SBORNÍK NÁRODNÍHO MUZEA V PRAZE
Řada B – Přírodní vědy • sv. 68 • 2012 • čís. 1–2 • s. 15–22

ACTA MUSEI NATIONALIS PRAGAE
Series B – Historia Naturalis • vol. 68 • 2012 • no. 1–2 • pp. 15–22

THE PRIABONIAN BRYOZOAN-DECAPOD ASSOCIATION FROM THE BOROVÉ FORMATION (THE ĎURKOVEC QUARRY, NE SLOVAKIA) AND ITS PALAEOECOLOGICAL IMPLICATIONS

MATÚŠ HYŽNÝ
Department of Geology and Paleontology, Faculty of Natural Sciences, Comenius University, Mlynská dolina G1, 842 15 Bratislava, Slovakia; e-mail: hyzny.matus@gmail.com

KAMIL ZÁGORŠEK
National Museum, Prague Cirkusová 1740, 193 00 Praha – Horní Počernice, Czech Republic; e-mail: kamil_zagorsek@nm.cz

Hyžný, M., Zágoršek, K. (2012): The Priabonian bryozoan-decapod association from the Borové Formation (the Ďurkovec quarry, NE Slovakia) and its palaeoecological implications. – Acta Mus. Nat. Pragae, Ser. B, Hist. Nat., 68(1–2): 15–22. Praha. ISSN 0036-5343

Abstract. Co-occurrence of decapod crustaceans with bryozoans is relatively uncommon and poorly recorded in the literature. An assemblage consisting of two decapod species, Coeloma vigil A. Milne-Edwards, 1865 and Ranina sp., associated with a small bryozoan association is reported from the Priabonian (Upper Eocene) of the Borové Formation (the Hornád Basin, NE Slovakia). The most common bryozoan taxon from the studied section is Reteporella sp. The rest of the association is composed of free living (probably belonging to the genera Lunulites sp. and/or Smittipora sp. and/or Cupuladria sp. and/or Reusirella sp.), rigid erect (Metrarabdotos, Myriapora sp. and/or Smittina sp.), and cyclostomatous forms (Hornera sp.). Based on the presence of the studied taxa and their mode of preservation it can be concluded that during the sedimentation of layers with large bryozoans within the Tomášovce Member of the Borové Formation, the environment was very shallow, marine, with permanent water currents.

■ Bryozoa, Decapoda, Priabonian, the Borové Formation, palaeoecology

Received April 19, 2012
Issued July 2012

Introduction

Bryozoans in general have ecological importance and influence the feeding and protection of other groups (e.g. Echinodermata and Polyplacophora), while competing for space with other organisms, mainly other Bryozoa, Porifera, and Polychaeta (Gordon 1972). Decapod crustaceans are known to associate with a variety of sessile inverterbrates (e.g. corals). Bryozoans are also one of the possibilities. In extant environments, colonial taxa (e.g. *Schizoporella*) often shelter a large and diversified invertebrate fauna including decapods (Lindberg and Stanton 1988; Mantelatto and Souza-Carey 1998; Morgado and Tanaka 2001, and references therein). A similar ecological role for bryozoans could also be assumed in the fossil record.

The Eocene was a good time for bryozoans. The family-level global diversity reached its peak during that time (Taylor and Larwood 1990). New areas in which moss animals had never been seen before, became available for population and billions of colonies grew, eventually forming rocks after their death.

To understand the position of the Bryozoa during the Eocene and Oligocene and the response of this group to various challenges, we initiated a systematic study of faunas and environments of the Upper Eocene. Eocene bryozoans have been extensively studied from the Liptov Basin (Borové Formation) and from the Rajec Basin (Zuberec Formation) in Slovakia by Zágoršek (1992, 1994, 1996a,b, 1997). New occurrences of a rich bryozoan fauna associated with decapod crustaceans at the Ďurkovec quarry (the Hornád Basin) provide additional information for reconstruction of palaeoecological settings of the sedimentary area and also document the evolution of the Tomášovce Member within the Borové Formation.

Geological settings

Geology and stratigraphy of the Borové Formation

The Borové Formation is part of the Podtatranská (Subtatric) Group, which is composed of sedimentary rocks of Paleogene age. The Borové Formation is a typical transgressive formation with occurrences of marine fauna, mostly bivalves and gastropods. Lithologically it consists of breccias, conglomerates, sandstones, limestones, and occasionally, also claystones (Gross et al. 1984). There are a few regional lithostratigraphic units of the Borové Formation in the Hornád Basin: the Hornád Member, the Chrasť Member and the Tomášovce Member (Gross et al. 1999). The latter represents the uppermost member of the Borové Formation occuring in the Hornádska and Šarišská vrchovina uplands and dates to the Priabonian – lower Oligocene (predominantly the youngest Priabonian) time (Filo and Siráňová 1996). The Tomášovce Member represents an up to 150 m

thick complex, composed of alternating fine-grained sandstones and siltstones with pyrite concretions and rare intercalations of medium-grained carbonate arenites and fine-grained petromict conglomerates.

Previous palaeontological studies of the Tomášovce Member

Since the 19th century, the Tomášovce Member has been reported as "the sandstones with plants imprints and macrofauna" (Hazslinszky 1852; Miczynski 1891; Staub 1891). More recent investigation (Filo and Siráňová 1996) showed that the Tomášovce Member is a sedimentary sequence containing a rich neritic macrofauna (mainly bivalves), benthic foraminifers, and a tropical flora dominated by a hydrophylous association of angiosperms.

The rich macrofloral association is composed of *Pinus*, *Araucarites*, *Magnolia*, *Dryophyllum*, *Castanopsis*, *Pasania*, *Quercus*, *Ficus*, *Cinnamomum*, *Laurus*, *Andromeda*, *Apocynophyllum*, *Banksia* and *Dryandroides* (Sitár in Filo and Siráňová 1996).

