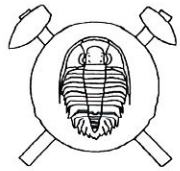
Graptolite biozones of the Bohemian Lower and Middle Ordovician and their historical development



Graptolitové biozóny českého spodního a středního ordoviku a jejich historický vývoj (Czech summary)

(1 table, 5 text-figs.)

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An overview on graptolite zones in the Prague Basin is done. As the rests of graptolites are preserved nearly exclusively in the clayey shale facies of the Klabava, Šárka and Dobrotivá Formations, a reasonable graptolite zonation is establish only in there. Revised biostratigraphical scheme is proposed for this part of the Bohemian Ordovician. Only two zones are distinguished inside the Šárka Formation. No subzones are recommended to be used in all units. Characteristics of every unit cover its definition, history, list of graptolite species and important localities.

Key words: biostratigraphy, graptolites, Ordovician, Prague Basin, historical development

Introduction

Graptolite biostratigraphy of the Bohemian Lower and Middle Ordovician has developed over more than seventy years. A considerable amount of new data collected during the last twenty years has led to several important refinements. The investigations have also shown the limits of validity of graptolite biostratigraphy in the Prague Basin resulting from the selective preservation of graptolites in different facies. Graptolites are significant and abundant faunal elements preserved only in the clayey shale facies of the Klabava, Šárka and Dobrotivá formations. Thus, graptolite zones widely used for interregional correlations can be established only in this part of the Bohemian Ordovician. In other facies of the three mentioned formations and in remaining formations of the Bohemian Ordovician graptolites are absent or too rare for the definition of graptolite biozones.

Detailed investigation of the boundary intervals between adjoining zones represents a problem. The only boundary studied in a section is that between the *Azygograptus ellesi–Tetragraptus reclinatus abbrevitus* and *Corymbograptus retroflexus* zones. Information on other boundaries is poor (some data from drilling or mines) or not available.

Bouček (1926) first introduced graptolite zones in the Šárka Formation. The same author (Bouček 1944) published the graptolite zonation of the sequence comprising the Klabava, Šárka and Dobrotivá formations. Subsequent investigations confirmed the validity of this biostratigraphical division and completed and refined it (Bouček, 1956, 1973; Havlíček and Vaněk, 1966; J. Kraft, 1974, 1977; J. Kraft and Mergl, 1979; J. Kraft and P. Kraft 1992, 1993, 1994, 1995; see Tab. 1).

This paper summarizes our knowledge of the graptolite biostratigraphy of the Klabava, Šárka and Dobrotivá formations and includes revised lists of their graptolite faunas. (The lists in the text are in systematic order; those in Figs 2 and 3 are arranged according to FADs.)

Klabava Formation

Clonograptus (*C.*) sp. Zone

D e f i n i t i o n : Taxon range zone of *Clonograptus* (*C.*) sp.
R e m a r k s : J. Kraft and Mergl (1979) described the graptolite assemblage with members of the genus *Clonograptus* Nicholson from the lower part of the Klabava Formation. Species composition and geological position of this locality suggest that this assemblage is older than that of the *Corymbograptus v-similis* Zone. Although this fauna is known from one locality only, it is evident that it represents the oldest graptolite zone in the Ordovician of Bohemia.

Species composition of the graptolite fauna: *Callograptus undosus* J. Kraft, *Dendrograptus bouceki* J. Kraft, *Dendrograptus* sp. (*sensu* J. Kraft and Mergl 1979), *Desmograptus callograptoides* Bouček, *Clonograptus* (*C.*) sp. (sp. B and C *sensu* J. Kraft and Mergl 1979), *Hunnegraptus*? sp. (*Clonograptus* sp. A *sensu* J. Kraft and Mergl 1979), *Baltograptus holubi* (J. Kraft), *Didymograptus* (s. l.) *goldschmidti* Monsen, *Didymograptus* (s. l.) sp. (*sensu* J. Kraft and Mergl 1979).

The presence of *Tetragraptus* (s. l.) cf. *quadribrachiatus* Hall is questionable. Owing to the high variablity of the length of the second order stipes in clonograptids it is not possible to determine reliably if rhabdosomes with the funicle and four second order stipes are tetragraptids or represent fragments of clonograptids or their juvenile stages.
L o c a l i t y : Sedlec – gorge.

Table 1. The development of the biostratigraphical division of the Klabava, Šárka and Dobrotivá formations. ⇨

Bouček 1926	Bouček 1932	Bouček 1944	Přibyl 1949	Bouček 1956
not commented	not commented	Horizon with *Glyptograptus teretiusculus*	*Glyptograptus teretiusculus* Zone	not commented
Zone with *Didymograptus murchisoni* var. *clavulus*	Zone with *Didymograptus clavulus*	Horizon with *Didymograptus clavulus*	*Didymograptus clavulus* Zone	
Zone with *Didymograptus murchisoni* var. *geminus*	Horizon with *Didymograptus murchisoni geminus*	Horizon with *Didymograptus geminus*	*Didymograptus geminus* Zone	
Zone with *Didymograptus v-fractus* var. *volucer*	Zone with *Didymograptus v-fractus volucer*	Horizon with *Didymograptus v-fractus volucer*	*Didymograptus v-fractus volucer* Zone	
		Horizon with *Didymograptus lonchotheca*	*Didymograptus lonchotheca* Zone	
not commented	not commented	Horizon with *Tetragraptus bigsbyi*	Horizon with *Tetragraptus bigsbyi*	*Tetragraptus bigsbyi* Zone
				Tetragraptus reclinatus abbreviatus Zone
		Horizon with *Schizograptus tardifurcatus*	*Schizograptus tardifurcatus* Zone	*Schizograptus tardifurcatus* Zone
		Horizon with *Hologroptus expansus*	*Hologroptus expansus* Zone	not commented

