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Upper Badenian Molluscs (Gastropoda, Bivalvia, Scaphopoda) from the Modra-Kráľová locality (Danube Basin, Slovakia)

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Abstract

This study focuses on the fossil molluscs (Gastropoda, Bivalvia, Scaphopoda) that were excavated in a trench dug near the church at the village of Modra-Kráľová. In the lower part of the profile (sample M1), there is an occurrence of a highly diversified molluscan community represented in particular by *Nassarius dujardini*, *Turritella pythagoraica pythagoraica*, *Clithon pictus tuberculatus*, *Pirenella disjuncta disjuncta*, *Cerithium crenatum* ssp., *Euspira helicina*, *Hydrobia stagnalis* ssp., and *Antalis* cf. *novemcostatum*. The following were ascertained among the molluscs: sessile and vagile benthos, epifauna, infauna, herbivores, detritovores, filtrators, and carnivores. The paleoenvironment was probably composed of shallow water with normal salinity, sufficient aeration, and relatively high dynamics.

The community from the upper part of the profile (sample M2) is markedly impoverished, being represented mainly by *Clithon pictus tuberculatus*, *Ostrea lamellosa*, and *Loripes dujardini*. The molluscs reflect a deeper paleoenvironment and less favourable paleoecological conditions, which were possibly influenced by a general decrease of water dynamics, causing a lower level of water aeration near the bottom, possibly even accompanied by a decline in salinity. On the basis of the abundant occurrence of the gastropod *Clithon pictus tuberculatus*, the age of the studied sediments was interpreted as Late Badenian, which is in accordance with the results of stratigraphic analyses of foraminifers (Zlinská et al., 2007); these deposits belong to the Late Badenian in the Ammonia beccarii Biozone (sensu Grill, 1941).

Key words: Gastropoda, Bivalvia, Scaphopoda, Upper Badenian, Modra-Kráľová, Danube Basin

Introduction

In the Danube Basin at the foot of the Malé Karpaty Mountains (Little Carpathian Mts.), there is an occurrence of shallow-water marine sediments (clays, sands and sandstones) of Late Badenian age. They outcrop in the area between the town of Modra and the village of Trstín, where rich molluscan associations (particularly of gastropods and bivalves) are typical. The oldest references concerning the fossils from this area date back to the first half of the 19th century, when Dionýz Štúr (in Hauer, 1848) described the molluscan fauna from the village of Königsberg (today Kráľová, a part of Modra). Based on the material obtained during new field research (Labajová, 2005; Zlinská et al., 2007; Hladilová and Fordinál, 2011), this article adds new findings to the existing information on molluscs from this locality.

Geographical and geological setting

The studied Kráľová locality is a part of Modra and is situated north of Modra and east of Harmónia on the eastern foot of the Malé Karpaty Mts. (Fig. 1). Geologically, it is located in the Blatné Depression, which is a part of the Danube Basin. In this area (Buday et al., 1962) the marginal shallow-water sediments are present, namely gray, green-gray, yellow-brown and brown calcareous clays with strata of fine- and medium-grained calcareous sands and sandstones, stratigraphically corresponding to the Báhoň Fm., Late Badenian in age (Fig. 2). The outcrop strip of Badenian sediments on the eastern foot of the Malé Karpaty Mts. can be traced from the village of Dechtice to Modra-Kráľová and southwards to Pezinok. At Kráľová, Častá, Doľany, Orešany and around Smolenice and Trstín, there are known occurrences of Badenian clays and sands. Between Trstín and Dechtice there are outcropping sediments of the latest Badenian age – abundant gravels and intercalations of fresh-water limestones that originated in sea-water of greatly reduced salinity (Buday et al., 1962; Zlinská and Fordinál, 1992).

The oldest report on the occurrence of Badenian fossils from the northeast border of the Malé Karpaty Mts. is attributed to Dionýz Štúr (1860), who presented the finding of fossils from Smolenice and Kráľová near Modra. Mořkovský (1959) discovered occurrences of brackish Upper Badenian molluscs near Boleráz, Doľany and Častá. From the Trstín-1 drill hole, northeast of Smolenice, there were findings of foraminifers (Gašpariková, 1965) and rich Badenian and Sarmatian molluscan associations (Švagrovský, 1970). At the northern border of Smolenice, the Badenian clays with foraminifers, molluscs and otoliths were described (Zlinská and Fordinál, 1992). Labajová (2005) and Zlinská et al. (2007) pre-processed fossils (molluscs and foraminifers) from new excavations at Kráľová. The Upper Badenian fossiliferous sediments from Dubová, in the locality adjacent to Modra-Kráľová, are described by Koubová et al. (2011).