The macrofauna is composed mainly of bivalves: *Nucula*, *Lucina*, *Miltha*, *Corbis*, *Tellina*, *Abra*, *Siliqua*, *Cardium*, *Nemocardium*, *Crassatella*, *Cyrena*, *Cyprina*, *Isocardia*, *Dosiniopsis*, *Meretrix*, *Pitar*, *Pectunculus*, *Anomia*, *Pecten*, *Chlamys*, *Psudamussium*, *Lima*, *Spondylus*, *Ostrea*, *Gryphaea*, *Modiolus*, *Thracia*, *Pholadomya*, *Teredo*, *Panope* and *Corbula* (Volfová 1962, 1963, 1964; Papšová 1967; Gross et al. 1973). Other faunal components include gastropods (*Turritella*, *Fusus* and *Clavilithes*), cephalopods (*Aturia*), decapod crustaceans, echinoids (?*Echinocyamus*, *Schizaster*), shark teeth and fish scales (Filo and Siráňová 1996; Krempaská 1998; Holec et al. 2005; Hyžný 2007).

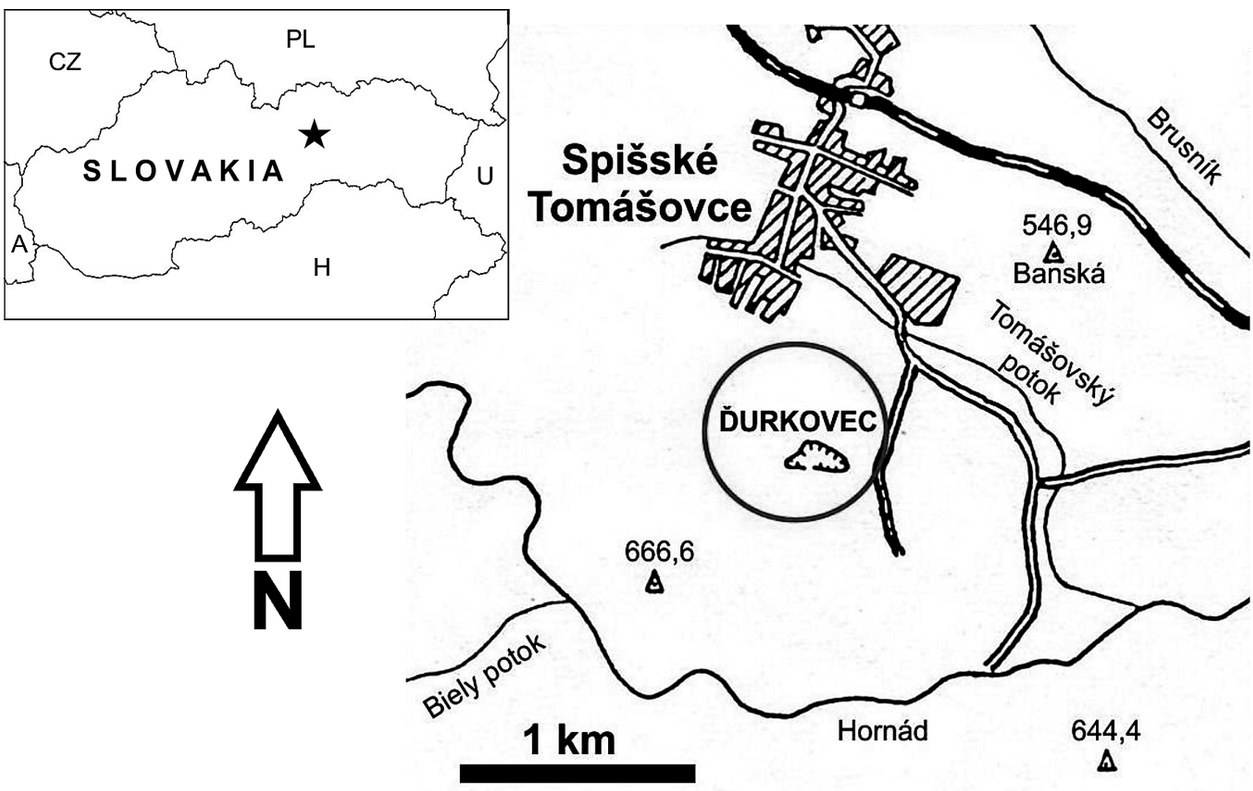
Studied section at the Ďurkovec quarry

The stratotype of the Tomášovce Member established by Filo and Siráňová (1996) is situated in the Ďurkovec quarry (Tex-fig. 1), 1 km south from the village of Spišské Tomášovce in the Spišská Nová Ves district (GPS location: N 48°57'0.21" E 20°28'21.74").

