sedimentation the G. bohemicus Zone in the Prague Basin is used in the sense of a biozone (taxon-range zone, Hedberg ed., 1976) instead of a chronozone. A systematic classification of the *Glyptograptus bohemicus* Marek I leave open. As it follows from the correlation table (tab. 1) G. bohemicus Zone roughly agree with the Cl. extraordinarius Zone and with a part of the G. persculptus Zone in Dob's Linn international stratotype in Scotland. The precence of Hirnantia fauna corroborates the above correlation.

Glyptograptus persculptus Zone: A community of climacograptid graptolites accompanied by rare glyptograptids from the G. bohemicus — G. persculptus group (tab. 2) was discovered in several localities (Želkovice — Horný 1956, ? Vočkov, Řepy — Štorch 1982) at the base of graptolitic shales. This graptolite assemblage was found just below the layer with species which indicate the base of the Silurian and there was always a nonfossiliferous layer of light bioturbated mudstones separating it from the earlier G. bohemicus Zone (pl. 1). Therefore I suppose that the basal layers of graptolitic shales described from Řepy, Želkovice and perhaps also from Vočkov correspond to the higher part of the G. persculptus Zone. Their delimination against the underlying strata was caused by a change of lithology and since this change could not occur at the same time all over the Basin, the base of graptolitic shales of the Želkovice Formation is somewhat diachronic (fig. 1).

Basal Silurian

In Bohemia, the base of the Akidograptus ascensus Zone, defined by the presence of *Akidograptus ascensus* Davies which is usually almost simultaneously accompanied by *Diplograptus modestus* Lapworth, is comparable with the base of the Silurian established in the base of the Par. acuminatus Zone at the section Dob's Linn (W i l l i a m s 1983) by the International Subcommission on Silurian Stratigraphy.

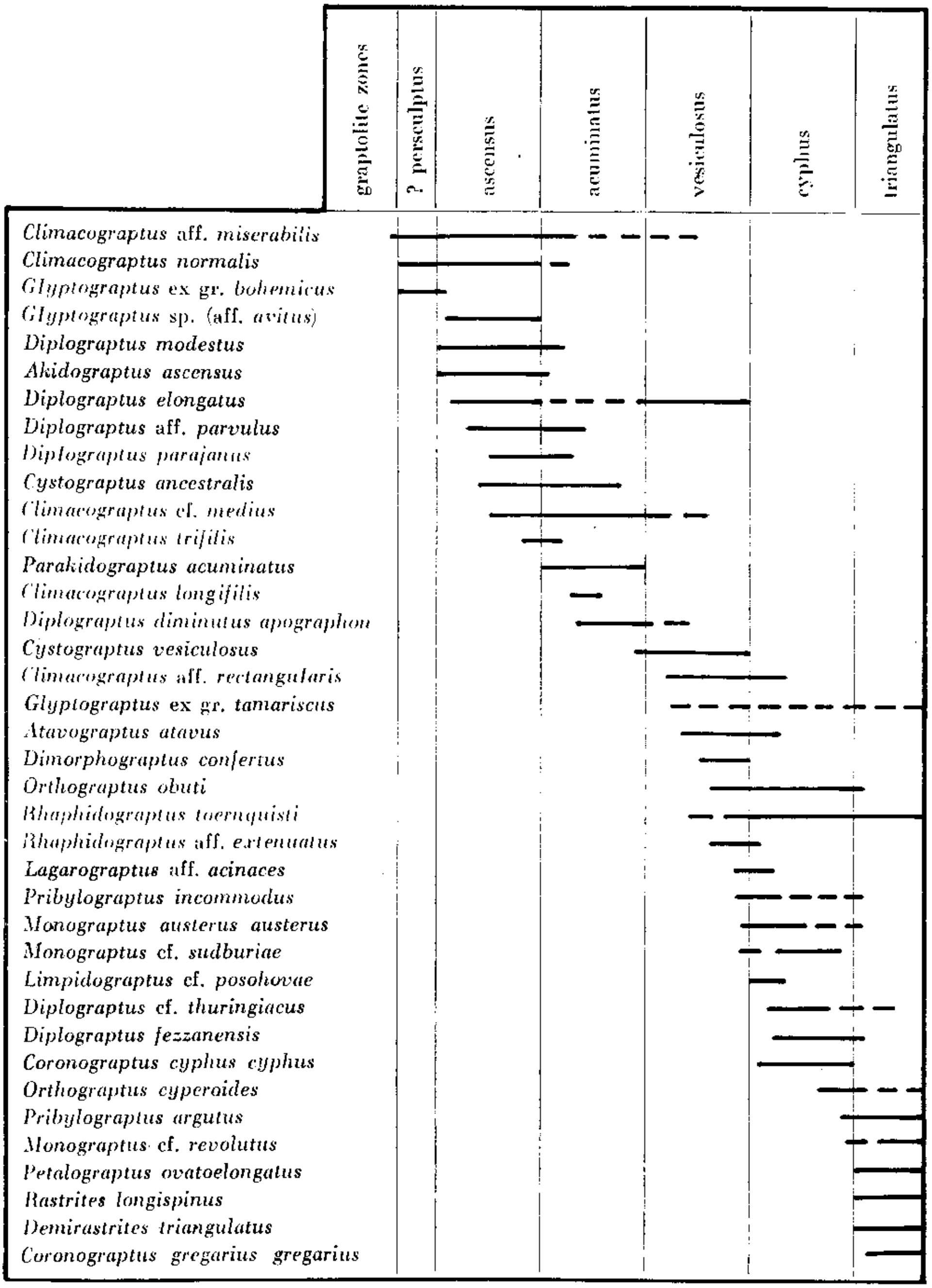
A k i d o g r a p t u s a s c e n s u s Z o n e : It is a sequence of layers extending from the first incidence of *Akidograptus ascensus* Davies to the first incidence of the guide species of the following Parakidograptus acuminatus Zone. The Akidograptus ascensus Zone is characterized by the following assemblage (pl. V): *Akidograptus ascensus* Davies, *Diplograptus modestus* Lapworth and *Climacograptus* aff. *miserabilis* Elles et Wood (? = angustus). In the upper layers of the zone, species (tab. 2) passing into the lower layers of the Par. acuminatus Zone were rarely observed. Abundant *Climacograptus trifilis* Manck is typical for layers bordering with the Par. acuminatus Zone. In majority of foreign countries A. ascensus is not considered an idependent zone and corresponds with the lower part of the Par. acuminatus Zone (H u t t 1975, W i l l i a m s 1983, A p o l l o n o v - B a n d a l e t o v - N i k i t i n eds. 1980, K o r e n ' et al. 1983). From southwest China (M u et al. 1983) and perhaps also from the Northern Canadian cordillera (L e n z 1982) is reported an assemblage corresponding most probably to the Bohemian A. ascensus Zone from the upper part of the G. persculptus Zone.

P a r a k i d o g r a p t u s a c u m i n a t u s Z o n e : In the Prague Basin, this zone represents the succession of layers from the first occurrence of *Parakidograptus acuminatus* (Nicholson) to the first occurrence of the guide species of the following Cyst. vesiculosus Zone. Besides numerous specimens of *Par acuminatus*, *Climacograptus* cf. *medius* Törnquist is also typical for the Par. acuminatus Zone. The base of the zone exhibits also *A. ascensus* Davies, *D. modestus* Lapworth, *Cl. trifilis* Manck, *Cystograptus ancestralis* Štorch and other species. In the middle of the zone, *Cl. trifilis* is succeeded by *Climacograptus longifilis* Manck and *Diplograptus diminutus apographon* Storch.

C y s t o g r a p t u s v e s i c u l o s u s Z o n e : The zone is defined by a vertical range of occurrence of the guide species *Cystograptus vesiculosus* (Nicholson). The guide species is accompanied by rare *Diplograptus elongatus* Churkin et Carter throughout the entire zone. Due to the fact that graptolites were insufficiently preserved the assemblage of the lower part of the Cyst, vesi-

Table 2

Stratigraphical distribution of the Ordovician—Silurian boundary graptolites from the Prague Basin (Barrandian area)



culosus Zone provides only partial information. It seems that the assemblage lacks monoserial graptolites of the family Monograptidae and dimorphograptids. In the second third of the zone there was established plentiful *Atavograptus atavus* (Jones) immediately followed by numerous *Dimorphograptus confertus* (Nicholson) and by other species (tab. 2). This assemblage is comparable to that from the upper part of the A. atavus Zone from the Lake District area (H u t t 1975) and from North Canada (L e n z 1982). *Lagarograptus* aff. *acinaces* (Törnquist) and *Orthograptus obuti* Rickards et Koren' were found in the uppermost layers of the Cyst. vesiculosus Zone. Together with plentiful *Monograptus austerus austerus* Törnquist, *Rhaphidograptus toernquisti* (Elles et Wood) and other species they form an assemblage which in the Prague Basin passes into the C. cyphus Zone and seems to correspond to the Lagarograptus acinaces Zone of the Lake District.

C o r o n o g r a p t u s c y p h u s Z o n e : In the Prague Basin, the zone is defined as the succession of layers ranging from the first occurrence of *Coronograptus cyphus* (Lapworth) to the first occurrence of *Demirastrites triangulatus* (Harkness). In the lower part of the zone C. cyphus is not so frequent and therefore its boundary with the underlying Cyst. vesiculosus Zone can be more easily determined according to the abrupt disappearance of dimorphograptids in all the sections. The base of the C. cyphus Zone is characterized also by an assemblage with *L.* aff. *acinaces* (Törnquist). In the upper parts frequent *C. cyphus* (Lapworth) and *Rh. toernquisti* (Elles et Wood) are accompanied by *Diplograptus* cf. *thuringiacus* Eisel, *Orthograptus obuti* Rickards et Koren', *Monograptus austerus austerus* Törnquist and *Diplograptus fezzanensis* Desio. The last named species is most abundant in the uppermost layers of the zone. The upper parts of the C. cyphus Zone correspond with the C. cyphus Zone in the Lake District.