P. Kraft 1987	J. Kraft and P. Kraft 1990	J. Kraft and P. Kraft 1992	J. Kraft and P. Kraft 1995	
not commented	not commented	not commented	not commented	
			"Glyptograptus" teretiusculus Zone	
			Didymograptus clavulus Zone	
			Didymograptus spinulosus Zone	
			Corymbograptus retroflexus Zone	
	Tetragraptus reclinatus abbreviatus Biozone	*Tetragraptus reclinatus* Biozone	*Tetragraptus-Azygograptus* Zone	*Tetragraptus reclinatus abbreviatus-Acrograptus* cf. *infrequens* Subzone
				Tetragraptus reclinatus abbreviatustus-Azygograptus suecicus Subzone
				Azygograptus suecicus-Acrograptus crassus Subzone
Hologroptus tardibrachiatus Zone	*Hologroptus tardibrachiatus* Biozone	*Hologroptus tardibrachiatus* Biozone	*Hologroptus tardibrachiatus* Zone	
not commented	*Corymbograptus v-similis* Biozone	*Corymbograptus v-similis* Biozone	*Corymbograptus v-similis* Zone	
	Horizon with *Clonograptus*	Horizon with *Clonograptus* (*C.*) sp.	Horizon with *Clonograptus*	

Havlíček and Vaněk 1966	Bouček 1973	J. Kraft 1974	J. Kraft 1977	J. Kraft and Mergl 1979
not established	*Cryptograptus tricornis* Zone	not commented	not commented	not commented
	Glyptograptus teretiusculus Zone			
Didymograptus clavulus Zone	*Didymograptus clavulus* Zone	*Didymograptus clavulus*		
	Didymograptus pseudogeminus Zone			
Didymograptus retroflexus Zone	*Corymbograptus retroflexus* Zone: *Corymbograptus retroflexus retroflexus* Subzone	*Corymbograptus retroflexus*		
	Corymbograptus retroflexus maximus Subzone			
	Pseudoclimacograptus paradoxus Horizon			
	Expansograptus ferrugineus Horizon			
Tetragraptus reclinatus abbreviatus Zone	*Tetragraptus reclinatus abbreviatus* Zone	not commented	*Tetragraptus* cf. *pseudobygsbyi* Zone	not commented
Schizograptus tardifurcatus Zone	*Schizograptus tardibrachiatus* Zone		*Schizograptus tardibrachiatus* Zone	
Didymograptus volucer volucer Zone	*Corymbograptus v-similis* Zone		*Corymbograptus v-similis* Zone	
Hologratpus expansus Zone				Association with *Clonograptus*

J. Kraft and P. Kraft 1993	J. Kraft and P. Kraft 1994	J. Kraft and P. Kraft this paper	Lithostr.	Chrono. 1	Chrono. 2
not commented	not commented	***Cryptograptus* aff. *tricornis* Zone**	Dobrotivá Fm.	Dobrotivian	Caradoc
		***Hustedograptus teretiusculus* Zone**			
		***Didymograptus clavulus* Zone**	Šárka Fm.	Oretanian	Llanvirn
		***Corymbograptus retroflexus* Zone**			
Tetragraptus-Azygograptus Zone: *Tetragraptus reclinatus abbreviatus-Acrograptus* cf. *infrequens* Subzone	*Azygograptus-Tetragraptus (reclinatus group)* Zone: *Tetragraptus reclinatus abbreviatus-Acrograptus* cf. *infrequens* Subzone	***Azygograptus ellesi-Tetragraptus reclinatus abbreviatus* Zone**	Klabava Fm.	Arenigian	Arenig
Tetragraptus reclinatus abbreviatustus-Azygograptus suecicus Subzone	*Tetragraptus reclinatus abbreviatustus-Azygograptus ellesi* Subzone				
Azygograptus suecicus-Acrograptus crassus Subzone	*Azygograptus ellesi-Acrograptus crassus* Subzone				
Hologratpus tardibrachiatus Zone	*Hologratpus tardibrachiatus* Zone	***Hologratpus tardibrachiatus* Zone**			
Corymbograptus v-similis Zone	*Corymbograptus v-similis* Zone	***Corymbograptus v-similis* Zone**			
Horizon with *Clonograptus* (*C.*) sp.	Horizon with *Clonograptus* (*C.*) sp.	***Clonograptus* sp. Zone**		Tremdn.	Tremdc.

Explanations:
Tremdn – Tremadocian,
Tremdc – Tremadoc,
Lithostr. – lithostratigraphy,
Chrono – chronostratigraphy,
1 – Gondwana stages,
2 – British stages.
Note that column with subdivision of J. Kraft and P. Kraft 1995 is front-end of some columns dated earlier as the paper was submitted in 1992.

Corymbograptus v-similis Zone

Definition: Taxon range zone of *Corymbograptus v-similis* Bouček.

Remarks: This zone was established by Havlíček and Vaněk (1966) under the designation *Didymograptus volucer volucer* on the basis of the graptolite assemblage known from borings and pits in the vicinity of Holoubkov and Sirá villages.

Originally it was placed between the *Hologratpus expansus* and *Schizograptus tardifurcatus* Zones. Bouček (1973) revised the Bohemian Lower Ordovician graptolite fauna and ascertained the identity of the graptolite assemblages with the *Hologratpus expansus* and *Schizograptus tardibrachiatus* (formerly designated as *S. tardifurcatus*) zones. In the revised biostratigraphical scheme for the Klabava Formation (Bouček 1973) he validated only the *Schizograptus tardibrachiatus* Zone underlain by the *Corymbograptus v-similis* Zone.

Of partial value are two loose shale fragments with *Corymbograptus v-similis* and *Hologratpus tardibrachiatus* on one bedding plane, giving evidence for the overlap of their stratigraphical ranges.

Bouček (1973) recorded only three graptoloid species from this zone. After discovery of further localities the number of species increased.

For comprehensive information about this zone see J. Kraft and P. Kraft (1992).

