

Table 7. Amount of bioclasts in the Přídolí-Lochkovian boundary interval

		SILURIAN	DEVONIAN			
		Upper Přídolí	Lower Lochkovian			
			Rad.	Kosoř	Kotýs	"scypb."
Crinoids	R	X		●	X	●
	Po	●	X	X	●	X
	Pd	•			X	●
Cephalopods	R	•		X	X	•
	Po	X	X	X	X	X
	Pd	•			X	•
Bivalves	R	•		•	X	•
	Po	X	X	X	X	X
	Pd	•			X	•
Ostracodes	R	●		•	X	X
	Po	X	X	X	X	X
	Pd	●			X	X
Trilobites	R	X		X	X	X
	Po	X	X	X	•	X
	Pd	X			X	•
Brachiopods	R	X		X	X	X
	Po	●	X	X	•	X
	Pd	X			X	•
Sponge spicules	R	X		•	X	X
	Po	X	X	X	X	X
	Pd	X			X	X
Mazueloidea	R	•		X	X	•
	Po	X	X	X	X	X
	Pd	•			X	•
Prasinophyta	R	•		X	X	X
	Po	X	X	X	X	X
	Pd	•			X	X
Acritarchs	R	•		X	X	X
	Po	X	X	X	X	X
	Pd	X			X	X

Localities: R – Radotín, Po – Požáry quarry, Pd – Podolí; Facies: Rad. – Radotín Limestone, Kosoř – Kosoř Limestone, Kotýs – Kotýs Limestone, "scypb." – coarse-grained crinoidal and cephalopod limestones of so-called "Scyphocrinites horizon"; relative content of bioclasts: ● – abundant, • – common, • – rare, X – bioclasts are not present, [X] – facies is not present at locality, [] – facies is present out of studied interval.

posited by debris flows. The deposition of coarse-grained bioclastic limestones in the lowermost part of the Lochkov Formation in the Radotín section was strongly influenced by the activity of these currents. The Podolí section is largely analogous to the former section. Shallow-water deposition in the Požáry quarry section was affected by wave-generated traction currents, and thus any micritic matrix was completely washed out.

6. The Lochkovian-Pragian boundary interval in the Barrandian area

The Lochkovian-Pragian boundary beds are exposed in many natural and artificially-exposed outcrops in the Barrandian area, even within the city of Prague. Three sections with different facies developments were chosen for this study (see fig. 1).

Černá rokle near Kosoř represents the relatively deep-

est-water development. On the other hand, shallower facies are encountered in old quarries near Cikánka. These two sections serve as auxiliary reference sections of the Lochkovian-Pragian boundary. The stratotype section at Homolka near Velká Chuchle represents transitional development (CHLUPÁČ – OLIVER 1989).

All these sections have been visited by many geoscience field trips and individuals during the past fifty years, and are described in excursion guides and some special papers (especially CHLUPÁČ 1999, 2000a, CHLUPÁČ et al. 1985, 2002, KRÍŽ 1999b). The original numbering of beds is used in this paper. The studied material includes 41 thin-sections.

6.1. Černá rokle near Kosoř

The outcrops of the Lower Devonian rocks are situated SE of Kosoř village on the SW margin of the city of Prague. The sequence of the Lochkovian-Pragian boundary beds is exposed in old quarries where paving material was extracted (see fig. 17).

This typical locality of the Radotín Limestone facies has been well-known since Barrande's times. Although a holostratotype of the Lochkovian-Pragian boundary was established here, the current stratotype at Homolka near Praha-Velká Chuchle was ratified in 1989 in accordance with the resolution of the Subcommittee on Devonian Stratigraphy (CHLUPÁČ – OLIVER 1989). The reason for this decision was the increased abundance of index conodonts in the Homolka section.

This section includes the uppermost part of the Lochkov Formation (Radotín Limestone facies, beds 53–80) and the lower part of the Praha Formation (Dvorce-Prokop Limestone facies, beds 81–87; fig. 18). The Lochkovian-Pragian boundary is located in shale interbed 80/81. The topmost bed of this section (87) is composed of massive nodular limestone. The overlying sequence, in which the beds are not numbered, continues up to the lower parts of the Zlíchov Formation.

The samples for thin-sections from the Lochkov Formation were taken from beds 56, 61, 62, 63, 64, 65, 66, 70, 75, 79, and 80 (fig. 18), especially in places where lithological changes mark the input of coarser detritus or another changes in depositional mechanics.

The samples from the Praha Formation were taken from beds 81, 82, 84 and 87 in order to document the boundary interval and to sample a bed of nodular limestone. The interbedded shales are intensely weathered, and thus were not amenable to sampling for thin-sections.

