# Llandovery–Wenlock boundary beds in the graptolite-rich sequence of the Barrandian area (Bohemia)

## Hraniční polohy llandovery a wenlocku ve facii graptolitových břidlic v Barrandienu (Czech summary)

*(4 plates, 5 text–figs.)*

PETR ŠTORCH

*Geologický ústav Akademie věd ČR, Rozvojová 135, 165 00 Praha 6*

Submitted April 19, 1994

Temporary excavations at Velká Ohrada and two other sections through the graptolite-rich Llandovery–Wenlock boundary strata have been examined bed by bed. In the *St. grandis, Cyrt. insectus, Cyrt. centrifugus*, and *Cyrt. murchisoni* Zones 43 graptolite taxa have been found. The diverse graptolite assemblages are listed, seven poorly known Bouček's and Přibyl's species redescribed and *Monograptus vittatus* sp.n. described. The Barrandian sections account for a distinct change in graptolite fauna at about the base of the *insectus* Zone as opposed to a very minor change at the base of the *centrifugus* Zone. The base of the *insectus* Zone and of the Wenlock Series respectively are correlated with the base of the *centrifugus* Zone in those regions in abroad (including the type Wenlock area), where the *insectus* Zone is not recognized.

## Introduction

Some doubts about absolute correlative potential of global boundary stratotypes of the Silurian series and stages have been confirmed in course of present discussion on an internationally acceptable Silurian standard graptolite zonal scheme. The Llandovery–Wenlock boundary sections in the type Wenlock area, for instance, little contributed to precise international correlation based on graptolites. In Bohemia and elsewhere in the world, however, the corresponding, but graptolite rich Llandovery–Wenlock boundary strata yield good basis for detailed graptolite biostratigraphy and correlation.

In Bohemia many sections through the graptolitic shales of Barrandian area have been studied by Bouček (1930, 1931a, 1937, 1942, 1946), Přibyl (1937, 1938a, 1938b, 1940a), Bouček and Přibyl (1952), Štorch (1980, 1986, 1991 MS) and Turek (1990). Comprehensive papers on the lower Silurian graptolite biostratigraphy of the Barrandian area were published by Bouček (1953) and Štorch (1994). The range–zones, partial–range zones, couple–range zones, partial couple–range zones, interval zones, and abundance zones have been recognized by Štorch (1994) and utilized in his zonal chart. The same zones are used in present paper.

The uppermost Telychian and lower Sheinwoodian, i.e. the Llandovery–Wenlock boundary interval, is developed in form of dark grey to black, graptolitic shales of Motol Formation. In course of *Cyrt. centrifugus* and *Cyrt. murchisoni* Zones the black calcareous shales alternated with dark muddy limestones with occassional laminae of fine biodetrital limestones. The calcareous graptolitic shales persisted into the succeeding *M. riccartonensis* and *Pr. dubius* Zones. The shales are bleached by fossil humid weathering where an old pre–Quartenary peneplain is preserved near the outcrops.

Recently the Llandovery–Wenlock boundary interval has been accessible to stratigraphical studies at several places in the SW part of Prague territory. Sedimentary sequence croping out at rocky slope above the Vltava River [locality "Na Vyskočilce" near Malá Chuchle, grid references X5544371, Y3456698 (Gauss – Krueger), text–fig. 1, no. 2] has already been described by Bouček (1953). It is slightly tectonized and disrupted by basalt sill between the *grandis* and *insectus* Zones. The steep slope is not suitable for extensive collecting and much old data came from isolated blocks fallen below the rock. Another locality has been studied at the opposite bank of Vltava River, in railway cutting, besides the railway bridge in Braník (X5544072, Y3457544, text–fig. 1, no. 3, locality "Hodkovičky" described by Přibyl 1938b and Štorch 1991). There the basalt sill penetrated the black shales below the base of the *murchisoni* Zone.

The best of Llandovery–Wenlock boundary sections, bearing common and moderately well preserved graptolites in the continuous sedimentary sequence, has been temporarily exposed by building excavations along Červeňan–

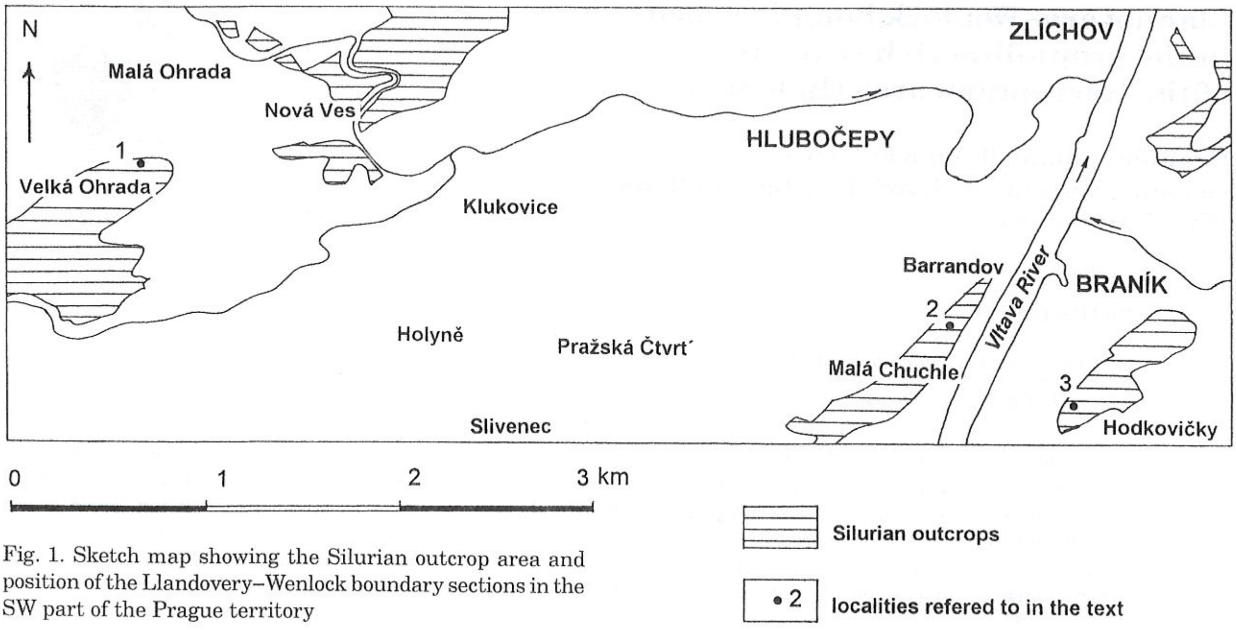



Fig. 1. Sketch map showing the Silurian outcrop area and position of the Llandovery–Wenlock boundary sections in the SW part of the Prague territory

ského Street at the eastern margin of Velká Ohrada Settlement (X5545408, Y3452684, text-fig. 1, no. 1). It can be well used as local Llandovery–Wenlock boundary reference section in the Barrandian area.

## Lithology and stratigraphy of Velká Ohrada reference section

The section beginns with the upper part of the upper Ordovician Kosov Formation and terminates with the upper Wenlock basalt tuffs in the Motol Formation. All the beds of about 40 m thick sequence dip about 30° to the South–West. No faults and few and weak folds have been recorded there. The rocks are bleached by deep fossil weathering typical of old, Tertiary peneplain at the SW and W periphery of Prague. The Silurian shales yielded common graptolites preserved as brown–black carbon films on light-grey bedding planes.

About four metres thick light–grey to white mudstones intercalated by few solid siltstone beds were exposed at the base of the section. They represent the upper part of the Kosov Formation. The last metre of this unit is composed of bioturbated and limonitized calcareous mudstones with infrequent pelocarbonate nodules. The calcareous rocks, though decalcified by fossil weathering, yielded uncommon brachiopods [*Dalmanella testudinaria* (Dalman), *Eostropheodonta squamosa* Havlíček, *Leptaenopoma* sp.] along with rare *Normalograptus persculptus* (Salter) = *Gl. bohemicus* Marek. The fossils belong to the famous *Hirnantia* Fauna and *persculptus* (= *bohemicus*) Biozone which both are well known from several other localities of the NE part of the Prague Basin (Marek and Havlíček 1967, Štorch 1986, 1991).

The mudstones of the Kosov Formation are overlain by 2 m of green– to yellow–coloured barren mudstone, a marker bed of the base of the Litohlavy Formation (Kříž 1975, Štorch – Pašava 1989, Štorch 1991).

According to precise dating by graptolites of neighbouring black shales, the base of the basal mudstone of Litohlavy Formation varies usually between the top of the *sedgwickii* Zone and the base of the *turriculatus* Zone, being preceded by about 15 m of graptolitic shales of the Želkovice Formation (Rhuddanian and Aeronian). In the NE part of the Prague Basin, where an intensive along–shore current of NE–SW direction (Štorch 1991) caused a long period of nondeposition, at several places the basal mudstone of the Litohlavy Formation was found at the immediate base of the Silurian sediments. At Velká Ohrada section the whole Želkovice Formation is missing and the Silurian sequence starts with this mudstone bed.

In this section the basal mudstone is succeeded by black graptolitic shales of the *griestoniensis* Zone. About 2 m thick sequence of the *griestoniensis* Zone is composed by almost regular alternation of graptolitic shales and light-coloured claystones. Common lamines, few mm in thickness, of fine, unsorted, clayey breccias are the only feature markedly different from the common lithology of the Litohlavy Formation. Breccias originated by rapid sedimentation of angular fragments of grey claystones, pale claystones, greenish claystones, and uncommon,

