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TITHONIAN-BERRIASIAN CALPIONELLIDS FROM THE ŠTRAMBERK-TYPE LIMESTONES, POLISH FLYSCH CARPATHIANS

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Abstract: Calpionellid fauna from the coral-bearing exotics of the Štramberk-type limestones from Polish Flysch Carpathians has been studied. Calpionellids of the Remanei Subzone and the Intermedia Subzone as well as the Calpionella Zone indicate the Late Tithonian (most of exotics) and the Early Berriasian age of exotics studied. In contrast to the Štramberk Limestone (Moravia), calpionellids of the Chitinoidella Zone have not been recognized in the studied material.

Key words: Polish Carpathians, Tithonian–Berriasian, Štramberk facies, calpionellids.

Introduction

The best developed Tithonian-Early Berriasian coral reef deposits are known from the Štramberk Limestone (Outer Carpathians, Moravia — Czech Republic). Great blocks of these limestones derived from the Baška cordillera occur within Cretaceous flysch of the Silesian Unit, particularly in the vicinity of Štramberk (Eliáš & Eliášová 1984, 1986).

Within the uppermost Jurassic-Paleogene flysch sequences of the Polish Flysch (Outer) Carpathians, exotics of the Štramberk-type limestones occur as pebbles, boulders and rarely klippes. The source areas of the exotic rocks, periodically emerged and eroded, were in continental margins of the Carpathian Basin and intrabasinal ridges (cordilleras) separating particular sedimentary basins (e.g. Książkiewicz 1965). The Štramberk facies both from Moravia and Poland is assumed to be of Tithonian–Early Berriasian age, however small size and lack of index fossils in most of exotics make it difficult to establish the spatial and age relationship between exotics.

Shallow water limestones of Tithonian or Tithonian–Berriasian age are also known from other parts of the Carpathian range: Austria (Ernstbrunn Limestone), Hungary, Romania, Ukraine (e.g. Patrulius et al. 1976). The term *Štramberk-type limestones* is also used for shallow water limestones older than Tithonian, for example, the Oxfordian-Tithonian deposits of the Apuseni Mts, Romania (Săsăran et al. 1999).

Analysis of exotics called *Štramberk-type limestones* from the Polish Carpathians made by Hoffmann (1992) showed that they are really developed in various facies reflecting different environments of sedimentation: from lagoon to basin. According to Hoffmann (1992) coral-microbial reefs were developed as patch reefs within cortoidal and grapestones facies in an environment of moderate energy. Apart from corals (Morycowa 1964, 1968, 1974; Kołodziej 1997) microbial structures played important role in formation of these reefs (Hoffmann 1992; Hoffmann & Kołodziej 1997).

Material and methods

The studies of calpionellids were based on exotics, which previously were the subject of coral taxonomy studies (Kołodziej 1997). Of about 400 pebbles and boulders from 15 localities of the Silesian, Sub-Silesian and Skole units of the Polish Flysch Carpathians 260 thin sections were made from 96 exotics. The pebbles and boulders studied are usually well rounded and creamy in colour.

Fig. 1 shows the general position of 7 localities from which coral-bearing limestones including calpionellids come. The localities and stratigraphic position of exotics-containing deposits as well as the museum numbers of exotics discussed in the paper are listed below. Only coral-bearing exotics (see Fig. 2.1) have been taken into consideration.