D e m i r a s t r i t e s t r i a n g u l a t u s Zone: A change of graptolite assemblage at the base of this zone is typical. This change of assemblages is discussed by B o u č e k (1953). The base of the zone is determined by the first occurrence of *Demirastrites triangulatus* (Harkness). It is immediately followed by *Petalograptus ovatoelongatus* Kurck, *Rastrites longispinus* Perner and *Coronograptus gregarius* (Lapworth). *D. fezzanesis, O. obuti, C. cyphus* and other species are disappearing.

The biostratigraphical research of the sections through the basal Silurian of the Prague Basin suggested that graptolite zones should be approached as biozones of various types. The basic criterion for definition of graptolite biozones (further only zones) in the Prague Basin was the fact whether they are easily distinguishable in the field, whether they offer a possibility of broad international correlation and in the interest of stable stratigraphic division, the traditional guide species should be employed as frequently as possible. However, these traditional guide species, important from the correlation view-point, do not always link up with each other in the vertical range. Once they mutually overlap on the zone boundary (*A. ascensus — Par. acuminatus*), once there is a gap between the first and the last occurrence (*Cyst. vesiculosus — C. cyphus*).

In the interval ranging from the base of the Silurian up to the base of the Dem. triangulatus Zone (corresponds with the lower part of the Želkovice Formation according to B o u č e k 1953) the subdivision into four biozones complying basically with the taxon-range zone in the sense of both Czechoslovak (C h l u p á č ed. 1978) and internationally recommended stratigraphical principles (H e d b e r g ed. 1976) seems the most suitable, despite some partial shortcomings.

Development of the Prague Basin environment during the Ordovician—Silurian boundary interval

Sediments of the Ordovician—Silurian boundary in the Prague Basin are preserved namely in the central graben-like segment (H a v l í č e k 1981), which exhibited a rapid subsidence and quite large thicknesses of sediments during the Ordovician. Deposits of the Kosov and Želkovice Formations were preserved only rarely outside the central segment (pl. 2) — near Hýskov, Nenačovice and Řepy. Due to lack of information on the evolution of the Prague Basin outside the central segment, the reconstruction of the former sedimentary conditions is very difficult.

The Kosov Series (upper Ashgill) is the period of intensive deformations of the Prague Basin. The deformations resulted in an abrupt change in the sedimentation and extinction of deep-water shelly fauna and trilobites (H a v - l í č e k 1981, 1982). The lithological development of the Kosov Formation gives evidence of a tectonically influenced shallow-water sedimentation (K u - k a l 1963a,b, H a v l í č e k 1982) in the central segment of the Basin. Conversely, in the marginal segment regions we presume erosion of earlier deposited Ordovician formations. This is testified by splinters and pebbles of Ordovician sediments in coarsely clastic beds of the Kosov Formation. In the closing of the Kosov a certain deepening of the Basin was observed. Even an eustatic uplift of the sea level cannot be ruled out (B e r r y - B o u c o t 1973). Besides current trace-fossils the upper Kosov Formation exhibits monotonous intertidal assemblages of infaunal lamellibranchs. In subsequent layers the sediments grow finer until up to the uppermost layers of the Kosov Formation where there was observed an invasion of a species-rich, according to H a v l í - č e k (1982) subtidal Hirnantia fauna which is usually found in fine, often calcareous silty to clayey deposits. The influx of the world-wide Hirnantia fauna brought brand-new faunal elements, unknown from the earlier formations of the Bohemian Paleozoic.

The development of sedimentation on the immediate Ordovician—Silurian boundary proved that the conditions had already stabilized. The break of sedimentation at the base of the Silurian resulting from the emergent Taconian phase as presumed by the older authors (P e r n e r - K o d y m 1919, M a r e k 1951, B o u č e k 1953 and others) should be excluded. The hypothesis that the Kosov Formation stratigraphically corresponds with the basal Silurian graptolite zones (T r o e d s s o n 1936, B o u č e k 1937b, P ř i b y l 1948) should be also ruled out. The sediments on the Ordovician—Silurian boundary change their colour and texture but do not change from the granulometric point of view in the north and south limb of the Basin as well as in the Řepy—Běchovice area. Bioturbated non-bedded siltstones and claystones of the uppermost Ordovician are replaced by dark clayey shales with variable silty admixture. Except for solitary cases (Š t o r c h 1980) the bioturbation disappears. It can be explained by an abiotic environment in the sediment (black colour, content of fromboidal pyrite). The dark colour of shales is caused by an increased content of disseminated organic matter. A similar change can be observed in numerous regions around the world; it results from global causes. Dark graptolitic shales exhibit an utter lack of benthic fauna. Only some localities displayed numerous tiny inarticulate brachiopods together with usually planctonic graptolites of the A. ascensus — Par. acuminatus Zones. I suppose that these small subcircular lingulids lived attached to various floating organisms (algae). The cause of the sudden world-wide spread of the dark graptolitic shale facies may be the extensive and rapid transgression on the Ordovician—Silurian boundary (B e r r y - B o u c o t 1973) and associated changes. We cannot presume that the change was accomplished simultaneously in all sites. The research focussed on the rather small area of the Prague Basin corroborated that the onset of graptolitic shales sedimentation might be shifting within a certain time interval (the upper part of the G. persculptus Zone).

Laminites represent a more expressive change of sedimentation in the framework of the Prague Basin. Contrary to clayey shales of the Silurian base (A. ascensus Zone) which granulometrically correspond with the sediments of the uppermost Ordovician, the Par. acuminatus Zone exhibits a periodical, more clastic sedimentation. Laminae with prevailing clayey substance and high content of disseminated organic matter interchange with laminae with prevailing coarse silty to fine sandy fraction. Sandy laminae may represent sedimentation from suspension, but they lack graded bedding. Comparative studies of various sections from the lithological view point and a detailed intrazonal biostratigraphy revealed that the laminites represent more condensed sedimentation than clayey and silty shales. The onset of laminites is chronologically identical with the break in sedimentation in the north limb of the Basin. The transient development of the section Řeporyje—Velká Ohrada suggests that the sedimentation in the Pankrác area might have been interrupted at that time as well. In such case we presume an additional washing of several centimeters to tens of centimeters of up to then unconsolidated graptolitic shales of the Silurian base (A. ascensus Zone — lower part of the Par. acuminatus Zone) and perhaps also of the part of the uppermost Ordovician (again several tens of centimeters of claystones and siltstones). Erosion of the part of the Kosov Formation has not been credibly corroborated in any site. The uppermost Ordovician underwent an anomalous development (coarser clastic deposits and absence of bioturbation in the upper layer) which permits the possibility of erosion of the uppermost layers of the bioturbated claystones only near Malá Chuchle and in the turn of the road near Velká Chuchle.

The relation between laminites and gaps in the north limb and the Pankrác area remains to be explained. The advancing lower Llandoverian transgression caused further eustatic deepening of the Prague Basin sedimentary area and flooding of additional parts of the Basin's marginal segments. In the central graben-like segment of the Basin, in deeper environment, mildly intensive bottom current probably originated. The current brought about either a shorter break of sedimentation (area of the north limb of the Basin) or a longer lasting gap, perhaps accompanied by a mild subaquatic erosion (Pankrác area). In sites with decreased washing capacity of the bottom current a disquiet, condensed sedimentation of laminites occurred. The current with fluctuating intensity alternated settling of the uppermost thin layer of the sediment with its washing out. Large accummulations of undamaged and insufficiently directed graptolite rhabdosomes (with intact fragile parts) found in clayey laminae indicate a low intensity of the flow. Rhabdosomes were infrequently established also in sandy laminae. The fine sandy material from clastic laminae comes probably from the sediments washed out from sites with a stronger flow (according to its sorting and ovalling of quartz grains). The influx of new clastic material from the land was strongly limited with regard to decreased rate of sedimentation in the basal Silurian of the Prague Basin. Direction of the bottom current was possible to determine according to the trending of graptolites in several cases on the locality Prague - Řepy (proximal ends of the rhabdosomes were oriented 20° to the NW).

The rate of graptolitic shales sedimentation in the Prague Basin basal Silurian was approximately established on the basis of data from North Canada and Alaska (C h u r k i n - C a r t e r - J o h n s o n 1977). Using the results of absolute age dating (Rb/Sr, K/Ar) the authors calculated the speed of graptolitic shales sedimentation and the time interval of several graptolite zones at the Ordovician—Silurian boundary. The G. persculptus Zone probably lasted 0.2 m.y., A. acuminatus Zone (which corresponds to the A. ascensus and Par. acuminatus Zones of the Prague Basin) ranged 0.4 m.y. and Cyst. vesiculosus and C. cyphus Zones 0.6 and 1.1 m.y., respectively. After biostratigraphical correlation and simple conversion the results can be applied also in the

Bohemian Silurian. Thus was determined that in the A. ascensus and Par. acuminatus Zone the sedimentation rates ranged between 1 mm (south limb of the Prague Basin) and 7.5 mm (Řepy, Běchovice) per 1 000 years. According to the sections majority of the speed of sedimentation in the Cyst. vesiculosus and C. cyphus Zones was about 1 mm per 1 000 years.

