The earliest brachiopod-bryozoan dominated community in the Ordovician of peri-Gondwana and its ancestors: a case study from the Klabava Formation ( Arenigian) of the Barrandian, Bohemia

Nejstarší společenstvo s dominantními mechovkami a brachiopody v ordoviku peri-Gondwany a jeho předchůdci: příklad z klubavského souvrství (arenig) Barrandínu, Čechy (Czech summary)

(6 figs)

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A remarkably rich fossil assemblage with bryozoans, orthid and lingulate brachiopods, siliceous sponges and other fauna is described from the uppermost layers of the Klabava Formation (Arenigian) in the western part of the Prague Basin, Bohemia. Its taxonomic composition is evaluated and its depth and local position toward the ancient shore line is discussed. The fossil assemblage probably represents transported material from a fissure in the steep rock walls of the shore cliff. The life assemblage was probably analogous to Recent cryptic communities of the rocky shore. The species Quadrotheca sp. is described, representing the earliest known orthothecid hyolith in the Ordovician of the Prague Basin.

Key words: Bryozoans; brachiopods; hyolithids; Arenigian; Ordovician; palaeoecology; palaeoclimate; palaeogeography

Introduction

In European sector of peri-Gondwana, the bryozoan-brachiopod-pelmatozoan (BBP) communities diversified from the Middle Ordovician and reached their maximum in the mid-Ashgillian time. There are only rare occurrences of the BBP communities in older Ordovician stages in contrast to the tropical and temperate palaeocontinents (Laurentia, Baltica). In European peri-Gondwana, the BBP communities rapidly spread from the late Berounian (“Caradocian”) to the mid Ashgillian. The shallow shelves of the Iberian Peninsula (NW and NE Spain), Montagne Noire, SW Sardinia, Libya (North Tripolitania), the Carnic Alps, and submarine volcanogenic elevations of the Armorican Massif showed a significant increase in carbonate deposition and thick carbonate sequence appeared there (Spjeldnaes, 1961, Havlíček, 1981, 1982, Havlíček et al., 1987, Villas, 1985, 1995, Villas et al., 1987, Mélou, 1990, Babin et al., 1982, Bergström – Massa, 1991, Boucot et al., 2003, etc.).

Carbonate deposition in mid-Ashgillian times was rapidly interrupted at the beginning of the Hirnantian as a response to cooling, regression and growth of the polar ice cap. Thinner carbonate-rich beds are reported from mid-Ashgill of Thuringia, Belgium and the Prague Basin. All occurrences are isochronous and indicate a brief warm interval preceding the Late Ordovician glaciation (Boucot et al., 2003).

The older stratigraphical records of the BBP communities in peri-Gondwana are less distinct and their warm climate origin is more speculative. In general, the commoner occurrences of the bryozoans, crinoids and cystoids should indicate shallower environment. Bryozoans are not fully described, but ramose, discoidal and encrusting, mostly trepostome and cyclomastome taxa are significant. The associated brachiopid fauna in the later communities has a similar composition in the Mediterranean Realm, with the dominance of orthid brachiopods (Svododaina, Drabcovia, Onniella, Omnitizina, Hirnantia, Jezeria, Gelidoridae, Saukrodicya and others). Stromphomenides Rafinesquina, Iberomena and Blyskavomena, a plectambonitid Aegiromena, a trilobed Bicuspina, a rhynchonellid Rostricellula and a large discinoid Trematis are locally common. Apart of the bryozoans and brachiopods, there are other remarkable and typical examples of the BBP faunas of Upper Ordovician in the Mediterranean Realm: cystoids (Arístocystites, Echinospheerites, Codiacystis, Heliocrinites, Hippocystis, Fungocystites, Macrocystella), crinoids (Caleidocrinus), trilobites with dominant illienids (Stenopareia) and homalonotids (Calymenella), gastropods of the large Oriosoma-type, large benthic Tentaculites and other but generally rare fauna.