Material and methods

The sediments were generally studied in the surface outcrops in the area between Modra and Trstín. For the purpose of the molluscan fauna study, a 180 cm deep trench was dug near the church in Modra, a part of Kráľová (Fig. 1). Two samples, namely Modra 1 (M1 from a depth of 160–140 cm) and Modra 2 (M2 from 95–70 cm) were studied in detail. As the sediments were incoherent, the majority of the fossils was obtained through their simple outwashing on sieves (63 μm – 2 mm fractions), some specimens (mainly oysters) being picked directly from the sediment. The fossil molluscs were studied and documented using the Nikon and SZP 11-BH binocular microscopes. Their photos were made with the Olympus Camedia C-5060 camera. The morphological details were studied and photographed with the JEOL JSM-649 OLV SEM at the Institute of Geological Sciences, Masaryk University in Brno. Four molluscan shells – two specimens from Modra 1 and two from Modra 2 – were analysed for C and O stable isotopes. The analyses were made in the laboratories of the State Geological Institute of Dionýz Štúr in Bratislava.

For the statistical calculations of the molluscan communities, the PAST programme (Paleontological Statistics – Hammer et al., 2001) was used.

Results

Description of the profile

The lithological profile of the Miocene sediments at the Modra-Kráľová locality (Fig. 3) reached a thickness of 180 cm. At the base (180–160 cm), the gray micaceous

Fig. 1. Schematic plan of the locality Modra-Kráľová.

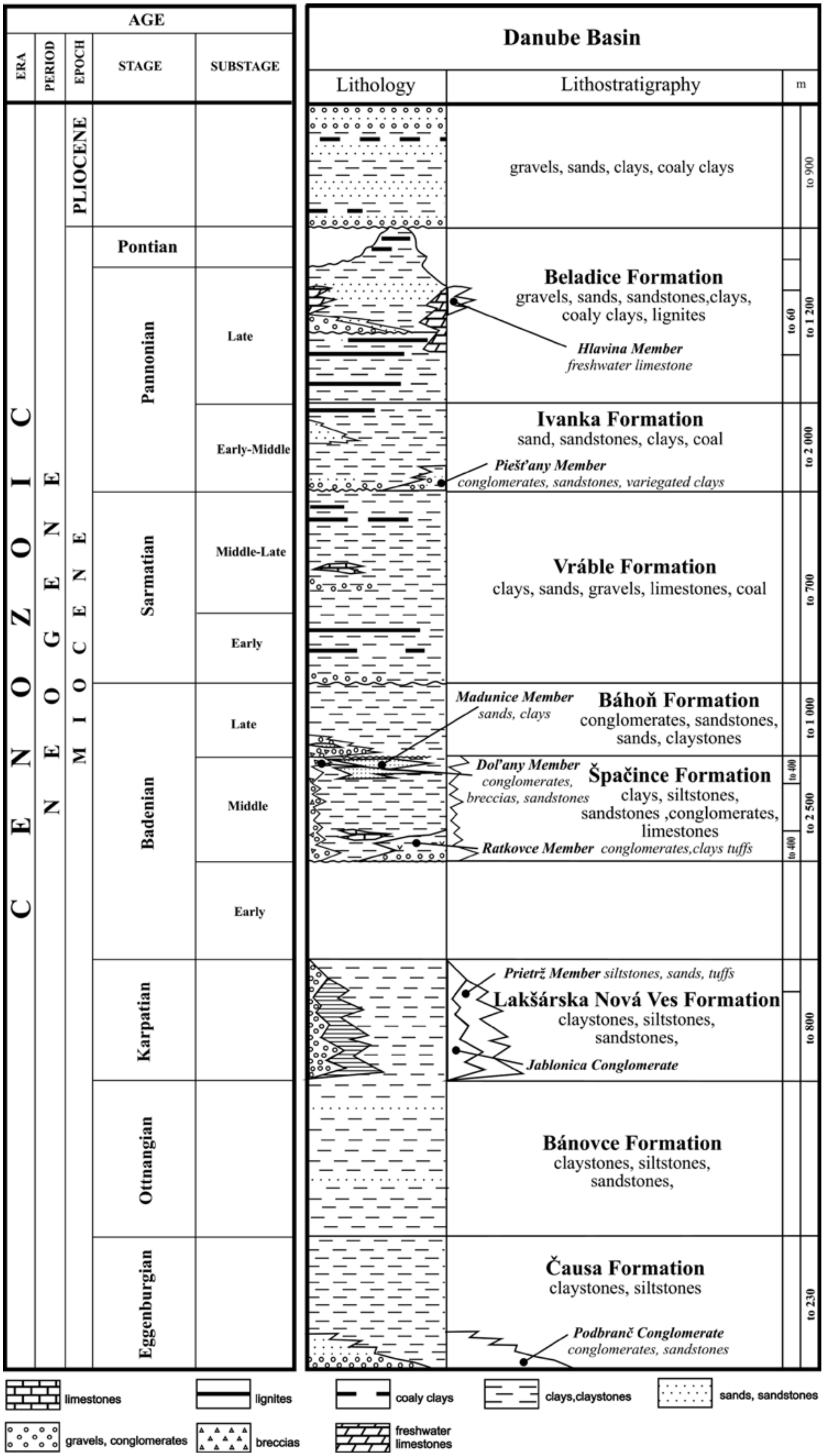

Fig. 2. Stratigraphic table of the area (Fordinál and Nagy, 2005 in Maglay et al., 2011).

sand was present; above this (160–140 cm) there was gray clayey sand with molluscan shells ***(sample M1)***. In its roof, clayey sediments were ascertained: in the interval of 140 to 120 cm, there was light-brown calcareous clay; above it (120–110 cm) light-brown clay was found; and in the interval of 110–95 cm, light-brown calcareous clay occurred again. In its roof (95–70 cm), there was an occurrence of light--brown calcareous clay with oyster shells ***(sample M2)*** and brown clay above it (70–30 cm). The uppermost part of the profile (30–0 cm) contained loam.