Species composition of the graptolite fauna *Dictyonema hornyi* J. Kraft, *Callograptus rokycanensis* Bouček, *Callograptus horaki* (Bouček), *Callograptus undosus* J. Kraft, *Callograptus* aff. *undosus* J. Kraft, *Dendrograptus klouceki* Bouček, *Dendrograptus bouceki* J. Kraft, *Dendrograptus* sp. (*sensu* J. Kraft and Mergl 1979) *Dendrograptus* sp. (*sensu* J. Kraft and P. Kraft 1992) *Desmograptus callograptoides* Bouček, *Pseudoreticulograptus inusitatus* (J. Kraft), *Tetragraptus* (s. l.) cf. *quadribrachiatus* (Hall), *Corymbograptus v-similis* Bouček, *Baltograptus deflexus* (Elles et Wood), *Baltograptus holubi* (J. Kraft), *Didymograptus* (s. l.) *simulans* Elles et Wood, *Didymograptus* (s. l.) *goldschmidti* Monsen, *Didymograptus* (s. l.) *densus* (Bouček), *Didymograptus* (s. l.) sp. (*sensu* J. Kraft and Mergl 1979), *Acrograptus nicholsoni* (Lapworth), *Acrograptus infrequens* J. Kraft.

Assemblages from this biozone differ between localities in their composition and relative abundance of species. For example: *Didymograptus* (s. l.) *simulans* is abundant in the vicinity of Volduchy village (borings), while *Corymbograptus v-similis* and *Baltograptus holubi* are very rare. Svojkovice-Závírka locality is characterized by the occurrence of *Baltograptus holubi* while *Corymbograptus v-similis* is very rare (only several fragments of stipes). On the other hand, only *Corymbograptus v-similis* has been found at Rokycany-Kalvárie. This phenomenon can be explained by an ecological dependence of individual species on the different characters of palaeoenvironmental preferences.

Localities: Sedlec – southern slope of the Sutice hill, Rokycany-Kalvárie, Rokycany-Práchovna, Svojkovice-Závírka.

Hologratpus tardibrachiatus Zone

Definition: Taxon range zone of *Hologratpus tardibrachiatus* (Bouček).

Remarks: This zone was introduced by Bouček (1944) under the designation Horizon with *Schizograptus tardifurcatus*. The same author (Bouček 1973) recorded the identity of this and the *Hologratpus expansus* Zones (see above). Moreover, P. Kraft (1987) recorded only one species of multibranched dichograptid from the Klabava Formation – *Hologratpus tardibrachiatus* (Bouček).

For comprehensive information about this zone see J. Kraft and P. Kraft (1993).

Species composition of the graptolite fauna: *Dictyonema krafti* Bouček, *Dictyonema hornyi* J. Kraft, *Dictyonema teskovense* P. Kraft, *Dictyonema* sp. (sp. n. ?; unpublished), *Callograptus rokycanensis* Bouček, *Callograptus horaki* (Bouček), *Callograptus undosus* J. Kraft, *Callograptus* aff. *undosus* J. Kraft, *Callograptus hanae* J. Kraft, *Callograptus ludmilae* J. Kraft, *Callograptus* sp. (sp. A *sensu* P. Kraft 1987), *Dendrograptus klouceki* Bouček, *Dendrograptus bouceki* J. Kraft, *Dendrograptus libertus* P. Kraft, *Dendrograptus titanus* P. Kraft, *Desmograptus callograptoides* Bouček, *Pseudoreticulograptus inusitatus* (J. Kraft), *Acanthograptus* sp. (sp. A *sensu* J. Kraft 1975), *Acanthograptus* sp. (sp. B *sensu* J. Kraft 1975), ?*Chaunograptus* sp. (*sensu* P. Kraft 1987), *Hologratpus tardibrachiatus* (Bouček), *Tetragraptus* (s. l.) cf. *quadribrachiatus* (Hall), *Tetragraptus postlethwaitii* Elles, *Baltograptus deflexus* (Elles et Wood), *Baltograptus holubi* (J. Kraft), *Baltograptus rokycanensis* (J. Kraft), *Didymograptus* (s. l.) *goldschmidti* Monsen, *Didymograptus* (s. l.) *cinereus* Monsen, *Didymograptus* (s. l.) *simulans* Elles et Wood, *Didymograptus* (s. l.) *chlupaci* J. Kraft, *Didymograptus* (s. l.) sp. (*sensu* J. Kraft and Mergl 1979), *Acrograptus nicholsoni* (Lapworth), *Acrograptus infrequens* J. Kraft.

The index species and *Baltograptus rokycanensis* represent the dominant components of the graptolite fauna in this zone. *Acrograptus infrequens* is abundant locally.

Localities: Starý Plzenec-sv. Blažej, Rokycany-Stráň (Valcha, gully, near the swimming pool), Volduchy-Kašparův vrch, Svojkovice (two localities east of the village).

Azygograptus ellesi-Tetragraptus reclinatus abbreviatus Zone

Definition: Interval zone defined by the FAD of *Azygograptus ellesi* as the base and the LAD of *Tetragraptus reclinatus abbreviatus* as the top.