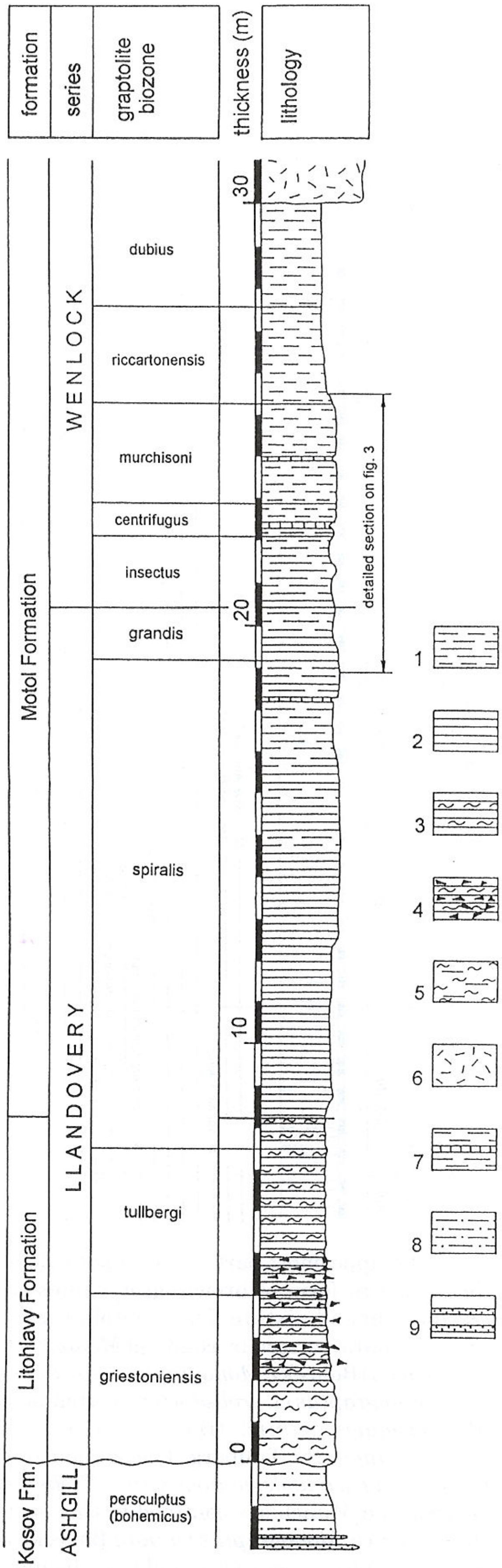



Fig. 2. Lower Silurian section exposed by the building excavations at Velká Ohrada
*1* – calcareous graptolitic shales; *2* – graptolitic shales; *3* – alternated graptolitic shales and light-coloured barren mudstones; *4* – laminae of clayey breccia; *5* – pale, greenish basal mudstone of the Litohlavy Fm.; *6* – basalt hyaloclastites and tuffs; *7* – thin beds of muddy limestone; *8* – mudstones of the uppermost Kosov Fm.; *9* – thin beds of siltstones and fine sandstones. All the rocks are bleached and decalcified by fossil weathering

subrounded, green, partly decomposed volcanic glasses. Quartz grains or pebbles are not present. The shaly fragments up to 10 mm in diameter account for rather high-energy depositional regimen.

Badly preserved graptolite fauna confined to dark beds consists of *Petalograptus tenuis* (Barrande), *Monograptus* cf. *priodon* (Bronn), *Monograptus veles* (Richter), *Monograptus proteus* (Barrande), and *Monoclimacis griestoniensis* (Nicol).

The laminae of clayey breccias gradually disappeared in the lower part of the succeeding *Monograptus tullbergi* Zone. About 3.5 m thick *tullbergi* Zone is formed by alternated graptolitic shales and pale barren mudstones. Here the index graptolite *Monograptus tullbergi* Bouček is common, being accompanied by *P. tenuis* (Barrande), *Retiolites geinitzianus angustidens* Elles and Wood, *Monograptus priodon* (Bronn), *Monograptus veles* (Richter), *Monoclimacis griestoniensis* (Nicol) a.o.

Almost regular alternation of graptolitic shales and light mudstones continues up to the lowermost part of the *Monograptus spiralis* Zone. The base of the *spiralis* Zone is formalized herein in the first bed containing common *M. spiralis* Geinitz. *M. tullbergi* Bouček is already missing in this bed. The base of the succeeding lithostratigraphic unit – the Motol Formation – is formalized at the top of the last light mudstone intercalation, herein 0.8 m above the base of about 12 m thick *spiralis* Zone. Greater part of the thickness of the *spiralis* Zone is formed by silty, often micaceous, partly bleached graptolitic shales. Any precise biostratigraphical data are limited by poor preservation of graptolites. The typical rhabdosomes of *M. spiralis* and of some other species allowed the rough biostratigraphic evaluation of these beds.

Completeness of the graptolite record much improved in the shales of the uppermost part of the *spiralis* Zone. Rich and moderately well preserved graptolite fauna throughout the *Stomatograptus grandis, Cyrtograptus insectus, Cyrt. centrifugus* and *Cyrt. murchisoni* Zones yields much new data about the graptolite history and fine stratigraphy across the Llandovery–Wenlock boundary.

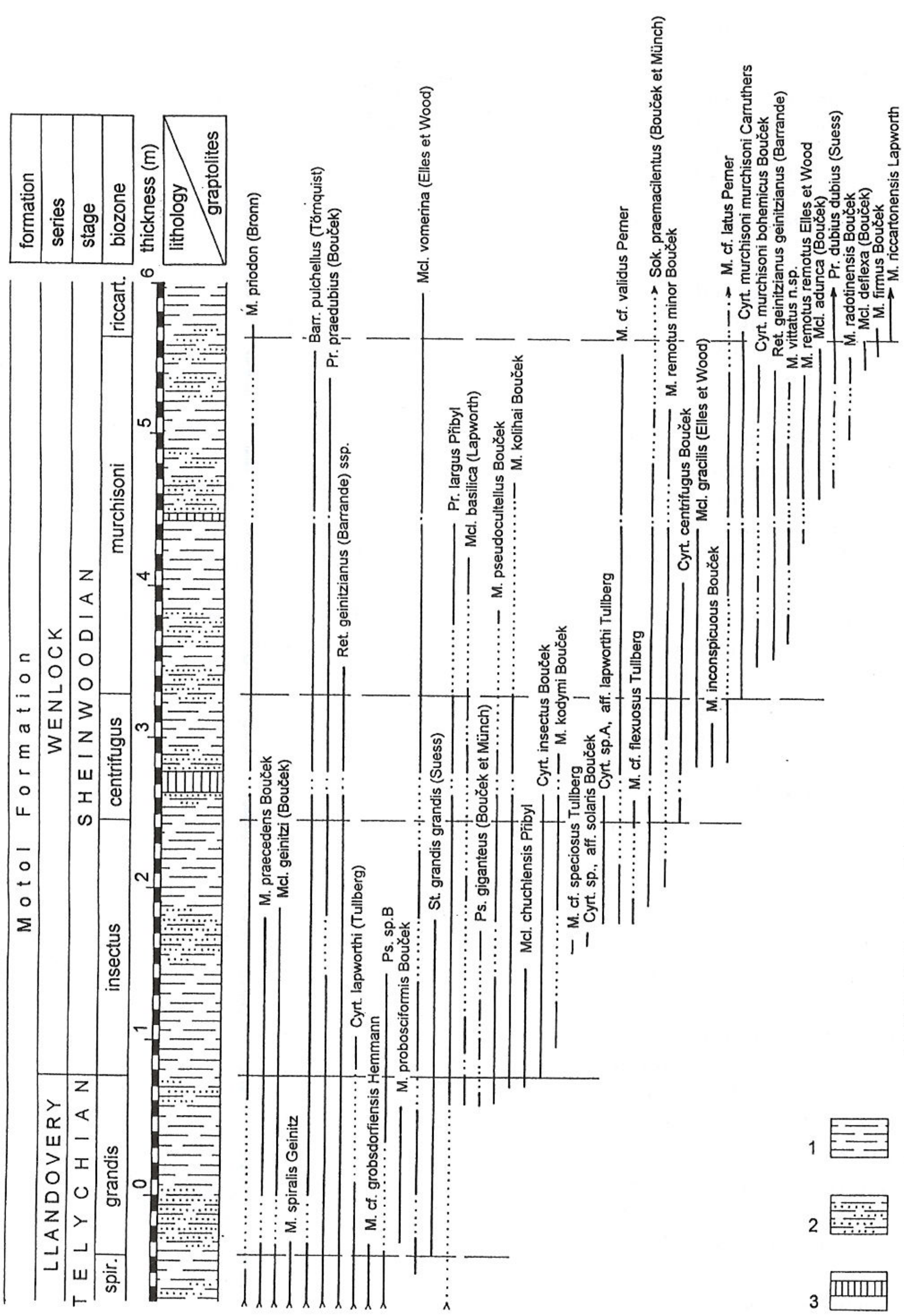



Fig. 3. Stratigraphic range of the graptolites through the Llandovery–Wenlock boundary interval at Velká Ohrada
*1* – graptolitic shale, decalcified and bleached; *2* – silty graptolitic shale, decalcified and bleached; *3* – muddy limestone, argillitized, decalcified

The uppermost part of the *spiralis* Zone is developed in form of brown–grey shales with variable silty admixture. The graptolite assemblage is characterized by common *Monograptus praecedens* (Bouček), *Monograptus spiralis* Geinitz, *Monograptus* cf. *grobsdorfiensis* Hemmann, *Monoclimacis geinitzi* (Bouček), and *Cyrtograptus lapworthi* Tullberg. Uncommon rhabdosomes of *Pseudoplegmatograptus* aff. *obscurus* Bouček and Münch are confined to this part of the sequence. *Monograptus wimani* Bouček, and *Streptograptus speciosus* (Tullberg) disappear about 1 m below the base of the succeeding *grandis* Zone. White bed of decalcified argillitized muddy limestone, 8 cm in thickness, can be regarded as useful marker horizon 0.9 m below the base of the *grandis* Zone at Velká Ohrada.

The *Stomatograptus grandis* Zone (partial–range zone after Štorch 1994) is well recognizable in the section. The shales become still less silty, having some bedding planes crowded by rather monotonous graptolite associations (composed by *Mcl. geinitzi* (Bouček), *Pseudoplegmatograptus obesus* ssp. a.o.). The base of 1.2 m thick zone is defined by the appearance of common and well determinable *Stomatograptus grandis grandis* (Suess) soon followed by another characteristic taxon – *Monograptus probosciformis* Bouček. A single specimen of bivalve *Praecardium* sp.n. (det. J. Kříž) was found in the lower part of the zone.

Several characteristic species of the succeeding *Cyrtograptus insectus Zone* [*Monograptus kolihai* Bouček, *Monograptus pseudocultellus* Bouček, *Monoclimacis basilica* (Lapworth), *Monoclimacis chuchlensis* Bouček, and *Pseudoplegmatograptus giganteus* Bouček and Münch] appear below the top of the *grandis* Zone. They are followed by *Cyrtograptus insectus* Bouček at the base of the *insectus* Zone (partial–range zone by Štorch 1994). Just above this level *Cyrtograptus lapworthi* (Tullberg) disappears, being relieved by *Monograptus kodymi* Bouček. Another graptolite taxa [e.g. *Pseudoplectograptus praemacilentus* (Bouček and Münch) and *Monograptus remotus minor* Bouček] appear whilst *St. grandis grandis* (Suess), *Mcl. chuchlensis* Přibyl, and *Pseudoplegmatograptus* sp.B (ex gr. *obesus*) disappear in the upper part of the *insectus* Zone. About 1.7 m thick zone is composed by alternation of more and less silty, greyish, often laminated graptolitic shales.