The Miocene sediments were deposited on granitoids of the Modra Massif.

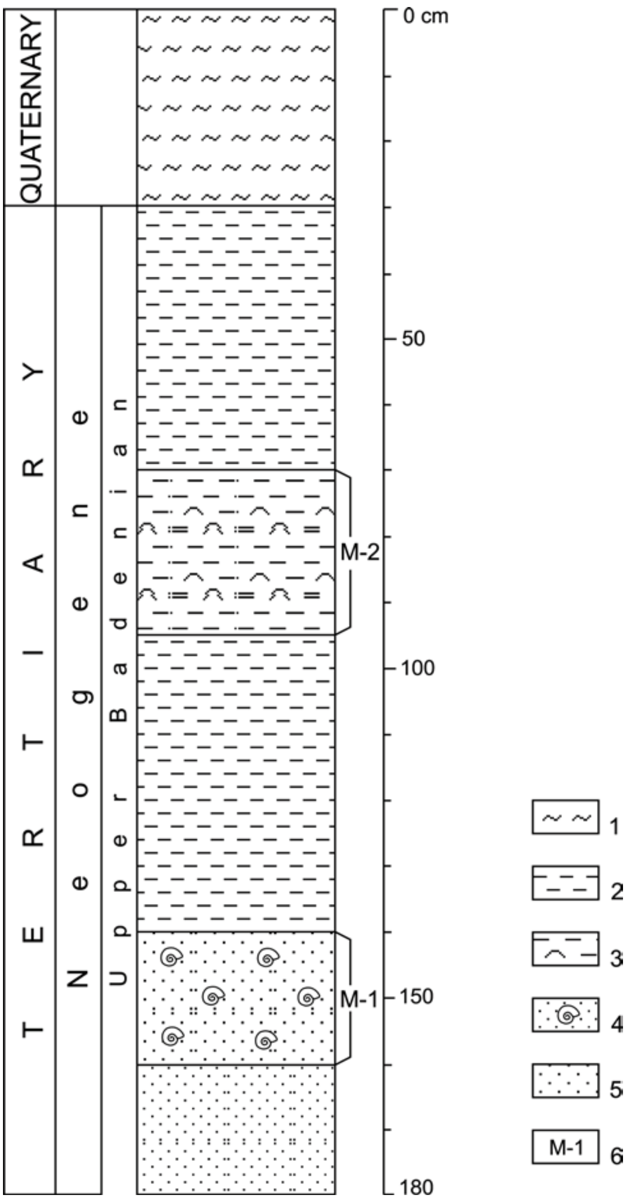

Fig. 3. Lithological profile through the trench at Modra-Kráľová. 1 – loams; 2 – clays; 3 – clays with shells of oysters; 4 – sands with gastropod shells; 5 – sands; 6 – labelling of samples.

Description of the studied samples

M1: In this sample there was a relatively diversified molluscan association (Figs. 4 and 5). The gastropods *Nassarius dujardini*, *Turritella pythagoraica pythagoraica*, *Clithon pictus tuberculatus*, *Pirenella disjuncta disjuncta*, *Cerithium crenatum* ssp., *Euspira helicina* and *Hydrobia stagnalis* ssp. are the most numerous taxa. Other ascertained species are less numerous: *Acteocina lajonkaireana*, *Chrysallida (Parthenina) interstincta* and *Pirenella* sp.; the remainder is represented by individuals only.

The bivalves are markedly dominated by the species *Loripes dujardini* and *Plagiocardium (Papillicardium) papillosum*; less abundant is *Lutraria* sp.; the remainder is represented by individuals. In the M1 sample even scaphopods of the species *Antalis* cf. *novemcostatum* were ascertained.

The state of preservation of the molluscan shells is relatively good, many of them being almost complete; other parts are only fragmentary. The shell surfaces are weathered and some shells are leached. Drilling traces caused by attacks of predators were frequently observed on the shells.

M2: In this sample there were great isolated valves of the bivalve species *Ostrea lamellosa*, frequently drilled by sponges and with tubes of serpulids attached to their surfaces (mentioned by Labajová, 2005). In addition to oysters, gastropods and bivalves were also found. The molluscan association is relatively less numerous than in sample M1 (Figs. 4 and 6). Among the gastropods, *Clithon pictus tuberculatus* dominates markedly; among the bivalves, there was also the *Loripes dujardini*, in addition to the above-mentioned *Ostrea lamellosa*. Scaphopods were not ascertained.

The state of preservation of the molluscan shells is more or less like the M1 sample, including the drilling traces caused by predators; however, there is a relatively higher occurrence of fragments.

