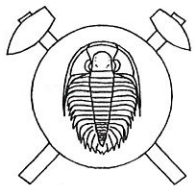
Llandovery–Wenlock boundary beds in the graptolite–rich sequence of the Barrandian area (Bohemia)



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

(4 plates, 5 text–figs.)

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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–

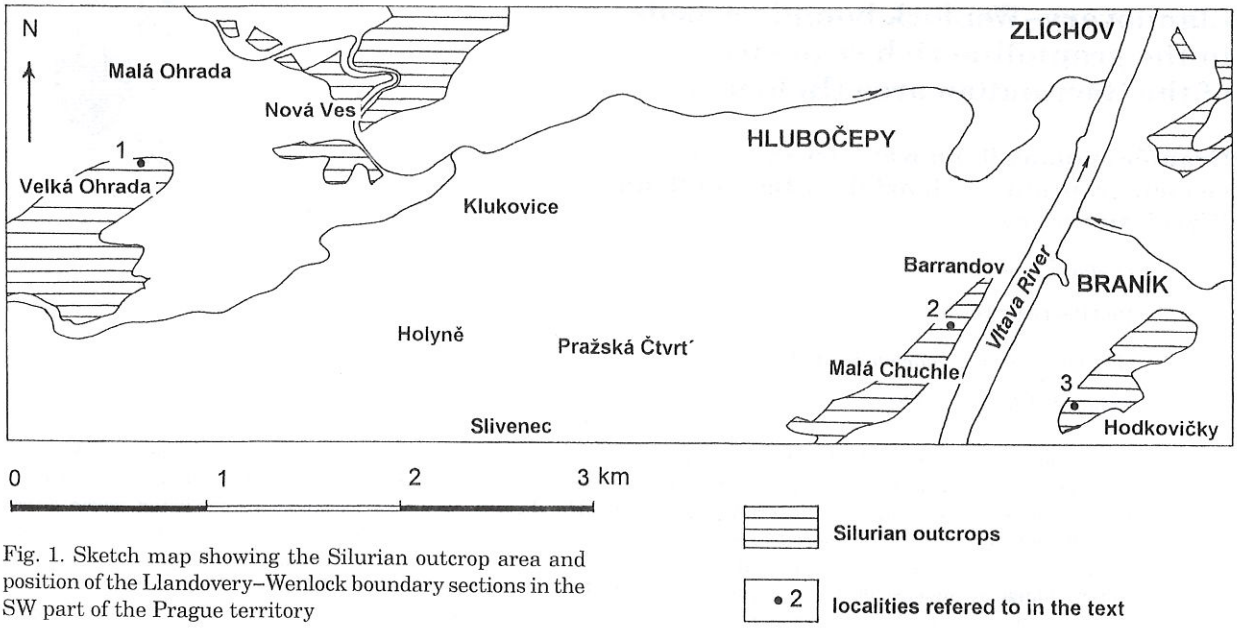

Fig. 1. Sketch map showing the Silurian outcrop area and position of the Llandovery–Wenlock boundary sections in the SW part of the Prague territory

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,

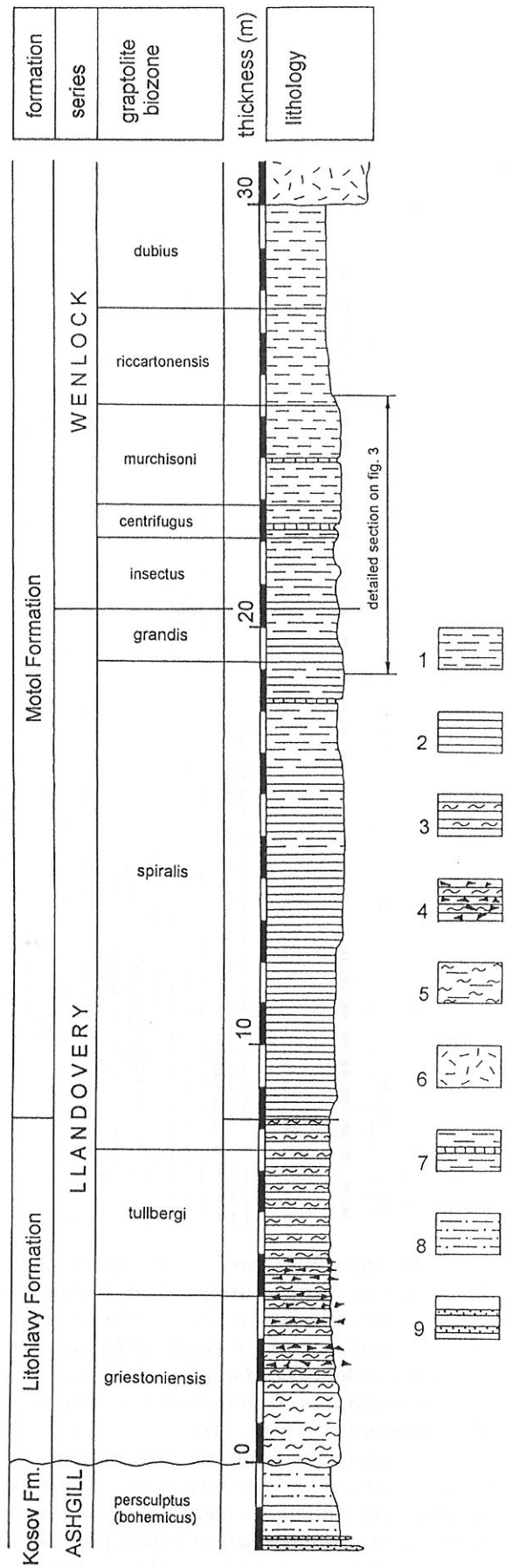

Fig. 2. Lower Silurian section exposed by the building excavations at Velká Ohrada
1 – calcareous graptolitic shales; *2* – graptolitic shales; *3* – alternated graptolitic shales and light-coloured barren mudstones; *4* – laminae of clayey breccia; *5* – pale, greenish basal mudstone of the Litohlavy 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.