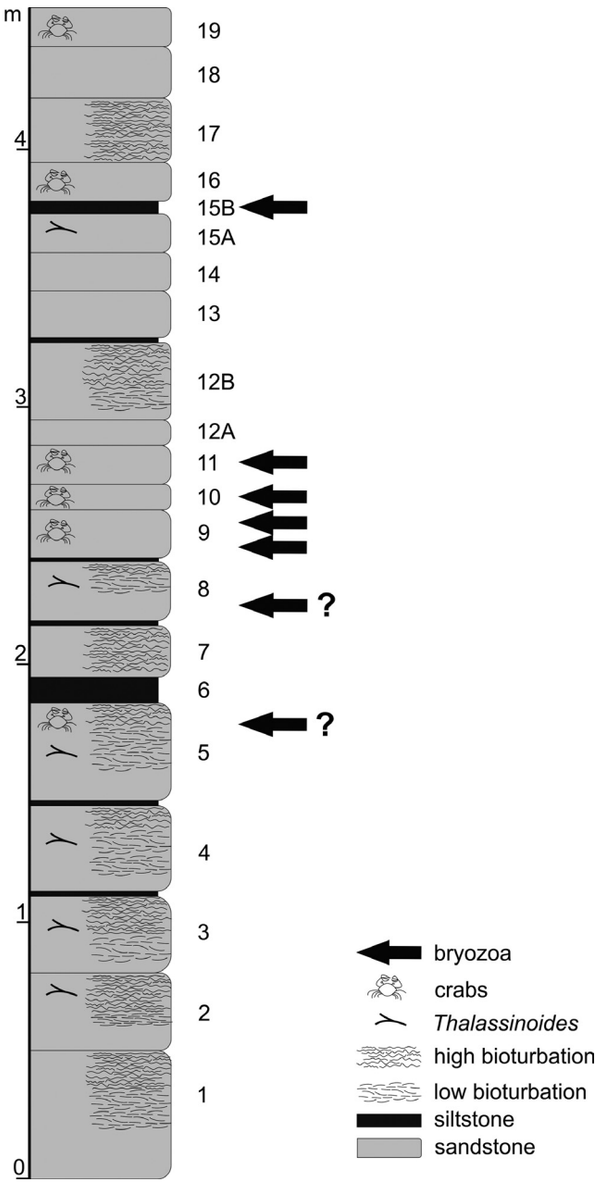
In the 19th century the Ďurkovec quarry was opened for sandstone extraction and its two levels are still active. As a consequence of the rapid progress of quarrying, the stratotype section (ca. 10 m sequence) as defined by Filo and Siráňová (1996) is no longer present. A reference section which is the subject of this study was established by the senior author in 2009. This new section can be correlated with the topmost three meters of the original stratotype section (Filo and Siráňová 1996, fig. 5). Unfortunately due to continuous quarrying in 2011 the new correlation section was completely destroyed.

The studied section (text-fig. 2) consists of a ca. 4.5 m sequence of alternating fine-grained calcareous sandstones and siltstones. The sequence starts with thick layered sandstones (up to 50 cm thick). The upper part of the sequence is composed of distinctly thinner layers (ca. 20 cm thick) with more siltstone intercalations. In the section, several bioturbated horizons occur; these are usually bound to the upper parts of the layers. The trace fossil association consists mostly of the ichnogenera *Planolites*, *Scolicia*, and *Thalassinoides*. Perpendicular burrows of unknown affinities have also been identified.

The quarry has been thoroughly studied since the 1960s. Since 1988, staff from the Civic Museum in Spišská Nová Ves have performed continuous research there which yielded a rich bivalve association containing *Pholadomya*, *Cyp-*



Text-fig. 1. Location of the study area (Ďurkovec quarry).



Text-fig. 2. Studied section at the Ďurkovec quarry. Note the co-occurrence of bryozoans and decapod crustaceans.

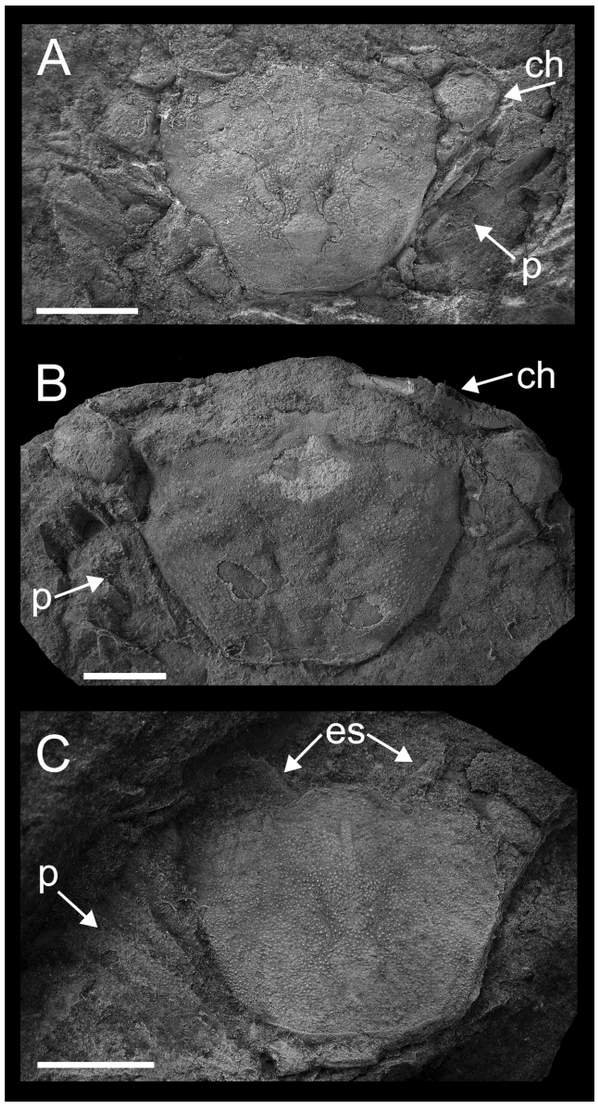
rina, *Panopea*, *Tellina*, *Pecten*, *Cardium*, and *Thracia* (Krempaská 1998). A shark tooth from *Xiphodolania* has also been found (Holec et al. 2005). Recently, the senior author found a rich association of bryozoans, the description of which is one of the goals of this paper.

Material and methods

The studied section was sampled bed-by-bed. All macrofauna were collected. The rate of bioturbation was estimated in relation to the entire section.