South limb and the southern part of the southwest closures of the Prague Basin at the Ordovician—Silurian boundary represent the deepest part of the Prague Basin with the most quiescent sedimentation. The Želkovice Formation exhibits no gaps and the agitated laminite sedimentation is limited to a short interval (Par. acuminatus and Cyst. vesiculosus Zones). Sedimentations of siliceous rocks ("phtanites") and silty silicites of the Dem. convolutus Zone in the south limb area are the earliest and the most expressive. The area of the most quiescent basal Silurian sedimentation corresponds to the region with an intensive subsidence in the upper Ordovician (Havlíček 1981). The Řepy—Běchovice area joins two distant localities with common lithologic development with similar larger thicknesses of the basal Silurian. Larger thicknesses and coarser muddy sediments in Řepy evidence more rapid sedimentation in the environment probably isolated by a rising zone (in sites of the present Prague Fault) from the areas exposed to the influence of the bottom current in the Pankrác area. The rising zone has been documented by Havlíček (1982) from the period of the Bohdalec Formation sedimentation.

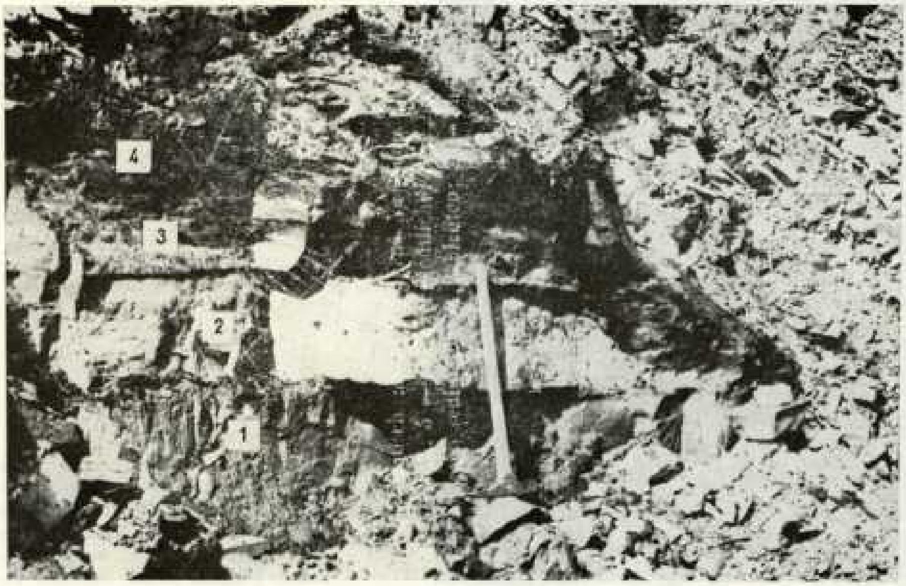
For a total reconstruction of the sedimentary area we lack data on the Ordovician—Silurian boundary from the substratum of the Silurian and Devonian sediments in the center of the Basin. Unfortunately, the base of the Silurian is not known south of Tachlovice Fault, nor from isolated Silurian blocks between Hýskov and Železná and from Nenačovice (pl. 2). In spite of this, the present research of the Ordovician—Silurian boundary yielded several important findings.

Conclusion

The evolution of the Prague Basin at the Ordovican—Silurian boundary is represented as a model open to further data.

An uninterrupted sedimentary succession has been established beyond doubt in the Řepy—Běchovice area, entire south limb and in the southern part of the southwest closures of the Prague Basin Silurian syncline. An interrupted sedimentary succession has been proved in the north limb and the Pankrác area.

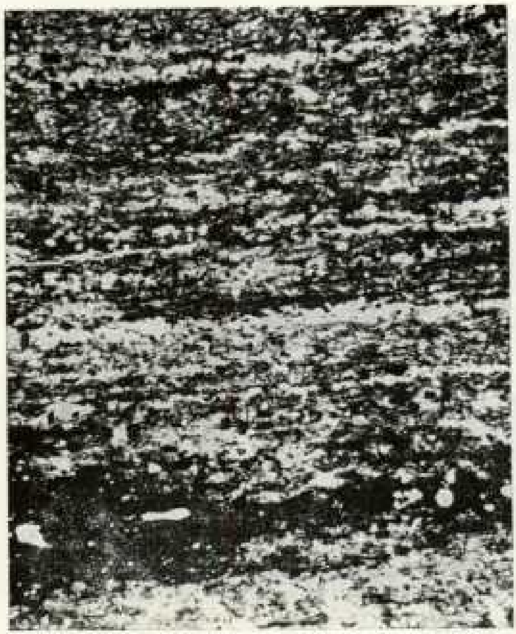
In the north limb the sedimentation is interrupted in the Par. acuminatus Zone and the same situation is extrapolated into the Pankrác area. The stratigraphic gap of the Pankrác area extends up to the Monocl. greistoneinsis Zone (fig. 1).



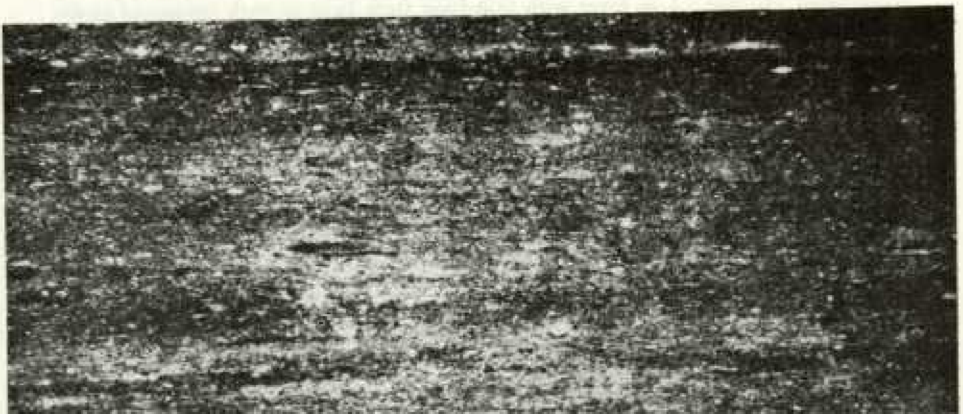
1. Ordovician—Silurian boundary at Prague - Řepy
1 — slightly calcareous bioturbated claystone with Hirnantia fauna; *2* — heavy bioturbated silstone; *3* — layer with transition from light to dark laminated shales (? G. persculptus Zone); *4* — dark clayey shales (A. ascensus Zone)

2. Light-grey bioturbated claystone to siltstone of the uppermost layers of the Kosov Formation. Černošice section. Parallel nicols; ×60

Photo (1) P. Storch, (2) J. Zoubek

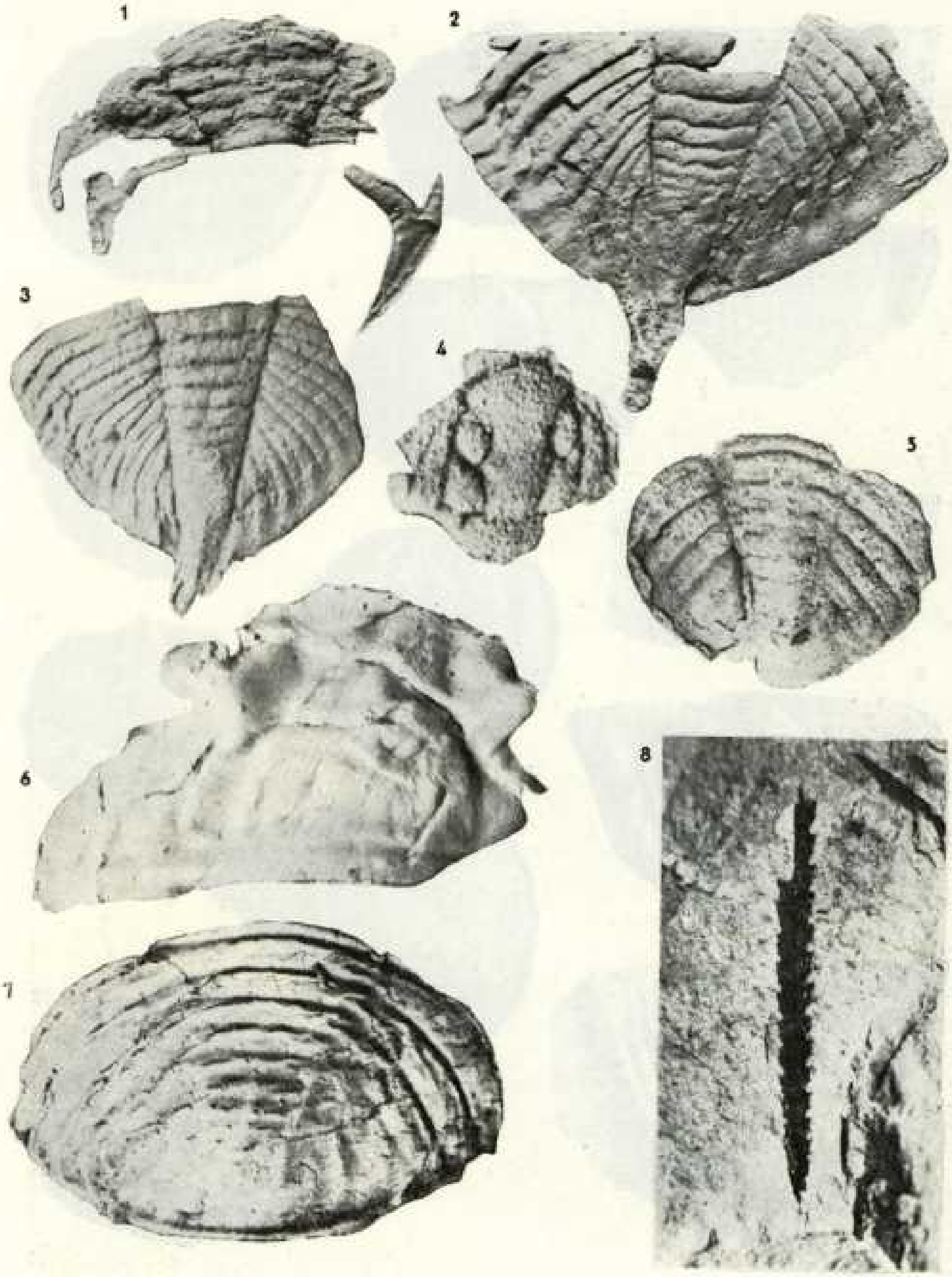


1. Laminite. Light laminae with silty and fine-grained sandy material, dark clayey laminae are rich in organic matrix. Uppermost part of Par. acuminatus Zone. Prague - Řepy section. Parallel nicols; ×20