The most famous BBP communities in the Prague Basin are of the late Berounian age. The “PolYeichus” facies (= PolYeichus Horizon; Hirnantia plateana Community of Havlíček, 1982) is known from the shallow, tectonic rising zone in the otherwise deep Prague Basin in the late Berounian (Zahofany and Bohdalec formations) (Havlíček – Vaněk, 1966, Havlíček, 1982). Slightly older examples of the BBP communities in the Prague Basin are generally restricted but are indicated by local accumulations of the characteristic taxa. There are examples from the lower Berounian (scattered data from the Libeň Formation; top of the Letná Formation and the lower Vinice Formation, Bicuspina Community of Havlíček, 1982). Their presence often preceded or followed the oolitic ironstones deposition confined to local rising zones (Havlíček, 1982).

The older units in the Ordovician succession of the Prague Basin lack any typical components of the BBP
communities. The only exception has been found in the western part of the Prague Basin near the village Ejpovice, close to the top of the Klabava Formations (late Arenigian). The remarkable mixture of stratigraphically “old” and “new” faunal elements, and the taxonomic composition of the fossil association with abundant bryozoans and orthid brachiopods is suggestive of the late Ordovician BBP communities. It represents the earliest known report of the BBP-like community in the Mediterranean Realm of peri-Gondwana. Its taxonomic composition, taphonomy and affinity are discussed herein.

Geological setting

The fauna has been found in the northeast part of the abandoned open iron ore mine near the village of Ejpovice, some 10 km east of Plzeň (Fig. 1). The open mine exhibits one of the best exposures of the Klabava, Šárka and Dobrotnič formations (Middle Ordovician) in the Barrandian. The facies succession indicates the gradual upward deepening of the area, from the near shore, shallow littoral lithofacies in the Klabava Formation (Arenigian) to the deep, open-shelf environment with the deposition of the black shale in the lower Dobrotnič Formation (upper Darrinillian).

The upper 15–20 m of the Klabava Formation is a succession of various volcanogenic rocks, mainly of reworked laminated tuffs and tuffaceous shale with a varied content of haematite and calcareous cement, commonly with calcareous and phosphatic bioclasts. The older succession of the Klabava Formation comprises conglomeratic beds, but these are not exposed at present time in the open mine. In the NE part of the open mine, the volcanogenic sequence is in a direct contact with the pre-Ordovician basement, represented by shore cliffs of Precambrian cherts. The cliffs are a part of the Upper Arenigian rocky shore line that trends in a SW–NE direction. The cliffs and their adjacent cover rocks have yielded the oldest known fossils of the rocky shore yet reported (Mergl, 1983). They are represented by stromatolites, encrusting bryozoans and other bryozoan-like biota.

The volcanogenic sequence of the top of the Klabava Formation commonly contains heterofacial intercalations and lenses of oolitic ironstones. These layers and lenses are 2 to 15 cm thick, with erosional bases and contain large amount of rounded to subangular, 5 to 20 mm sized chert pebbles. Siliciclastic material is a less significant component of the ironstones. The matrix of ironstones is mostly muddy, with some carbonate. The ooids of ironstones are 1 to 2 mm in size, usually flattened and with nuclei of quartz grain or fragments of phosphatic brachiopod shells. The ironstones rapidly and unevenly taper laterally. Deformations of the unconsolidated underlying sediments are sometimes present. Fossils in the ironstones are rare and differ from those of the adjacent volcanogenic rocks. In the ironstones, there are mostly organophosphatic lingulate brachiopods, bryozoan-like biota encrusting the pebbles, and broken pieces of stromatolitic mats. In the volcanogenic rocks, the shells of orthid brachiopods and hexactin spicules of siliceous sponges pre-

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Fig. 1. A – The Bohemian Massif showing the Czech Republic and the Ordovician of the Prague Basin; B – The Ordovician of the Prague Basin showing the described locality in Ejpovice (FT), and localities of the *Nocturnella nocturna* Community (asterisks) and the *Marcusodontia* Community (rectangles); C – Map of the abandoned and flooded ironstone open mine near Ejpovice showing the outcrop of Proterozoic chert cliffs (black), localities of the *Nocturnella nocturna* Community (asterisks) and the *Marcusodontia* Community (rectangles), and the site of described locality with its rich bryozoan-brachiopod association (FT).
vail. Unlike the ironstones, diverse trace fossils are common in the volcanogenic rocks.