The bryozoan material was obtained from rock samples, and was usually preserved as impressions of dissolved skeletons or as remains of the skeleton. The selected specimens were sorted under a binocular microscope and documented by an online camera DP70 (Olympus). The best preserved examples of each species were cleaned ultrasonically and studied using a low-vacuum Hitachi S-3700N SEM at the National Museum, Prague, the Czech Republic. This instrument allowed backscattered electron images to be obtained of uncoated specimens temporarily mounted on stubs using adhesive carbon tabs, or affixed to stage mounts with carbon plastic.

The decapod crustacean material was preserved either as isolated dorsal carapaces or intact with all appendages, including preserved chelipeds and eye stalks (Text-fig. 3). The specimens were prepared using a fine pneumatic needle. To enhance greater contrast the specimens were coated with ammonium chloride prior to photography.



Text-fig. 3. *Coeloma vigil* A. Milne-Edwards. Nearly complete specimens from several different layers. A – layer 15; B – layer 11; C – layer 16. All specimens are deposited at KGP MH. Key: ch=chelipeds; es=eye stalks; p=pereiopods. Scale bar 10 mm. Specimens were covered with ammonium chloride prior to photography.

The fossil material is deposited in the following institutions: Department of Geology and Paleontology, Comenius University, Bratislava, Slovakia (KGP MH); National Museum, Praha, the Czech Republic (NMP); and Natural

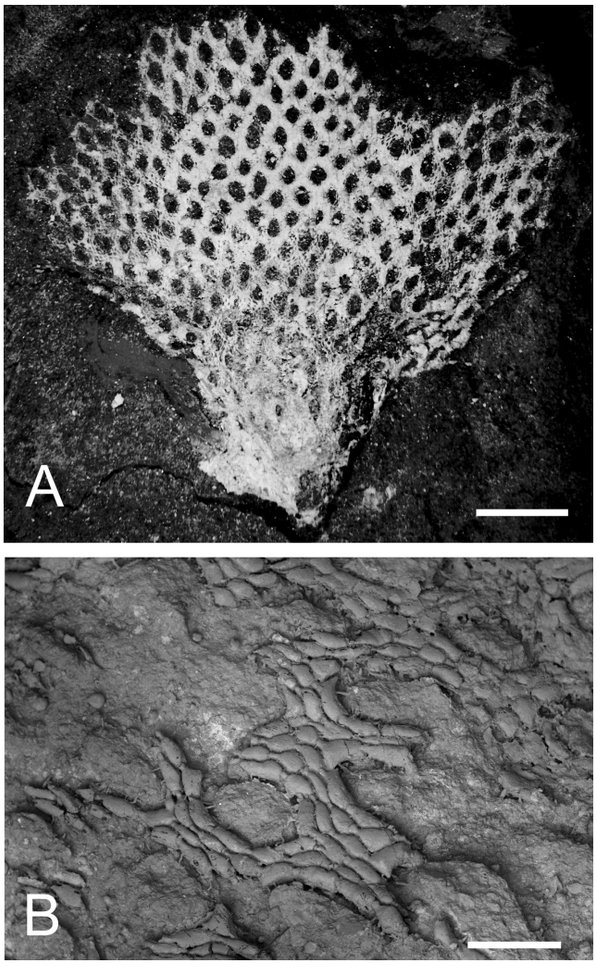
History Museum of the Slovak National Museum, Bratislava, Slovakia (SNM Z).

Results

Bryozoans from the Ďurkovec quarry

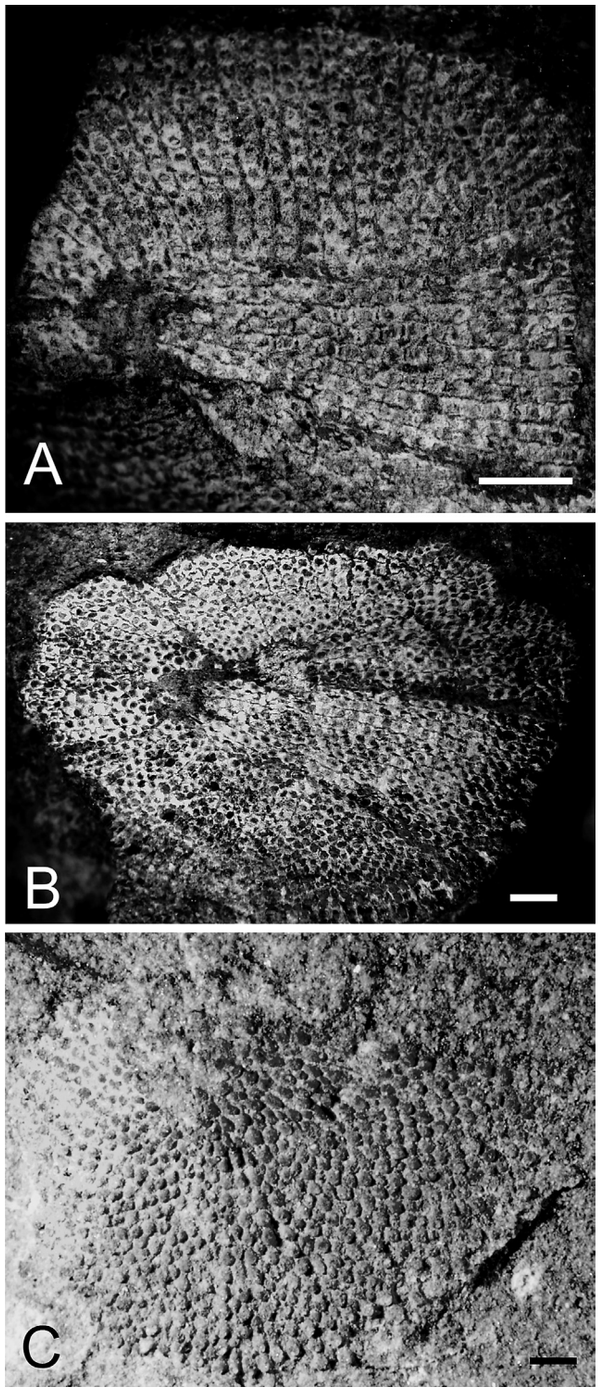
Altogether about 100 fragmentary specimens of different sizes and modes of preservation were found in the studied section. Generally, the preservation of the material is very poor; no surface features on the colonies are visible, only the impressions partly retain the original skeleton. However, the shape and size of the colonies can be easily estimated.