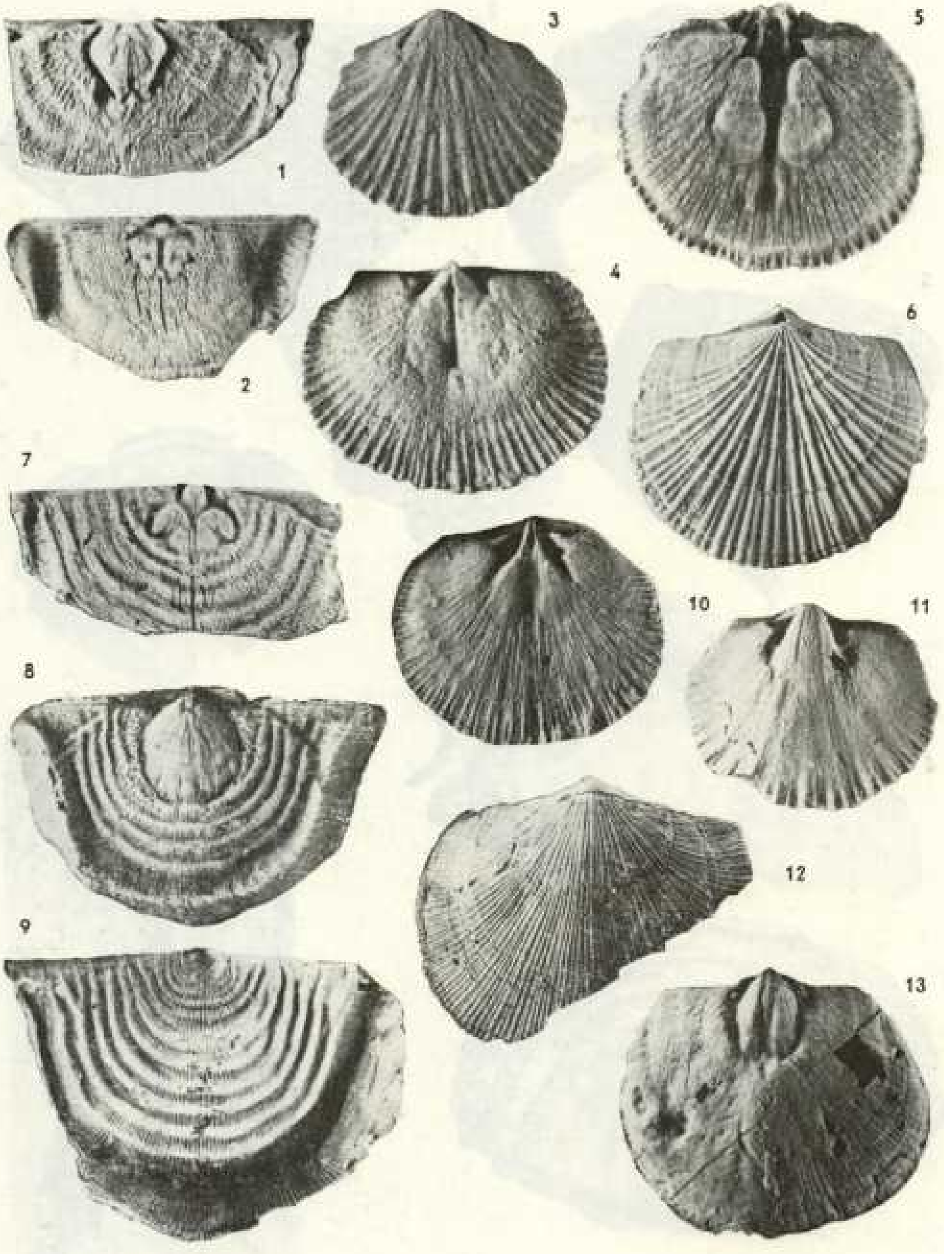


2. Clayey to silty shale. Lamination is present due to different content of organic matrix. Lower part of Par. acuminatus Zone. Prague - Řepy section. Parallel nicols; ×20

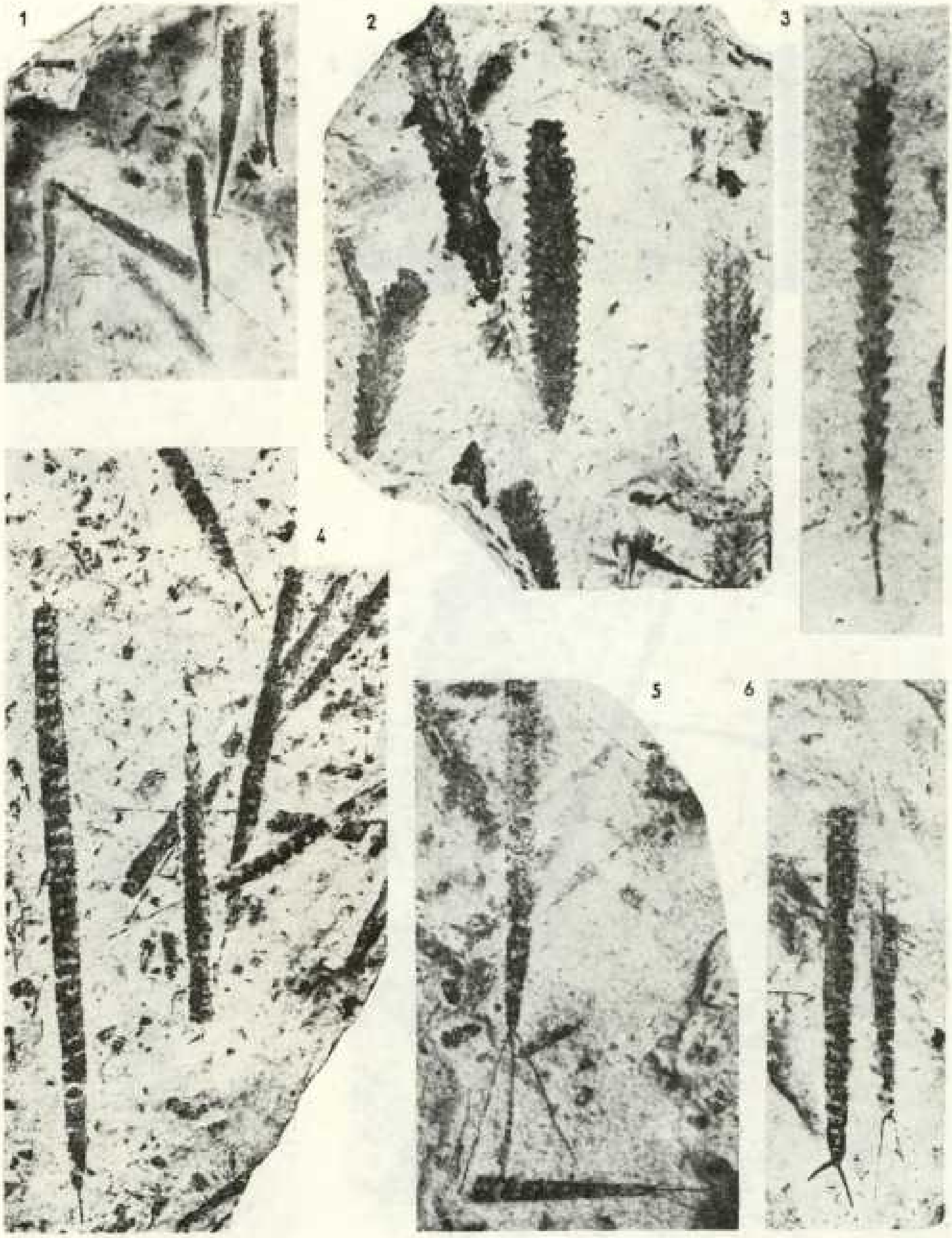
Photos J. Zoubek



Uppermost Ordovician Hirnantia fauna
1, 2, 3 — *Mucronaspis mucronata* (Brongniart), 4 — *Primaspis (Bojokoralaspis)* spec. nov.; 5 — *Duftonia* sp.; 6, 7 — *Brongniartella platynota* (Dalman); 8 — *Glyptograptus bohemicus* Marek. Figs. 1, 8 (×3); fig. 2 (×2.5); figs. 3, 5 (×5.5); fig. 4 (×9); figs. 6, 7 (×2)
Photos P. Štorch