The ironstone beds may be interpreted as a replaced material of shallow littoral origin. The ooids and pebbles were washed basinswards and their deposition in discrete layers and lenses repeatedly interrupted the more or less continuous sedimentation of the volcanogenic material in the area. There is distinct increase in the development of the ironstone beds upwards in the succession of the Klabava Formation.

A rapid change of sedimentation took place at the Klabava/Sárka formations boundary. The base of the Sárka Formation is marked by massive oolitic ironstone beds that are the start of a continuous succession of oolitic ironstones without volcanogenic intercalations. The thickness of the Sárka Formation is about 20 m in the area. These ironstones lack the pebbles, coarse siliciclastic material and any macrofossils. The deposition of silt siliciclastic material had ceased from the beginning of the Sárka Formation, probably because of the shift of the shore line far to the NW. It is probable that the cliffs of Precambrian cherts, the important source of pebbles in the ironstones of the Klabava Formation, were buried by the onlap at the beginning of the Sárka Formation deposition.

Material and preservation

A rich fossil association has been collected from a single thicker lens of the oolitic ironstone, about 2 m below the Klabava/Sárka Formations boundary. Almost all of the fossils come from an internal intercalation at about mid-thickness of the lens (Fig. 3 C). The maximum thickness of the intercalation is 3 cm and it tapers laterally, following the lateral wedging of the ironstone lens. The ironstone lens is estimated to have originally occupied some 5–10 m², although its actual size had been reduced by about a half by weathering when the fauna was collected in 1982. The ironstone contains fewer pebbles than other ironstone lenses in the area.

This fossil-rich intercalation is formed by a mat of siliceous sponges, bryozoan fragments, calcareous and organophosphatic brachiopod shells mixed with ooids. The carbonate and siliceous substances of shells have been removed and the fossils are preserved as variably deformed internal and external moulds. The bryozoan zoaria are preserved as fragile mineral infillings of the zooecia, with original walls etched. Siliceous spicules of sponges are absent, leaving only external moulds or hollow superficial incrustations. Internal moulds of larger shells (gastropods, hyolithids, brachiopods) are mostly imperfect or missing. Unlike the calcareous shells, the phosphatic shells remain intact, with the original laminated shell substance favourably preserved (Fig. 2). All fossils are only loosely attached to the rock and their surface and internal details are soft and fragile. In great part this is the result of dissolution of the original carbonate matrix between fossils and ooids by weathering but the possibility of an originally large amount of unpreserved organic material (e.g. algal mat) between the fossils cannot be excluded. In total, some 1100 specimens were determined in addition to uncounted sponge spicules.

Figured specimens are deposited in the palaeontological collections of the Museum of West Bohemia, Plzeň (PCZCU). The other material is kept in the author’s collections in the Department of Biology, University of West Bohemia, Plzeň.

Taphonomy and origin of the fossil assemblage

The taphonomy of the fossils indicates that the accumulation did not take place in situ. The valves of brachiopod shells are always loosed, and commonly incomplete. Bryozoan zoaria, both ramose and discoïdal, are fragmental, broken into small pieces. Lingulate brachiopods are preserved as isolated valves, often with broken margins or worn edges. Hollow gastropod and hyolithid shells are collapsed, being commonly incomplete, with apertures broken. Almost all of the larger fossils, apart the bryozoans, are cracked without the detachment of fragments by weak compression of still unconsolidated sediment.