Bioclasts

The Lochkov Formation is composed mainly of fine-grained microsparitic Radotín Limestone. Complete and fragmented shells of tentaculites, ostracods, and sponge spicules comprise most of the bioclasts (see table 8). In

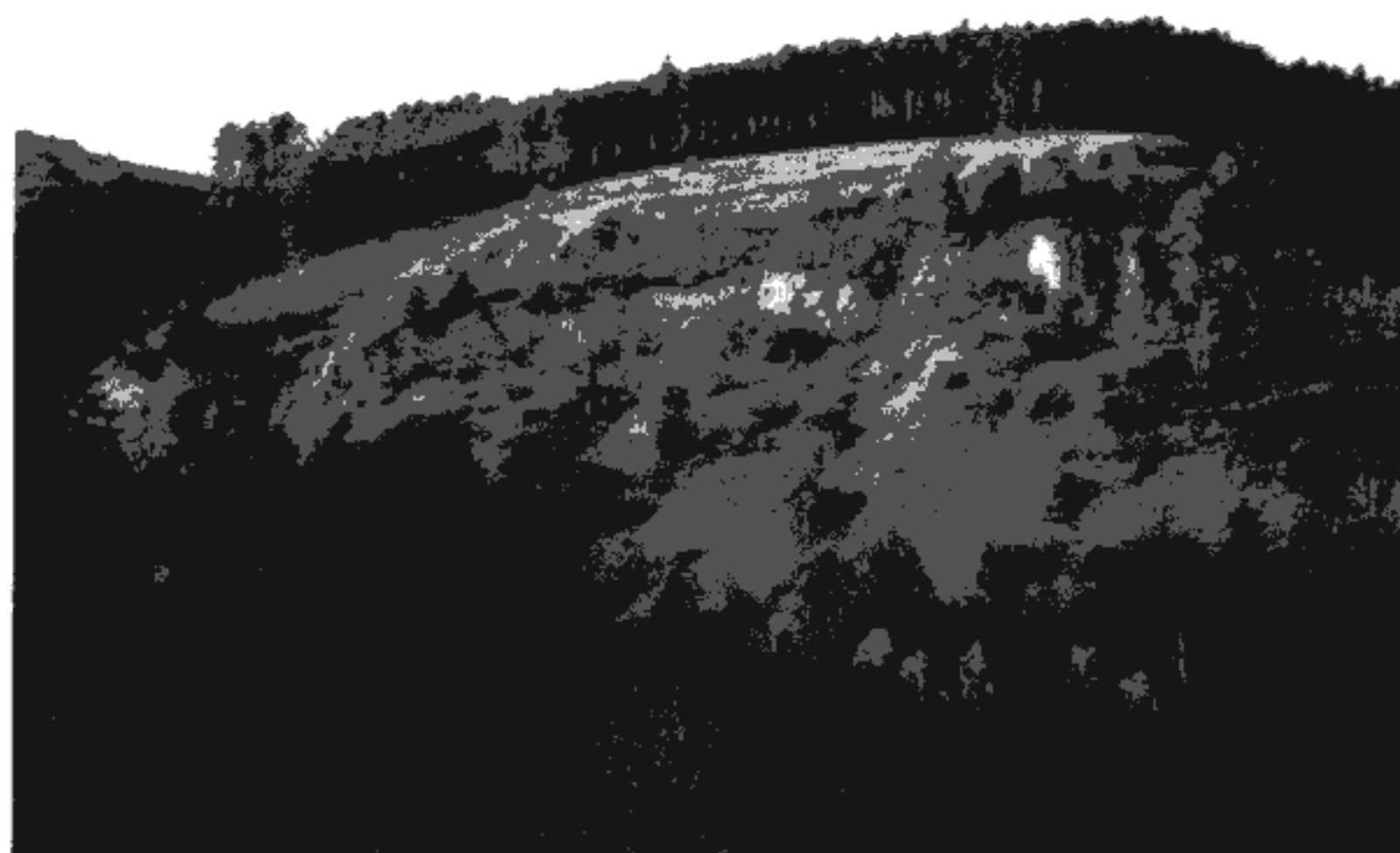


Figure 17. General view on the old quarries in Černá rokle near Kosoř. The studied section is situated on the left-hand side.

coarser-grained limestones fragments of brachiopod and bivalve shells, trilobite carapaces, and crinoids are also present. Fragments of crinoid stems abound in the light-coloured biosparitic limestones (e. g. bed 64).

The same types of bioclasts as in the Radotín Limestone are also present in small amounts in the Dvorce-Prokop Limestone of the Praha Formation, in which micritic matrix is abundant. The larger input of coarser, derital material (more than 10 %) can be observed only in some beds. Most of bioclasts are like a fine hash of fragmented shells of silt size (tentaculites, sponge spicules, ostracods, brachiopods, bivalves, trilobites, crinoids).

Microfacies analysis

SMF 9 (wackestone to packstone) is the dominant facies in the Radotín Limestone of the Lochkov Formation (fig. 18). In addition, some beds, such as 56 and 64, contain layers of coarse, detrital limestones, which correspond to SMF 5. This microfacies belongs to Facies Belts 2 to 3 (deeper shelf). Microbioclastic calcisiltite–wackestone (SMF 2) occurs in laminated limestone bed 65.

SMF 9, with a small amount of bioclasts (wackestone to mudstone), also dominates the Dvorce-Prokop Limestone of the Praha Formation. The overlying nodular micritic limestones (bed 87) may be classified as SMF 3 (pelagic mudstone), or as SMF 1 (spiculite) because of high proportion of sponge spicules. This succession of standard microfacies reflects the gradual deepening of the sedimentary basin after the Lochkovian-Pragian boundary regressive event (CHLUPÁČ and KUKAL 1986, 1988), which corresponds to the transition from Facies Belt 2 (deeper shelf) to Facies Belt 1 (the basin).

6.2. Homolka near Velká Chuchle

The Lochkovian-Pragian boundary beds are exposed in the abandoned Homolka quarry in the valley between Velká Chuchle and Slivenec in the SW part of Prague.