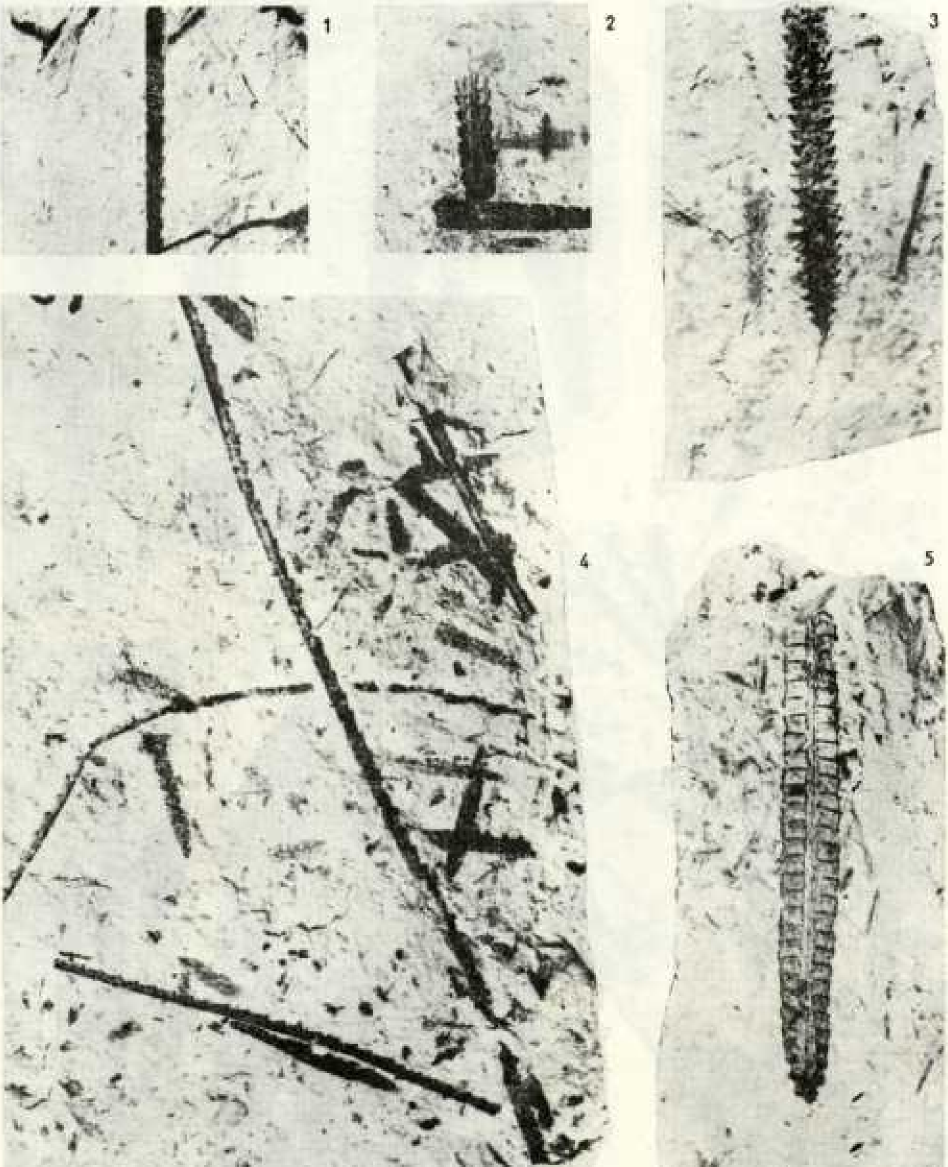


Uppermost Ordovician Hirnantia fauna
1, 2 — *Leptaenopoma trifidum* Marek et Havlíček; 3, 4 — *Draborthis caelebs* Marek et Havlíček; 5, 6 — *Dalmanella testudinaria* (Dalman); 7, 8, 9 — *Leptaena rugosa* Dalman; 10, 11 — *Trucizetina subrotundata* Havlíček; 12, 13 — *Hirnantia sagittifera* (McCoy) Fig. 1 (×2); figs. 2, 7, 8, 9, 12, 13 (×1.5); fig. 3 (×5); figs. 4, 11 (×4); figs. 5, 6, 10 (×3)
Photos ÚUG — H. Vršťalová

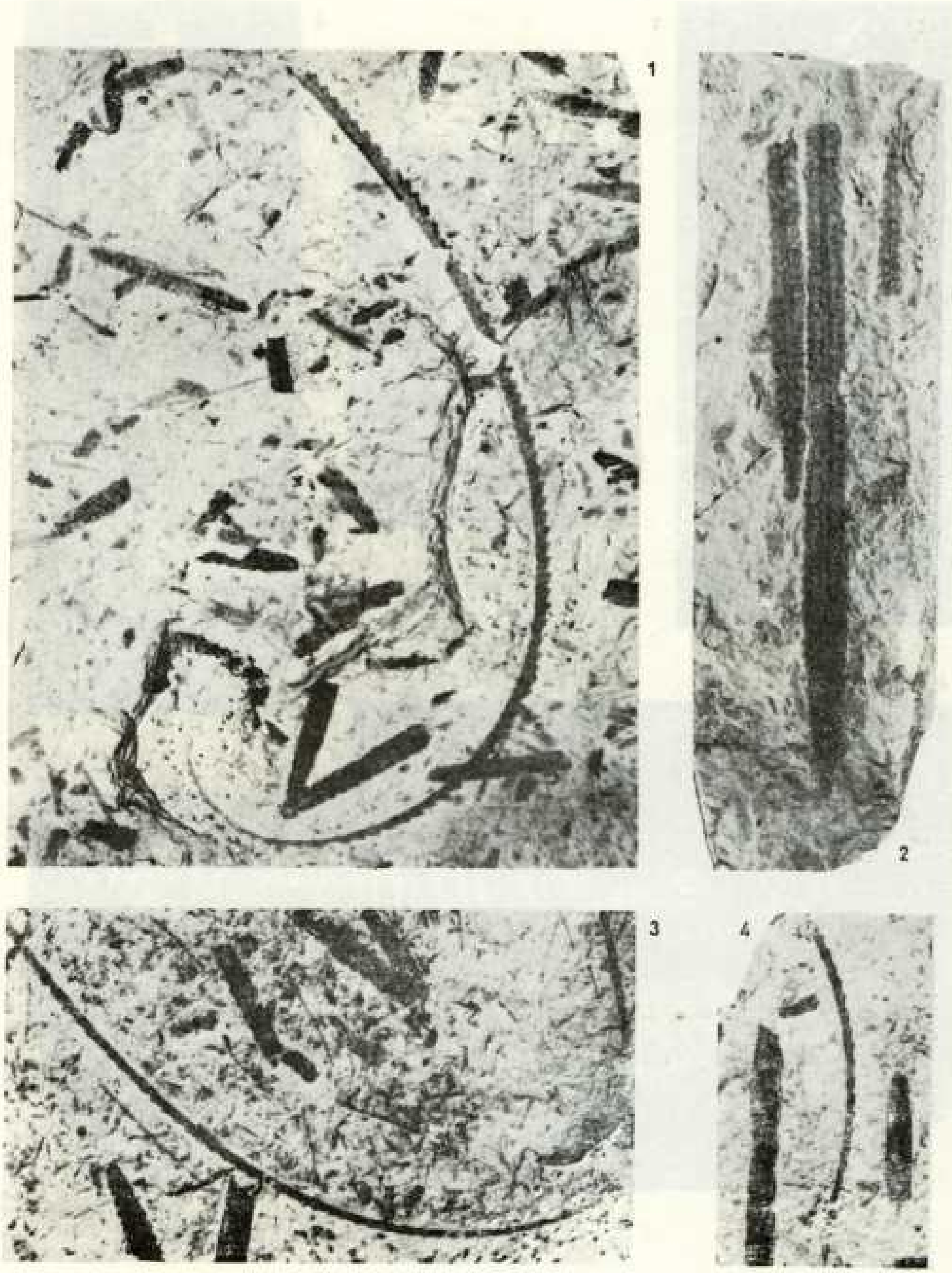


Graptolite assemblages of A. ascensus Zone (1, 2) and Par. acuminatus Zone (3, 4, 5, 6)
1 — *Akidograptus ascensus* Davies, 2 — *Diplograptus modestus* Lapworth, 3 — *Parakidograptus acuminatus* (Nicholson), 4 — *Climacograptus* cf. *medius* Törnquist, 5 — *Climacograptus trifilis* Manck, 6 — *Climacograptus longifilis* Manck. Figs. 1, 3 (×3); figs. 2, 4, 5, 6 (×2)