The intercalation of the shelly fauna mixed with abundant spicules of siliceous sponges within the ironstone represents a thanatocoenosis. The shells and dead zoaria were trapped in soft and possibly sticky mat of decayed sponges and algae (?) elsewhere and this primary accumulation was subsequently washed basinwards together with ooids, small pebbles and some muddy material (Fig. 3). However, the origin of the ironstone lens could be not have been instantaneous. The first stage of ooid sedimentation was interrupted by deposition of the sponge mat with trapped fossils. Subsequent rapid supply of ooids buried the mat and preserved the fossiliferous intercalation inside the ironstone lens. The absence of fossils below and above the fossiliferous intercalation also supports the conclusion about a stepped deposition of ironstone lens (Fig. 3 C).

The original living place of the species preserved in a thanatocoenosis should be traced shoreward from their burial place. In this instance it is indicated by the presence of layered bryozoan-like encrusting fossils on pebbles within the intercalation and the absence of fossils in adjacent volcanogenic sediments below and above the ironstone lens.

Taxonomic composition of fossil assemblage

It is notable that the intercalation is highly fossiliferous. The species composition and abundance of fossils has no counterpart in the Klabava Formation in the area. Although some elements of the thanatocoenosis (bryozoans, orthids Nocturnellia nocturna and Ranorthis lipoldi) can be found in adjacent volcanogenic sediments, their relative abundance is quite different. Several fossils are known only from the thanatocoenosis.

Apart from the sponge spicules, the fossil assemblage consists mainly of orthid brachiopods, lingulate brachi-
opods, bryozoans, sponges, one gastropod, one hyolith, and one trilobite species.

Orthid brachiopods are represented by *Nereidella pribylí* (Havlíček), *Ranorthis lipoldi* Havlíček, *Nocturnella nocturna* (Barrande), *Protohesperonomia* ? sp., *Nicolella* ? sp. and *Poramborthis* sp. Only *Nereidella*, *Ranorthis* and *Nocturnella* are common. All the brachiopods were epibenthic, with the largest being *Nereidella* and *Poramborthis*, while shell width of the other genera is always less than 5 mm.

Lingulate brachiopods are represented by *Lithobolus plebeius* Mergl, *Orbithele rimosâ Mergl, Numericoma vulcanogenâ Mergl*, and *Elkania lineola* (Havlíček). Apart from *Lithobolus*, which probably lived as a shallow burrower in a soft bottom, other genera were epibenthic or attached to elevated substrates. Absence of siphonotretoctid brachiopods is noteworthy, since these brachiopods are abundant in more basinward sediments of the Klaba Formation of the same age. All the lingulate brachiopods are fairly thick-walled relative to their shell size. Their mature size is about 10 mm except for the only 2 mm high conical shell of the ephippelasmine *Numericoma*.

Bryozoans are represented by three or more poorly known species. The first has a ramose zoarium of long slender zooecia. The second species is massive, low-mound shaped with large zooecia. The third species has a low, single-layered irregularly discoidal zoarium of large polygonal zooecia. However, the bryozoans cannot be studied by sectioning and their taxonomic position is open. The encrusting bryozoan-like species *Berenicea? ventera* Prantl covers the surface of small pebbles scattered in the thanatocoenosis.

Gastropod and hyolithid shells are less common. The first are represented by a hyperstrophic clisospirid *Miospira helmhackeri* (Perners). Hyoliths are known from one newly discovered species *Quadrotheca* sp. that is described below. The trilobite *Pseudopetigurus hoffmani* Perners is very rare. There are no remains of pelmatozoans. Sponges are preserved as clusters of loose spicules which can be referred to *Hyalospongia*. The globular spinoce bodies associated with spicules are similar to those described by Počta (1898) and referred by him to the sponge *Pyritionema feistmanteli* Počta. They are probably skeletons of a large radiolarian, probably the genus *Anacrusa* Nazarov (cf. Nazarov – Popov, 1980). The approximate relative abundance of specimens (apart from sponges) is presented in Fig. 4. However, their quantitative presence is strongly affected by their fragmentary state and different modes of shelly material preservation.