The differences between both the samples are evident even from the statistical evaluations (Fig. 7). In sample M1 almost all calculated values are higher than in sample M2: the number of taxa is nearly two-fold and the number of individuals is several-fold higher. All the calculated diversity values (based on Shannon, Simpson and Margalef) are also higher, as well as the Fischer alfa index and the evenness and equitability values. On the contrary, in sample M1 the dominance value is significantly lower in comparison with that of sample M2.

Moreover, foraminifers are present in both samples dominated by the species *Elphidium macellum* (F. – M.), *E. fichtelianum* (Orb.), *Borelis melo* (F. – M.), *Ammonia beccarii* (L.) and miliolid foraminifers – *Quinqueloculina*, *Triloculina* (Zlinská et al., 2007). These species indicate that the sediments are of Late Badenian age and belong to the Ammonia beccarii Biozone (sensu Grill, 1941). The results of the isotopic analyses of the molluscan shells from samples M1 and M2 are presented in Fig. 8. The values from both of these samples are relatively homogeneous, the δO values varying from –0.51 to –3.36 ‰; the δC values from 0.04 to 1.36 ‰.

Discussion

From the stratigraphic point of view particularly, the abundant occurrence of the gastropod *Clithon pictus tuberculatus* in both samples is important; as after Švagrovský (1955) this taxon is restricted to the Upper Badenian. It is also in accordance with the stratigraphic analysis of foraminifers (Zlinská et al., 2007). The other ascertained molluscs have broader stratigraphic ranges.

As far as the paleoecological interpretations are concerned (Bagdasaryan et al., 1966; Tatishvili et al., 1968; Baluk, 1970; Iljina, 1966), the sample M1 provides several groups of molluscs: the most numerous one is vagile benthos – both infauna *(Paphia, Lutraria, Turritella, Calyptraea, Euspira, Nassarius)*, and epifauna *(Hydrobia, Murex, Alaba)*. The community is also differentiated according to the feeding strategies: the bivalves are mostly filtrators; among the gastropods there are relatively abundant phytophages *(Hydrobia, Pirenella, Turritella, Calyptraea, Rissoa)* and detritophages *(Turritella)*; even filtrators were ascertained *(Calyptraea)*, as well as predators *(Euspira, Murex)* and species combining predation and scavenging *(Nassarius)*, which are relatively highly abundant. The great activity of predators is evident even from the numerous attack (drilling) traces (ichnospecies *Oichnus paraboloides* Bromley, 1981) on the molluscan shells (including documentation of possible cannibalism).

Although the found species are rather more typical for (sub)tropical and temperate waters, they are mostly eurytherm. Furthermore, they are also generally tolerant even to the fluctuation of water dynamics and water transparency. This would correspond with the supposed relatively shallow water environment (up to about 80 m), which is preferred by the majority of the present genera, some of which *(Cerithium, Pirenella)* are bound to algae zones.

The ascertained molluscan genera mostly demand sufficient water aeration, but they are largely tolerant of a certain deficiency in oxygen content, and some of them even to the presence of hydrogen sulphide. The majority of them are euryhaline, or demanding normal salinity, but they accept its fluctuations. The present taxa are broadly euryvalent even in their demands for the type of bottom sediment – they prefer mainly sandy bottoms, but occur also on clayey ones, part of them living directly on algae. This is fully in agreement with the sediments in this part of the profile (clayey sands).

Although the actual present taxa are almost identical in both samples, the molluscan association from sample M2 is both qualitatively and quantitatively markedly impoverished in comparison with the one from sample M1, which is why even the general character of the paleoenvironment is slightly different in both samples. With regard to the type of sediments (calcareous clays) and to the noticeable decrease of phytophages, it can be concluded that the paleoenvironment had relatively lower dynamics and a decreasing plant – particularly algae – food supply. This was probably the consequence of a slight deepening of the sedimentary basin, connected with possible lower water lighting and aeration (including the probable presence of hydrogen sulphide at the bottom). The paleotemperature probably did not change markedly in comparison with that of sample M1. With regard to the noticeable dominance of gastropods *Clithon pictus tuberculatus* bound to the environments with lower than normal salinities (Švagrovský, 1955), even certain salinity changes (decreases) cannot be excluded in sample M2 compared to that of M1.

	M 1	M 2
GASTROPODA		
Clithon pictus tuberculatus (Schréter, 1915)	130	138
Diloma (Paroxystele) orientalis orientalis (Cossmann & Peyrot, 1916)	3	
Chrysallida (Parthenina) interstincta (Montagu, 1803)	21	
Alaba costellata anomala (Eichwald, 1830)	7	2
Cerithium crenatum ssp.	84	
Cerithium bronni Partsch	1	12
Pirenella disjuncta disjuncta (Sowerby in Sedgwick & Murchison, 1833)	118	
Pirenella nodosoplicata (M. Hoernes, 1856)		4
Pirenella sp.	21 fr.	5 fr.
Hydrobia frauenfeldi (Hörnes, 1856)	59	
Hydrobia stagnalis ssp.	120 fr.	8
Turritella pythagoraica pythagoraica Hilber, 1882	138	12
Calyptraea chinensis (Linnaeus, 1766)	1	
Euspira helicina (Brocchi, 1814)	82	10 + 4 fr.
Murex sp.	2	
Nassarius dujardini (Deshayes, 1844)	224	13
Hinia sp.		4 fr.
Dorsanum duplicatum duplicatum (Sowerby, 1829)	12	
Retusa truncatula (Bruguiere, 1792)	6	
Acteocina lajonkaireana (Basterot, 1825)	48	
Gastropoda indet.	fr.	fr.
BIVALVIA		
Anadara cf. *diluvii* (Lamarck, 1805)	1	
Ostrea lamellosa (Brocchi, 1814)		10
Loripes dujardini (Deshayes, 1850)	75	28
Cerastoderma sp.		1 + 7 fr.
Plagiocardium (Papillicardium) papillosum (Poli, 1791)	63	4 fr.
Timoclea marginata (Hoernes, 1870)	2	
Paphia sp.	6	
Lutraria sp.	25	
Bivalvia indet.	2 fr.	fr.
SCAPHOPODA		
Antalis cf. *novemcostatum* (Lamarck, 1818)	5	