This section was ratified as the stratotype of the Lochkovian-Pragian boundary by the Subcommittee on Devonian Stratigraphy of IUGS, at the International Geological Congress in 1989 (CHLUPÁČ and OLIVER 1989, see figs. 19 and 20).

The Lochkov Formation is comprised of the coarser-grained Radotín to Kosoř Limestone facies (beds 1–11), and the Praha Formation by the Dvorce-Prokop Limestone (beds 12–50, see fig. 21). The Lochkovian-Pragian boundary is based on the first occurrence of the conodont *Eognathodus sulcatus sulcatus* (WEDDIGE 1987) in bed 12. The overlying unnumbered sequence is of the nodular Dvorce-Prokop Limestone.

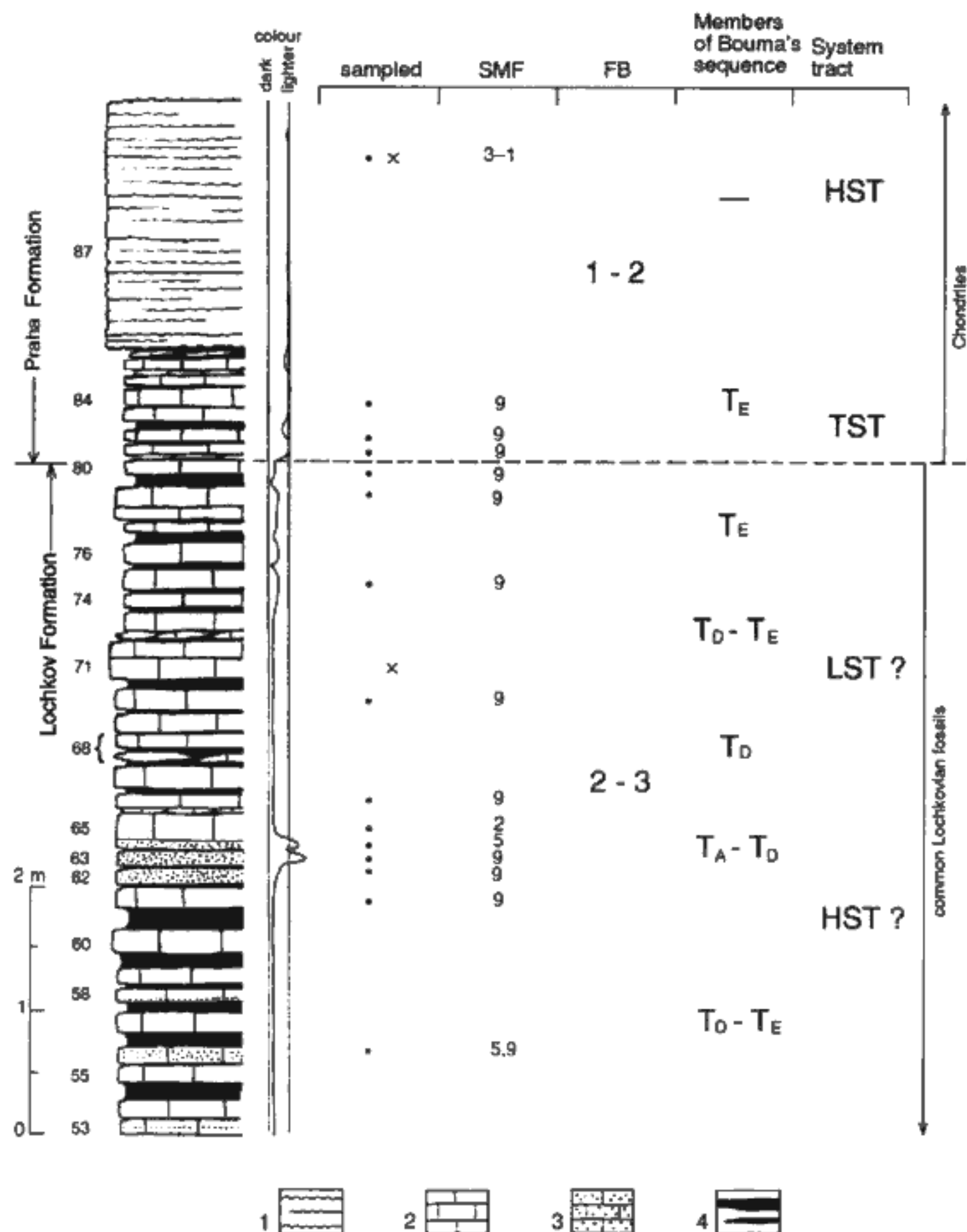
The samples were taken from beds 2, 5, 9, 10, 11 (Lochkov Formation), 12, 13, 14, 15, 22, 26, 28, 30, 36, 41, and 46 (Praha Formation, see fig. 21).

Bioclasts

Crinoid fragments are abundant in the limestones of the upper part of the Lochkov Formation, which corresponds somewhat to the Kosoř Limestone (see tab. 8). Shell fragments of brachiopods, bivalves, tentaculites, and ostracods, and trilobite carapaces are less plentiful. Abundant chitinozoans occur in the micritic limestone of bed 10. Fine organic hash of silt size is common.