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**Fig. 2.** Taphonomy of fossils in the thanatocoenosis. A. – *Orbithele rimosâ Mergl* with original organophosphatic shell, in left part pre-diagenetically broken; B. – *Lithobolus plebeius* Mergl, with three post-diagenetic fractures of original shell; C, D – Branches of zoaria of bryozoans, with carbonatic material completely removed and zooecia preserved as mineral infillings; E – *Nereidella pribylí* (Havlíček) preserved as external moulds with calcareous shells completely removed; A, B – × 5.8; C, D, E – ×2.8. Klaba Formation ( Arenigian); Ejpovice.
Affinity of the assemblage to other benthic communities in the area

The benthic communities of the upper part of the Klaba
va Formation are well known, despite the limited outcrop
of the formation and lack of precise stratigraphical data
There are two main littoral communities: The Nocturnel-
ia nocturna Community and the Marcusodictyon Com-
munity.

The Nocturnellia nocturna Community was wide-
spread along the NW margin of the basin, and flourished
in a shallow subtidal environment. It is a typical low-di-
versity community, with prominent dominance of the
small entelitoid Nocturnellia nocturna (Barrande), rarely
associated with orthoids Pratilina bohemica (Barrande),
and Pratilina desiderata (Barrande). Mergl (1992) sub-
divided this community to two sub-communities, mainly
on presence of the small plectorthoid Ranothis lipoldi
Havlíček. This orthid-dominated community is locally
enriched by a diverse fauna including the bellerophontid
Modestopira mergi Frýda, ostracods, conodonts and rarely
the cliospirid Mimospira helmackeri (Perner). Linge-
ulate brachiopods Numericoma vulcanogena Mergl and
Fagusella indelibata Mergl are locally common, indicat-
ing, together with other rare lingulate brachiopods, a
slightly deeper environment and less firm bottom. Other
benthic fossils are highly localised, and remains of bry-
ozoans, trilobites and tunicates are exceptional. Sponges
are somewhat local and commonly absent. The Noctur-
nellia nocturna Community is a typical-level bottom
community. The bioclasts of this community were sort-
ed by currents and waves into shelly pavements and also
transported with volcanogenic material over long distanc-
es along the ancient SW-NE coast of the basin.

The Marcusodictyon Community is a shallow, hard-
bottom benthic community known from rocky shore
cliffs. The biota are represented by weakly diversified
encrusting and commonly colonial organisms (*Marcusodictyon*, bryozoan-like *Berenicea ? vetera*, trepostomate bryozoans and microbial and algal mats). The community is known from N slope of open mine in Ejpovice, some 100–200 m from the locality with the described fossil assemblage. Thin stromatolitic mats attached to abraded rock walls of the cliffs, with encrusting *Berenicea ? ventera* and a discoidal small trepostomate bryozoan have been found there. Other encrusting mats on the cliffs are formed by the bryozoan-like *Berenicea ventera* and *Marcusodictyon* sp. Both species are known on abraded and worn surface of the cliffs, on boulders, and the former also on pebbles trapped in cliff fissures and in adjacent sediments. Gravel bottoms with pebbles in small beaches adjacent to cliffs were probably occupied by the encrusting bryozoan-like *Berenicea ? ventera*. The same encrusting species are known in a few other sites along the almost 60 km long NW limb of the basin.

The thanatocoenosis in Ejpovice contains elements of both communities. There are species characteristic of the *Nocturnellia nocturna* Community, especially the *Nocturnellia/Ranorthis* Sub-community (Mergl, 1992). Several species in the thanatocoenosis are unknown outside it. The presence of bryozoans indicates a hard- or firm marine bottom. The dominance of epibenthic, fixo-sessile orthid, elkaniid and acrothelid brachiopods favours the suggestion about the supposed hard-bottom origin for the organisms preserved in the thanatocoenosis.