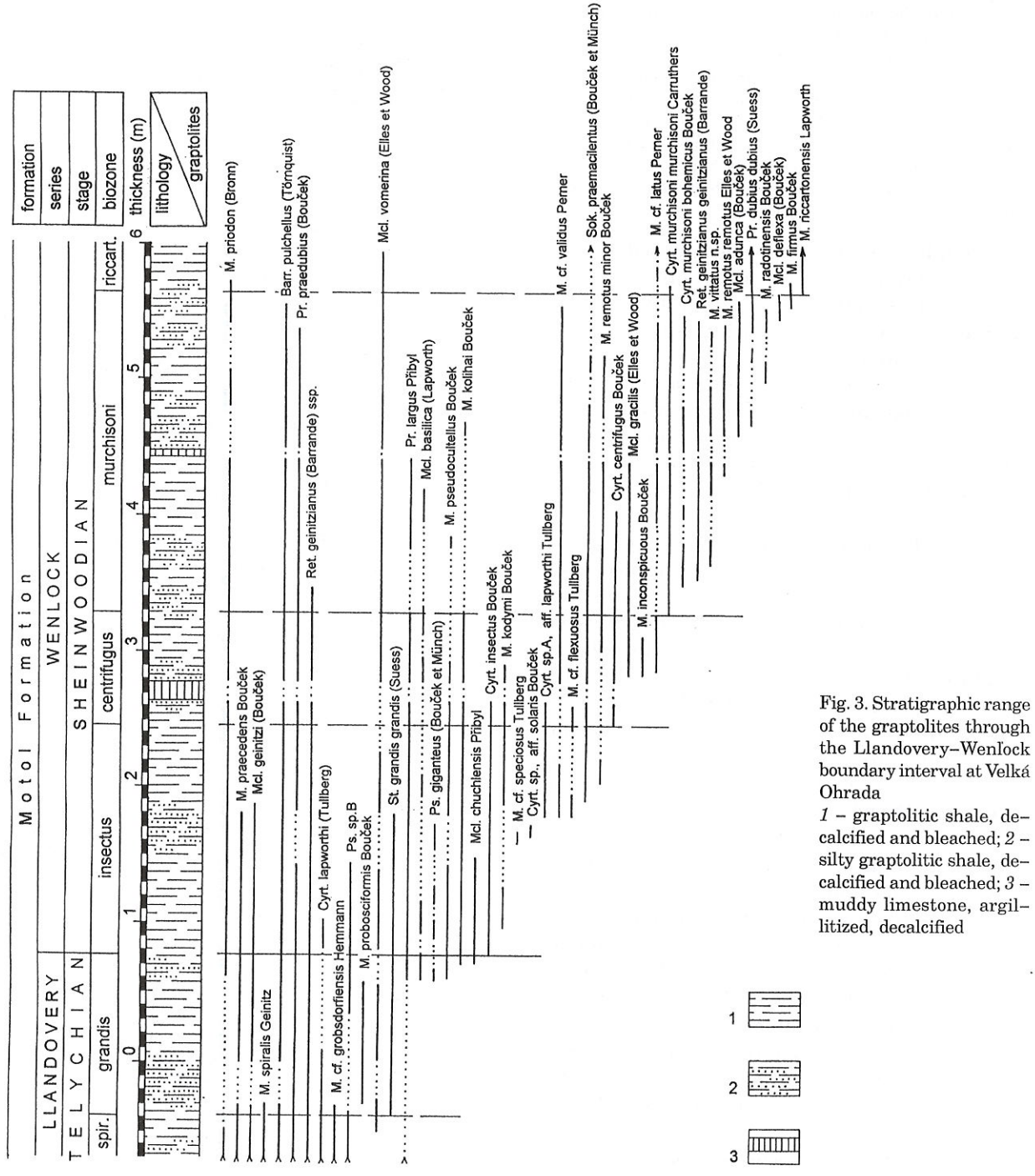

Fig. 3. Stratigraphic range of the graptolites through the Llandovery–Wenlock boundary interval at Velká Ohrada
1 – graptolitic shale, decalcified and bleached; *2* – silty graptolitic shale, decalcified and bleached; *3* – muddy limestone, argillitized, decalcified

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 proboscis-formis* 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 re-

corded 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

Diagnosis: See Mitchell, 1987 for Monograptinae.

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

Type species (subsequent designation by Bassler, 1915): *Lomatoceras priodon* Bronn, 1835, from the Silurian of Germany.
Diagnosis: 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.

Holotype: By monotypy. The specimen no. L 30165 from the Motol Formation at Vyskočilka near Malá Chuchle, Prague, Bohemia.
Material: About 80 flattened complete specimens from Velká Ohrada and Vyskočilka, including the type collection.

Description: 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.

Remarks: *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

Lectotype: 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.
Material: 28 flattened, mostly complete rhabdosomes from Velká Ohrada and Řepy, and the type collections of Bouček (1931b) and Bouček and Přibyl (1951).

Diagnosis: 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.

Description. 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–