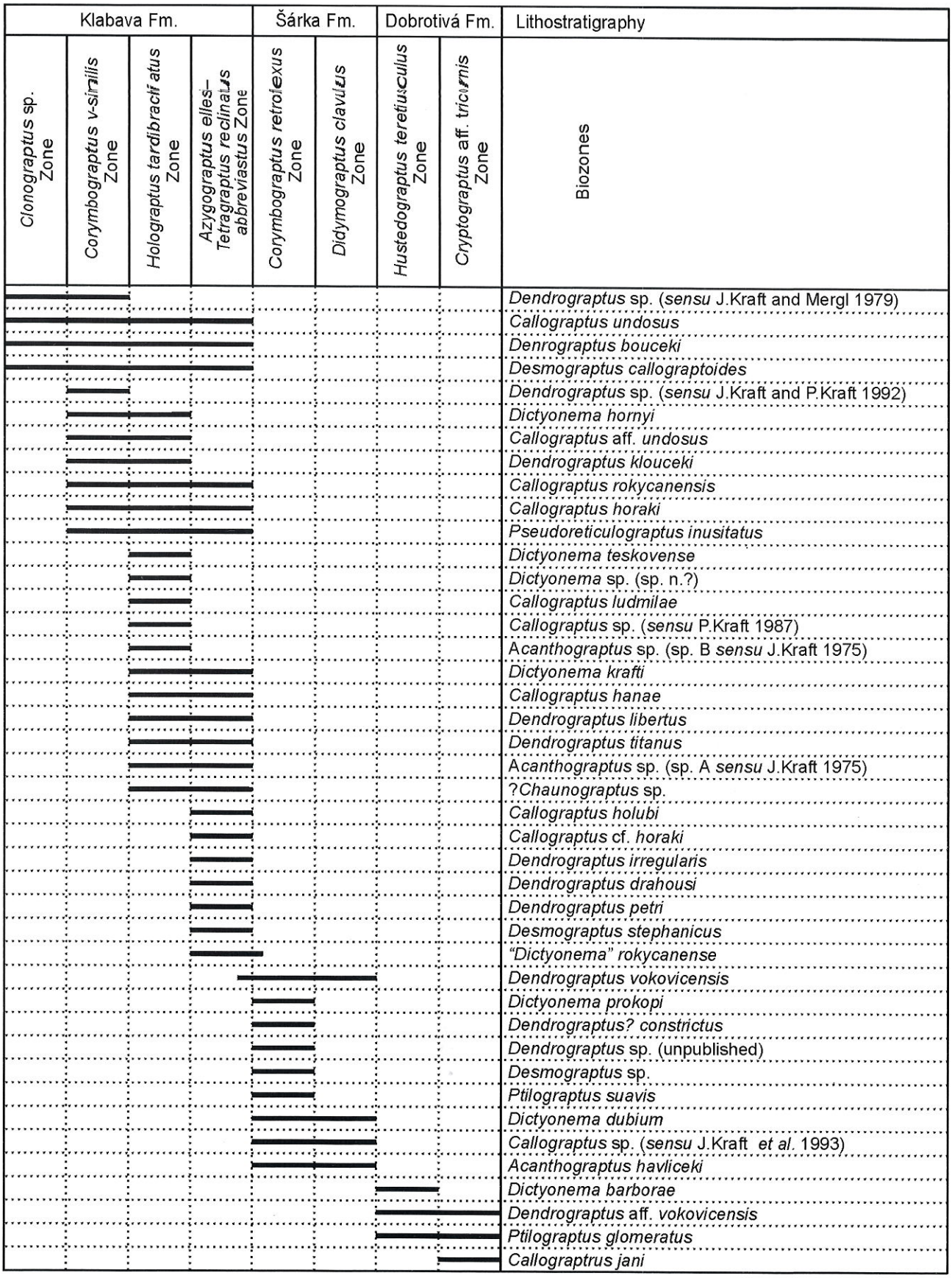


Fig. 1. Stratigraphical ranges of dendroids in the Klabava, Šárka and Dobrotivá formations.

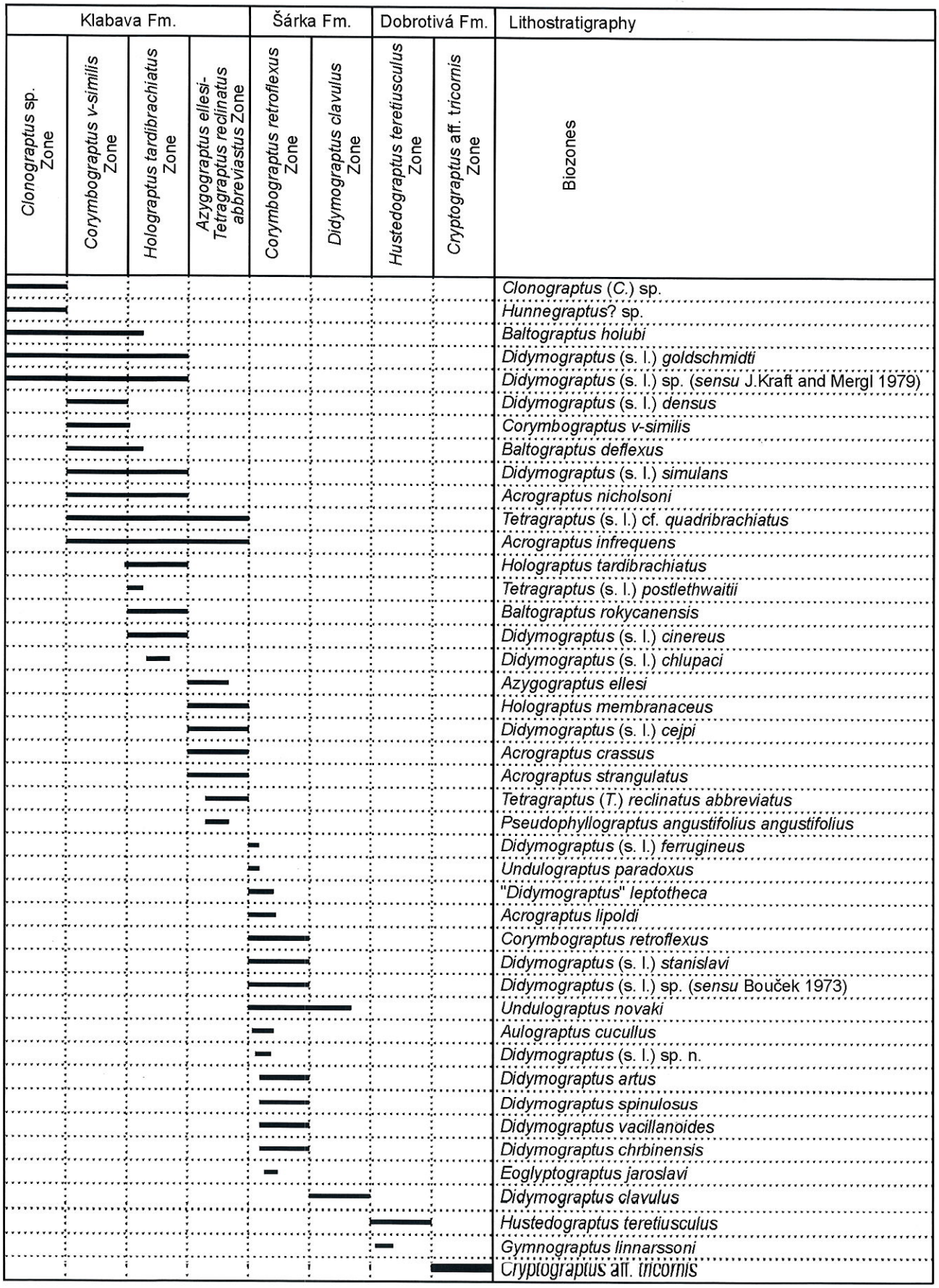


Fig. 2. Stratigraphical ranges of graptoloids in the Klabava, Šárka and Dobrotivá formations.