1 — stream in Leńcze village, 5 km north of Kalwaria Zebrzydowska; Lower Istebna Beds (Late Senonian), Silesian Unit;

2 — Gródek on the Dunajec (Lake Rożnowskie), 15 km north of Nowy Sącz; Ciężkowice Beds (Eocene), Silesian Unit;

3 — Krzywa stream in Krzywica village, 7 km west of Skawina; Verovice Beds (Barremian), Sub-Silesian Unit: exotics UJ 140P/12, UJ 140P/112;

4 — Jastrzębia stream in Jastrzębia village, 1.5 km east of Lanckorona; Grodziszcze Beds (Early Aptian), Sub-Silesian Unit: exotic UJ 140P/10;

5 — Rędzina stream in Woźniki village, 6 km north of Wadowice; Gaize Beds (Late Aptian–Albian), Sub-Silesian Unit: exotics UJ 140P/103, UJ 140P/115, UJ 140P/116; UJ 140P/117 come from black shales within Gaize Beds;

6 — Lipnik Hill (Wapielnica) near Przemyśl, 5 km southeast of Przemyśl; Ropianka Formation (Inoceramus Beds) (Maastrichtian–Paleocene), Skole Unit: exotic UJ 140P/14 was collected from the hill in the vicinity of the Kruhel klippe, now poorly exposed;

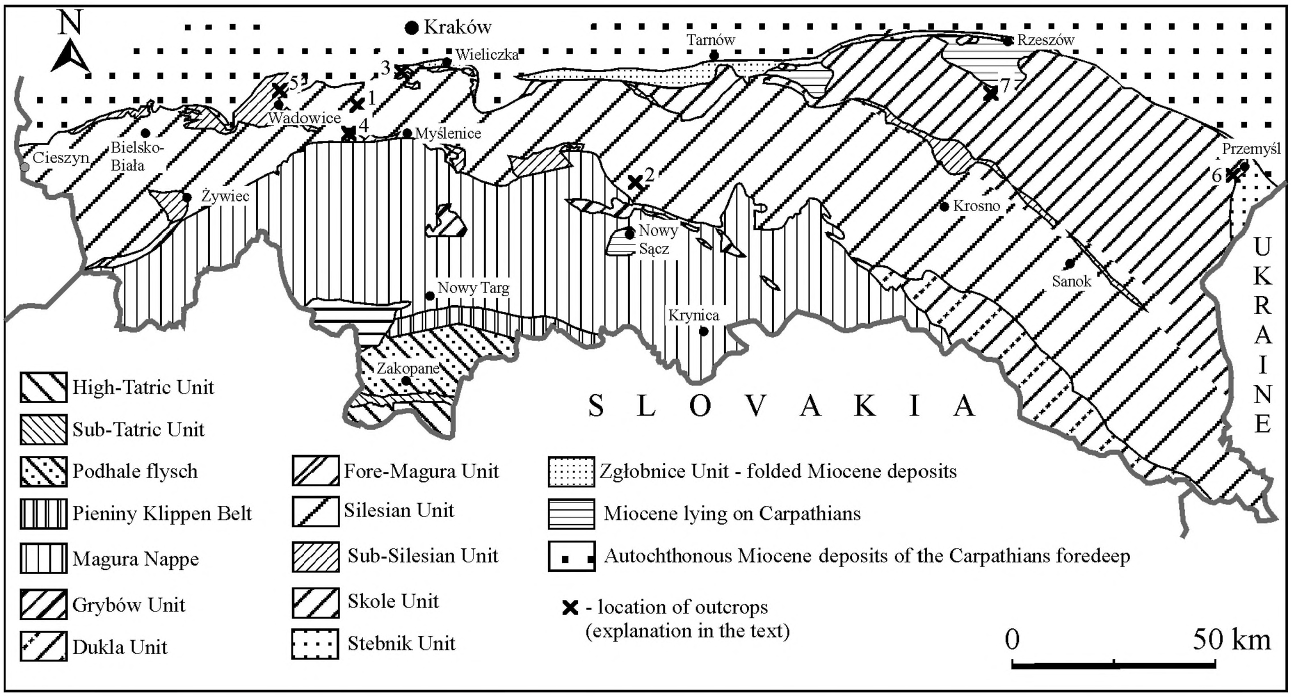

Fig. 1. Geological sketch-map of the Polish Carpathians (simplified after Książkiewicz 1972; Malata et al. 1996) and the localities of the studied outcrops.