The original life assemblage preserved in the thanatocoenosis probably lived on the rocky bottom of supralittoral and shallow sublittoral on the cliffs or in their close proximity. However, erect ramose zoaria of bryozoans indicate some sheltered places in the shore rocks, probably any crevices, small caves or similar places. Studies of Recent fauna show that the cryptic communities can be present at as much as 1–2 metres depth, below boulders and small shaded caves. They have a quite different fauna compared to exposed places of the adjacent open bottom (Asgaard – Bromley, 1991, Ruggiero, 2001). The material (broken zoaria, shells) detached from the walls of some crevice or cave was probably trapped in a litter of sponges and (?) algae at about the same place. This clustered accumulation has subsequently been transported basinwards by occasional, probable storm currents, together with ooids and pebbles from the nearby sea bottom. The accumulation was deposited as a discrete layer, now inside the ironstone lens. The known local shore configuration suggests that transport was only several tens of meters, with some 100–200 m as the maximum.

**Ancestors and offsprings of the assemblage**

The ancestors of the taxa of the thanatocoenosis may be found in the older units of the Prague Basin and in other, more distant areas. The earliest Ordovician unit in the Prague Basin, the Třenice Formation (Upper Tremadocian) has several genera that may be considered as the direct ancestors of some of the taxa present in the thanatocoenosis (Fig. 5).

The plectorthid *Ranorthis lipoldi*, one of the dominant species in Ejpovice, is also locally common in other sites of the upper Klabava Formation. The ancestor species *Ranorthis prima* (Havlíček) is known from a banded haematite lens from Holoubov (locality Ouzký) where it is common and represents the earliest known species of the genus. A similar species is known from Bavaria (Sdzuy et al., 2001). Although the genus is known in the upper Arenigian of France (Melou, 1982), its centre of distribution was the Baltic area with several successive species in the Billingen and Volkovsk stages (Egerquist, 2004).

The genus *Poramborthis* is very rare in the thanatocoenosis and fragments of its shell with characteristic microornament occur less frequently in the tuffaceous sediments with the *Nocturnellia nocturna* Community. The genus is represented by several stratigraphically successive species in the Třenice and Milina formations in the Prague Basin (Havlíček, 1977). It is also known in the Lower and Upper Tremadocian of Bavaria (Sdzuy, 1955, Sdzuy et al., 2001) and Spain (Havlíček – Joso- pait, 1972). It is a typical species of European sector of peri-Gondwana, being unknown outside the area.

The other orthid brachiopods are unknown in the older units of the basin, but they have relatives among fau-
na of the Baltic area. The small enteletoid Nocturnella nocturna is more related to the Baltic Upper Ordovician genus Oanduporella Hints than to Mediterranean Realm genera, such as Drabovia Havlíček, Drabovinella Havlíček or Hirnantia Lamont. The commonest orthid in the thanatocoenosis, the dalmanellloid Nereidella pribyli, is related to Baltic species of the genus Paurorthis Schuchert – Cooper, especially to P. resima (Rubel) from the Billingen Stage.

The affinity of other rare orthid species from Ejpovice is less clear. Protohesperonomia sp. described by Mergl (1991) is known only in external moulds with characteristic parvicostellate ornament and its affinity is enigmat-
ic. It is similar to Protohesperonomia Williams – Curry (Family Hesperonomiidae Ulrich – Cooper), know only from Ireland in a fauna of Laurentian affinity. However, it is also worth noting that some orthid genera (Apheoorthothina Havlíček, Robertorthis Havlíček, Eoorthis Walcott) in the diversified orthid brachiopod assemblage from the base of the Třenice Formation are similarly puzzling in a palaeogeographic sense, since they have no relatives in the earliest Ordovician of the Mediterranean Realm.