A mixture of coarser-grained unsorted bioclasts (of crinoids, brachiopods, and trilobites) and micritic matrix

Figure 18. Černá rokle near Kosoř: Section of the Lochkovian-Pragian boundary interval. 1 – grey micritic limestones; 2 – dark grey and grey microsparitic limestones; 3 – lighter sparitic limestones; 4 – calcareous shales. ● – sample taken for thin-section, × – sample taken for chemical analysis; SMF – standard microfacies; FB – facies belt; LST – low-stand system tract; TST – transgressive system tract; HST – high-stand system tract (modified after CHLUPÁČ et al. 1985, interpretation after VOREL 2001, 2002, in press).



dominates the lowest part of the Dvorce-Prokop Limestone of the Praha Formation. Higher in the section the size of bioclasts decreases (ostracods, tentaculites, sponge spicules, bivalves, bryozoans, chitinozoans, etc.).

Microfacies analysis

The predominant facies of the Lochkov Formation is SMF 5 (grainstone composed mainly of crinoid stems with relics of micritic matrix, see fig. 21). The laminated micritic limestone of bed 10 can be classified as SMF 2 (microbioclastic calcisiltite-wackestone). These microfacies correspond to the deeper part of Facies Belt 4, or to a transition between FB 3 and 4 (talus slopes of sand-sized crinoidal material in the deeper shelf).

The lowermost beds of the Praha Formation (12 and 13) also correspond to SMF 5 (grainstone). The amount of micritic matrix increases upwards. This type of limestone

can be classified as SMF 9 (packstone to wackestone). A gradual deepening of the sedimentary basin after the regressive event at the Lochkovian-Pragian boundary is also observable (a transition from FB 3-4 to FB 2).

6.3. Cikánka near Praha-Slivenec

The Lochkovian-Pragian boundary beds are exposed in the left side of the old quarry called "Ve skále", which is about 2 km SW of Praha-Slivenec, N of Radotín Valley (see fig. 22).

The complex of quarries called "Na Cikánce" is a classic site for Lower Devonian rocks. The Slivenec marble has been quarried here since the thirteenth century (RYBAŘÍK 1992). The abandoned "Ve skále" quarry is a type locality of the Slivenec Limestone, and serves as a reference section of the Lochkovian-Pragian boundary (CHLUPÁČ et al. 1985).

The Lochkov Formation is represented by the Kosoř

Limestone, and in its uppermost part by the Kotýs Limestone (beds 1–11), the latter of which was previously designated by SVOBODA and PRANTL (1949) as the “lower Koněprusy Limestone”. The Praha Formation (beds 11–17) is present as the Slivenec Limestone, and higher in this section as the nodular Řeporyje and Dvorce-Prokop Limestones (fig. 23). The Lochkovian-Pragian boundary is within bed 11, in which a lower, grey-coloured part of the Lochkovian fauna still occurs. The upper part of the limestones with Pragian fauna consists of pink to red-coloured carbonate rocks (CHLUPÁČ et al. 1985).

The samples were taken from the type section in the abandoned “Ve skále” quarry, which serves as a reference section of the Lochkovian-Pragian boundary (CHLUPÁČ et al. 1985, WEDDIGE 1987). This locality is protected by law to prevent it from being affected by mining in the active

quarries. The samples were taken from beds 2, 4, 5, 7, 8, 10, 11 (two samples), 12, and 16 (fig. 23).

Bioclasts

The fauna of the Kosoř and Kotýs limestones is very abundant, and is preserved mainly as coarse-grained organic detritus. The amount of bioclasts is larger than in the previous sections (more than 50 %). In the coarse-grained bioclastic limestones fragments of crinoid stems dominate the bioclastic fraction, while the remains of brachiopods, bryozoans, and trilobites are less abundant (see tab. 8). Some beds contain more abundant tentaculites, ostracods, sponge spicules, bivalves, and unidentified fine organic hash. Very similar assemblages of organisms occur in the Lochkov and Praha formations.

Table 8. Amount of bioclasts in the Lochkovian-Pragian boundary interval

		DEVONIAN				
		Upper Lochkovian			Lower Pragian	
		Rad.	Kosoř	Kotýs	Dv.-pr.	Sliv.
Crinoids	Čr	•	X	X	•	X
	VCh		●	X	•	X
	Cik	X		●		●
Brachiopods	Čr	•	X	X	•	X
	VCh		●	X	•	X
	Cik	X		●		●
Trilobites	Čr	•	X	X	•	X
	VCh		•	X	●	X
	Cik	X		•		●
Ostracodes	Čr	●	X	X	●	X
	VCh		•	X	●	X
	Cik	X		•		•
Tentaculites	Čr	●	X	X	●	X
	VCh		•	X	●	X
	Cik	X		•		•
Sponge spicules	Čr	•	X	X	•	X
	VCh		•	X	•	X
	Cik	X		•		•
Others (bivalves, gastropods, bryozoans)	Čr	•	X	X	•	X
	VCh		•	X	•	X
	Cik	X		•		•
Chitinozoans	Čr	•	X	X	•	X
	VCh		•	X	•	X
	Cik	X		•		/
Mazueloidea	Čr	•	X	X	/	X
	VCh		/	X	/	X
	Cik	X		/		/
Prasinophyta	Čr	•	X	X	/	X
	VCh		•	X	/	X
	Cik	X		/		/

Localities: Čr – Černá rokle, VCh – Velká Chuchle, Cik – Cikánka; Facies: Rad. – Radotín Limestone, Kosoř – Kosoř Limestone, Kotýs – Kotýs Limestone, Dv.-pr. – Dvorce-Prokop Limestone, Sliv. – Slivenec Limestone; relative content of bioclasts: ● – abundant, • – common, ◐ – rare, / – sporadic, [X] – facies is not present at locality, [] – facies is present out of studied interval.