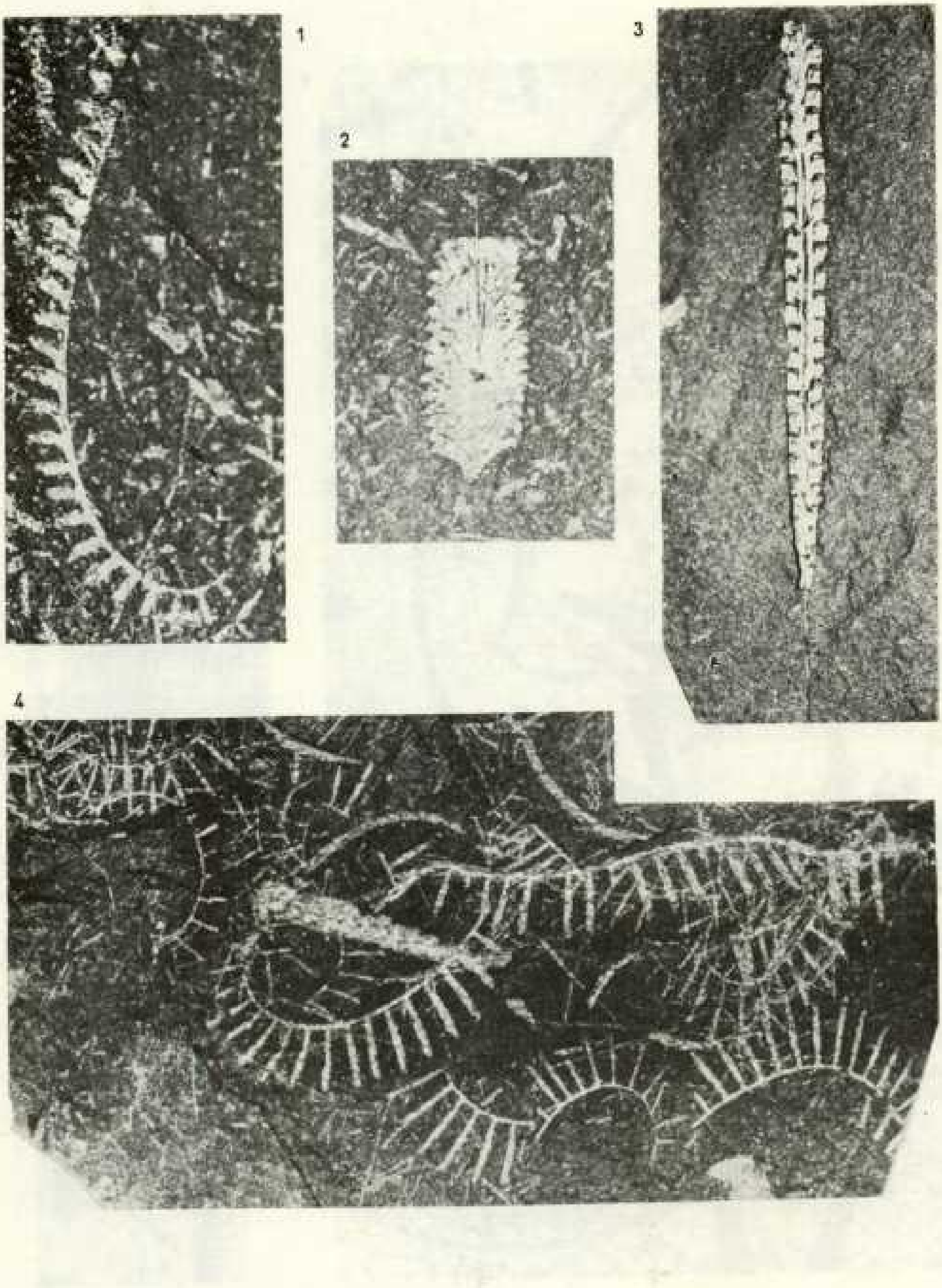
Photos P. Štorch



Graptolite assemblage of Cyst. vesiculosus Zone
1, 4 — *Atavograptus atavus* (Jones), 2, 5 — *Cystograptus vesiculosus* (Nicholson), 3 — *Dimorphograptus confertus* (Nicholson). All specimens (×2) Photos P. Storch



Graptolite assemblage of C. cyphus Zone
1 — *Coronograptus cyphus cyphus* (Lapworth), 2 — *Diplograptus fezzanensis* Desio, 3, 4 — *Monograptus austerus austerus* Törnquist. All specimens (×2) Photos P. Štorch



Graptolite assemblage of Dem. triangulatus Zone
Demirastrites triangulatus (Harkness), 2 — *Petalograptus ovatoelongatus* Kurck, 3 — *Rhaphidograptus toernquisti* (Elles et Wood), 4 — *Rastrites longispinus* Perner. All specimens (×3)

Photos P. Štorch

The chapter on the evolution of the uppermost Ordovician surveys the *Hirnantia sagittifera* Community of the Prague Basin. The G. bohemicus Zone from the uppermost Ordovician of the Prague Basin was defined in the chapter on biostratigraphy.

Detailed biostratigraphy of the Silurian permitted, besides more accurate delimitation of the Ordovician—Silurian boundary on the base of the Akidograptus ascensus Zone and determination of the sequence of graptolite faunas, a precise correlation of the Silurian sections with those abroad, including correlation with the Dob's Linn international stratotype in Scotland (tab. 1).

The Silurian base of the Prague Basin is defined by the first occurrence of *Akidograptus ascensus* and *Diplograptus modestus* and is comparable with the base of the Parakidograptus acuminatus Zone in Dob's Linn. Several localities of the Prague Basin (Želkovice, ? Vočkov, Prague - Řepy) exhibited dark shales with graptolites already below the base of the A. ascensus Zone. The assemblage probably corresponds to the uppermost part of the G. persculptus Zone.

The onset of graptolitic shales was not simultaneous within the whole Basin; it occurred perhaps in the course of the upper part of the G. perscuptus Zone which is the uppermost Ordovician graptolite zone according to the present conception. In several parts of the Prague Basin graptolitic shales were established with certainity not before the base of the A. ascensus Zone and the G. persculptus Zone was developed still in the form of light-coloured bioturbated siltstones and claystones of the Kosov Formation. The slight disproportion between the Kosov and Želkovice Formations lithostratigraphic boundary and the Ordovician—Silurian (based on biostratigraphy) is shown in fig. 1.

K tisku doporučil I. Chlupáč
Přeložila T. Hlavatá

References

Apollonov M. K. - Bandaletov S. M. - Nikitin I. F. eds. (1980): Granica ordovika i silura v Kazachstane. — Izd. Nauka. Alma-Ata.

Berry W. B. N. - Boucot A. J. (1973): Glacio-eustatic control of Late Ordovician — Early Silurian Platform sedimentation and faunal changes. — Geol. Soc. Amer. Bull., 84, *275—284.* New York.

Bouček B. (1937a): Stratigrafie siluru v dalejském údolí u Prahy a v jeho nejbližším okolí. — Rozpr. Čes. Akad. Věd Umění, Tř. II, 46, 27. Praha.

— (1937b): Stratigraphie et parallélisme de l'Ordovicien supérieur de la Bohême. — Bull. Soc. géol. France, Sér. 5, 7, *439—458.* Paris.

— (1946): Příspěvek k poznání siluru a nejmladšího ordoviku na pravém břehu vltavském u Prahy. — Věst. Král. Čes. Společ. Nauk, Tř. mat.-přírodověd., II. Praha.

— (1953): Biostratigrafie, vývoj a korelace želkovických a motolských vrstev českého siluru. — Sbor. Ústř. Úst. geol., Odd. paleont., 20, *421—484.* Praha.

B o u č e k B. - P ř i b y l A. (1958): Studie o litologii kosovských vrstev českého ordoviku. — Rozpr. Čs. Akad. Věd, R. mat. přír. Věd, 68, 8. Praha.

C h l u p á č I. (1953): Poznámky ke stratigrafii králodvorských břidlic v okolí Litně. — Čas. Nár. Muz., Odd. přírodověd., 122, 1, *28—33*. Praha.

C h l u p á č I. ed. (1978): Zásady československé stratigrafické klasifikace. — Věst. Ústř. Úst. geol., 53, 6, *322—331*. Praha.

C h u r k i n M. - C a r t e r C. - J o h n s o n B. (1977): Subdivision of the Ordovician and Silurian time scale using accumulation rates of graptolitic shale. — Geology, 5, *452—456* .Cardiff.

H a v l í č e k V. (1980): Vývoj paleozoických pánví v Českém masívu (kambrium — spodní karbon). — Sbor. geol. Věd, Geol., 34, *31—65*. Praha.

— (1981): Development of a linear sedimentary depression exemplified by the Prague Basin (Ordovician—Middle Devonian; Barrandian area — central Bohemia). — Sbor. geol. Věd, Geol., 35, *7—48*. Praha.

— (1982): Ordovician in Bohemia: development of the Prague Basin and its benthic communities. — Sbor. geol. Věd, Geol., 37, *103—136*. Praha.

H a v l í č e k V. - M a r e k L. (1973): Bohemian Ordovician and its international correlation. — Čas. Mineral. Geol., 18, *225—232*. Praha.

H e d b e r g H. D. ed. (1976): International Stratigraphic Guide. — A. While - Intersci. Publ., *1—200*. New York — London — Sydney — Toronto.

H o r n ý R. (1956): Zóna Akidograptus ascensus v jižním křídle barrandienského siluru. — Věst. Ústř. Úst. geol., 31, *62—69*. Praha.

— (1958): Zpráva o stratigraficko-paleontologickém výzkumu a mapování středočeského siluru. — MS archív Ústř. úst. geol. Praha.

— (1960): Stratigrafie a tektonika západních uzávěrů siluro-devonského synklinoria v Barrandienu. — Sbor. Ústř. Úst. geol., Odd. geol., 26, 1, *495—530*. Praha.

H u t t J. (1975): The Llandovery graptolites of the English Lake District. — Monogr. Palaeontogr. Soc., 2, *57—137*. London.

J a e g e r H. (1977): Das Silur/Lochkov-Profil im Frankenberger Zwischengebirge (Sachsen). — Freiberg. Forsch.-H., R. C, 326, *45—59*. Freiberg.