Fig. 4. Modra 1 (M1) and Modra 2 (M2) – list of molluscs.

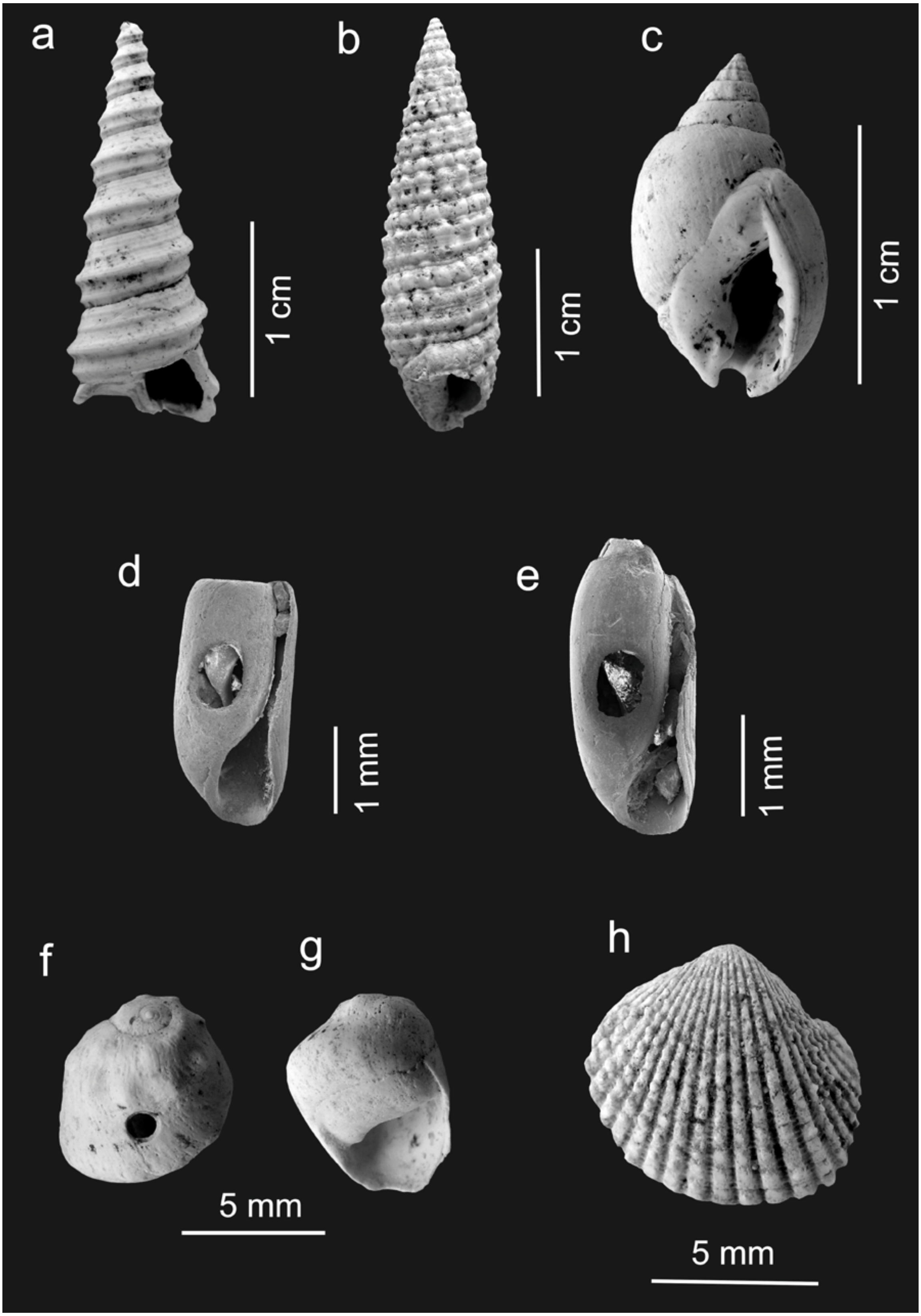

Fig. 5. Selected molluscs from the sample Modra 1 (M1). a – *Turritella pythagoraica pythagoraica* Hilber; b – *Cerithium crenatum* ssp.; c – *Nassarius dujardini* (Deshayes); d – *Retusa truncatula* (Bruguière), SEM photograph; e – *Acteocina lajonkaireana* (Basterot), SEM photograph; f, g – *Clithon pictus tuberculatus* (Schréter); h – *Plagiocardium papillosum* (Poli).