Microfacies analysis

In the upper part of the Lochkov Formation SMF 11 and SMF 5 occur frequently (fig. 23). Limestones with larger amounts of micritic matrix can be classified as SMF 9 (beds 5 and 8). However, the assignment of some limestones to SMF 11 is problematic. The sedimentary environment of the Lochkov Formation corresponds to FB 4 (talus slopes of crinoidal detritus at the elevation margins). This detritus has been intensively reworked in some places, and thus the depositional environment approaches that of FB 5.

SMF 5 predominates in the Slivenec Limestone (Pragian), though SMF 9 (packstone with abundant crinoidal fragments) occurs in some beds (e. g. bed 12). These microfacies belong to FB 4 (talus slopes of crinoidal, sand-sized detritus). The increasing amount of micritic matrix reflects a gradual deepening of the sedimentary basin. The facies change to the Řeporyje Limestone higher in the section is observed.

6.4. Conclusions

Černá rokle near Kosoř

The microfacies analysis has revealed this as the deepest marine environment. The upper part of the Lochkov Formation (Radotín Limestone) corresponds to FB 2 to 3, and the Praha Formation (Dvorce-Prokop Limestone) to FB 1 to 2. The facies shift was caused by the gradual deepening of the sedimentary basin following the Lochkovian-Pragian boundary regressive event.

The depth of the basin is estimated to have been a few hundred metres, which corresponds to an outer shelf environment. This is also supported by the occurrence of the trace fossil *Zoophycos* in the Radotín Limestone of the Lochkov Formation (bed 65), and by the abundance of *Chondrites* in the Dvorce-Prokop Limestone (Pragian). The ichnogenus *Zoophycos* indicates an environment be-

Figure 19. Homolka near Velká Chuchle. General view of the stratotype section of the Lochkovian-Pragian boundary with a mark on the left-hand side.