The base of the *Cyrtograptus centrifugus* Zone is marked by common, mostly juvenile procladia of *Cyrt. centrifugus* Bouček. Besides the index species the graptolite association is dominated by *Monograptus priodon* (Bronn), *Monograptus* cf. *validus* Perner, *Monoclimacis vomerina* (Elles and Wood), and *Retiolites geinitzianus* ssp. Also *Mcl. basilica* (Lapworth), *M. kolihai* Bouček, *M. pseudocultellus* Bouček, and *Psp. praemacilentus* (Bouček and Münch) are common. In about the middle of the zone *M. kodymi* Bouček disappears and *M.* cf. *latus* Perner, *M. inconspicuous* Bouček, and *Mcl. gracilis* (Elles and Wood) appear.

At Velká Ohrada the lower part of uniform, 0.8 m thick sequence of brown–grey silty shales of the *centrifugus* Zone (partial–range zone) is disrupted by second, white, 14 cm thick, bed of argillitized muddy limestone.

At Velká Ohrada the base of *Cyrtograptus murchisoni* Partial –range zone is marked by the first occurrence of *Cyrtograptus murchisoni bohemicus* Bouček. Rare *Cyrt. murchisoni murchisoni* Carruthers appears little higher. The two subspecies are hard to tell apart when fragmentary and/or not well preserved. *Cyrt. murchisoni bohemicus* seems to be much more common than the nominate subspecies. Besides *Cyrt. murchisoni bohemicus* Bouček and mumerous long-ranging species (such as *M. priodon, M. validus, Mcl. vomerina, Pr. largus, Pr. praedubius*) the *murchisoni* Zone assemblage is composed by *Ret. geinitzianus geinitzianus* (Barrande), *Monograptus remotus minor* Bouček, *M. remotus remotus* Elles and Wood, *Monograptus vittatus* sp.n., and *Mcl. gracilis* Elles and Wood. *Monograptus radotinensis* Bouček, *?Monoclimacis adunca* (Bouček), and *Pristiograptus dubius dubius* (Suess) are confined to the upper part of 2.4 m thick *murchisoni* Zone. *Monoclimacis deflexa* (Bouček) and *M. firmus* Bouček were found just below the first *Monograptus riccartonensis* Lapworth – the zonal index species of the next zone. The *murchisoni* Zone is composed by decalcified and bleached brown–grey shales with variable silty admixture. The third horizon of white, decalcified and argillitized muddy limestone, 6 cm in thickness, occurs in about the middle of the zone.

Nongraptolite fauna of the *murchisoni* Zone is represented by flattened nautiloid shells ("*Dawsonoceras*", surprisingly common "*Phragmoceras*" a.o.), *Aptychopsis* sp., and rare brachiopods *Valdaria budili* Havlíček. Several mm long chains of chitinozoan cysts are frequent on bedding planes. Dendroid graptolites were represented by rare fragments of *Dictyonema* sp., and *Dendrograptus* sp.

The base of about 2 m thick *Monograptus riccartonensis* Zone (taxon–range zone) is accompanied by almost total breakdown of diversified graptolite assemblage of the *murchisoni* Zone. Fifteen of its 19 graptolite species disappeared at about the base of the *riccartonensis* Zone and only one – *M. riccartonensis* Lapworth – appeared, being possible successor of *M. firmus*. Retiolitids, *Barrandeograptus,* and *Cyrtograptus* disappeared, *Monograptus* and *Monoclimacis* were severely reduced in both species diversity and abundance. Bedding planes of soft, brownish, decalcified shales are crowded by siculae whilst mature graptolite rhabdosomes, mostly of *M. riccartonensis* Lapworth are uncommon. Mass juvenile mortality characterizes both the present zone and succeeding *dubius* Zone. The two zones yield good evidence of one of big crises in graptolite history. The *riccartonensis* Zone assemblage consists of common rhabdosomes of the index species accompanied by infrequent *M.* cf. *latus* Perner, *Monoclimacis hemipristis* (Meneghini), and *Pr. dubius dubius* (Suess). *Pseudoplegmatograptus wenlockianus* Štorch was found in about the middle of the zone, *Pr. dubius latus* Bouček appears in the upper part of the zone. *Monograptus solitarius* Bouček and *Streptograptus antennularius* (Meneghini), reported by Bouček (1953), have not been recorded at present section.

At Velká Ohrada the graptolite bearing sequence finished with about 2.2 m of pale–brown, soft, decalcified shales of the *Pristiograptus dubius* Zone. The graptolite fauna is represented by *Pr. dubius dubius* (Suess) and *Pr. dubius latus* (Bouček). Many bedding planes are crowded by isolated siculae. The zone was taken by Štorch (1994) as the interval zone of *Pr. dubius* ranging from the last occurrence of *M. riccartonensis* up to the appearance of *Monograptus belophorus* (Meneghini).

Graptolite shales are succeeded by white to green, often spotted, argillitized basalt hyaloclastites and tuffs, more than 10 m in thickness, intercalated with badly weathered lenses of biodetrital limestones. Volcaniclastites are related to adjacent Řeporyje volcanic centre (Kříž 1990). They belong to initial period of volcanic activity, common to Řeporyje and Svatý Jan volcanic centres, and dated by underlying sediments of the *dubius* Zone and overlying sediments of *belophorus* Zone (Štorch 1991 MS). At present section the volcaniclastics are cutted by erosional disconformity and covered by Cretaceous sandstones.

## Conclusions

A total of 43 graptolite species have been recorded in the *grandis, insectus, centrifugus,* and *murchisoni* Zones. Graptolite taphocenoses account for gradual increase in species diversity, without any prominent radiation and/or extinction events. Despite this statement, several well determinable species of promising correlative potential appear at about the base of the *insectus* Zone (*Ps. giganteus, M. kolihai, M. kodymi, M. pseudocultellus, Mcl. basilica, Mcl. chuchlensis,* and *Cyrt. insectus*). The base of the succeeding *centrifugus* Zone lacks such distinct faunal change.

The base of the Wenlock Series was formally placed at the base of the *centrifugus* Zone in the Wenlock area in England. Graptolite evidence of the *centrifugus* Zone, however, is insufficient in the type area, being based on the presence of *Pr. watneyae* and *Mcl.* aff. *vomerina* the stratigraphic range of which is not well known. In general, the graptolites are neither common and diverse in the type Wenlock area (Holland and Bassett 1989) and precise correlation with graptolite–rich sequences is difficult. Graptolite zones equal to the *grandis* and *insectus* Zones of Bohemia have not yet been recognized in Great Britain (Bassett et al. 1975, Rickards 1976, White et al. 1992). According to some graptolite successions elsewhere (Bornholm Island, Bjerreskov 1975, Arctic Canada, Lenz and Melchin 1990, China, Mu et al. 1986, and Poland, Teller 1969) *Cyrt. insectus* occurs along with or in the lower part of stratigraphic range of *Cyrt. centrifugus.* In the Barrandian area, however, *Cyrt. insectus* clearly precedes *Cyrt. centrifugus* as already shown by Bouček (1953) and Štorch (1991). Here the appearance of *Cyrt. insectus* is accompanied by a distinct change in the associated graptolite fauna as opposed to a very minor change at the base of the *centrifugus* Zone. The faunal change at the base of the *insectus* Zone in Bohemia is correlable to that observed at the base of the *centrifugus* Zone where the *insectus* Zone is not recognized. That is why in Bohemia the base of the Wenlock Series is placed traditionally at the base of the *insectus* Zone despite the last zonal chart by Loydell and Cave (1993) which refered the Bohemian *insectus* Zone to the top of the Llandovery Series.

The above described Llandovery–Wenlock boundary reference section at Velká Ohrada is remarkable from another points of view as well.

The *Hirnantia* Fauna (Havlíček 1982, Štorch 1986) and *Glyptograptus persculptus* (= *bohemicus*) were found in the light mudstones just below the top of the upper Ordovician Kosov Formation. The mudstones were succeeded by long period of nondeposition (Štorch 1986, 1991). Both Rhuddanian, Aeronian, and lower Telychian sediments are missing and the Kosov mudstones are overlain by thick basal mudstone of the Litohlavy Formation.

At Velká Ohrada the first graptolite shales above the basal mudstone of the Litohlavy Formation contain graptolites of the *griestoniensis* Zone. The basal mudstone attained the highest stratigraphic level in the sequence if compared to the other localities in the Barrandian area. Thin laminae of clayey breccias in the *griestoniensis* and lower *tullbergi* Zones could be related to big storms or some unknown volcanic events. Basalt tuffs and hyaloclastites overlying the graptolite shales of the *dubius* Zone document the first eruptions in the adjacent Řeporyje volcanic centre.

Depositories of the graptolite material. Abbreviations are used as follows: PŠ – author's collection at Czech Geological Survey, Prague, L – National Museum, Prague, GSE – Institute of Geological Sciences, Edinburgh.

## Systematic part

### Family Monograptidae Lapworth, 1873

D i a g n o s i s : See Mitchell, 1987 for Monograptinae.

### Genus *Monograptus* Geinitz, 1852, emend Bulman, 1970

T y p e s p e c i e s (subsequent designation by Bassler, 1915): *Lomatoceras priodon* Bronn, 1835, from the Silurian of Germany.

D i a g n o s i s : After Bulman, 1970.

### *Monograptus pseudocultellus* Bouček, 1932

Pl. II, fig. 6; pl. III, figs. 5, 6; text–fig. 5, figs. 12–14

1932 *Monograptus pseudocultellus* n. sp., Bouček, p. 153, text–fig. 1g.

H o l o t y p e : By monotypy. The specimen no. L 30165 from the Motol Formation at Vyskočilka near Malá Chuchle, Prague, Bohemia.

M a t e r i a l : About 80 flattened complete specimens from Velká Ohrada and Vyskočilka, including the type collection.

D e s c r i p t i o n : The rhabdosome is small, weakly dorsally flexed, having a slightly ventrally reflexed proximal end. The maximum length is 12 mm. The dorso–ventral width increases quickly from 0.75–0.9 mm at th1 and 0.95–1.1 at th3 to the maximum of 1.1–1.2 (1.4) mm which is attained at th5.

The sicula is prominent, 1.3–1.5 mm long. The apex reaches to about the base of th2. The sicular aperture is 0.2–0.3 mm wide, and is furnished with a 0.3–0.4 mm long virgella. The stipe is terminated by a few mm long nema.

The first theca originates 0.2–0.3 mm above the sicular aper- ture. The length of the th1 is 0.75–0.95 mm. The thecae are hooked, of modified *priodon* type. The prothecae are robust, box–like, having the free ventral wall weakly inclined or almost parallel to the rhabdosome axis. The S–shaped interthecal septum is nearly perpendicular to the rhabdosome axis. The metathecae grow slightly upwards, then turn downwards and form slender but prominent hooks terminated by dorso–proximally facing apertures. The metathecal hook occupies two–fifths of the width of the rhabdosome. The closely packed thecae number about 6.5 in distal 5 mm. The two–thecae repeat distance of th2 (2TRD 2) is 1.2–1.3 (1.1–1.4) mm, the 2TRD 5 is 1.35–1.6 mm.