The most common taxon is *Reteporella*, which is easily determinable due to the fan shape of its colonies. The colonies are usually very large (the largest specimen is 62 mm in diameter), forming extensive fans, without broken branches (Text-fig. 4).

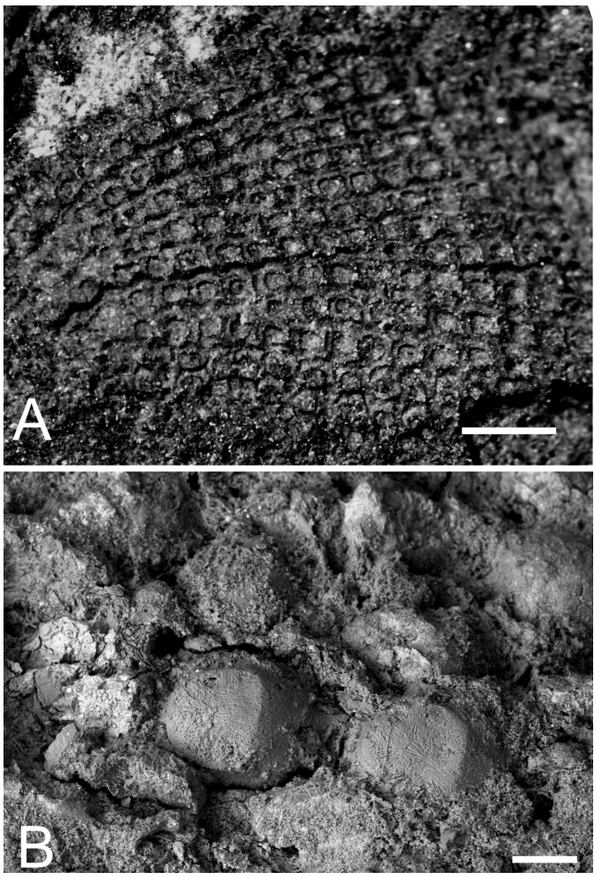


Text-fig. 4. *Reteporella* sp., deposited in NM Prague under number T 3318. A – Large colony suggesting very short transport. Scale bar 10 mm. Optic photography. B – the detail of branch showing the mode of preservation (no original skeleton preserved). Scale bar 1 mm. SEM photography (BSE detector).

The second group of bryozoans belongs to the free living forms, perhaps belonging to the genus *Lunulites* and/or *Smittipora* and/or *Cupuladria* and/or *Reusirella*. Due to the poor state of preservation, more detailed determination is impossible (Text-fig. 5). However, the size and remaining structures resemble free living genera from Východná (Priabonian, Gross and Köhler 1980). Larger colonies are similar to *Smittipora* as described by Zágoršek (1996b), the smaller one (Text-fig. 6) showing the characteristic arrangement of autozooecia, resembles *Lunulites* as reported by



Text-fig. 5. Free living colonies, showing a mode of preservation which does not allow for precise determination but clearly exhibiting features characteristic for *Smittipora* and/or *Cupuladria* and/or *Reusirella*. (note the clear intrazooecial buds). Specimen deposited in NM Prague under number T 3319. A – imprint, B – counterpart to fig A. C – Specimen deposited in SNM under number Z 37724. Optic photography. Scale bar 1 mm.



Text-fig. 6. *Lunulites*(?), deposited in NM Prague under number T 3320. A – optic (scale bar 1 mm) and B – SEM (BSE detector) photography (scale bar 100 µm) showing characters suggesting determination as *Lunulites* (square shape and linear arrangement of autozooecia, short cryptocyst and presence of vibracularia).

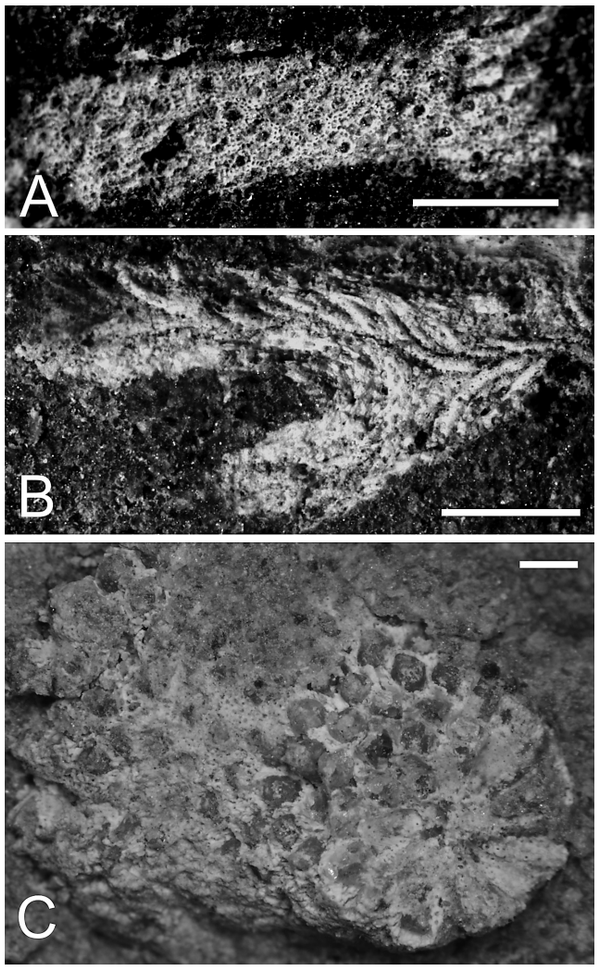
Zágoršek (1994). One colony shows characteristic reproduction from the fragment, similar to those from the Langian section Korytnica, Poland (Zágoršek et al. 2012).