Remarks: This zone was introduced by Bouček (1944) with index species determined as *Tetragraptus bigsbyi*. Later, the same author (Bouček 1956) distinguished two biostratigraphical units in the upper portion of the Klabava Formation: *Tetragraptus reclinatus abbreviatus* and *Tetragraptus bigsbyi* zones. Havlíček and Vaněk (1966) recognized in this sequence only the *Tetragraptus reclinatus abbreviatus* Zone. Bouček (1973) accepted this opinion, but did not exclude the possibility of the existence of a possible, separate independent biostratigraphical unit in the uppermost part of the Klabava Formation.

P. Kraft (1988) studied the biostratigraphical relations at the Rokycany-Stráň (quarry) locality. He subdivided this zone into three subzones: *Azygograptus suecicus–Acrograptus crassus*, *Tetragraptus reclinatus abbreviatus–Azygograptus suecicus* and *Tetragraptus reclinatus abbreviatus–Acrograptus* cf. *infrequens*. Moreover, he recognized that *Tetragraptus reclinatus abbreviatus* is absent in its lower part and therefore he used a new zonal designation for this zone *Tetragraptus–Azygograptus* Zone. J. Kraft and P. Kraft (1994) introduced the designation *Azygograptus–Tetragraptus* (*reclinatus* group) which corresponds to the chronological order of the index species' FADs and expresses more precisely the nature of the index tetragraptid.

The distribution of graptolite species ascertained at Rokycany-Stráň (quarry) has not been confirmed at other localities (except for the absence of *Tetragraptus reclinatus abbreviatus* in the lower part of this zone). Therefore we propose abandonment the concept of three subzones and use of the *Azygograptus ellesi–Tetragraptus reclinatus abbreviatus* Zone for this unit.

For comprehensive information about this zone see J. Kraft and P. Kraft (1994).

Species composition of the graptolite fauna: *Dictyonema krafti* Bouček, *"Dictyonema" rokycanense* J. Kraft, *Callograptus rokycanensis* Bouček, *Callograptus holubi* Bouček, *Callograptus horaki* (Bouček), *Callograptus* cf. *horaki* (Bouček), *Callograptus undosus* J. Kraft, *Callograptus hanae* J. Kraft, *Dendrograptus irregularis* Bouček, *Dendrograptus bouceki* J. Kraft, *Dendrograptus libertus* P. Kraft, *Dendrograptus titanus* P. Kraft, *Dendrograptus drahousi* J. Kraft, P. Kraft et Seidl, *Dendrograptus petri* J. Kraft, *Desmograptus callograptoides* Bouček, *Desmograptus stephanicus* P. Kraft, *Pseudoreticulograptus inusitatus* (J. Kraft), *Acanthograptus* sp. (sp. A *sensu* J. Kraft 1975), ?*Chaunograptus* sp. (*sensu* P. Kraft 1987), *Hologroptus membranaceus* (Bouček), *Tetragraptus* (*T.*) *reclinatus abbreviatus* Bouček, *Tetragraptus* (s. l.) cf. *quadribrachiatus* (Hall), *Pseudophyllograptus angustifolius angustifolius* (Hall), *Didymograptus* (s. l.) *cejpi* (J. Kraft), *Azygograptus ellesi* Monsen, *Acrograptus crassus* (Monsen), *Acrograptus strangulatus* (Bouček), *Acrograptus infrequens* J.Kraft.

Tetragraptus (*T.*) *reclinatus abbreviatus* and *Azygograptus ellesi* dominate in the graptolite assemblage of this zone. *Dictyonema rokycanense, Hologroptus membranaceus* and *Acrograptus infrequens* are abundant locally.

Localities: Klabava-Starý hrad, Rokycany-Stráň (quarry), Mýto-Svatoštěpánský rybník.

A sequence, several metres thick, of tuffitic shales, tuffites and iron ore is developed in the boundary interval between clayey shales of the Klabava and Šárka formations at all known localities. The boundary between the tuffitic sediments and iron ores is sharp and coincides with that between the formations. In the tuffitic shales and tuffites no graptolites have been found. In the iron ores thin intercalations of black clayey shales with graptolites including *Corymbograptus retroflexus* rarely occur.

Šárka Formation

Corymbograptus retroflexus Zone

Definition: Taxon range zone of *Corymbograptus retroflexus* (Perner).

Remarks: This zone was introduced by Bouček (1926) as the *Didymograptus v-fractus volucer* Horizon. The same author (Bouček 1944) established the horizon with *Didymograptus lonchotheca* underlying it. Havlíček and Vaněk (1966) considered the horizon with *D. lonchotheca* as a local representative of the lowermost part of the the *Didymograptus* (=*Corymbograptus*) *retroflexus* Zone.

Bouček (1973) subdivided this zone into two subzones (*C. retroflexus maximus* and *C. retroflexus retroflexus*) and established two horizons underlying it (*Expansograptus ferrugineus* and *Pseudoclimacograptus paradoxus*).

J. Kraft (1974) and J. Kraft and P. Kraft (1995), on the basis of new investigations of several sections and the revision of graptolites, recognized only the *Corymbograptus retroflexus* Zone in the lower part of the Šárka Formation.