R e m a r k s : *M. pseudocultellus* Bouček is easily distinguished from *M. cultellus* Törnquist, as well as from any other Telychian and Sheinwoodian monograptids, by the general form and size of the rhabdosome and broad, box–like prothecae terminated by prominent but slim, hooked metathecae. The present material of *M. pseudocultellus* matches well Bouček s (1932) type material.

### *Monograptus kolihai* Bouček, 1931

Pl. II, fig. 4; pl. IV, fig. 8; text–fig. 5, figs. 6, 11, 18

1931b *Monograptus kolihai* n. sp., Bouček, p. 8, text–fig. 8a, b.

1951 *Monograptus (Mediograptus) kolihai* Bouček, 1931, Bouček and Přibyl, p. 14, pl. 3, figs. 4, 5, text–fig. 3g, h

L e c t o t y p e : Designated Přibyl (1948, p.39). The specimen no. L 30671 figured by Bouček (1931b, fig. 8a) from the Motol Formation of Vyskočilka near Malá Chuchle, Prague, Bohemia.

M a t e r i a l : 28 flattened, mostly complete rhabdosomes from Velká Ohrada and Řepy, and the type collections of Bouček (1931b) and Bouček and Přibyl (1951).

D i a g n o s i s : Rhabdosome small, slender, dorsally curved, widening from 0.4–0.6 mm to the maximum of 0.55–0.75 mm which is attained at th3–th6. Sicula small, apex reaching the first metathecal lobe. The distance between sicular aperture and the first metatheca is 0.8–1.0 mm. Prothecae long, tubular, metathecae lobate, incurved. Apertures face the ventral wall of the protheca and are expanded into lateral processes. They are always distant from the ventral prothecal wall. The 2TRD 2 is 1.9–2.1 mm, 2TRD 10 = 3.1–3.5 mm, distal thecae number 6 in 10 mm.

D e s c r i p t i o n . The rhabdosome is dorsally curved throughout, though the curvature is stronger in the proximal part. Commonly the length is 10–20 mm and it rarely exceeds 30 mm. The rhabdosome widens rapidly from the initial width of 0.4–0.6 mm at the level of th1 to the maximum 0.55–0.75 mm which is reached at th3–th6.

The sicula is small but prominent, 0.8–0.95 mm long and 0.2–0.25 mm wide aperturally. The apex reaches almost to the level of the first thecal lobe. Long, 0.25–0.4 mm wide tubular prothecae are terminated by short, lobate metathecae. Prominent metathecal lobes occupy half to three–fifths of the width of the rhabdosome. The metathecae are incurved, obscuring completely the dorsal–facing aperture. The aperture is always separated from the ventral wall of the protheca. The present flattened material, shows that the metathecal lobe expands transversely into symmetrical lateral processes. The thecae overlap for about one–quarter of their length. The distance between the sicular aperture and th1 aperture is 0.8–1.0 mm. The two thecae re–

peat distance (2TRD) is (1.6) 1.9–2.1 mm at the level of th2. The 2TRD 5 is 2.4–3.0 (3.2) mm and 2TRD 10 is 3.1–3.5 mm (3.65 mm). The distal thecae number about 6 in 10 mm.

R e m a r k s : The metathecal lobes of *M. kolihai* have never been seen adjoining the ventral walls of the prothecae as they often did in other related species. The spiny appearance of the apertural margin was created by flattening and distortion of the theca in the course of rock compaction. The author supposes that the metathecae of *M. kolihai* are similar to those described by Teller (1986) as the isolated proximal fragments of his *M. flexuosus* Tullberg. In all their diagnostic features and dimensions the specimens from Velká Ohrada agree with the type material of Bouček (1931) from Vyskočilka.

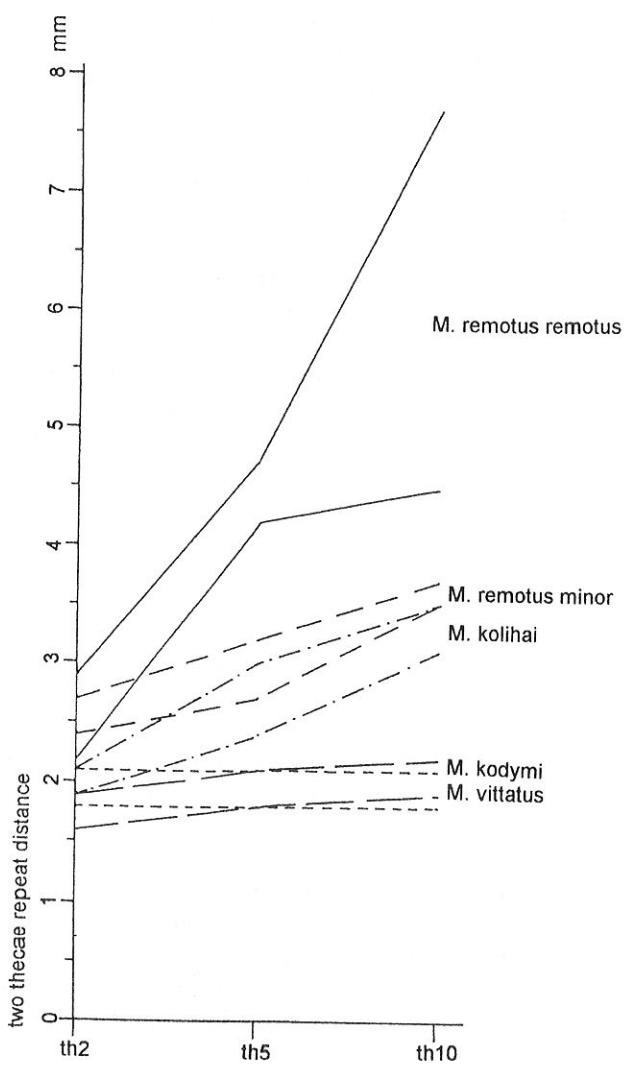



Fig. 4. The differences in the 2TRD values among *M. kolihai, M. kodymi, M. vittatus, M. remotus remotus* and *M. remotus minor*

*Monograptus kodymi* Bouček, 1931

Pl. II, figs. 4, 5; pl. IV, fig. 5; text–fig. 5, figs. 17, 19

1931b *Monograptus kodymi* n. sp., Bouček, p. 8, text–fig. 8e,f.

1951 *Monograptus (Mediograptus) kodymi* Bouček, 1931, Bouček and Přibyl, p. 16, pl. 3, figs. 1–3, text–fig. 3d.

?1965 *Monograptus danbyi* sp. nov., Rickards, p. 266, pl. 30, fig. 2, text–fig. 3h.

L e c t o t y p e : Designated Přibyl (1948, p. 39). The specimen no. L 30669 figured by Bouček (1931b) from the Motol Formation at Vyskočilka near Malá Chuchle, Prague. Bohemia.

M a t e r i a l : 28 flattened, mostly complete rhabdosomes from Velká Ohrada and Řepy, and the type collections of Bouček (1931b) and Bouček and Přibyl (1951) from Vyskočilka.

D i a g n o s i s : The slender, dorsally curved rhabdosome widens from 0.4–0.6 mm to the maximum 0.65–0.85 mm within the 4–7 proximal thecae. Dorsal curvature is accentuated proximally. Sicula 0.85 –1.0 mm long, the apex reaching the first metathecal lobe. Prothecae tubular, metathecae with prominent, transversely expanded symmetrical lobes. Incurved lobe occupies about half of the rhabdosomal width. The 2TRD 2 = 1.6–1.9 mm, 2TRD 10 = 1.9–2.2 mm, distal thecae number 9.5–10.5 in 10 mm.

D e s c r i p t i o n . The slender rhabdosome rarely exceeds 20 mm in length. It is dorsally curved throughout but the most prominent curvature is confined to its proximal part. The rhabdosome widens from 0.35–0.6 mm (at the level of the first metathecal lobe) to 0.45–0.7 mm, at the level of th3 up to the maximum 0.65–0.85 mm which is reached at th4–th7.

The small but prominent sicula is 0.85–1 mm long and 0.2 mm wide aperturally. The sicular apex reaches the first metatheca. The ventral walls of the tubular prothecae are parallel to the dorsal wall of the rhabdosome. The dorsal walls of the short, incurved metathecae form large lobes which, perhaps, completely cover the proximo–dorsally or dorsally facing apertures. The metathecal lobe is slightly transversely expanded into two symmetrical lateral processes. The lobe is not fully in contact with the free ventral prothecal wall, and occupies about half of the total width of the rhabdosome. The thecae overlap for about quarter of their length. The two thecae repeat distance – 2TRD 2 is 1.6–1.9 mm, 2TRD 5 = (1.6) 1.8–2.1 mm, 2TRD 10 = 1.9–2.2 mm. The most distal thecae number 9.5–10.5 in 10 mm.