7 — Lubeńka stream in Lubenia village, 12 km south of Rzeszów; Babica Clays (Late Paleocene), Skole Unit: exotic UJ 140P/1.

Exotics and thin-sections can be found in the collection of the Institute of Geological Sciences of Jagiellonian University.

Previous study of the stratigraphic position of Štramberk facies from Moravia and Poland

The age of Štramberk Limestone from Moravia was often discussed mainly by Czech and Slovak geologists.

Houša (1990), on the basis of calpionellid fauna, stated that limestones from the Kotouč quarry (Štramberk) can be divided into two parts. The younger part contains calpionellids belonging to Chitinoidella, Crassicollaria and Calpionella Zones (without Calpionella elliptica Subzone), which indicates the age of Late Middle Tithonian–Early Berriasian. The older part does not contain calpionellids, however, its age has been estimated as Early Tithonian on the basis of ammonite fauna (Oloriz & Tavera 1982). According to Houša (1990) the basal part of these limestones was formed during the Early Tithonian. The ammonites present in the Štramberk-type limestones from the uppermost Jurassic-Lower Cretaceous deposits from the Silesian Unit of Moravia also confirm that sedimentation of the Štramberk facies continued during the Early Berriasian (Eliáš & Vašíček 1995).

Recently Houša et al. (1999) have presented the correlation of magnetostratigraphy and calpionellid biostratigraphy on the Tithonian/Berriasian boundary interval in the Western Carpathians, including also the Štramberk section (Kotouč quarry).

Up to now age determinations show that Štramberk-type limestone sedimentation from the Polish Carpathians is of similar age to the Štramberk Limestone. Wójcik (1913, 1914) on the basis of macrofauna (mainly bivalves, gastropods, ammonites and brachiopods) determined the age of "coral klippe" from Kruhel Wielki near Przemyśl as Tithonian and suggested that it can also represent the Kimmeridgian and Berriasian. Studies on calpionellid fauna (Geroch & Morycowa 1966; Morycowa 1964, 1988) indicate the Late Tithonian age in most of the Štramberk-type limestones from Kruhel (klippe and pebbles). The study of these authors confirmed Wójcik's supposition that some of the limestones were deposited during the Early Berriasian. According to Morycowa (1988) shallow water carbonate sedimentation could persist locally till the Early Valanginian. The presence of calpionellids pointing to Berriasian age has been determined by Morycowa (1968) in exotics from vicinity of Rożnowskie Lake. The age of the block from Woźniki based on calpionellids and ammonites was determined as the middle part of Late Tithonian (Książkiewicz 1974; Morycowa 1974; Kutek 1994), and limestones from Inwałd as Middle or Late Tithonian (Nowak 1976).

Discussion on studied calpionellids and stratigraphical implications

Coral-bearing limestones containing calpionellids represent biolithites and bioclastic limestones. Calpionellids occur within sediment (biopelmicrite/biopelsparite) between the reefal fauna or biodetritus. Apart of corals high diversity biota occur, namely microbial structures, algae, foraminifers, molluscs,