Species composition of the graptolite fauna: *Dictyonema dubium* Počta, *Dictyonema prokopi* J. Kraft, P. Kraft et Seidl, *"Dictyonema" rokycanense* J. Kraft, *Callograptus* sp. (*sensu* J. Kraft et al. 1993), *Dendrograptus*? *constrictus* Perner. *Dendrograptus vokovicensis* Bouček, *Dendrograptus* sp. (unpublished), *Desmograptus* sp. (*sensu* J. Kraft et al. 1993), *Acanthograptus havliceki* J. Kraft, *Ptilograptus suavis* Počta, *Didymograptus artus* Elles et Wood, *Didymograptus spinulosus* Perner, *Didymograptus vacillanoides* Perner, *Didymograptus chrbinensis* Bouček, *Aulograptus cucullus* (Bulman), *Didymograptus* (s. l.) *ferrugineus* (Suess), *Didymograptus* (s. l.) *stanislavi* (Bouček), *Didymograptus* (s. l.) sp. (*Expansograptus* cf. *extensus sensu* Bouček 1973), *Didymograptus* (s. l.) sp. n. (unpublished), *Corymbograptus retroflexus* (Perner), *Acrograptus lipoldi* Bouček, *"Didymograptus" leptotheca* (Perner), *Undulograptus novaki* (Perner), *Undulograptus paradoxus* (Bouček), *Eoglyptograptus jaroslavi* (Bouček).

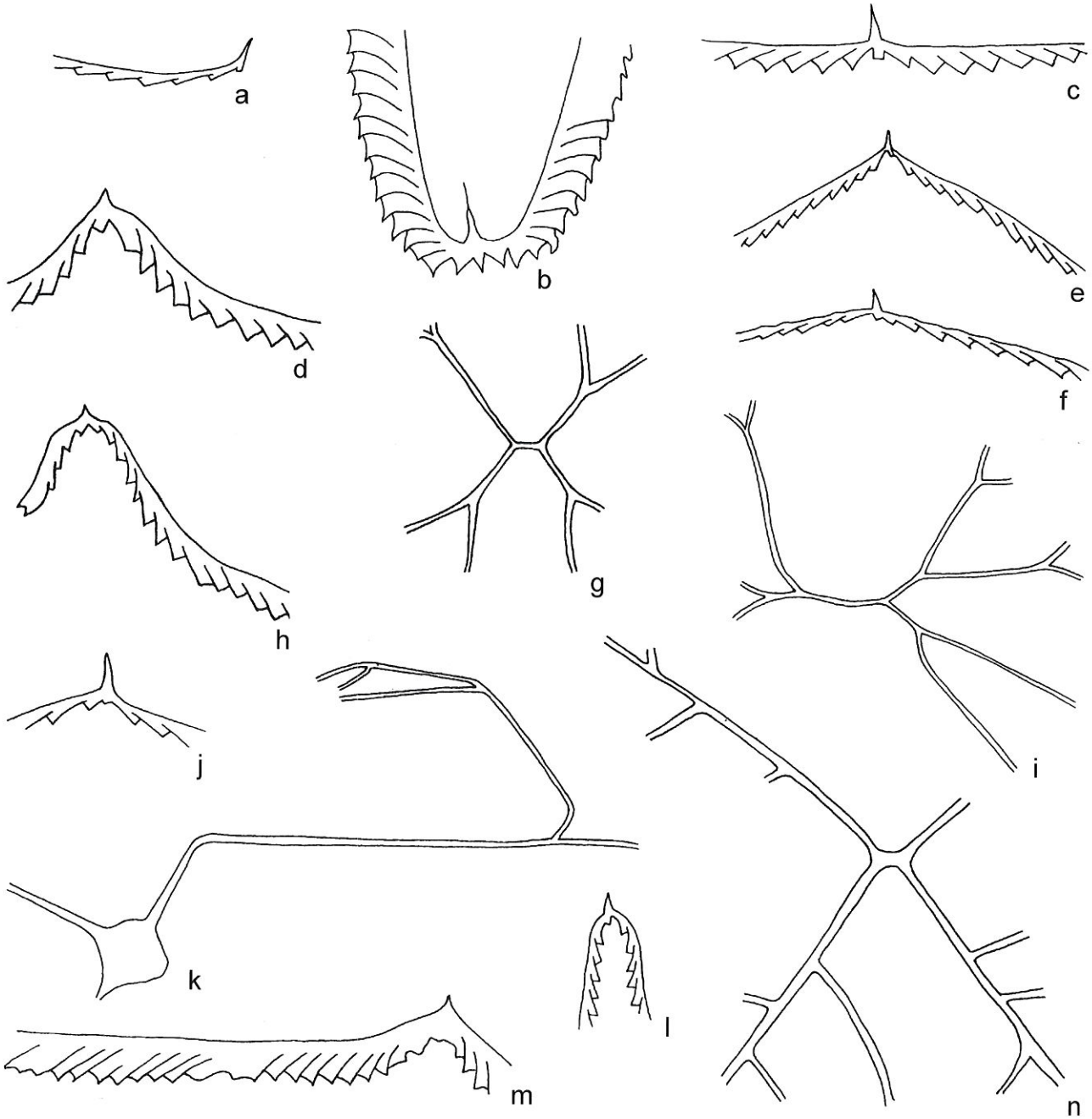


Fig. 3. Illustrations of selected graptolite species from the Klabava Formation. a – *Azygograptus ellesi* Monsen; b – *Tetragraptus* (*T.*) *reclinatus abbreviatus* Bouček; c – *Didymograptus* (s. l.) *goldschmidti* Monsen; d – *Baltograptus holubi* (J. Kraft); e – *Acrograptus infrequens* J. Kraft; f – *Acrograptus crassus* (Monsen); g – *Clonograptus* (*C.*) sp.; h – *Baltograptus deflexus* (Elles et Wood); i – *Hunnegraptus*? sp.; j – *Acrograptus nicholsoni* (Lapworth); k – *Holograptus membranaceus* (Bouček); l – *Baltograptus rokycanensis* (J. Kraft); m – *Corymbograptus v-similis* Bouček; n – *Holograptus tardibrachiatus* (Bouček). The magnification of all specimens is x4, except fig. k: x0.5, figs i, n: x1, figs g, m: x2.