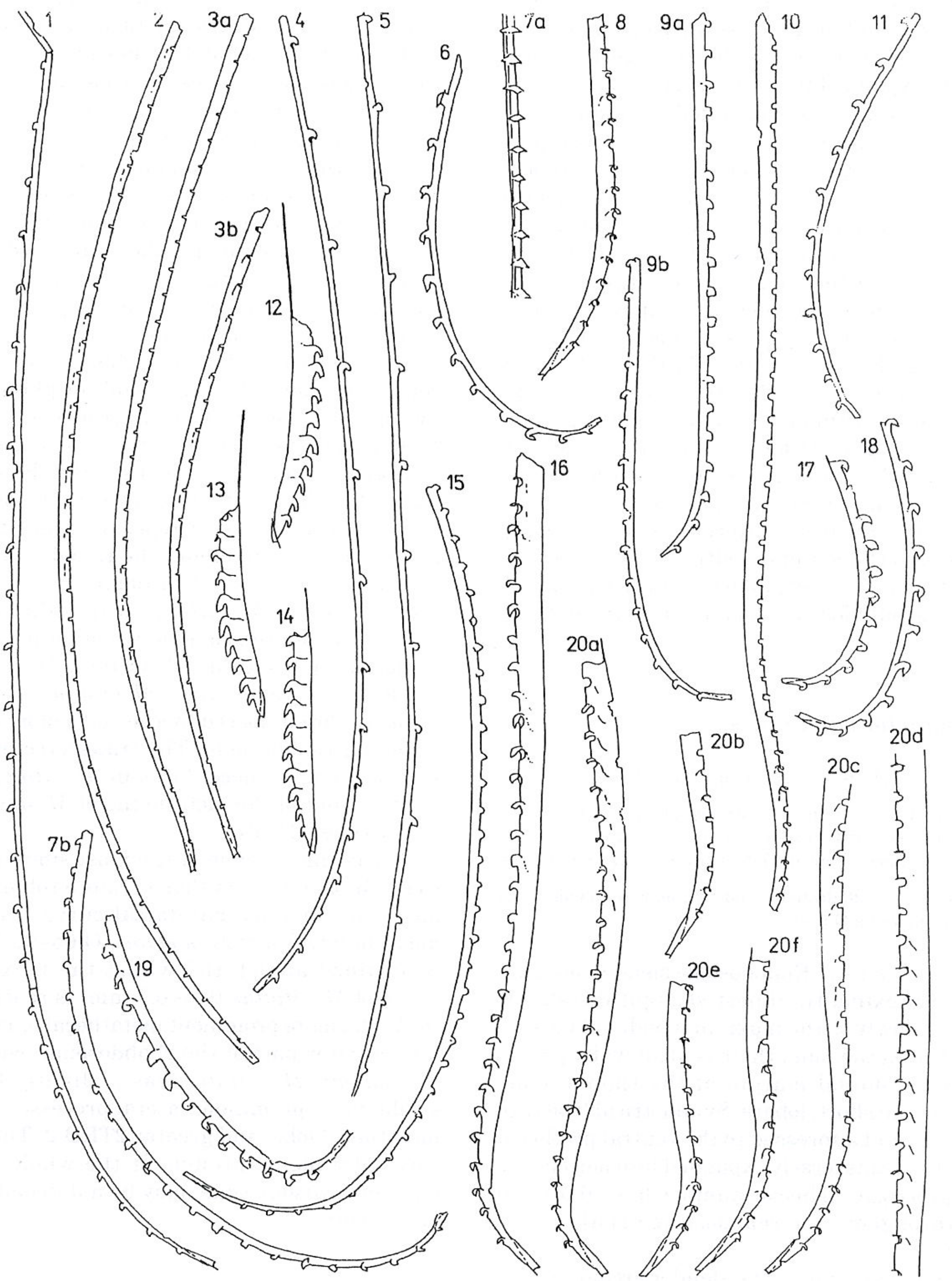



Fig. 5.
1 – *Monograptus remotus minor* Bouček, 1931, PŠ 485, (*murchisoni* Zone)
2, 3a, b – *Monoclimacis chuchlensis* Přibyl, 1941, 2 – PŠ 484, 3a,b PŠ 487, (*insectus* Zone)
4, 5 – *Monograptus remotus remotus* Elles and Wood, 1913, 4 – PŠ 586/1, 5 – PŠ 586/2, (*murchisoni* Zone)
6, 11, 18 – *Monograptus kolihai* Bouček, 1931, 6 – PŠ 481, 11 – PŠ 467, 18 – PŠ 477/1, (11 – *insectus* Zone, 6, 18 – *centrifugus* Zone)
7a, b, 9a, b, 15 – *Monograptus vittatus* sp. n., 7a, b – PŠ 466, 9a,b – PŠ 483, 15 – PŠ 476, (*murchisoni* Zone)
8, 10, 16, 20a–f – *?Monoclimacis adunca* (Bouček, 1931), 8 – PŠ 479/2 10 – PŠ 479/1, 16 – PŠ 482, 20a–f – PŠ 475, (*murchisoni* Zone)
12, 13, 14 – *Monograptus pseudocultellus* Bouček, 1932, 12 – PŠ 478/1, 13 – PŠ 478/2, 14 – PŠ 480, (*insectus* Zone)
17, 19 – *Monograptus kodymi* Bouček, 1931, 17 – PŠ 599/1, 19 – PŠ 599/2, (*insectus* Zone)
(All specimens from Velká Ohrada, x4, except of fig. 10 (x2)

Remarks: *M. kodymi* is characterized by prominent and rather closely packed thecae the metathecal lobes of which are slightly transversely expanded into lateral processes. Paired lateral processes were recorded in obliquely oriented rhabdosomes. A nodular, almost streptograptid appearance was given to the metathecae when they were flattened in normal (i.e. dorsoventral) position. The average dimensions of *M. kodymi* from both Velká Ohrada, Řepy, and Vyskočilka differ slightly from those of the lectotype which is rather wide (up to 0.85 mm) and has less densely packed thecae (2TRD 2 = 1.9 mm, 2TRD 5 = 2.1 mm, 2TRD 10 = 2.2 mm). All the parameters of Bouček's type specimens lie, however, within the variability of the present material. Teller (1986) synonymized both *M. kodymi, M. kolihai,* and *M. remotus minor* (former *kolihai minor)* with his *M. flexuosus* despite their entirely different thecal spacing, shape, and rhabdosome width. The incurved, lobate, transversely expanded metathecae appear to be the only feature common to some of these species.

*Monograptus vittatus* n. sp.

Pl. IV, figs. 3 ,4, ?6; text–fig. 5, figs. 7a,b, ?9a,b, 15

Holotype: Complete, flattened specimen no. PŠ 476 (pl. VI, fig.4, text–fig. 4, fig. 15), from the *Cyrt. murchisoni* Zone of Velká Ohrada, Prague, Bohemia.

Material: 26 flattened, mostly complete rhabdosomes from Velká Ohrada.

Diagnosis. Rhabdosome slender, dorsally curved proximally, almost straight distally. It widens slowly to the maximum width of 0.6–0.7 mm. Prothecae long, their ventral walls parallel to the dorsal margin of the rhabdosome. Metathecae short, lobate. Symmetrical lobes are incurved and adpressed to the ventral prothecal wall, and transversely expanded into paired lateral processes. Thecae number 9.5–10.5 in 10 mm throughout the rhabdosome (2TRD = 1.8–2.1 mm).

Description. The slender arcuate rhabdosome attains a length of more than 40 mm. The dorsal curvature is prominent proximally, much less so distally. The initial width of the rhabdosome, i.e. height of the first theca, is 0.3–0.35 (0.25–0.4) mm. The rhabdosome is 0.35–0.4 (0.5) mm wide at the level of th3 and slowly widens to the maximum of (0.55) 0.6–0.7 mm reached at about th15.

The sicula is 1–1.2 mm long, the apex reaches up to the first metathecal lobe. The sicular aperture, about 0.2 mm wide, is provided with a short, thin virgella. The distance between the sicular aperture and the dorsal wall of the first theca is 1.1–1.4 (1.7) mm.

The thecae have tubular prothecal portions having ventral walls parallel to the dorsal wall of the rhabdosome. The short, incurved metatheca forms a prominent lobe, adpressed to the protheca and covering the thecal aperture. The metathecal lobe is transversely expanded into symmetrical lateral processes which are well seen when the rhabdosome is obliquely or dorsoventrally oriented to the bedding plane. The "wing–span" of the lateral processes in the "scalariform" view is about 0.6 mm. The thecal lobe occupies about two–fifths of the rhabdosomal width. Thecae overlap a little in the present material. The two thecae repeat distance (2TRD) is 1.8–2.1 mm throughout the rhabdosome and thecae number 9.5–10.5 in 10 mm.

Remarks. *M. vittatus* n.sp. differs from most of the related slender streptograptid–like monograptids (such as *M. kolihai, M. remotus remotus, M. remotus minor, M. minimus*) in having more closely spaced thecae and a more slowly widening rhabdosome. The transverse expansion of the metathecal lobes in *M. vittatus* resembles that of the metathecae of *M. flexuosus* sensu Teller (1986).

The rhabdosome of the most similar species – *M. kodymi* – is shorter, more robust, and has stronger proximal dorsal curvature. The maximum width of *M. kodymi* (O.65–0.85 mm) is attained at th4–th7 whilst the maximum width of *M. vittatus* (0.6–0.7 mm) is reached at th15. The more prominent metathecal lobes take up a greater part of the rhabdosomal width in *M. kodymi. M. vittatus* has a slightly longer sicula, more prominent lateral processes on the metathecal lobe, and greater 2TRD 2. The species, infrequent throughout the whole of the *Cyrt. murchisoni* Zone, may be a descendant of *M. kodymi.*

*Monograptus remotus remotus* Elles and Wood, 1913

Text–fig. 5, figs. 4, 5

1913 *Monograptus remotus,* sp. nov., Elles and Wood, p. 461, pl. 46, fig. 9a,b, text–fig. 319.

?1926 *Monograptus remotus* Elles and Wood, Gortani, p. 10, pl. figs. 12,13.

?1945 *Monograptus remotus* Elles and Wood, Waterlot, p. 84, pl. 39, p. 403

1951 *Monograptus (Mediograptus) remotus* Elles and Wood, 1913, Bouček and Přibyl, p. 18, pl. 3, fig. 6, text–fig 3i,j.

Lectotype: Designated Přibyl (1948, p. 39). The specimen no. GSE 2622 figured by Elles and Wood (1913, pl. 46, fig. 9b, text –fig. 319) from Gala Beds of Rigg Burn, NNW of Langholm. Scotland.

Material: 15 flattened, mostly incomplete specimens from Velká Ohrada and Motol, and the specimen figured by Bouček and Přibyl (1951).

Diagnosis: Rhabdosome very slender, dorsally curved proximally, almost straight distally. It widens slowly from 0.35–0.4 mm to the maximum of 0.55 mm. Prothecae long slender tubes terminated by small, incurved, lobate metathecae. Metathecal lobe adpressed to the ventral prothecal wall. Thecal spacing increases dramatically distally (2TRD 2 = 2.2–2.9 mm, 2TRD 5 = 4.2–4.7 mm, and 2TRD 10 = 4.5–7.7 mm). Distal thecae number 3 in 10 mm.

Description: The rhabdosome is arcuate proximally and becomes almost straight distally. The longest measures 44 mm. The dorso –ventral width increases slowly from 0.35–0.4 mm at the level of the first metatheca to the distal maximum of 0.55 mm.

The sicula is about 0.8 mm long and 0.2 mm wide aperturally. Its apex reaches the dorsal wall of the first metatheca. The prothecae are very long, slender tubes. Small, incurved, lobate metathecae occupy less than half of the dorsoventral width of the rhabdosome. They are adpressed to ventral prothecal walls. The first metathecal lobe grows up 0.8–1.0 mm above the sicular aperture. The two thecae repeat distance is 2.2–2.9 mm at the level of th2 (2TRD 2). The 2TRD 5 = 4.2–4.7 mm and 2TRD 10 = 4.5–7.7 mm. The most distal thecae number about 3 in 10 mm.

Remarks: The present material matches the type one figured by Elles and Wood (1913) in both the dorsal curvature of the rhaddosome, thecal spacing and shape. The thecal lobes take up the same proportion of the total width of the rhabdosome. They are probably simple, without prominent lateral processes, although the appearance of the thecal lobes may be much influenced by mode of preservation.

*Monograptus remotus minor* Bouček, 1931

Text–fig. 5, fig 1

1931b *Monograptus kolihai minor* n. var., Bouček, p. 8, text–fig. 8c,d.

1951 *Monograptus (Mediograptus) kolihai minor* Bouček, 1931, Bouček and Přibyl, p. 15, pl. 3, figs. 7,8, text–fig. 3e,f.