K o r e n' T. N. et al. (1983): Granica ordovika i silura na Severo-Vostoke SSSR. — Izd. Nauka. Leningrad.

K ř í ž J. (1975): Revision of the Lower Silurian stratigraphy in Central Bohemia. — Věst. Ústř. Úst. geol., 50, 5, *275—282*. Praha.

K ř í ž J. - P o j e t a J. (1974): Barrandes colonies concept and a comparison of his stratigraphy with the modern stratigraphy of the middle Bohemian lower Paleozoic Rocks (Barrandian) of Czechoslovakia. — J. Paleont., 48, 3, *489—494*. Tulsa.

K u k a l Z. (1961a): Složení černých břidlic liteňských vrstev barrandienského siluru. — Zpr. geol. Výzk. v r. 1960, *78—81*. Ústř. úst. geol. Praha.

— (1961b): Složení a vznik sedimentů vrstev kosovských barrandienského ordoviku. — Věst. Ústř. Úst. geol. 36, 5, *347—350*. Praha.

— (1963a): Výsledky sedimentologického výzkumu barrandienského ordoviku. — Sbor. geol. Věd, Geol., 1, *103—138*. Praha.

— (1963b): Sedimentární textury barrandienského ordoviku. — Rozpr. Čs. Akad. Věd, R. mat. přír. Věd, 73 (2). Praha.

L e n z A. C. (1979): Llandoverian graptolites zonation in the northern Canadian Cordillera. — Acta palaeont. pol., 24, 1, *137—153*. Warszawa.

— (1982): Llandoverian graptolites of the Northern Canadian Cordillera: *Petalograptus, Cephalograptus, Rhapidograptus, Dimorphograptus, Retiolitidae,* and *Monograptidae*. — Life Sci. Contr. Royal Ontario Mus., 130, *1—154*. Toronto.

Lespérance P. J. - Sheehan P. M. (1981): **Hirnantian fauna in and around** Percé, Québec. — *In*: Field meeting, Anticosti — Gaspé, Québec, 1981, V. (2), Stratigraphy and Paleontology, *231—245*. Montréal.

Li Ji-jin - Qian Yi-yunan - Zhang Jun-ming (1983): Ordovician—Silurian Boundary Section at Beigong of Jingxian, Anhui Province. — *In*: Papers for the Symposium on the Cambrian—Ordovician and Ordovician—Silurian Boundaries Nanjing, China, October 1983, *123—129*. Nanjing.

Marek L. (1951a): Nález druhu *Akidograptus acuminatus* (Nich.) v českém siluru. — Věst. Ústř. Úst. geol., 26, 3, *382—384*. Praha.

— (1951b): Nové nálezy ve vrstvách kosovských (dξ2). — Sbor. Ústř. Úst. geol., Odd. paleont., 18, *233—244*. Praha.

— (1954): *Glyptograptus bohemicus* n. sp. z vrstev kosovských (dξ2). — Sbor. Ústř. Úst. geol., Odd. paleont., 21, *7—10*. Praha.

— (1963a): Bellerophontid gastropods in the Kosov Beds (Ordovician) of Bohemia. — Věst. Ústř. Úst. geol., 38, 4, *273—276*. Praha.

— (1963b): Zpráva o výzkumu fauny vrstev kosovských českého ordoviku. — Zpr. geol. Výzk. v r. 1962, *103—104*. Ústř. úst. geol. Praha

Marek L. - Havlíček V. (1967): The articulate brachiopods of the Kosov Formation (Upper Ashgillian). — Věst. Ústř. Úst. geol., 42, 4, *275—284*. Praha.

Marešová L. (1954): Průzkum uranonosnosti silurských uloženin v Barrandienu. — MS Geofond. Praha.

Mu En-zhi et al. (1983): Ordovician-Silurian Boundary of Yichang, Hubei. — *In*: Papers for the Symposium on the Cambrian—Ordovician and Ordovician—Silurian Boundaries Nanjing, China, October 1983, *94—106*. Nanjing.

Perner J. - Kodym O. sen. (1919): O rozčlenění svrchního siluru v Čechách. — Čas. Mus. Král. čes., 93, *6—24*. Praha.

— (1922): On the zonal division and correlation of the Silurian of Bohemia. — Amer. J. Sci., 5, 4, *19*. Washington.

Prantl F. (1949): Some Llandoverian Radiolarites from Bohemia. — Věst. Král. Čes. Společ. Nauk, Tř. mat.-přírodověd., *1—6*, Praha.

Prantl F. - Přibyl A. (1940): Příspěvek k poznání siluru v okolí Stodůlek. — Věst. Král. Čes. Společ. Nauk, Tř. mat.-přírodověd., *1—13*. Praha.

— (1944): Příspěvek k poznání geologických poměrů u Tachlovic. — Rozpr. Čes. Akad. Věd Umění, Tř. II, 54, 3. Praha.

Přibyl A. (1940): Stratigrafické rozčlenění graptolitových zón z tak zvaných „Barrandeových kolonií". — Věst. Král. Čes. Společ. Nauk, Tř. mat.-přírodověd., *1—12*. Praha.

— (1948): Bibliographic Index of Bohemian Silurian Graptolites. — Knih. St. geol. Úst. Republ. Čs., 22. Praha.

Štěpánek P. (1984): Geologie pankrácké štoly. — MS archív Ústř. úst. geol. Praha.

Štorch P. (1980): Litologický vývoj a biostratigrafie želkovického souvrství v jv. křídle Barrandienu. — MS (Rigorózní práce), Geofond. Praha.

— (1982): Ordovician-Silurian boundary in the northernmost part of the Prague Basin (Barrandian, Bohemia). — Věst. Ústř. Úst. geol., 57, 4, *231—236*. Praha.

Troedsson G. F. (1936): The Ordovician—Silurian Boundary in Europe, mainly in the Scandinavian-Baltic Region. — Report of XVI intern. Geol. Congr. Washington 1933. Washington.

Williams S. H. (1983): The Ordovician—Silurian graptolite fauna of Dob's Linn, southern Scotland. — Palaeontology, 26, 3, *605—639*. London.

Hranice ordovik-silur v pražské pánvi (Barrandien)

(Résumé anglického textu)

P e t r Š t o r c h

Předloženo 2. dubna 1984

Práce se zabývá hraničním intervalem ordovik—silur v oblasti pražské pánve. V návaznosti na starší práce jsem se pokusil o rekonstrukci vývoje sedimentačního prostoru pražské pánve na hranici ordovik—silur na základě litologických a detailních stratigrafických výzkumů.

Po období synsedimentárních deformací pánve dochází v nejvyšším kosovském souvrství k uklidnění a určitému prohloubení sedimentačního prostoru. Již v nejvyšších lavicích křemenných pískovců flyšoidní svrchní části kosovského souvrství (stupeň Kosov) se objevuje kromě ichnofosilií chudé intertidální (H a v l í č e k 1982) společenstvo infaunních mlžů. Výše dochází v souvislosti s tektonickým uklidněním ke zjemňování sedimentů. V často vápnitých prachových až jílových uloženinách nejvyšších poloh kosovského souvrství se objevuje druhově bohatá, světově rozšířená, podle H a v l í č k a (1982) mělce subtidální h i r n a n t i o v á f a u n a. Její imigrace přinesla do Čech zcela nové faunistické prvky, ze starších souvrství neznámé.

Podle charakteru vývoje hraničního intervalu bylo v rámci pražské pánve vymezeno pět oblastí (příl. 2). V úseku Řepy—Běchovice, v celém j. křídle a v j. části jz. uzávěrů silurské synklinály pražské pánve byl zjištěn nepřerušený vrstevní sled. V severním křídle a v pankrácké oblasti je naopak přerušovaná sedimentace. Plošné a vertikální rozšíření hiátů je znázorněno na obrázku 1.

Na bezprostřední hranici ordoviku a siluru nedochází k podstatné změně sedimentace. Granulometricky se sedimenty téměř nemění, tmavá barva jílových graptolitových břidlic bazálního siluru je dána vysokým obsahem rozptýlených organických látek. Změnu textury způsobenou náhlým vymizením bioturbací v tmavých břidlicích lze vysvětlit abiotickým redukčním prostředím v sedimentu. Proto v graptolitových břidlicích nenacházíme nepřemístěnou bentózní faunu.

Určitou změnu dynamiky sedimentace vyjadřuje nástup písčito-slídnatých laminitů během zóny Par. acuminatus, který se podle biostratigrafie časově kryje s přerušením sedimentace v s. křídle pánve a pravděpodobně i s přerušením sedimentace v pankráckém úseku. Aplikací výsledků autorů C h u r k i n - - C a r t e r - J o h n s o n (1977) byla v pražské pánvi stanovena rychlost sedimentace graptolitových břidlic. V zónách A. ascensus—C. cyphus se pohybuje okolo 1 mm za 1000 let (max. rychlost 7,5 mm za 1000 let byla vypočtena pro lokalitu Praha - Řepy).

Souhrnný přehled fauny kosovského souvrství je uveden v kapitole o vývoji nejvyššího ordoviku. Zóna G. bohemicus je definována v nejvyšším ordoviku pražské pánve v kapitole o biostratigrafii.