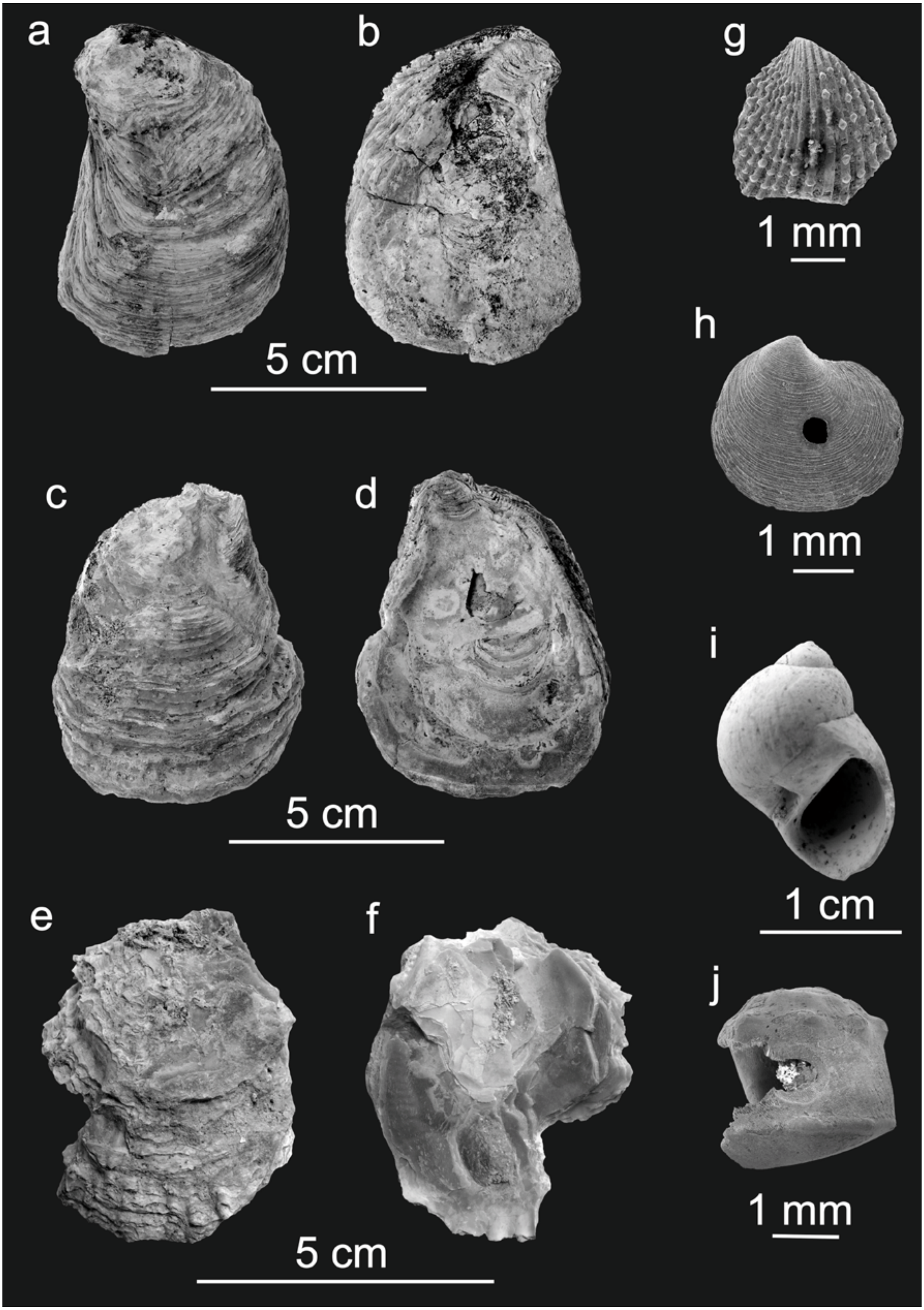

Fig. 6. Selected molluscs from the sample Modra 2 (M2). a, b, c, d, e, f – *Ostrea lamellosa* (Brocchi); g – *Plagiocardium papillosum* (Poli), fragment, SEM photograph; h – *Loripes dujardini* (Deshayes), drilled valve with trace fossil *Oichnus paraboloides* Bromley, SEM photograph; i – *Euspira helicina* (Brocchi); j – *Clithon pictus tuberculatus* (Schréter) – drilled fragment with trace fossil *Oichnus paraboloides* Bromley, SEM photograph.