Localities: Rokycany-Drahouš, Mýto – western bank of Svatoštěpánský rybník, Praha-Jenerálka.

Bouček (1926) introduced the *Didymograptus murchisoni geminus* Zone overlying the *Didymograptus v-fractus volucer* (=*C. retroflexus*) Zone. Havlíček and Vaněk (1966) did not accepted this zone and recognized only the *Corymbograptus retroflexus* and *Didymograptus clavulus* zones in the Šárka Formation. Bouček (1973), however, considered this zone to be valid under the new name *Didymograptus pseudogeminus* Zone. According to Bouček (1973), the index species does not occur in the underlying *Corymbograptus retroflexus* Zone. J. Kraft (1974) found specimens corresponding to the description of *Didymograptus pseudogeminus* in association with *Corymbograptus retroflexus*.

J. Kraft and P. Kraft (1995) reintroduced this zone as the *Didymograptus spinulosus* Interval Zone (*D. pseudogeminus* is a synonym of *D. spinulosus*). The validity of this zone is doubtful due to the unclear stratigraphical

position of this interval and some taxonomical problems. Therefore, we prefer to distinguish only two biozones within the Šárka Formation.

Didymograptus clavulus Zone

Definition: Taxon range zone of *Didymograptus clavulus* Perner.

Remarks: This zone was introduced by Bouček (1926). It is characterized by a dramatic reduction of graptolite diversity reflecting a relatively sudden change of environment.

Species composition of the graptolite fauna: *Dictyonema dubium* Počta, *Callograptus* sp. (*sensu* J. Kraft et al. 1993), *Dendrograptus vokovicensis* Bouček, *Acantho-*

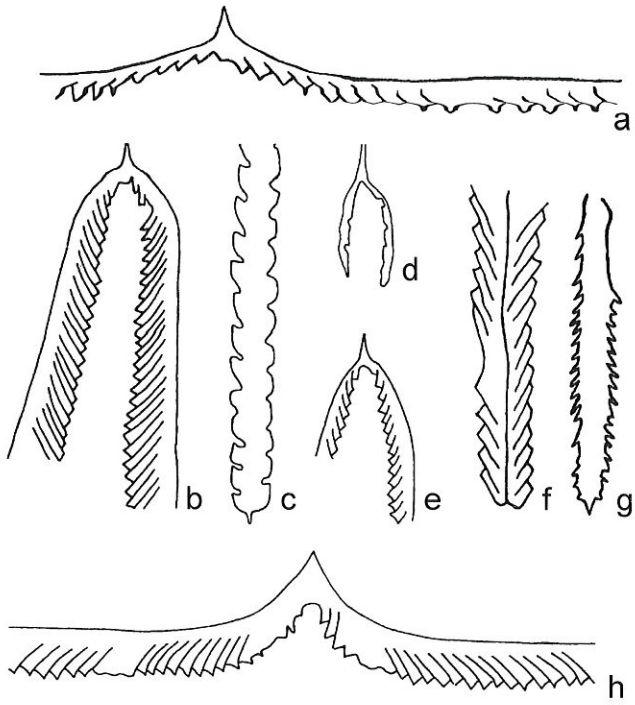
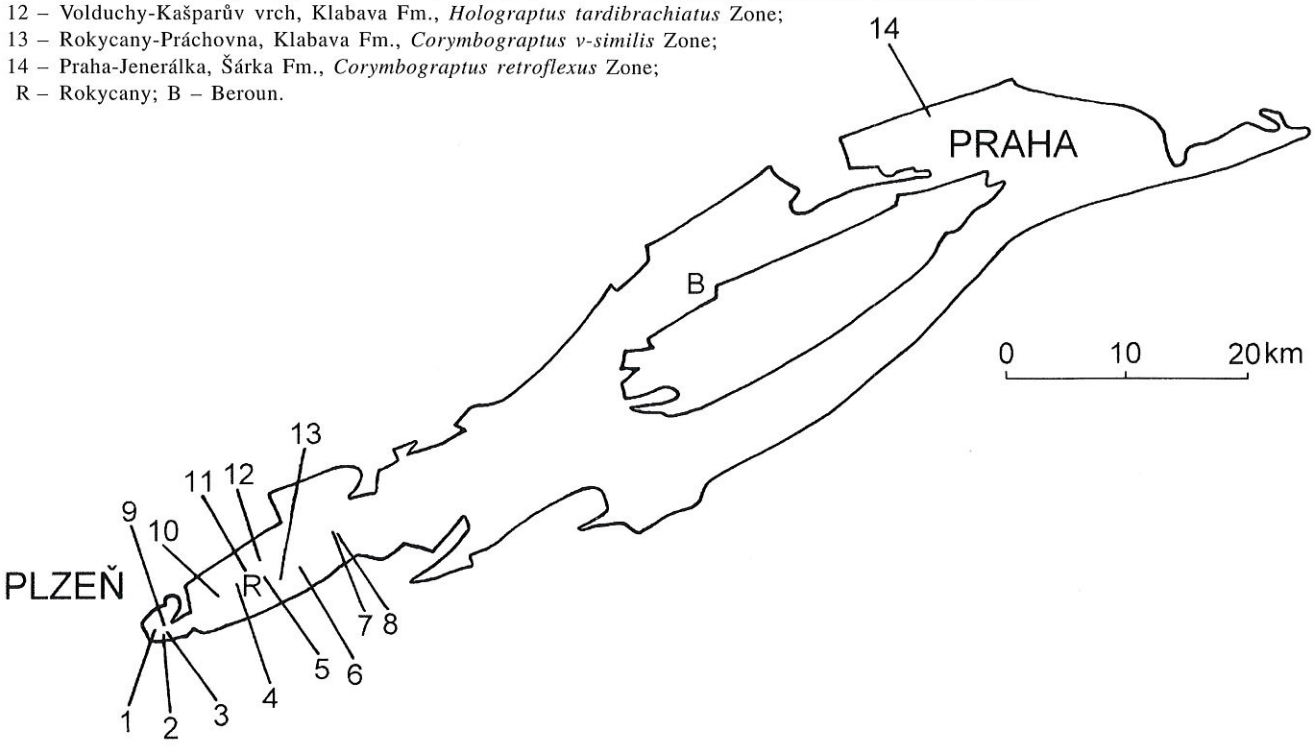