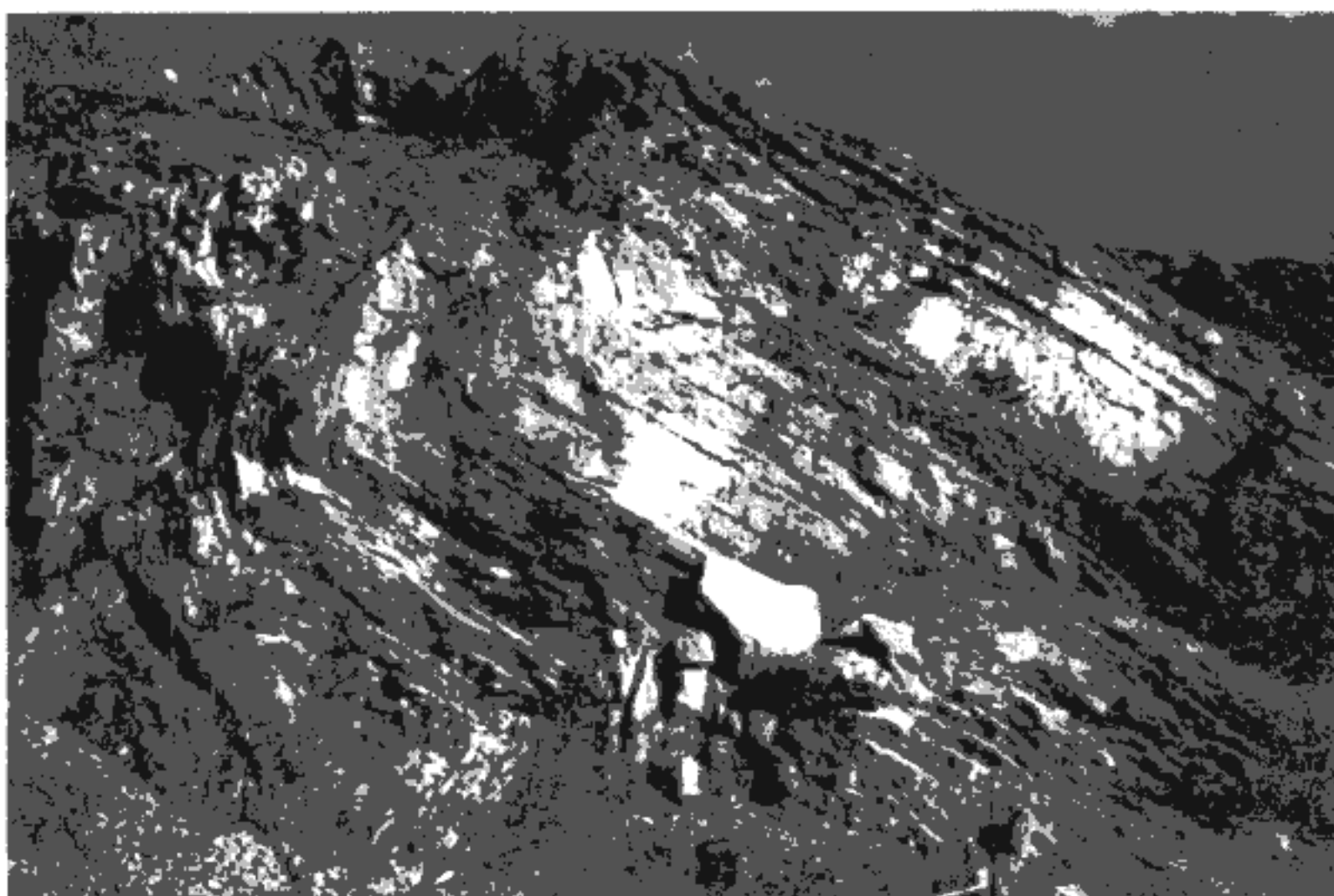
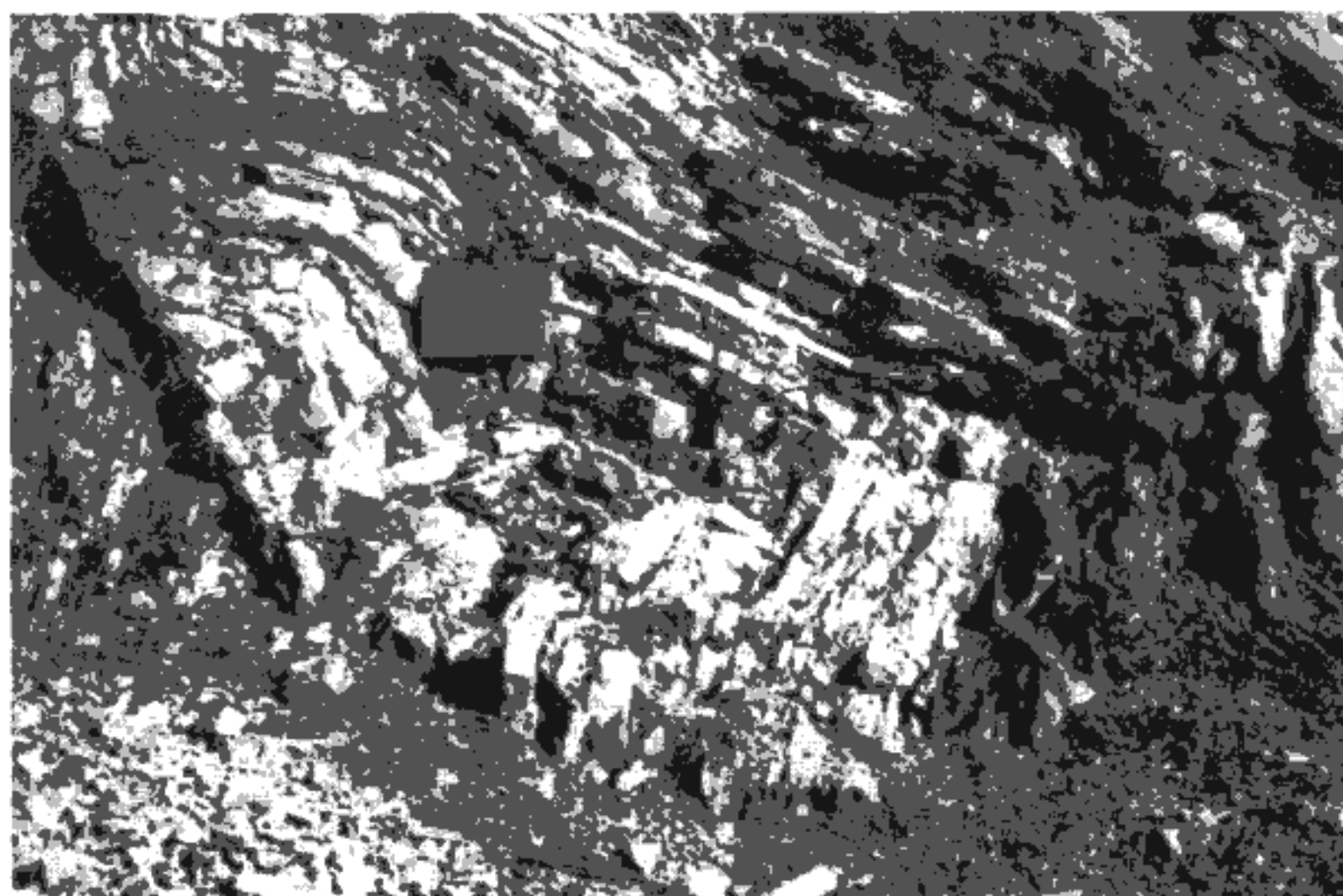


Figure 20. Studied section of the Lochkovian-Pragian boundary beds in Velká Chuchle. The boundary is marked by white line.



low the wave base, and commonly occurs in flysch turbidite sequences (PEK and MIKULÁŠ 1996). The preservation of trace fossils in carbonates depends on the degree of recrystallization.

The presence of the shallow-water SMF 5 (crinoidal grainstones, in beds 56, 64, etc.) within the deep-water environment, in which SMF 9 dominates, is intriguing. This association cannot be explained by the abrupt shallowing of a sedimentary basin and the onset of conditions favourable for SMF 5 deposition, but rather by the redeposition of bioclastic material from shallow parts of the basin by turbidite currents (VOREL 2001, 2002, in press). HLADIL et al. (1996) have also suggested a turbidity current mecha-

nism for the deposition of the micritic Dvorce-Prokop Limestone, although no clear evidence for this presumption is given in their paper.

Homolka near Velká Chuchle

The stratotype section at Velká Chuchle corresponds to the transitional development of boundary beds in which the Lochkov Formation belongs to FB 4 and the Praha Formation to FB 3 to 4 due to gradual deepening. We estimate a depth of a few hundred metres, which corresponds to the continental shelf close to the source of the bioclastic material.