Báze siluru je v pražské pánvi definována nástupem druhu *Akidograptus ascensus* (společně s *Diplograptus modestus*), což odpovídá bázi zóny Par. acuminatus v Dob's Linn. Na několika lokalitách (Želkovice, Praha - Řepy, ? Vočkov) byly již v podloží zóny A. ascensus zjištěny tmavé břidlice s graptolity. Společenstvo odpovídá nejspíše svrchní části zóny G. persculptus, která je v současném pojetí nejvyšší ordovickou graptolitovou zónou. V některých částech pražské pánve se graptolitové břidlice objevují prokazatelně až na bázi zóny A. ascensus a zóna G. persculptus je vyvinuta ještě v podobě světlých bioturbovaných prachovců a jílovců nejvyššího kosovského souvrství. Drobná disproporce mezi litostratigrafickou hranicí kosovského a želkovického souvrství a chronostratigrafickou hranicí ordovik—silur (založenou na biostratigrafii) je znázorněna na obrázku 1.

Detailní biostratigrafie siluru přinesla, vedle formálního upřesnění hranice ordovik—silur v pražské pánvi na bázi zóny Akidograptus ascensus a poznání sledu graptolitových společenstev, přesnou korelaci se základními profily v zahraničí (tab. 1).

Vysvětlivky k tabulkám a obrázku 1

Tabulka 1. Korelační tabulka biostratigrafického členění hraničního intervalu ordovik—silur.

Pozn.: Výskyt světově rozšířené hirnanciové fauny se zdá být omezen na zóny G. persculptus—Cl. extraordinarius (G. bohemicus); zóna G. persculptus neodpovídá ve všech oblastech stejnému stratigrafickému rozsahu a má i poněkud proměnlivé graptolitové společenstvo.

Tabulka 2. Stratigrafické rozšíření graptolitů hraničního intervalu ordovik—silur v pražské pánvi (Barrandien).

1. Litologický (faciální) vývoj a biostratigrafické, chronostratigrafické a litostratigrafické poměry na hranici ordovik—silur v pražské pánvi (Barrandien).

1 — prachovec až jemnozrnný křemenný pískovec; *2* — prachovec a prachová břidlice; *3* — laminit; *4* — jílovec a jílovitá břidlice; *5* — křemičitá břidlice až prachovito-jílovitý silicit. Ve sloupci znázorňujícím litologický vývoj a v biostratigrafické kolonce je znázorněn časový interval a rozšíření přerušení sedimentace; rovněž je znázorněn diachronický nástup sedimentace graptolitových břidlic (želkovické souvrství).

Vysvětlivky k přílohám

Příl. I

1. Profil hranicí ordovik—silur v Praze - Řepích.

1 — slabě vápnitý bioturbovaný jílovec s hirnanciovou faunou; *2* — intenzivně bioturbovaný prachovec; *3* — vrstva s přechodem ze světlých do tmavých laminovaných břidlic (zóna ? G. persculptus); *4* — tmavé jílovité břidlice (zóna A. ascensus).

2. Světle šedý bioturbovaný jílovec až prachovec z nejvyšších poloh kosovského souvrství. Profil Černošice. Rovnoběžné nikoly; ×60. Foto (1) P. Štorch, (2) J. Zoubek

Příl. II

1 Laminit. Světlé laminy jsou tvořeny převážně prachovou a jemně písčitou komponentou, tmavé jílovité laminy obsahují hodně organické substance. Nejvyšší část zóny Par. acuminatus. Profil Praha - Řepy. Rovnoběžné nikoly; ×20.

2. Jílovitá až prachovitá břidlice. Laminace je zřetelná z rozdílného obsahu organické substance. Spodní část zóny Par. acuminatus. Profil Praha - Řepy. Rovnoběžné nikoly; ×20. Foto J. Zoubek

Příl. III

Hirnanciová fauna nejvyššího ordoviku.
1, 2, 3 — *Mucronaspis mucronata* (Brongniart), 4 — *Primaspis (Bojokoralaspis)* spec. nov.; 5 — *Duftonia* sp.; 6, 7 — *Brongniartella platynota* (Dalman); 8 — *Glyptograptus bohemicus* Marek. Obr. 1, 8 (×3); obr. 2 (×2,5); obr. 3, 5 (×5,5); obr. 4 (×9); obr. 6, 7 (×2). Foto P. Štorch

Příl. IV

Hirnanciová fauna nejvyššího ordoviku.
1, 2 — *Leptaenopoma trifidum* Marek et Havlíček; 3, 4 — *Draborthis caelebs* Marek et Havlíček; 5, 6 — *Dalmanella testudinaria* (Dalman); 7, 8, 9 — *Leptaena rugosa* Dalman; 10, 11 — *Trucizetina subrotundata* Havlíček; 12, 13 — *Hirnantia sagittifera* (McCoy). Obr. 1 (×2); obr. 2, 7, 8, 9, 12, 13 (×1,5); obr. 3 (×5); obr. 4, 11 (×4); obr. 5, 6, 10 (×3). Foto ÚÚG — H. Vršťalová

Příl. V

Graptolitové společenstvo zóny A. ascensus (1, 2) a Par. acuminatus (3, 4, 5, 6).
1 — *Akidograptus ascensus* Davies, 2 — *Diplograptus modestus* Lapworth, 3 — *Parakidograptus acuminatus* (Nicholson), 4 — *Climacograptus* cf. *medius* Törnquist, 5 — *Climacograptus trifilis* Manck, 6 — *Climacograptus longifilis* Manck. Obr. 1, 3 (×3); obr. 2, 4, 5, 6 (×2). Foto P. Štorch

Příl. VI

Graptolitové společenstvo zóny Cyst. vesiculosus.
1, 4 — *Atavograptus atavus* (Jones), 2, 5 — *Cystograptus vesiculosus* (Nicholson), 3 — *Dimorphograptus confertus* (Nicholson). Vše zvětšeno 2×. Foto P. Štorch

Příl. VII

Graptolitové společenstvo zóny C. cyphus.
1 — *Coronograptus cyphus cyphus* (Lapworth), 2 — *Diplograptus fezzanensis* Desio, 3, 4 — *Monograptus austerus austerus* Törnquist, Vše zvětšeno 2×. Foto P. Štorch

Příl. VIII

Graptolitové společenstvo zóny Dem. triangulatus.
1 — *Demirastrites triangulatus* (Harkness), 2 — *Petalograptus ovatoelongatus* Kurck, 3 — *Rhaphidograptus toernquisti* (Elles et Wood), 4 — *Rastrites longispinus* Perner. Vše zvětšeno 3×. Foto P. Štorch

Příl. 1

Korelace nejdůležitějších profilů hranicí ordovik—silur v pražské pánvi (Barrandien). 1 — žlutošedý jílovec až prachovec; 2 — tmavě šedá břidlice; 3 — tmavě šedá prachovitá břidlice; 4 — tmavě šedý laminit; 5 — černá křemičitá břidlice; 6 — zpevnění sedimentů na kontaktu s intruzemi; 7 — zelenošedá jílovitá sedimentární brekcie; 8 — intruzívní bazalt („diabas"); 9 — bioturbace; 10 — bentózní hirnanciová fauna; 11 — oxidy a hydroxidy železa; 12 — přerušení sedimentace; 13 — zlom; 14 — drobné tektonické porušení.

Příl. 2

Mapa zachovalé části sedimentačního prostoru bazálního siluru (želkovické souvrství) pražské pánve.
1 — výchozy sedimentů spodního siluru (liteňská skupina); Rozdělení na oblasti podle charakteru sedimentace v bazálním siluru: 2 — oblast Pankráce; 3 — severní křídlo; 4 — jihozápadní uzávěry; 5 — jížní křídlo; 6 — oblast Řep a Běchovic. Lokality: 7 — výskyt hirnanciové fauny; 8 — profily vyobrazené na příloze 1; 9 — profily sestavené podle B. Boučka, R. Horného, J. Kříže a A. Přibyla (B — Běchovice, C — Černošice, D — Běleč, E — Želkovice, H — Hlásná Třebaň, K — Karlík, L — Loděnice, M — Malá Chuchle, O — Řeporyje - Velká Ohrada, R — Řepy, S — Sedlec, U — Velká Chuchle, V — Vočkov, Z — Zadní Třebaň, e — Nenačovice, n — Jinonice - Nová Ves, p — Pankrác, t — Tachlovice, y — Hýskov).

Граница между ордовиком и силуром в Пражском бассейне (Баррандиен)

Граница между ордовиком и силуром в Пражском бассейне характеризована непрерывной последовательностью напластования, а внезапным повышением содержания органического вещества, сопровождаемым изменением окраски и текстуры пород. Биотурбидитовые аргиллиты а алевролиты самой верхней, косовской свиты ордовика, содержащие в восточной части бассейна изобильную фауну рода Hirnantia, переслаиваются на базе силура (в Пражском бассейне на базе зоны A. ascensus) темноцветными граптолитовыми сланцами. Выразительное изменение осадконакопления наступило в виде начала седиментации слюдисто-песчанистых ламинитов в пределах зоны Par. acuminatus. Это изменение соответствует по времени перерыву осадкообразования в северном крыле бассейна и в Панкрацкой области, в которой стратиграфический перерыв продолжается по зону Monocl. griestoniensis. Развитие осадконакопления и последовательность сообществ животных указывают на постепенное успокоение осадкообразования на углубляющейся седиментационной площади, начавшееся уже в самой верхней части косовской свиты. В представленной работе приводится обзор фауны косовкой и нижней части жельковицкой свит. Возможность детальной стратиграфии граничного интервала в Пражском бассейне и его корреляции с соответствующим промежутком на иностранных территориях была предоставлена анализом сообществ граптолитов.

Přeložil A. Kříž