The other shared feature with older units of the Prague Basin is the presence of hyperstrophic gastropod Mimospira. This clisiospirid genus is known in the Třenice and Milina formations (Růžička, 1927, Mergl, 1984)

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Fig. 5. Palaeogeographical reconstructions for the early Ordovician (after Cocks – Torsvik, 2002) with the distribution of some key Tremadocian– Arenigian genera indicated: Ranorthis (triangles), Poramborthis (dots), Mimospira (rectangles).
in allied and hitherto undescribed species related to *Mimospira helmhackeri*. The clisospirids are typical warm water gastropods, known mainly in the Baltic area in the Ordovician (Frýda, 1989), but in the Prague Basin they are known only in the Lower and early Middle Ordovician and from the mid-Ashgillian (the top of the Králův Dvůr Formation; Frýda, 1989). The later occurrence is clearly related to the pre-Hirnantian climate warming episode (Boucot et al., 2004).

Bryozoans are unknown in the earlier Ordovician in the Prague Basin, but the rapid radiation of the phylum begun only in the Arenigian. The cystoids, both rhombiferans and diploporites are known from the Třenice and Milina formations where they are also associated with the brachiopods *Ranorthis* and *Poramborthis*. The cystoids are unknown in the Klabava Formation, but with a few exceptions, echinoderms are totally in this unit; their absence is probably related to some physical limits of the environment. The cystoids, however, are common elements in the Tremadocian of Bavaria where they occur with the orthid genera *Poramborthis* and *Ranorthis*.

There are also common genera among the lingulate brachiopods. *Orbithele* is known in the lowest part of the Třenice Formation. It is common in the Milina Formation and *Orbithele rimoso* from the intercalation in Ejpovice is the youngest known species of the genus yet reported. *Elkania* is known also from the Třenice Formation and the rare species from Ejpovice is also the youngest known occurrence of the genus in the Prague Basin. Sponges having large hexactin and pentactine spicules are almost unknown in the younger Ordovician units of the Prague Basin, in contrast to their abundant presence from the Třenice Formation to the top of the Klabava Formation. In general, the species-rich communities near the base of the Třenice Formation near Holoubkov, and moderately diversified fauna of the Milina Formation in the Komárov area, can be taken as forerunners of the fauna preserved in the thanatocoenosis in Ejpovice.

The immediately overlaying Šárka Formation has nothing common with the fauna from the intercalation, but this difference is related to rapid subsidence and deepening of the basin and lack of data about shallow littoral environment. Some similar faunistic elements are known from the Libeň and Letná formations (Berounian), but the bryozoans did not become abundant in the Prague Basin until the deposition of the Zahofany and Bohdalec formations. The remarkable hyolith *Quadrotheca* known in the intercalation in Ejpovice is known from the Zahofany Formation (Berounian).

The fauna from Ejpovice is a remarkable mixture of the earlier Ordovician groups and genera, (*Ranorthis, Poramborthis, Orbithele, Elkania, Mimospira* and hexactinellid sponges) and of new Middle and Upper Ordovician elements represented by bryozoans, orthids *Nocturnellia* and *Nereidella,* the ephiippelasmatine *Numericoma* and the orthothecid *Quadrotheca*. Many elements have clear Baltic affinity.

### Systematic palaeontology

**Class Hylolitha Marek, 1963**

**Order Orthothecida Marek, 1967**

**Family Orthothecidae Syssoiev, 1957**

**Genus Quadrotheca Syssoiev, 1958**

**Type species:** *Hylithes (Orthotheca) quadrangularis* Holm, 1893; Upper Ordovician, Sweden.

**Quadrotheca sp.**

**Fig. 6**

**Material:** Six incomplete shells, (specimens PCZCU 10657-1062) preserved as external moulds in oolitic ironstone.

**Description:** The conch is straight and long with an estimated maximum length of 30 mm. The shell is thin and fragile. The angle of divergence is less than 10°, probably between 7–8° (apical part of the shell is always broken off). The cross section is rectangular, almost square. All four sides are flat to weakly concave in the adult part of the conch.