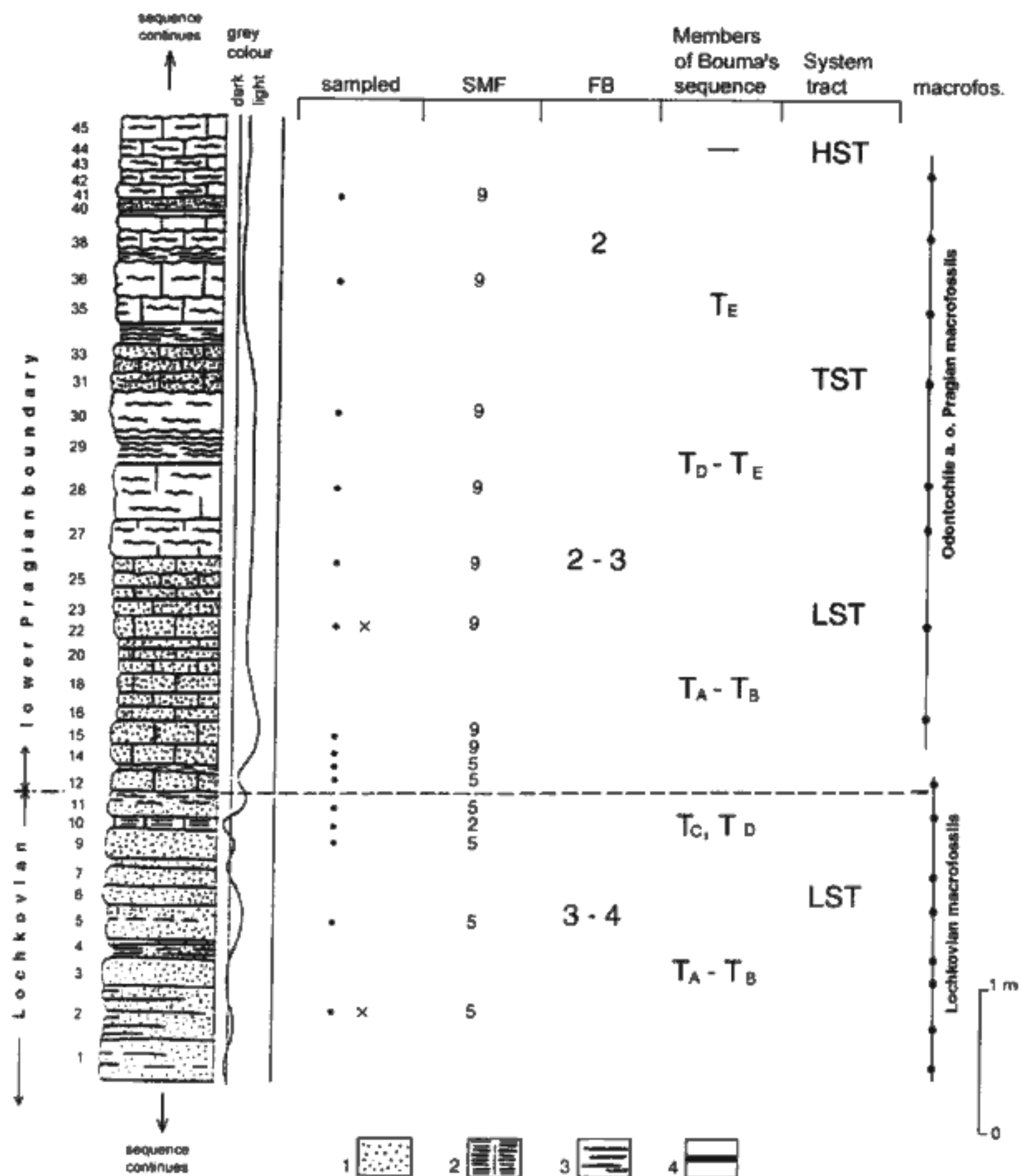
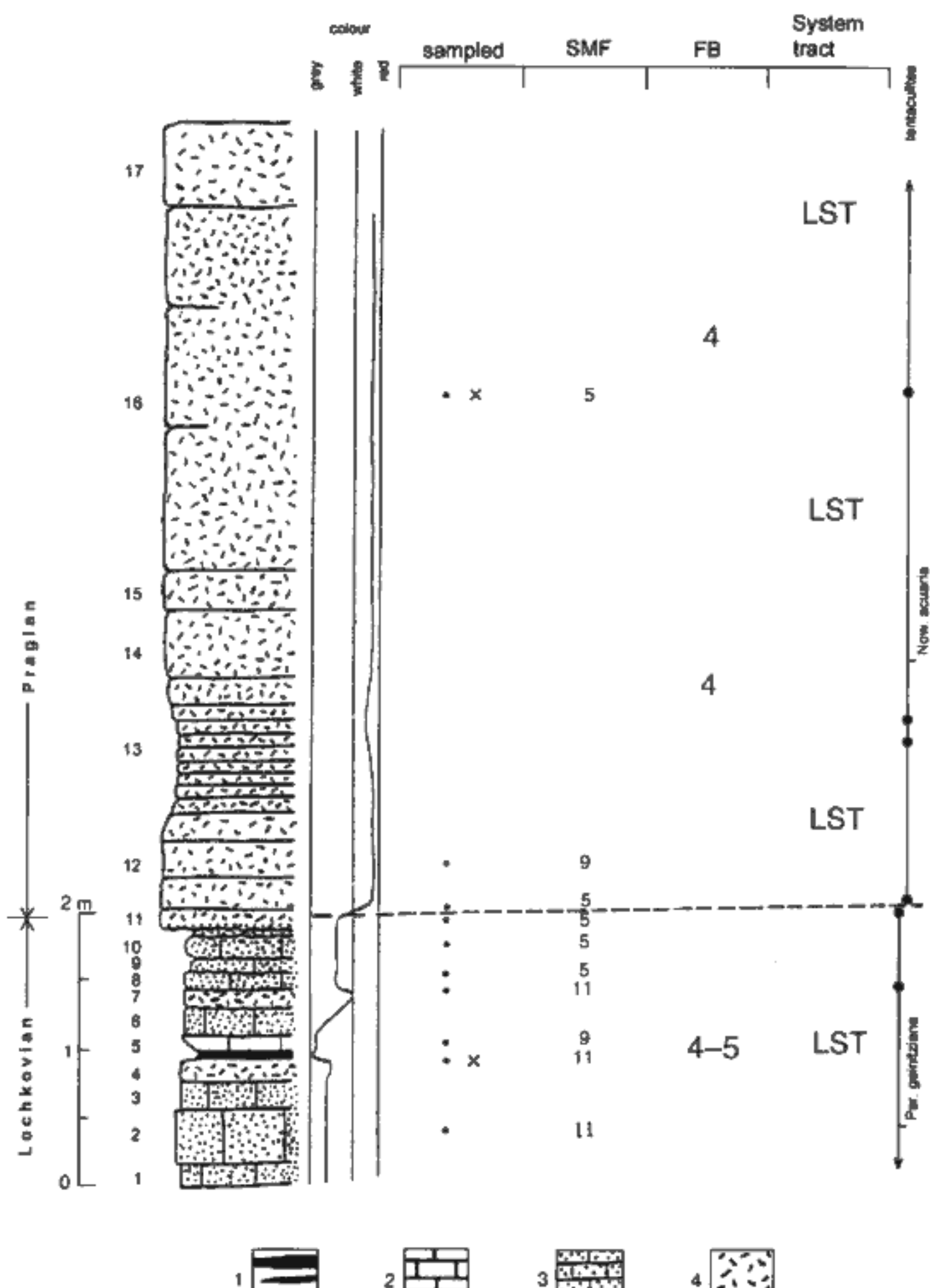