Lectotype: Designated Přibyl (1948, p. 39). The specimen no. L 30667 figured by Bouček (1931b, fig. 8d) from the *Cyrt. murchisoni* Zone of Vyskočilka near Malá Chuchle, Prague, Bohemia.

Material: 28 flattened, mostly fragmentary rhabdosomes from Velká Ohrada, 10 rhabdosomes from Motol, and the type collection of Bouček (1931b).

Diagnosis: Slender, several cm long rhabdosome, dorsally curved throughout, the curvature accentuated proximally. The initial width 0.3–0.35 mm, the maximum 0.5–0.55 mm reached by th5–th10. Tubular prothecae long and slender, short metathecae incurved and adpressed to the rhabdosome. The 2TRD 2 = 2.4–2.7 mm, 2TRD 5 = 2.7–3.2 mm, 2TRD 10 = 3.5–3.7 mm. Distal thecae number 5 in 10 mm.

Description: The slender, arcuate rhabdosome attains a length of more than 7 cm. Its proximal end is dorsally curved whilst the distal portion is only weakly flexed. The dorso–ventral width of the rhabdosome increases slowly from 0.3–0.35 mm at the level of the first metatheca to the maximum of 0.5–0.55 mm which is reached between th5 and th10.

The sicula is 0.8–1.2 mm long and its apex reaches to almost the first metathecal lobe. The sicular aperture is 0.2 mm wide, and is furnished with a short, thin virgella. The distance between the sicular aperture and the first metatheca is about 1.3 mm. The short, incurved, lobate metathecae grow out from the long, tubular prothecae. Metathecal lobes adpressed to the ventral prothecal wall occupy two–fifths to half of the total width of the rhabdosome and cover the apertures. Thecal overlap appears to be rather low. The 2TRD 2 is 2.4–2.7 mm, 2TRD 5 is about 3.2 mm (2.7 mm in the type specimen), and the 2TRD 10 reaches 3.5–3.7 mm. Most distally the two thecae repeat distance is about 4 mm and the thecae number 5 in 10 mm.

Remarks. Bouček (1931b) and Bouček and Přibyl (1951) considered *M. remotus minor* to be a late subspecies of *M. kolihai* Bouček. The two taxa differ however in thecal form. The metathecae in *M. kolihai* are much less adpressed to the rhabdosome, having a distinct space left between their dorsally facing apertures and the ventral prothecal walls. The lateral processes of the metathecal lobes of *M. kolihai* have not yet been recorded in *M. remotus minor*. The metathecae of *M. remotus minor* are probably close to those of *M. remotus remotus* in shape. *M. remotus minor* differs from the type subspecies in having more closely spaced thecae. Gradual distalward elongation of the prothecae is less dramatic in the former subspecies.

The type specimen of *M. remotus minor* figured by Bouček (1931b, fig. 8d) has particularly closely spaced thecae (2TRD 2 = 2.4 mm, 2TRD 5 = 2.7 mm) whilst the specimen figured as fig. 8c, as well as the other rhabdosome from the same slab of the shale, correspond to my present material in thecal spacing. The thecal shape is difficult to see in Bouček's (1931b) poorly preserved type material.

## Genus *Monoclimacis* Frech, 1897

Type species (by original designation): *Graptolithus vomerinus* Nicholson, 1872, emend. Lapworth, from the Coniston Flags (Silurian) of Northern England.
Diagnosis: After Bulman, 1970

### *Monoclimacis chuchlensis* Přibyl, 1940

Pl. IV, figs. 1, 2, 7; text-fig. 5, figs. 2, 3a,b

1940b *Monoclimacis chuchlensis* n. sp., Přibyl, p. 11, pl. 2, figs. 1–5.

Holotype: Original designation Přibyl, 1940b, figured on pl. 2, fig. 1. Specimen no. L 30672, from the *Cyrt.* insectus Zone of Vyskočilka near Malá Chuchle, Prague, Bohemia.
Material: 17 flattened, mostly complete but immature rhabdosomes from Velká Ohrada and the type collection of Přibyl (1940b) from Vyskočilka (mostly distal fragments).

Diagnosis. Rhabdosome slender, ventrally curved proximally, almost straight distally. Initial width of the rhabdosome 0.25–0.3 mm, maximum of 0.8 mm attained about 8 cm away from the proximal end. Thecae elongated, monoclimacid, having pronounced geniculum and narrow apertural excavations. Proximal thecae with tiny apertural hoods. Thecae number 9.5–10.5 in 10 mm, 2TRD is 1.8–2.2 mm throughout the rhabdosome.
Description. The rhabdosome is slender, almost straight distally. It is characterized, however, by prominent ventral curvature in the several cm long proximal portion, although the proximal end is weakly dorsally reflexed in some specimens. The dorso–ventral width of the rhabdosome increases from 0.25–0.3 mm at th1 to 0.35–0.45 mm at the level of th10. A width of 0.5 mm is reached by th15–th30. The maximum width of 0.8 mm was observed in the distalmost fragments derived from very long (over 10 cm) specimens.

The sicula is 1–1.3 mm long and 0.25 mm wide aperturally. The sicular aperture is provided with a tiny virgella and a small ventral lobe. Th1 is 0.85–1.1 mm long. The sicular apex reaches the level of its apertural excavation or a little higher up. The thecae are slender, having pronounced genicula and small, narrow, apertural excavations. The excavations occupy about one–third of the width of the rhabdosome. Tiny apertural hoods were observed in the most proximal thecae of some rhabdosomes. The free supragenicular thecal wall is parallel to the dorsal wall of the rhabdosome. It is 0.95–1.0 mm long in the distal thecae. Badly preserved interthecal septa appear to be short and the thecal overlap small. The two thecae repeat distance (2TRD) is 1.8–2.2 mm throughout the rhabdosome. Commonly the thecae number 9.5–10.5 in 10 mm.
Remarks. The present material from Velká Ohrada is composed of immature, up to 40 mm long rhabdosomes. Přibyl's original description (1940b) of *Mcl. chuchlensis*, however, was based on more distal rhabdosomal fragments than any recently found. The proximal part of *Mcl. chuchlensis* had been unknown till now.

Common features, such as thecal count, slow widening, and ventral curvature of the rhabdosome, and narrow apertural excavations, related the present immature rhabdosomes to the distal fragments of *Mcl. chuchlensis*. In addition, the medial part of the rhabdosome has been recently exposed by careful preparation on the type slab. It matches well the corresponding portions of the rhabdosomes from Velká Ohrada. *Mcl. chuchlensis* can be distinguished from all other monoclimacids by its distinctly ventrally curved, slowly widening rhabdosome, and narrow apertural excavations.

### ?*Monoclimacis adunca* (Bouček, 1931)

Pl. III, figs. 1–3, 7; text-fig. 5, figs. 8, 10, 16, 20a–f

1931b *Monograptus aduncus* n. sp., Bouček, p. 295, fig. 2a–c.
1940b *Monoclimacis adunca* (Bouček 1931), Přibyl, p. 8, pl. 1, figs. 11–13.

Lectotype: designated Přibyl (1940b, p. 8). The specimen no. L 30665 figured by Bouček (1931b, fig. 2a) from the *Cyrt. murchisoni* Zone at Vyskočilka near Malá Chuchle, Prague, Bohemia.
Material: Nearly 100 flattened, mostly complete specimens from Velká Ohrada and the type collection of Bouček (1931b) and Přibyl (1940b).

Diagnosis. Rhabdosome dorsally curved most proximally and then weakly ventrally curved, distal part straight. It widens from 0.5–0.7 mm (th1 level) and 0.6–0.8 mm (th3 level) to a maximum of 1.1 mm, reached about 8 cm away from the sicular end. Distal thecae of monoclimacid type, with strong genicula and apertural hoods. Proximal thecae with apertural hooks. Apertural hooks and hoods often prominent but can be negligible in some specimens. The 2TRD 2 = 1.6–1.8 mm, 2TRD 5 = 1.7–1.9 mm, distal thecae number 10–10.5 in 10 mm.

D e s c r i p t i o n . The rhabdosome is weakly doubly curved proximally. The most proximal portion is dorsally curved until the th5–8. Thereafter the curvature is ventral until about the th20–25. The sicula is 1.7–1.9 mm long, reaching up to the level of the dorsal wall of the first metatheca, or a little above. The sicular aperture is 0.3–0.35 mm in diameter.

The thecae (of monoclimacid type) are often provided with more or less prominent, apertural hooks and/or hoods. The proximal thecae are geniculate, with weakly inclined ventral, supragenicular walls. They are terminated by prominent, proximally facing apertural hooks of monograptid appearance. Distally the apertural hooks retreated, being reduced into the apertural hoods composed of the dorsal metathecal walls. In some specimens (e.g. the lectotype), however, particularly in the distal parts, the apertural hooks and hoods are almost negligible. Thecae in this case are of the typical monoclimacid appearance. The dorso–ventral width is 0.5 mm at the level of th1, 0.6 mm at th3, and 0.7–0.8 mm at th5 in these rhabdosomes. The maximum width of 1.1 mm is attained about 8 cm away from the sicular end. The width of those specimens, provided with prominent apertural hooks, is 0.7 mm at th1, and 0.8 mm at th3. The thecae overlap for one–third to two–fifths of their length in the distal part of the rhabdosome.

The two thecae repeat distance is 1.6–1.8 mm at the level of th2, the 2TRD 5 is 1.7–1.9 mm. Distally the 2TRD values are about 1.9 mm and the thecae number 10–10.5 in 10 mm.

R e m a r k s : Surprising variability in the apertural hooks and/or hoods and, consequently, in the thecal appearance was observed in ?*Mcl. adunca*. The rhabdosomes vary from those without apertural hooks and hoods, to those with moderately developed hoods, up to those with prominent hook–like apertural structures. No rhabdosome was found in scalariform or subscalariform position and the variability of the apertural structures does not depend on the orientation of the rhabdosome. The differences in the apertural shape between the rhabdosomes appear to have been primary.

?*Mcl. adunca* differs from ?*M. radotinensis* Bouček, 1931 by less curved proximal part of the rhabdosome and by the thecal shape. The metathecae of ?*M. radotinensis* are hooked throughout the rhabdosome and match the most proximal metathecae of ?*Mcl. adunca*.

A c k n o w l e d g e m e n t s : I thank D.K. Loydell for his helpful critical reading through the systematic part of the manuscript.

*Translated by the author*

R e f e r e n c e s

*Bassett, M. G.* et al. (1975): The type Wenlock Series. – Nat. Env. Research Council, Inst. Geol. Sci., 75, 13, 1–19. London.

*Bassler, R.* (1915): Bibliographic index of American Ordovician and Silurian fossils. – Bull. US. Nat. Mus., 92, 1–718.

*Bjerreskov, M.* (1975): Llandoverian and Wenlockian graptolites from Bornholm. – Foss. and Strata, 8, 1–94. Oslo.