The ornament consists of thin and high costellae of two sizes. The coarser costellae are some 0.4 mm apart. The intercalated costellae are about their half height; numbering four or five between the coarser costellae. This ornament is present on the ventral, dorsal and lateral sides of the conch. Growth lines are low and weak. Lines are rarely extended into coarser very short lamellae. The lateral surface of the coarser costellae bears growth lines inclined anteriorly, indicating that along the shell aperture these coarser costellae formed a margin of short spines. Shell interior and the operculum are unknown.

**Remarks:** Despite the lack of data on the shell interior and the operculum, the shell is very similar to *Q. (?) rediviva* Marek 1967, especially in its rectangular cross-section and its ornament. *Quadrotheca* sp. differs in its more elongate shell with smaller apical angle and the ornament more clearly divided into coarser and finer costellae which are also on the lateral sides of the conch. The species is much older in its stratigraphical occurrence, since the *Q. (?) rediviva* is known from the Zahofany and Bohdalec formations (Berounian Stage). The species thus represents the earliest representative of the genus yet known. It is also the earliest representative of the order Orthothecida Marek, 1967 in the Ordovician of the Prague Basin. Another orthothecid genus, *Bacrotheca* Novák, 1891, is common in the overlying Šárka Formation. However, this genus, represented by the common species *B. teres* (Barrande, 1867) differs from *Quadrotheca* sp. in its distinctly rounded cross section of the shell and more uniformly sized costellae.

The presence of *Quadrotheca* sp. in association with bryozoans and abundant orthid brachiopods is reminiscent of younger fossil associations of the Zahofany and Bohdalec formations. The genus probably represents a
common and characteristic element of the BBP communities not only in the Prague Basin and its presence may be suggested in other parts of the peri-Gondwana.

**Occurrence**: Upper Arenigian, Klaba Formation, uppermost part; Barrandian, Ejpovice open iron mine.

**Conclusions**

The presence of the bryozoan-brachiopod dominant fossil association in the Klaba Formation (Arenigian) indicates that: (1) the origin of the Upper Ordovician typical BBP communities in the Mediterranean Realm can be sought in shallow temperate part of peri-Gondwana back in the Arenigian; (2) the oldest communities of the BBP community type in the Mediterranean Realm are of the Arenigian age; (3) the oldest communities of the BBP community type in the Mediterranean Realm have many elements of undoubted Baltic affinity and to a lesser extent also of the Laurentian affinity; (4) the oldest communities of the BBP community type in the Mediterranean Realm have numerous elements common with the Tremadocian and earlier Arenigian; (5) early records of the bryozoan radiation are also of Arenigian date in the Mediterranean Realm.

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**References**


**Fig. 6.** *Quadrotheca* sp.

A, B – External mould showing cross-section of the shell and its dorsal side, ×5.8; C – Almost complete shell showing dorsal side, external mould, ×5.8; D – Collapsed shell, external mould, ×5.8. Klaba Formation (Arenigian); Ejpovice.


Nejstarší společenstvo s dominantními mechovkami a brachiopody v ordoviku peri-Gondwany a jeho předchůdci: příklad z klabavského souvrství (arenig) Barrandienu, Čechy

Z nejvyšší části klabavského souvrství (arenig) ze západní části pražské pánve je popsána druhově bohatá asociace fosilií s mechovkami, orthidními a lingulárními brachiopody, kříženými houbami a další faunou. Její taxonomické složení a pozice vůči bývalé březní linii je vyhodnocena a komentována. Fosilie pravděpodobně reprezentují materiál se stěn nebo ze stěrin pobřežních skalisek. Společenstvo bylo analogické recentním kryptickým společenstvím skalnatých pobřeží. V systematické části je popsán druh Quadrathecus sp., který je nejstarším ordovickým zástupcem orthothecidních hyolithů v pražské pánvi.

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