The third group of bryozoans are rigid erect forms, perhaps belonging to *Metrarabdotos* and/or *Smittina* (Text-fig.7A). A more precise determination is impossible due to the preservation. The size of the fragment is much smaller than those of *Reteporella* and the free living taxa, indicating much longer transport to the depositional area.

The last group are erect rigid cyclostomatous bryozoans, from which the genus *Hornera* is clearly identified (Text-fig. 7B).

Decapod crustaceans from the Ďurkovec quarry

Decapod crustaceans represent some 5% of all macrofossils, and some 10% of all macrofaunal remains found at the Ďurkovec quarry. Their distribution, however, seems to be restricted to several horizons. A preliminary report on the crab fauna from the Ďurkovec quarry was published by Hyžný (2007); an updated list of taxa occurring there was given in Hyžný (2011). In the studied section two crab species were recorded, *Coeloma vigil* A. MILNE-EDWARDS, 1865 and *Ranina* sp.; the latter is represented by a single fragmentary specimen from the topmost part of the section (cf. Hyžný 2007).



Text-fig. 7. rigid erect bryozoans. A – colony perhaps belonging to *Metrarabdotos* and/or *Smittina*, deposited in NM Prague under number T 3321. B – erect rigid cyclostomatous bryozoans belonging perhaps to the genus *Hornera*, deposited in NM Prague under number T 3322. C – colony perhaps belonging to *Myriapora*, deposited in NM Prague under number T 3323. All photographs were taken under the optic microscope, all scale bars 1 mm.

The most common crab in the section, *C. vigil*, is a well known taxon reported from the Upper Eocene to ?Middle Oligocene of Europe (Jagt et al. 2010, table 1). The specimens from the Ďurkovec quarry correspond to all the previously published descriptions (Milne-Edwards 1865; Allasinaz 1987; De Angeli and Beschin 2001; Ilyin 2005).

Although bryozoans often foul decapods when alive, no fouled specimen has been found in the studied section. This can be attributed to taphonomic processes as the epicuticle upon which epibionts such as bryozoans attach to living crabs is lightly calcified and tends to be readily lost during fossilization (Waugh et al. 2004).

Palaeoecology

The occurrence of large fragments of colonies and even near-complete colonies of free living bryozoans indicate the absence of, or only very short, post mortem transport. *Lunulites* produce fragile colonies which can easily be broken (O'Dea 2006). Therefore, the preservation of large fragments of this taxon indicates relatively rapid burial by sed-

iment without long transportation. Therefore, it is highly probable that large reteporiforms and free living colonies may be regarded as autochthonous and document the palaeoenvironment of the Tomášovce Member.

When alive, *Lunulites* preferred tropical to subtropical waters with sandy bottoms, with slow but continuous water flow, and a very low sedimentation rate. This statement may be also supported by the presence of *Reteporella*, which grows in higher energy water, usually close to underwater currents (Hayward and Ryland 1996), at a very shallow depth (up to 50–100 m).

The presence of cyclostomatous genera, especially *Hornera*, also indicates a shallow water environment, while large colonies of *Metrarabdotos* and/or *Smitina* and/or *Myriapora* may indicate a deeper setting (ca. 100 m), and a slight decrease of oxygen. However, large erect colonies are usually preserved as very small fragments, which may indicate longer transport. Thus, such colonies might originally have lived in a different environment and subsequently were transported to the shallow water where reteporiforms and *Smittipora*/*Lunulites* lived. *Metrarabdotos*, *Smitina* and *Myriapora* fragments were deposited during transgressive, highstand times when water depth was greater. Later, during lowstand times, the fragments were reworked and redeposited in shallower water together with *Smittipora*/ /*Lunulites* bryozoans. A similar mechanism has been described by Derman and Gürbüz (2007) from the Miocene of the Adana Basin (Turkey). The second possibility is that the transport from a deeper to a shallower part of the basin may be explained by currents, as in the Miocene of Fine Basin, western Tuscany in Italy (Bartolini et al. 1975). Large erect colonies are very rigid and may therefore survive long transport. The presence of a bottom current is supported by the occurrence of reteporiforms and *Smittipora*/*Lunulites* colonies.

The preservational state of specimens of the crab *C. vigil* suggests rapid burial with limited subsequent disturbance, which is reflected in the entire intact specimens with preserved appendages (Text-fig. 3). It is difficult to judge whether the specimens represent corpses or moults, as both states may result in very similar preservation (Bishop 1986). The co-occurrence of bryozoans and decapods in layers 9–11 can be correlated with a limited bioturbation rate in these horizons (Text-fig. 2), which supported the preservation of both groups.

In can be concluded, that the environment during the sedimentation of layers with large bryozoans within the Tomášovce Member was very shallow with permanent water currents. A comparable environment has also been suggested for the Eocene locality Východná in the Liptov Basin (Zágoršek 2000). Similarly the dominance of free living bryozoans from the Miocene of other localities, represented by sections BAS in Turkey, Rousínov in Moravia, the Czech Republic, and Korytnica in Poland (Zágoršek 2010), indicate a warm shallow marine environment with high energy. This is in accordance with previous results published by Filo and Siráňová (1996) who interpreted the settings of the Tomášovce Member as a shallow neritic marine environment with the prevalence of euryhaline forms and accessory littoral elements.