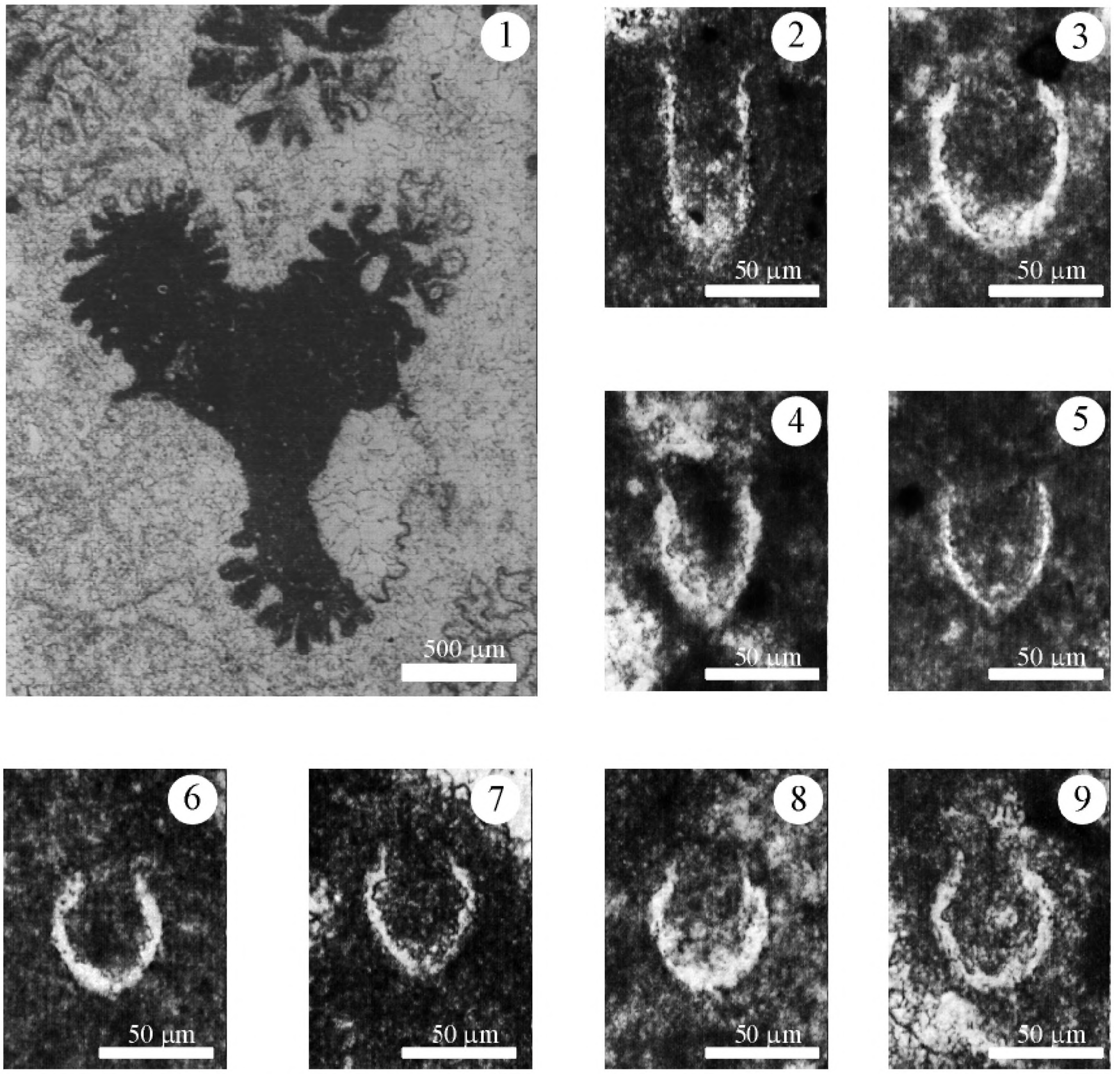

Fig. 2. Representative micrographs of the studied material. **1** — general view of coral-bearing limestone with calpionellids; **2** — *Crassicollaria intermedia*, exotic UJ 140P/12; **3** — *Calpionella alpina* (large form), exotic UJ 140P/1; **4** — *Crassicollaria brevis*, exotic UJ 140P/1; **5** — *Tintinopsella carpathica*, exotic UJ 140P/103; **6** — *Calpionella alpina* (small, sphericular form), exotic UJ 140P/10; **7–9** — *Calpionella alpina* (small, spherical form), exotic UJ 140P/112.

sclerosponges, brachiopods, polychaetes, echinoderms, bryozoans.

Microscopic studies of coral-bearing exotics revealed the presence of calpionellid fauna in 15 of them. Minute quantities of calpionellids were found in 6 exotics. Moreover, the observed sections of these specimens were equatorial and oblique, which made their indication impossible. In the case of 9 exotics stratigraphical indication was provided.