*Bouček, B.* (1930): O stratigrafických poměrech pásma eα "kolonie Lapworth" u Zdic. – Čas. Nár. Muz., 104, 88–97. Praha.

– (1931a): Zpráva o nálezu zony Cyrtograptus rigidus Tullb. a jiných v českém Gotlandienu. – Věst. Stát. geol. Úst., 7, 174–181. Praha.

– (1931b): Předběžná zpráva o některých nových druzích graptolitů z českého Gotlandienu. – Věst. Stát. geol. Úst., 7, 293–313. Praha.

– (1932): Předběžná zpráva o některých nových druzích graptolitů z českého Gotlandienu. (Část II.). – Věst. Stát. geol. Úst., 8, 150–155. Praha.

– (1937): Stratigrafie siluru v dalejském údolí u Prahy a v jeho nejbližším okolí. – Rozpr. Čs. Akad. Věd, Umění, Ř. mat-přír. Věd, 46. Praha.

– (1942): O novém odkryvu siluru u Lodenic. – Zpr. Geol. Úst., 17, 165–172. Praha.

– (1946): Příspěvek k poznání siluru a nejmladšího ordoviku na pravém břehu vltavském u Prahy. – Věst. Král. čes. Společ. Nauk, 11. Praha.

– (1953): Biostratigrafie, vývoj a korelace želkovických a motolských vrstev českého siluru. – Sbor. Ústř. Úst. geol., Paleont., 20, 421–484. Praha.

*Bouček, B. – Přibyl, A.* (1951): O některých tenkých druzích rodu Monograptus Geinitz, zvláště z podrodů Globosograptus a Mediograptus. – Rozpr. Čs. Akad. Věd, Ř. mat.–přír. Věd, 61, 13, 1–31. Praha.

– (1952): Contribution to our Knowledge of the Cyrtograptids from the Silurian of Bohemia and on their Stratigraphical Importance. – Rozpr. Čs. Akad. Věd, Ř. mat.–přír. Věd, 62, 9, 1–59. Praha.

*Bulman, O.M.B.* (1970): In C. Teichert (ed.): Treatise on Invertebrate Palaeontology. Part V, Graptolithina, with sections on Enteropneusta and Pterobranchia. – Geol. Soc. Amer. and Univ. Kansas Press. Tulsa.

*Elles, G.L. – Wood, E. M. R.* (1913): A monograph of British Graptolites. – Monogr. Palaeontogr. Soc., 9, 415–486. London.

*Gortani, M.* (1926): Graptoliti del piano di Wenlock nelle Alpi Carniche. Giornale Geol. – Ann. Mus. Geol., Ser. 2, 1 Bologna.

*Havlíček, V.* (1982): Ordovician in Bohemia: Development of the Prague Basin and its benthic communities. – Sbor.

geol. Věd, Geol., 37, 103–136. Praha.

*Holland, C. H. – Bassett, M. G.* (eds.) (1989): A Global Standard for the Silurian System. – Nat. Mus. Wales, Geol. Ser., 9. Cardiff.

*Kříž, J.* (1975): Revision of the Lower Silurian stratigraphy in central Bohemia. – Věst. Ústř. Úst. geol., 50, 275–283. Praha.

– (1990): The Silurian of the Prague Basin (Bohemia) – tectonic, eustatic, and volcanic controls on facies and faunal development. *In: M. G. Bassett – P. D. Lane – D. Edwards* (eds.): The Murchison Symposium: proceedings of an international conference on The Silurian System. – Spec. Pap. Paleont., 44, 179–203. London.

*Lenz, A. C. – Melchin, M. J.* (1990): Wenlock (Silurian) graptolite biostratigraphy of the Cape Phillips Formation. Canadian Arctic Islands. – Canad. J. Earth Sci., 27, 1–13. Ottawa.

*Loydell, D.K. – Cave, R.* (1993): The Telychian (Upper Llandovery) stratigraphy of Buttington Brick Pit, Wales. – Newslett. Stratigr., 29, 91–103. Berlin, Stuttgart.

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

*Mitchell, C. E.* (1987): Evolution and phylogenetic classification of the Diplograptacea. – Palaeontology, 30, 353–405. London.

*Mu En-zhi* et al. (1986): Correlation of the Silurian Rocks of China (A part of the Silurian correlation for East Asia). – Spec. Pap. (Geol. Soc. Amer.), 202, 1–80. Boulder.

*Přibyl, A.* (1937): O stratigrafických poměrech vrstev želkovických e$\alpha_1$ u Hlásné Třebáně. – Věst. St. geol. Úst., 13, 4. Praha .

– (1938a): Stratigrafie graptolitových zon na "Vyskočilce" u Malé Chuchle. – Věda přír., 19, 112–113. Praha.

– (1938b): Graptolitová asociace v liteňských břidlicích u Hodkoviček. – Věda přír., 19, 157. Praha.

– (1940a): Stratigrafické rozčlenění graptolitových zon z takzv. "Barrandových kolonií". – Věst. Král. čes. Společ. Nauk, Tř. math. -přírodověd., 1–11. Praha.

– (1940b): Revise českých graptolitů rodu Monoclimacis, Frech. Rozpr. Čes. Akad. Věd Umění, Tř. II, 50, (23), 1–19. Praha.

– (1948): Bibliographic index of Bohemian Silurian graptolites. – Knih. St. geol. úst. Čs. Republ., 22, 1–96. Praha.

*Rickards, R. B.* (1965): New Silurian graptolites from the Howgill Fells (Northern England). – Palaeontology, 8, 247–271. London.

– (1976): The sequence of Silurian graptolite zones in the British Isles. – Geol. J., 11, 153–188. Liverpool.

*Štorch, P.* (1980): Demirastrites pribyli Bouček, 1953 (Graptolithina) and the Demirastrites pribyli Biozone in the lower Silurian of Bohemia. – Věst. Ústř. Úst. geol., 55, 305–309. Praha.

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

– (1991): Faciální vývoj, stratigrafie a korelace svrchního ordoviku a spodního siluru pražské pánve (Barrandien). – MS Ph.D. Thesis. Charles University. Prague.

– (1994): Graptolite biostratigraphy of the Lower Silurian (Llandovery and Wenlock) of Bohemia. Geol. J., 29, 137–165, Liverpool.

*Štorch, P. – Pašava, J.* (1989): Stratigraphy, chemistry, and origin of the Lower Silurian black graptolitic shales of the Prague Basin (Barrandian, Bohemia). – Věst. Ústř. Úst. geol., 64, 143–162. Praha.

*Teller, L.* (1969): The Silurian biostratigraphy of Poland based on graptolites. – Acta geol. pol., 19, 1–393. Warszawa.

– (1986): Morphology of selected Monograptidae from the Wenlock of NE Poland. – Palaeontographica, Abt. A, 192, 51–73. Stuttgart.

*Turek, V.* (1990): Comments to upper Wenlock zonal subdivisions in the Silurian of Central Bohemia. – Čas. Mineral. Geol., 35, *4,* 337–353. Praha.

*Waterlot, G.* (1945): Les graptolites du Maroc, premiere partie, généralitiés sur les graptolites. – Not. Mém. Serv. Mines Carte géol. Maroc., 63, 1–112. Rabat.

*White, D. L. – Barron, H. F. – Barnes, R. P. – Lintern, B. C.* (1992): Biostratigraphy of late Llandovery (Telychian) and Wenlock turbiditic sequences in the SW Southern Uplands, Scotland. – Trans. Roy. Soc., 82, 297–322. Edinburgh.

## Hraniční polohy llandovery a wenlocku ve facii graptolitových břidlic v Barrandienu

Graptolitové břidlice hraničních poloh llandovery a wenlocku byly detailně studovány ve stavebních výkopech na v. okraji Velké Ohrady (Praha 5) a na lokalitách Hodkovičky (železniční zářez) a Vyskočilka u Malé Chuchle. Profil u Velké Ohrady zachytil souvislý vrstevní sled od svrchní části kosovského souvrství (nejvyšší ordovik) po střední část motolského souvrství (střední část wenlocku) a je použit jako referenční profil hranice llandovery–wenlock v Barrandienu. V hraničním intervalu, zahrnujícím graptolitové zóny *St. grandis, Cyrt. insectus, Cyrt. centrifugus* a *Cyrt. murchisoni*, bylo v bohatých společenstvech zjištěno 43 druhů graptolitů. Na základě nového materiálu bylo revidováno 7 nedostatečně známých druhů: *Monograptus pseudocultellus* Bouček, 1932, *M. kodymi* Bouček, 1931, *M. kolihai* Bouček, 1931, *M. remotus remotus* Elles and Wood, 1913, *M. remotus minor* Bouček, 1931, *Monoclimacis chuchlensis* Přibyl, 1940 a *?Mcl. adunca* (Bouček, 1931). Jako nový druh byl popsán *M. vittatus* sp.n. ze zóny *murchisoni*. Studované profily ukazují významnou změnu graptolitové fauny na bázi zóny *insectus,* na rozdíl od nepatrné změny na bázi zóny *centrifugus.*

Báze wenlocku byla formálně stanovena na bázi zóny *centrifugus* v oblasti Wenlock v Anglii, na profilech s chudou graptolitovou faunou, bez diagnostických druhů. Přesná korelace bazálního stratotypu s graptolitovými sekvencemi v oblastech mimo Británii není dosud možná. Graptolitové zóny ekvivalentní českým zónám *grandis* a *insectus* nebyly v Británii dosud rozlišeny. Z graptolitových sekvencí na Bornholmu (Dánsko), v Polsku, v arktické Kanadě a v Číně je však zřejmé, že *Cyrt. insectus* se mnohde objevuje společně s *Cyrt. centrifugus*. V Barrandienu *Cyrt. insectus* předchází *Cyrt. centrifugus* a dovoluje vymezení samostatné zóny *insectus.* Báze zóny *insectus* v Barrandienu je proto korelována s bází zóny *centrifugus* v Anglii a v dalších oblastech, kde zóna *insectus* není rozlišena. Ze stejných důvodů je možno bázi wenlocku klást v Barrandienu i nadále na bázi zóny *insectus*. Profil na Velké Ohradě přinesl též nové nálezy hirnantiové fauny a *Glyptograptus persculptus (= bohemicus)* v kosovském souvrství, doklady o podmořském hiátu ve spodním a středním llandovery a údaje o stratigrafickém postavení bazálního jílovce litohlavského souvrství. Hyaloklastity v zóně *Pr. dubius* dokládají počátek bazaltového vulkanismu v řeporyjském vulkanickém centru.

## Explanation of plates

### Plate I

1 – *Cyrtograptus insectus* Bouček, 1931, PŠ 571, (*insectus* Zone).
2, 3 – *Cyrtograptus centrifugus* Bouček, 1931, 2 – PŠ 572, 3 – PŠ 488, (*centrifugus* Zone).
4 – *Cyrtograptus murchisoni bohemicus* Bouček, 1933, PŠ – 486, (*murchisoni* Zone).