Summary

The autochthonous association of large bryozoans, *Reteporella,* and free living forms, *Smittipora*/*Lunulites* with *Coeloma vigil* crabs is reported for the first time from the Upper Eocene strata of the Tomášovce Member (the Borové Formation). A normal marine, shallow warm (tropical to subtropical) environment with sandy bottom is suggested for the studied horizons. Continuous underwater current brought food for the bryozoans, which was also beneficial for the crab fauna. A continual decrease of the sedimentation rate in the upper parts of the section is predicted.

Acknowledgement

This paper benefited from the constructive reviews by Rodney M. Feldmann (Kent State University, Ohio, USA) and Alessandro Garassino (Museo Civico di Storia Naturale di Milano, Milan, Italy). The paper is a part of the project NAKI MKČR, number DF12P01OVV021 (Type material and unique items in collections of the natural science museum: methods of handling and publicising this significant cultural heritage). The work has also been supported by the research grant, APVV 0280-07, received by Daniela Reháková (Comenius University, Bratislava, Slovakia).

References

Allasinaz, A. (1987): Brachyura Decapoda oligocenici (Rupeliano) del Bacino Ligure Piemontese. – Bolletino del Museo Regionale di Scienze Naturali Torino, 5: 509–566.

Bartolini, C., Berlato, S., Bortolotti, V. (1975): Upper Miocene shallow-water turbidites from western Tuscany. – Sedimentary Geology, 14(2): 77–85, 97–122.

Bishop, G.A. (1986): Taphonomy of the North American de capods. – Journal of Crustacean Biology, 6(3): 326–355.

De Angeli, A., Beschin, C. (2001): I crostacei fossili del territorio vicentino. – Natura Vicentina, 5: 5–54.

Derman, S., Gürbüz, K. (2007): Nature, Provenance and Relationships of Early Miocene Palaeovalley Fills, Northern Adana Basin, Turkey: Their Significance for Sediment-Bypassing. – Turkish Journal of Earth Sciences, 16: 181–209.

Filo, I., Siráňová, Z. (1996): Tomášovské vrstvy – nova litostratigrafická jednotka podtatranskej skupiny [The Tomášovce Member – A new lithostratiraphic Unit of the Subtatric Group]. – Geologické práce, Správy, 102: 41–49 (in Slovak with English Summary).

Gordon, D.P. (1972): Biological relationships of an Intertidal Bryozoan population. – Journal of Natural History, 6: 503–514.

Gross, P., Buček, S., Ďurkovič, T., Filo, I., Maglay, J., Halouzka, R., Karoli, S., Nagy, A., Spišák, Z., Žec, B., Vozár, J., Borza, V., Lukáčik, E., Janočko, J., Jetel, J., Kubeš, P., Kováčik, M., Žáková, E., Mello, J., Polák, M., Siráňová, Z., Samuel, O., Snopková, P., Rakov,á J., Zlinská, A., Vozárová, A., and Žecová, K. (1999): Vysvetlivky ku geologickej mape Popradskej kotliny, Hornádskej kotliny, levočských vrchov, Spišsko-Šariš-

ského medzihoria, Bachurne a Šarišskej vrchoviny. 1 : 50 000. [Explanantion to geological map of Poprad basin, Hornad basin, Levoče Mts., Spiš middle Mts., Bachurne a Šariš Mts.]. – Geologická služba Slovenskej republiky (GÚDŠ), Vydavateľstvo Dionýza Štúra, Bratislava (in Slovak).

Gross, P., Köhler, E. (1980): Geológia Liptovskej kotliny. [Geology of Liptov basin]. – Geologická služba Slovenskej republiky (GÚDŠ), Vydavateľstvo Dionýza Štúra, Bratislava, 217 pp. (in Slovak).

Gross, P., Köhler, E., Samuel, O. (1984): Nové litostratigrafické členenie vnútrokarpatského paleogénu [A new lithostratigraphical division of the Inner-Carpathian Paleogene]. – Geologické práce, Správy, 81: 103–117 (in Slovak with English Summary).

Gross, P., Papšová, J., Köhler, E. (1973): Sedimentológia a stratigrafia vrchnej časti bazálnej litofácie centrálnokarpatského paleogénu od Šarišskej vrchoviny po Liptovskú kotlinu. – Manuskript: archív Geologická služba Slovenskej republiky (GÚDŠ), Bratislava (in Slovak).

Hayward, P.J., Ryland, J.S. (1996): Some British Phidoloporidae (Bryozoa: Cheilostomatida). – Zoological Journal of the Linnean Society, 117: 103–112.

Hazslinszky, F. (1852): Das Thal der Schvinka bei Radács im Sároser Comitate, südöstlich von Eperies. – Jahrbuch des Keiser-König geologisches Reichsanstalt Wien.

Holec, P., Krempaská, Z., Pomorský, F. (2005): Zub žraloka druhu *Xiphodolania eocaena* (Woodward, 1889) v lome Ďurkovec pri Spišských Tomášovciach (Slovensko) [Shark tooth of species Xiphodolania eocaena (Woodward, 1889) from Ďurkovec stone quarry near Spišské Tomášovce (Slovakia)]. – Mineralia Slovaca, 37: 83–86.

Hyžný, M. (2007): Paleogene crab fauna of Borové Formation (localities Ďurkovec and Hlinisko), Western Carpathians, Slovakia. – In: Garassino, A., Feldmann, R. M., Teruzzi, G. (eds.). 3rd Symposium on Mesozoic and Cenozoic Decapod Crustaceans – Museo di Storia Naturale di Milano. – Memorie della Societŕ Italiana di Scienze Naturali e del Museo Civico di Storia Naturale di Milano, 35(2): 59–61.