Calpionellid fauna occurs in the material studied in a small amount, but it was able to document the following species: *Crassicollaria intermedia* (Durand-Delga 1957); *Crassicollaria brevis* Remane 1962; *Calpionella alpina* Lorenz 1902; *Tintinopsella carpathica* (Murgeanu & Filipescu 1933). As the material does not come from the continuous sedimentary section, the age of the exotics was determined on the calpionellid assemblage from the particular exotics. The Rome Standard Zones (Allemann et al. 1971) were used with their subdivision in standard subzone according to the Sümeg meeting (Remane et al. 1986). The most actual biochronological calpionellid zonations (Pop 1997; Reháková & Michalík 1997; Grün & Blau 1997; Remane 1998) were taken into consideration to determine the stratigraphical position of the particular exotics. Moreover, the argumentation of the age determination was based on important recent biostratigraphic publications on calpionellids, namely Houša (1990), Reháková (1995), Lakova et al. (1999).

Calpionellid fauna occurring in particular exotics is described below along with the interpretation of the stratigraphical span of the possible stratigraphic position of the exotics (Fig. 3).

Exotic — UJ 140P/14. The exotic contains the oldest calpionellid assemblage. Fully hyaline calpionellids belong to the Remanei Subzone of the Standard Crassicollaria Zone. Moreover *Crassicollaria intermedia* has been found. This form appears in the upper part of the Remanei Subzone (e.g. Remane 1985; Grün & Blau 1997). The whole calpionellid assemblage occurring in this exotic pointed to the upper part of the Remanei Subzone.