Fig. 4. Illustration of selected graptolite species from the Šárka and Dobrotivá formations. a – *Didymograptus* (s.l.) *stanislavi* (Bouček), x4; b – *Didymograptus clavulus* Perner, x2; c – *Undulograptus novaki* (Perner), x3.5; d – *Aulograptus cucullus* (Bulman), x4; e – *Didymograptus spinulosus* Perner, x2; f – *Hustedograptus teretiusculus* (Hisinger), x3.5; g – *Cryptograptus* aff. *tricornis* (Carruthers), x4; h – *Corymbograptus retroflexus* (Perner), x2.

Fig. 5. Principal localities of the graptolite fauna in the Klabava, Šárka and Dobrotivá formations.
1 – Starý Plzenec-Černá stráň, Dobrotivá Fm., *Cryptograptus* aff. *tricornis* Zone;
2 – Sedlec-gorge, Klabava Fm., *Clonograptus* (*C.*) sp. Zone;
3 – Sedlec – southern slope of the Sutice hill, Klabava Fm., *Corymbograptus v-similis* Zone;
4 – Rokycany-Drahouš, Šárka Fm., *Corymbograptus retroflexus* Zone;
5 – Rokycany-Kalvárie, Klabava Fm., *Corymbograptus v-similis* Zone;
6 – Svojkovice-Závírka, Klabava Fm., *Corymbograptus v-similis* Zone;
7 – Mýto – Svatoštěpánský rybník, Klabava Fm., *Azygograptus ellesi–Tetragraptus reclinatus abbreviatus* Zone;
8 – Mýto – western bank of Svatoštěpánský rybník, Šárka Fm., *Corymbograptus retroflexus* Zone
9 – Sedlec – western slope of the Sutice hill, Dobrotivá Fm., *Hustedograptus teretiusculus* Zone;
10 – Klabava-Starý hrad, Klabava Fm., *Azygograptus ellesi–Tetragraptus reclinatus abbreviatus* Zone;
11 – Rokycany-Stráň (Valcha, gully, near the swimming pool), Klabava Fm., *Hologaptus tardibrachiatus* Zone;
(quarry), Klabava Fm., *Azygograptus ellesi–Tetragraptus reclinatus abbreviatus* Zone;
12 – Volduchy-Kašparův vrch, Klabava Fm., *Hologaptus tardibrachiatus* Zone;
13 – Rokycany-Práchovna, Klabava Fm., *Corymbograptus v-similis* Zone;
14 – Praha-Jenerálka, Šárka Fm., *Corymbograptus retroflexus* Zone;
R – Rokycany; B – Beroun.



graptus havliceki J. Kraft, *Didymograptus clavulus* Perner, *Undulograptus novaki* (Perner).
Locality: At present there is no accesible exposure of this zone.

Dobrotivá Formation

Hustedograptus teretiusculus Zone

Definition: Taxon range zone of *Hustedograptus teretiusculus* (Hisinger).
Remarks: Bouček (1944) recorded the horizon with *Glyptograptus teretiusculus* from the lower part of the Dobrotivá Formation. Havlíček and Vaněk (1966) did not distinguish any biostratigraphical units in the Dobrotivá Formation but stated that *Glyptograptus teretiusculus* is abundant in its lower part and *Cryptograptus tricornis* is locally abundant in its upper part. Bouček (1973) established two graptolite zones in the Dobrotivá Formation on the basis of the stratigraphical ranges of mentioned species.
Species composition of the graptolite fauna: *Dictyonema barborae* J. Kraft, *Dendrograptus* sp. (aff. *vokovicensis* Bouček), *Ptilograptus glomeratus* Počta, *Hustedograptus teretiusculus* (Hisinger), *Gymnograptus linnarssoni* Moberg.
Locality: Sedlec – western slope of the Sutice hill.

Cryptograptus *aff.* tricornis *Zone*

Definition: Taxon range zone of *Cryptograptus* aff. *tricornis* (Carruthers).
Remarks: This zone was introduced by Bouček (1973).
Species composition of the graptolite fauna: *Callograptus jani* J. Kraft, *Dendrograptus* sp. (aff. *vokovicensis* Bouček), *Ptilograptus glomeratus* Počta, *Cryptograptus* aff. *tricornis* (Carruthers).
Locality: Starý Plzenec-Černá stráň.

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Graptolitové biozóny českého spodního a středního ordoviku a jejich historický vývoj.

Práce podává ucelený přehled o graptolitových biozónách českého ordoviku pražské pánve. Vzhledem k tomu, že fosilní zbytky náležející této skupině se vyskytují hojně pouze ve faciích jílovitých břidlic klabavského, šáreckého a dobrotivského souvrství, lze použitelné graptolitové zóny stanovit pouze v takto omezených tělesech spodno- a střednoordovických sedimentů.

Východiskem pro tuto publikaci se stalo revidované biostratigrafické schema sestavené na základě nových stratigrafických a taxonomických výzkumů. Zóna *Clonograptus (C.)* sp. je zde poprvé uvedena v této kategorii. U zóny *Azygograptus ellesi–Tetragraptus reclinatus abbreviatus* došlo ke změně názvu a byla zpochybněna platnost tří, dříve uváděných subzón. V šáreckém souvrství lze bezpečně prokázat existenci pouze dvou zón. U obou zón dobrotivského souvrství došlo ke změně názvu.

U každé zóny je v přehledu uvedena charakteristika, která obsahuje její definici, historii, seznam druhů graptolitů a nejvýznamnější lokality.