Figure 21. Homolka near Velká Chuchle: Section representing the Lochkovian-Pragian boundary stratotype. 1 – fine-grained biotrititic to biomicritic limestones; 2 – laminated micritic limestones; 3 – nodular micritic limestones; 4 – calcareous shale interbeds; • – sample taken for thin-section, x – sample taken for chemical analysis; SMF – standard microfacies; FB – facies belt; LST – lowstand system tract; TST – transgressive system tract; HST – highstand system tract (modified after CHLUPÁČ et al. 1985, interpretation after VOREL 2001, 2002, in press).



Figure 22. General view of Cikánka quarries. The sections is situated in the center of the photograph behind the wall of an active quarry.

Figure 23. Cikánka near Praha-Slivenec: Section of the Lochkovian-Pragian boundary interval. 1 – calcareous shales; 2 – dark grey and grey microsparitic limestones; 3 – lighter sparitic limestones; 4 – coarse-grained bioclastic and sparitic limestones; • – sample taken for thin-section, × – sample taken for chemical analysis; SMF – standard microfacies; FB – facies belt; LST – lowstand system tract (modified after CHLUPÁČ et al. 1985, interpretation after VOREL 2001, 2002, in press).



Cikánka near Praha-Slivenec

In an area of shallow marine deposition at Cikánka, both the Lochkov and Praha formations belong to FB 4 or 5. The deposition took place at a depth of a few tens of metres. Coarse-grained bioclastic limestones represent taluses of sand-sized detritus at the margins of crinoid biostromes.

An attempt at sequence stratigraphy was made and described in detail for all three sections by VOREL (in press). Those conclusions are noted schematically on the corresponding figures (18, 21, and 23).

The classification of some limestones as SMF 11 seems to be problematic. The manner in which the crinoid stems that dominate the coarse-grained bioclastic limestones were reworked probably differed from the way in which a mixture bioclasts is usually reworked. Crinoid stems consisting of single calcite crystals were less susceptible to

fragmentation, rounding, coating than other bioclasts. The well-sorted crinoidal Kotýs and Slivenec Limestones are of shallow-water development (Cikánka), but correspond only partly to SMF 11, which is typical for a littoral zone. Although the sedimentary environment fully corresponds to this microfacies (deposition at a depth of a few tens of metres) the rounding and coating of bioclasts are rare.

The bathymetric conditions in these sections accord well with the Lochkovian and Pragian facies distribution in the Barrandian area (e. g. CHLUPÁČ et al. 1992, 1998). Coarser-grained limestones are concentrated in the NW flank of the Barrandian (Svatý Jan pod Skalou, Stydlé vody, Zadní Kopanina, Cikánka), whereas finer-grained deeper-water sediments predominate towards the SE (Karlštejn, Radotín, etc.). Such a trend is observed in the Prague Basin beginning in the Silurian, where the shallow-water facies are attached to volcanic elevations (cf. CHLUPÁČ et al. 1992, 1998).