In sample M2, numerous representatives of sessile benthos (*Ostrea lamellosa* valves) occur. Nevertheless, in light of the general character of bottom sediments, as well as the observed frequent drillings and attachments of epifauna on their surfaces, they were probably exposed for a relatively long time to the conditions of the bottom surface and during that time redeposited over a short distance. On the contrary, vagile benthos – both infauna *(Turritella, Euspira, Nassarius)*, and epifauna *(Hydrobia)* – is strikingly reduced in comparison with the underlying beds. It corresponds with the above-mentioned assumption of lower aeration of the water near the bottom. Food specialists among molluscs are similar to those from sample M1: the bivalves belong to the filtrators, which dominate even among gastropods; phyto- and detritovores *(Hydrobia, Pirenella, Turritella, Alaba)* are less abundant and there are even relatively more numerous predators +/– scavengers *(Euspira, Nassarius)*. Traces of their activity *(Oichnus paraboloides)* were ascertained on the molluscan shells.

From the isotopic δO data, the water paleotemperatures were calculated using the Craig (1965) Calcite Paleotemperature Equation:

$$t\ (^\circ C) = 16.9 - 4.2\ (\delta_c - \delta_w) + 0.13\ (\delta_c - \delta_w)^2,$$

where δ_c denotes the $\delta^{18}O$ value of the sample relative to the PDB standard, and δ_w denotes the $\delta^{18}O$ value of seawater relative to the SMOW standard. For these calculations the value $\delta_w = -1$ ‰ was presumed for the Badenian sea-water (according to Savin, 1977).

The calculated paleotemperatures are 14.9 °C and 15.9 °C in sample M1, and 17.8 °C and 27.5 °C in sample M2. The value 17.8 °C ascertained from one of the two analysed *Ostrea* valves is generally in accordance with the results from sample M1, though not fully in accordance with the supposed water deepening. On the other hand, the value 27.5 °C, calculated from the second *Ostrea* valve, seems to be rather high; moreover, neither of the values from the *Ostrea* valves is mutually in accordance. These discrepancies can generally be explained by the supposed short distance redepositions of *Ostrea* valves, as mentioned above.

The $\delta^{13}C$ values ascertained from sample M2 seem to be slightly lower in comparison with the values from sample M1. Generally, the lower $\delta^{13}C$ values demonstrate that molluscs built CO_2 that was rich in ^{12}C into their shells. Carbon dioxide rich in ^{12}C is produced during the oxidation of organic matter. The greater consumption of oxygen for the oxidation of organic matter results in the lowering of O_2 content in water. The lowering of O_2 content near the bottom is also presumed from the paleoecological analyses. Nevertheless, these results are far from conclusive as there are only two data; moreover, the redeposition of oyster valves could undoubtedly play a role.

The statistical evaluations of both the molluscan communities (Fig. 7) yielded results confirming that the molluscan community from sample M1 (sands) is distinctly more diversified and stable; thus it existed in a more favourable paleoenvironment in comparison with sample M2 (clays). The molluscs from sample M2 reflect less favourable paleoecological conditions, and probably a certain stress factor acting more distinctly. As mentioned above, this stress factor was most probably represented by a general decrease in water dynamics, causing lower water aeration near the bottom, possibly even accompanied by a decline in salinity.

	M 1	M 2
Taxa	26	14
Specimens	1256	260
Dominance D	0.09218	0.307
Shannon H	2.601	1.795
Simpson 1-D	0.9078	0.693
Evenness e	0.5182	0.4298
Margalef	3.504	2.338
Equitability J	0.7982	0.68
Fisher alfa	4.639	3.168

Fig. 7. Modra 1 and 2 – statistical evaluations (PAST).

Conclusions

Fossil molluscan fauna (Gastropoda, Bivalvia, Scaphopoda) were discovered in a trench dug near the local church at the locality of Modra-Kráľová. Molluscs occurred in two horizons within the studied profile. In the lower sample (M1), there was a highly diversified molluscan community represented in particular by the taxa of *Nassarius dujardini*, *Turritella pythagoraica pythagoraica*, *Clithon pictus tuberculatus*, *Pirenella disjuncta disjuncta*, *Cerithium crenatum* ssp., *Euspira helicina*, *Hydrobia stagnalis* ssp., and *Antalis* cf. *novemcostatum*. From the paleoecological point of view, molluscs with different life and feeding strategies – sessile and vagile benthos, epifauna, infauna, herbivores, detritovores, filtrators, carnivores – were ascertained. The paleoenvironment was probably represented by shallow water with normal salinity, sufficient aeration, and with relatively high dynamics.

The community from the upper part of the profile (M2 sample) is markedly impoverished in comparison with the M1 sample, being represented mainly by the taxa of *Clithon pictus tuberculatus*, *Ostrea lamellosa*, and *Loripes dujardini*. These molluscs reflect a deeper paleoenvironment and less favourable paleoecological conditions, possibly influenced by a certain stress factor, most probably by a general decrease in water dynamics causing lower water aeration near the bottom, possibly also accompanied by a decline in salinity.

	δ13C	δ18O	t
M1	(‰VPDB)	(‰ VPDB)	SMOW -1
Loripes sp.	1.36	-0.51	14.873213
Turritella sp.	0.6	-1.23	15.940877
M2			
Ostrea sp. 1	0.04	-1.22	17.830292
Ostrea sp. 2	1.1	-3.36	27.536048

Fig. 8. Isotopic analyses of molluscs.