Hyžný, M. (2011): Synopsis of fossil decapod crustaceans from Slovakia (Western Carpathians). – Neues Jahrbuch für Geologie und Paläontologie Abhandlungen, 260(2): 165–171.

Ilyin, I.V. (2005): Cretaceous and Paleogene decapod crustaceans of the western part of Northern Eurasia. – Moscow State University Press. 296 pp.

Jagt, J.W.M., van Bakel, B.W.M., Fraaije, R.H.B. (2010): *Coeloma rupeliense* (Crustacea, Decapoda, Brachyura) from the Bilzen Formation (Rupel Group, Lower Oligocene) in northeast Belgium. – Bulletin de l'Institut royal des Sciences naturelles de Belgique, Sciences de la Terre, 80: 245–252.

Krempaská, Z. (1998): Niektoré výsledky geologického a paleontologického výskumu v lome Ďurkovec v Slovenskom raji. – Natura Carpatica, 39: 27–32.

Lindberg, W.J., Stanton,G. (1988): Bryozoan-associated decapod crustaceans: community patterns and a case of cleaning symbiosis between a shrimp and crab. – Bulletin of Marine Science, 42(3): 411–423.

Mantelatto, F.L.M., Souza-Carey, M.M. (1998): Brachyura (Crustacea, Decapoda) associated to *Schizoporella unicornis* (Bryozoa, Gymnolaemata) in Ubatuba Bay (SP), Brazil. – Brazilian Archives of Biology and Technology, 41(2): 212–217.

Miczynski, K. (1891): Über einige Pflanzreste von Radács bei Eperjes (Comitat Sáros). – Mitteilungen aus dem Jahrbuche der königlich Ungarischen geologischen Anstalt, 3: 52–63.

Milne-Edwards, A. (1865): Monographie des Crustacés Fossiles de la Famille des Canceriens. – Annales des Sciences Naturelles, 5e série, 3: 297–351.

Morgado, E.H., Tanaka, M.O. (2001): The macrofauna associated with the bryozoan *Schizoporella errata* (Walters) in southeastern Brazil. – Scientia Marina, 65(3): 173–181.

O'Dea, A. (2006): Asexual propagation in the marine bryozoan *Cupuladria exfragminis*. – Journal of Experimental Marine Biology and Ecology, 335(2): 312–322.

Papšová, J. (1967): Mäkkýše paleogénu východného Slovenska, dielčia záverečná správa za roky 1961–1967. – Manuscript: Geologická služba Slovenskej republiky (GÚDŠ), Vydavateľstvo Dionýza Štúra, Bratislava, 66 pp. (in Slovak).

Staub, M. (1891): Etwas über die Pflanzen von Radács bei Eperjes. – Mitteilungen aus dem Jahrbuche der königlich Ungarischen geologischen Anstalt, 3: 68–77.

Taylor, P.D., Larwood, G.P. (1990): Major evolutionary radiations in the Bryozoa. – Systematics Association, 42: 209–233.

Volfová, J. (1962): Makrofauna centrálneho paleogénu východného Slovenska. – Geologické Práce, 63: 93–97.

Volfová, J. (1963): Záverečná zpráva o makrofaune na liste Hranovnica (1:50 000), úloha: 02-A-I. – Manuscript: Geologická služba Slovenskej republiky (GÚDŠ), Vydavateľstvo Dionýza Štúra, Bratislava, 14 pp.

Volfová, J. (1964): Ročná zpráva o predbežných makropaleontologických výskumoch na liste Spišská Nová Ves (úloha: 02-A-I). – Manuscript: Geologická služba Slovenskej republiky (GÚDŠ), Vydavateľstvo Dionýza Štúra, Bratislava, 3 pp.

Waugh, D.A., Feldmann, R.M., Crawford, R.S., Jakobsen, S.L., Thomas, K.B. (2004): Epibiont preservational and observational bias in fossil marine decapods. – Journal of Paleontology, 78(5): 961–972.

Zágoršek, K. (1992): Priabonian (Late Eocene) Cyclostomata Bryozoa from the Western Carpathians (Czechoslovakia). – Geologica Carpathica, 43(4): 235–247.

Zágoršek, K. (1994): Late Eocene (Priabonian) Cheilostomata Bryozoa from Liptov Basin Western Carpathians (Slovakia). – Neues Jahrbuch für Geologie und Paläontologie Abhandlungen, 193(3): 361–382.

Zágoršek, K. (1996a): Eocénne membraniporiformné machovky (Bryozoa -Malacostega a Pseudomalacostega) zo Západných Karpát. – Mineralia Slovaca, 28: 120–128.

Zágoršek, K. (1996b): Eocénne koilostégne machovky (Bryozoa – Coilostega) zo Západných Karpát. – Mineralia Slovaca, 28: 523–534.

Zágoršek, K. (1997): Eocene Anascan Bryozoa from New localities in the Western Carpathians, Slovakia. – Geologica Carpathica, 48(6): 401–409.

Zágoršek, K (2000): Eocénna batymetria Slovenska na základe rastových foriem machoviek [Eocene bathymetry of Slovakia based on Bryozoa growth forms] – Mineralia Slovaca, 32(5–6): 89–98.

Zágoršek, K (2010): Bryozoa from the Langhian (Miocene) of the Czech Republic. – Acta Mus. Nat. Prague, Ser. B, Hist. Nat., Praha 66(1–4): 1–255.

Zágoršek, K., Radwańska, U., Radwański, A.(2012): Bryozoa from the Korytnica Basin (Middle Miocene; Holy Cross Mountains, Central Poland). – Bulletin of Geosciences, 87(2): 201–218.