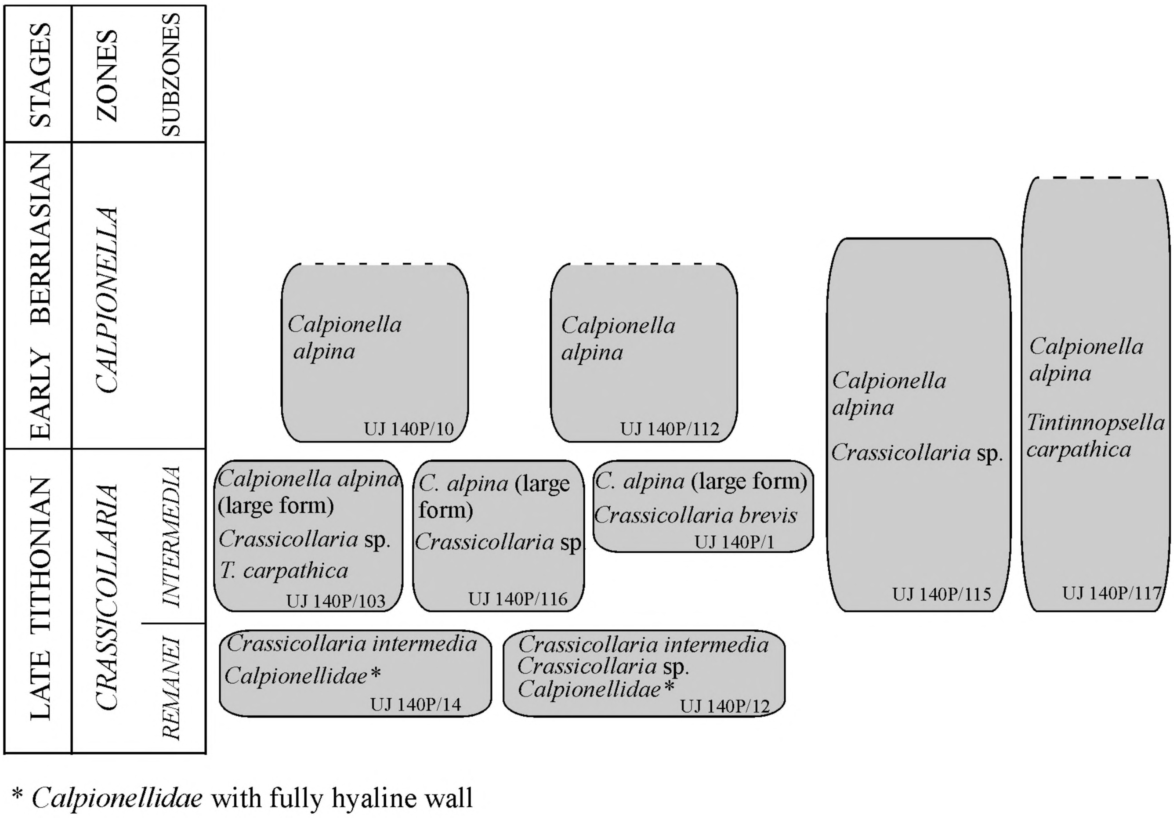

Fig. 3. Calpionellid assemblages occurring in the particular exotics with stratigraphical span of possible stratigraphic position of the exotics (Calpionellid zonation after Remane et al. 1986 — Rome Standard Zones and their subdivision into standard subzones according to the Sümeg meeting).

Exotic — UJ 140P/12. A similar calpionellid assemblage, which means specimens of *Crassicollaria intermedia* (Fig. 2.2) and other *Calpionellidae* (with fully hyaline wall) was observed in this exotic. There are also specimens with characteristic crassicollarian collar (described as *Crassicollaria* sp.). This suggests the Late Tithonian age, namely the upper part of the Remanei Subzone, for the examined exotic.

Exotics — UJ 140P/103, UJ 140P/116, UJ 140P/1. In all these three exotics the age has been determined as Late Tithonian — Intermedia Subzone. Its base is defined by the appearance of the large form of *Calpionella alpina* (Remane et al. 1986). In these three exotics the large form of *Calpionella alpina* has been found (Fig. 2.3). Apart from *Calpionella alpina* (large form) specimens, some *Crassicollaria* sp. (in UJ 140P/103, UJ 140P/116), *Crassicollaria brevis* (Fig. 2.4; in UJ 140P/1), *Tintinopsella carpathica* (Fig. 2.5; in UJ 140P/103) have been observed. *Crassicollaria brevis* is typical in the upper part of the Intermedia Subzone which allows us to state a more precise age for the exotic UJ 140P/1. Some authors prefer to use the name *Calpionella grandalpina* Nagy 1986 for the large form of *Calpionella alpina*, but the taxonomy of the genus *Calpionella* presented by Nagy (1986) is controversial.

Exotics — UJ 140P/112, UJ 140P/10. Only *Calpionella alpina* (small, spherical form) occurs in both of these exotics (Figs. 2.6–2.9). Their loricas are much smaller and more globular if compared to Late Tithonian forms. Moreover these specimens are more abundant than in Late Tithonian exotics. The lower boundary of the Calpionella Zone is determined on the basis of the event, described as an "explosion" of *Calpionella alpina* and transition to smaller, globular forms (Allemann et al. 1971). Considering the size, shape and abundance of the occurring specimens it is possible to suggest that the *Calpionella alpina* specimens belong to the lower part of the Calpionella Zone — Calpionella alpina Subzone sensu Reháková & Michalík (1997).

Exotics — UJ 140P/115, UJ 140P/117. In the case of these exotics a minute quantity of *Calpionella alpina* has been found. The size and shape of the specimens are not conclusive enough to determine the precise calpionellid zone. The age might be provisionally determined as not older than the Intermedia Subzone. Specimens of *Crassicollaria* sp. found in exotic UJ 140P/115 enable determination of the upper boundary for the age of the exotic. It is known that the occurrence of *Crassicollaria* sp. is limited to the Crassicollaria and Calpionella Zones, however in the upper part of the Calpionella Zone (Vocontian C Zone) *Crassicollaria* sp. is observed sporadically (Remane 1964). In the exotic UJ 140P/117 *Calpionella alpina* and *Tintinopsella carpathica* have been found. This makes determination of the precise age impossible. The most approximate determination is the Calpionella Zone.