Even the results of statistical evaluations have confirmed that the molluscan community from the M1 sample is more diversified and stable in comparison with the M2 sample.

The isotopic analyses of 4 molluscan shells confirmed that the δO and δC values ascertained from both samples are relatively homogeneous, the δO values varying from –0.51 to –3.36 ‰, and the δC values from 0.04 to 1.36 ‰. The calculated paleotemperatures are 14.9 °C and 15.9 °C in the M1 sample, and 17.8 °C and 27.5 °C in the M2 sample. The slight lowering of the δ^{13}C values from the M2 sample in comparison with the M1 reflects that mollusc-built CO_2 that was rich in ^{12}C in their shells, probably as a result of the oxidation of organic matter.

On the basis of abundant occurrence of gastropod *Clithon pictus tuberculatus*, the age of the studied sediments was interpreted as Late Badenian, which is in accordance with the results of the stratigraphic analyses of foraminifers (Zlinská et al., 2007), placing these deposits into Late Badenian Ammonia beccarii Biozone (sensu Grill, 1941).

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Svrchnobadenští měkkýši (Gastropoda, Bivalvia, Scaphopoda) z lokality Modra-Kráľová (Podunajská pánev, Slovensko)

V Podunajské pánvi na svazích Malých Karpat se vyskytují mělkovodní mořské sedimenty (jíly, písky, pískovce) svrchnobadenského stáří. Na povrch vycházejí v oblasti mezi městem Modra a obcí Trstín a jsou charakteristické bohatými výskyty měkkýšů (zvláště gastropodů a bivalvií). Nejstarší zmínky o fosiliích z této oblasti pocházejí již z první poloviny 19. století, kdy Dionýz Štúr (in Hauer, 1848) popsal měkkýší faunu z obce Königsberg (dnes Kráľová, místní část Modry), další údaje přinášejí práce Štúra, 1860; Mořkovského, 1959; Gašparikové, 1965; Švagrovského, 1970; Zlinské a Fordinála, 1992 a Koubové et al., 2011. Náš článek doplňuje dosavadní informace o měkkýších z lokality Modra-Kráľová, a to na základě materiálu získaného během nových terénních výzkumů (Labajová, 2005; Zlinská et al., 2007; Hladilová a Fordinál, 2011).

V nově odkrytém profilu na lokalitě Modra-Kráľová (kopaná rýha poblíž kostela) se měkkýši vyskytovali ve dvou horizontech. Ve spodním (vzorek M1), bylo zjištěno velmi diverzifikované společenstvo, v němž jsou zastoupeny zejména taxony *Nassarius dujardini, Turritella pythagoraica pythagoraica, Clithon pictus tuberculatus, Pirenella disjuncta disjuncta, Cerithium crenatum* ssp., *Euspira helicina, Hydrobia stagnalis* ssp., *Loripes dujardini, Plagiocardium papillosum* a *Antalis* cf. *novemcostatum.* Z paleoekologického hlediska reprezentují zjištění měkkýši různý způsob života (sesilní a vagilní bentos, epifauna, infauna) i různé potravní strategie (herbivoři, detritofágové, filtrátoři i dravci). Paleoprostředí bylo patrně mělkovodní s normální salinitou, dostatečně provzdušněné a mělo poměrně vysokou dynamiku.

Asociace měkkýšů z vyšší části profilu (vzorek M2) je ve srovnání se vzorkem M1 výrazně ochuzena a vyskytují se v ní hlavně taxony *Clithon pictus tuberculatus, Ostrea lamellosa* a *Loripes dujardini.* Měkkýší fauna svědčí o relativně větší hloubce vody a méně příznivých paleoekologických podmínkách, které byly patrně ovlivněny nějakým stresovým faktorem, nejspíše celkovým snížením dynamiky prostředí, v jehož důsledku se zhoršilo provzdušnění vody u dna, nelze ovšem vyloučit ani mírný pokles salinity. Rovněž výsledky statistických vyhodnocení obou vzorků jednoznačně potvrdily, že měkkýší společenstvo ze vzorku M1 je výrazně diverzifikovanější a stabilnější než společenstvo ze vzorku M2.

Z izotopických analýz C a O provedených na 4 schránkách měkkýšů vyplývá, že hodnoty δO a δC jsou v obou vzorcích (M1 i M2) relativně homogenní, přičemž hodnoty δO kolísají od –0.51 do –3.36 ‰ (VPDB), hodnoty δC od 0.04 do 1.36 ‰ (VPDB). Mírné snížení hodnot δ^{13}C ve vzorku M2 oproti vzorku M1 nasvědčuje tomu, že během tvorby schránek měkkýšů bylo paleoprostředí obohaceno izotopem ^{12}C, patrně v důsledku oxidace organické hmoty.

Vzhledem k hojnému výskytu gastropoda *Clithon pictus tuberculatus* bylo stáří studovaných sedimentů interpretováno jako svrchní baden, což je v souladu s výsledky stratigrafických analýz foraminifer (Zlinská et al., 2007), na jejichž základě byly tyto sedimenty zařazeny do svrchního badenu, biozóny Ammonia beccarii (sensu Grill, 1941).