All from Velká Ohrada, x 3.

### Plate II

1 – *Monograptus probosciformis* Bouček, 1931, PŠ 573, (*grandis* Zone).
2 – *Pseudoplegmatograptus giganteus* Bouček and Münch, 1952, PŠ 511b, (*grandis* Zone).
3 – *Stomatograptus grandis grandis* Suess, 1851, PŠ 574, (*grandis* Zone).
4 – *Monograptus kolihai* Bouček, 1931 and *Monograptus kodymi* Bouček, 1931, PŠ 78, (*insectus* Zone).
5 – *Monograptus kodymi* Bouček, 1931, PŠ 599/1 (*insectus* Zone).
6 – *Monograptus pseudocultellus* Bouček, 1932, PŠ 478/1, (*insectus* Zone).

1–3, 5, 6 – from Velká Ohrada, 4 – from Řepy, 1, 4–6 x5, 2 x4, 3 x2.5.

### Plate III

1–3, 7 – ?*Monoclimacis adunca* (Bouček, 1931), 1, 2, 7 – PŠ 475, 3 – PŠ 479/2, (*murchisoni* Zone).
4 – *Pseudoplectograptus praemacilentus* (Bouček and Münch, 1952), PŠ 510, (*centrifugus* Zone).
5, 6 – *Monograptus pseudocultellus* Bouček, 1931, 5 – PŠ 478/2, 6 – PŠ 480. (*insectus* Zone).

All from Velká Ohrada, 1–3 x5, 4 x10, 5, 6 x9, 7 x3.

### Plate IV

1, 2, 7 – *Monoclimacis chuchlensis* Přibyl, 1940, 1, 2 – PŠ 487, 7 – PŠ 484, (*insectus* Zone).
3, 4, ?6 – *Monograptus vittatus* n.sp., 3 – PŠ 466, 4 – PŠ 476, ?6 – PŠ 483 (*murchisoni* Zone).
5 – *Monograptus kodymi* Bouček, 1931, PŠ 599/2, (*insectus* Zone).
8 – *Monograptus kolihai* Bouček, 1931, PŠ 481, (*centrifugus* Zone).

All from Velká Ohrada, 1, 3–8 x5, 2 x3.

## *RECENZE*

**H. Miller: Abris der Plattentektonik.** – 146 str., 97 obr., Ferdinand Enke Verlag, Stuttgart, 1992.

Kniha profesora všeobecné geologie mnichovské univerzity H. Millera je určena pro širší geologickou veřejnost a studenty přírodovědných disciplin. Klade si za cíl vyplnit prostor mezi specializovanými pracemi a populárně-vědeckou literaturou, zabývající se deskovou tektonikou a s ní souvisejícími disciplínami. Jak sám autor v úvodu podotýká, kniha vychází z tradic především německé a středoevropské geologické školy. Svědčí o tom výběr citací v textu (Wegener, Stille, Ampferer aj.) a velký prostor, který je v knize věnován dnes již klasickému pojetí orogenetického cyklu a geosynklinální teorii. Už z toho je zřejmé, že čtenář od této knihy nemůže očekávat vyčerpávající přehled nejnovějších poznatků současné vědy, zejména z oblasti výzkumů rozhraní kůry a pláště, získaných moderními metodami hlubinné reflexní seizmiky, izotopové geologie atd. Kniha však podává historicky ucelený přehled vývoje názorů na základní aspekty dynamiky litosféry. Širší okruh zájemců se tak seznámí nejen se základními principy deskové tektoniky, ale může pochopit i myšlenkové proudy, které vedly k jejímu formulování a rozvinutí do dnešní podoby syntetické vědní disciplíny. Dalším kladem je i snaha autora dát deskovou tektoniku do širšího geologického rámce. Poukázat na vztah pohybů litosférických desek k magmatismu, orogenezi a vzniku ložisek nerostných surovin. K úplnému výčtu chybí jen více informací o metamorfóze, deformaci a zemětřesné činnosti.

Kniha je rozdělena do 11 kapitol. První tři úvodní kapitoly jsou věnovány teoretickým základům deskové tektoniky, nomenklatuře a historickému přehledu hlavních argumentů, které vedly k jejímu vzniku, přičemž se hlavní důraz klade na význam paleomagnetických výzkumů.

Ve čtvrté, nejrozsáhlejší kapitole, která je jádrem knihy, jsou geologicky charakterizovány litosferické desky, hlavní typy rozhraní, jejichž geologická stavba je dokumentována schematy i velice instruktivními seizmickými řezy z recentních rozhraní. Nechybí zde ani popis současné konfigurace hlavních litosférických desek a některých mikrodesek a paleogeografické rekonstrukce pohybů litosférických desek od spodního kambria do současnosti. Všechny rekonstrukce však pocházejí již z počátku 80. let a v některých případech existují již novější.

V páté kapitole podává autor velmi stručně charakteristiku magmatismu na deskových rozhraních i uvnitř desek na základě geochemie stopových prvků, což je na několika stranách textu velice obtížné. Chybí zde obsáhlejší výčet literatury, kde by si čtenář mohl doplnit potřebné informace.

V dalších dvou kapitolách autor rozebírá jednotlivé případy kolizí litosférických desek a charakterizuje stavbu různých typů kolizních orogenů, zejména na kokrétních příkladech z evropských alpid. Samostatné, i když velmi stručně pojaté kaptitoly, jsou věnovány i problematice mikrodesek a exotických terénů a genezi magmat v horkých skvrnách (kap. 7 a 8).

Poměrně značná pozornost je věnována vzniku pánví a sedimentaci v různých částech litosférických desek. Zde však autor, věren tradici, aplikuje terminologii používanou v geosynklinální teorii do současné představy o vzniku pánví a jejich deformaci v různých geotektonických prostředích.

Závěrečné kapitoly jsou věnovány distribuci ložisek nerostných surovin vzhledem k jednotlivým petrotektonickým rozhraním, jejich sepětí s geologickými procesy na okrajích i uvnitř litosférických desek a shrnutí dosavadních poznatků. Jsou zde diskutovány zejména modely plášťové konvekce, geneze magmat a dynamiky pohybů litosférických desek.

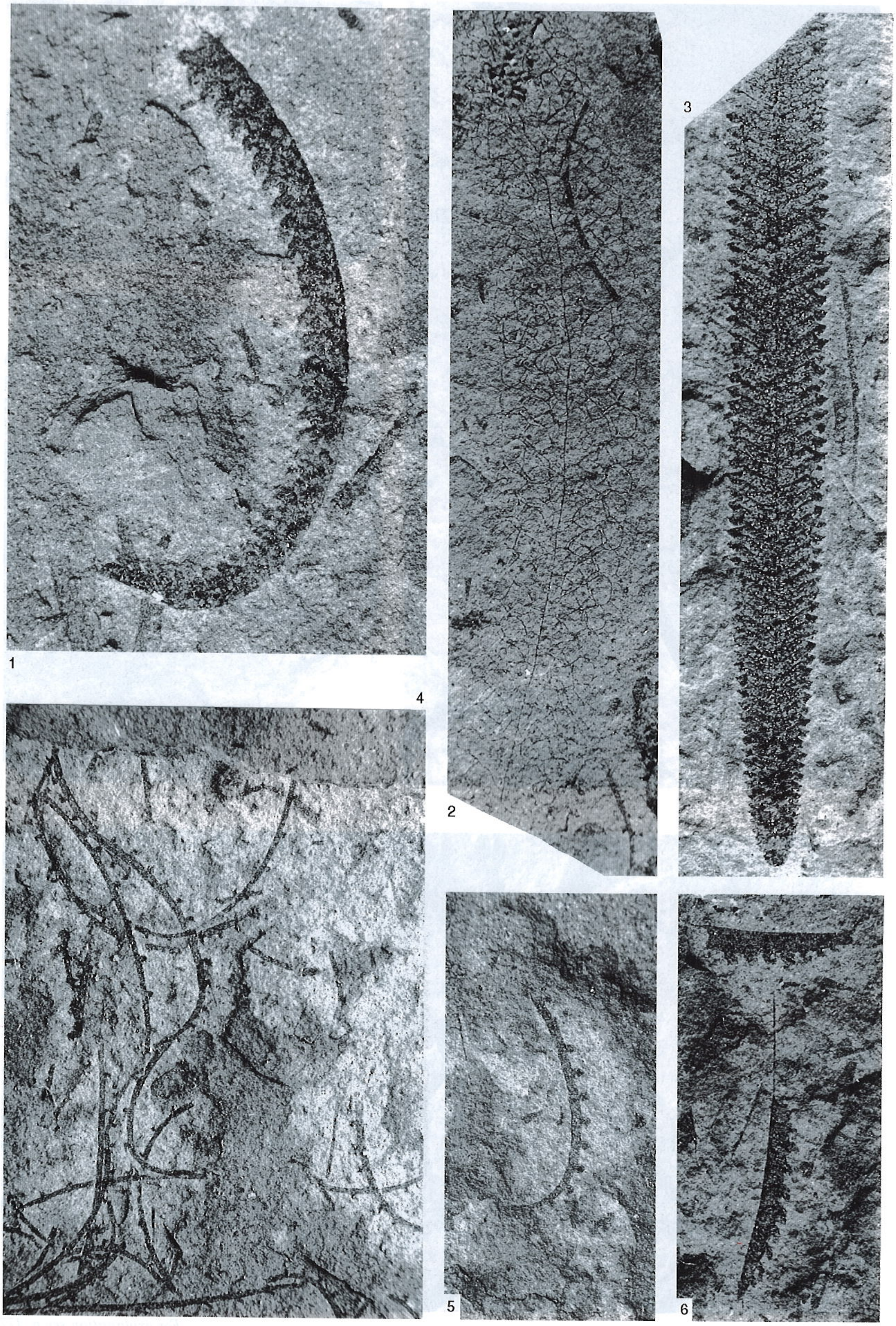
Kniha představuje stručné, přehledné a jednoduché seznámení se základními prinicipy deskové tektoniky. Lze ji doporučit především zájemcům zabývajícím se přírodovědnými disciplínami. Užitečná jim bude zejména tím, že postihuje vývoj geologického myšlení od dob formulování geosynklinální teorie do dneška a tím, že konfrontuje terminologii a principy této teorie s novými moderními poznatky.

*Václav Kachlík*

P. Š t o r c h : Llandovery–Wenlock boundary beds in the graptolite-rich sequence .. (Pl. I)


*For explanation see p. 177*

P. Š t o r c h : Llandovery–Wenlock boundary beds in the graptolite-rich sequence .. (Pl. II)



P. Štorch: Llandovery–Wenlock boundary beds in the graptolite-rich sequence .. (Pl. III)

P. Š t o r c h : Llandovery–Wenlock boundary beds in the graptolite–rich sequence .. (Pl. IV)