In the examined material the calpionellid fauna represent the Crassicollaria Zone in five cases. In two cases the Remanei

Subzone was identified, and in three others the Intermedia Subzone. In the case of two exotics, calpionellid fauna characteristic for the Calpionella Zone has been observed, suggesting Early Berriasian age. The age of two other exotics can be estimated as either Late Tithonian (Intermedia Subzone) or Early Berriasian (Calpionella Zone). In the case of the 6 undescribed exotics more precise estimation of their stratigraphical position was impossible.

According to the literature dealing with the exotics of Štramberk-type specimens of *Crassicollaria parvula* and *Calpionella* cf. *elliptica* have been illustrated (Morycowa 1968) as well as *Calpionella elliptica* has been described (e.g. Morycowa 1964). Both species are characteristic for the upper part of the Calpionella Zone, which confirms the Middle Berriasian age of some exotics. Some specimens presented by Morycowa (1968, Table IX, Figs. 7, 8, 9, 10, 12) determined as *Calpionellites darderi* do not seem to represent this species. The specimen on the Table IX, Fig. 12 (Morycowa 1968) is almost certain to be a specimen from the genus *Remaniella*. The present study has not observed *Crassicollaria parvula*, *Calpionella elliptica* or *Remaniella* in the investigated material, however, the appearance of such calpionellids has been described by Morycowa (1964, 1968, 1974).

Generally, the studies on the calpionellid fauna of the exotics of Štramberk-type have shown some similarities to the calpionellid fauna occurring in allodapic limestones of the Lower Cieszyn Limestones (basinal equivalent of the Štramberk facies) from the western part of the Polish Flysch Carpathians, where Crassicollaria and Calpionella Zones have been determined (Ciborowski 2000).

Conclusions

Generally, the whole calpionellid fauna occurring in the material studied suggests a Late Tithonian-Early Berriasian age for the Štramberk-type limestones. On the basis of the detailed studies of exotics, Crassicollaria and Calpionella Zones have been recognized. Within the Crassicollaria Zone, known from the Štramberk Limestone (Houša 1990), Remanei and Intermedia Subzones have been determined by the present authors. Compared to the calpionellid zonation of Štramberk Limestone from Moravia (Houša 1990) the present authors have not observed the Chitinoidella Zone. The youngest examined exotics show a similar age to the youngest part of Štramberk Limestone according to the Houša (1990) scheme. However, it must be admitted that *Calpionella elliptica* occurring in the Štramberk-type limestones (Morycowa 1964, 1968) suggests the possibility of extension of the Štramberk facies to the Calpionella elliptica Subzone.

According to Houša (1990) the thickness of the Štramberk Limestone in Kotouč quarry close to Štramberk attains 140 m in the case of the Crassicollaria Zone and 200 m in the case of the Calpionella Zone. However, there is a dispute whether Štramberk Limestone from the Kotouč quarry exist as olistholiths containing boulders and blocks belonging to different zones of reef and different ages (Eliáš 1983; Eliáš & Eliášová 1984) or, as presumed by Houša (1983), huge tectonic blocks show internal unity showing the standard succession of calpionellids.

Both previous works and the study of Štramberk-type limestones stratigraphy from the Polish Carpathians presented here show mainly Late Tithonian (Crassicollaria Zone) calpionellid assemblage.

It cannot be excluded that some of exotics called Štramberk-type limestones from the Polish Flysh Carpathians are older than Tithonian. According to Malik (1979), analysis of exotics from the Grodziszcze Beds shows that some exotics containing corals represent Oxfordian-?Early Tithonian and can be correlated to the Oxfordian and Kimmeridgian of the Foreland of the Polish Carpathians, where corals are known (Morycowa & Moryc 1976).

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