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The importance of mollusc fauna in the study of travertine deposits

A Mollusca-fauna jelentősége a travertínó-kutatásban

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(4 figures)

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Tárgyszavak: travertínó, Mollusca-fauna, biosztratigráfia, paleoökológia

Összefoglalás

A travertínó különböző üledéktípusaiban a Mollusca-maradványok sokszor tömegesen fordulnak elő. A kvarter malakológiai vizsgálatok két legjelentősebb területe a biosztratigráfia és a környezet-rekonstrukció. A munka az elvi- módszertani ismertetés mellett a magyarországi kutatások legfontosabb eredményeiről tájékoztat.

Abstract

Mollusc shells often occur in large numbers in various types of travertines. The two main fields of Quaternary (Quarter malacological) studies are: biostratigraphy and reconstruction of the palaeoenvironment. The present study gives information about the latest results of Hungarian investigations and deals with methodological and theoretical questions.

Introduction

Mollusc shells, – i.e. that of bivalves and snails – are composed mainly of calcium carbonate. Consequently they are frequent large quantities in masses in Quaternary sediments, especially in the carbonatic ones. A study of these shells may supply important data about the age and the sedimentary environment of the deposits.

Aquatic and terrestrial species occur with equal frequency in different types of travertines. The shells of the aquatic ones may be embedded *in situ* (thanatocenosis) or may be carried together from different biotopes, forming a taphocenosis. A small number of the terrestrial forms live on aquatic plants (reed, sedge etc.). After their death the shells fall directly into the water. Most of the terrestrial forms are carried in from the surrounding land. In both cases a taphocenosis is formed.

Mollusc remnants may be found in any type of travertine in the broad sense, but they are most significant in the soft types of sediments. In the hard, compact rock types the shells get dissolved during the diagenesis or their material may be replaced by crystalline calcite. In this way the malacological material is mainly in the form of moulds. Moulds and neomorphically replaced shells are often difficult to distinguish. This may cause difficulties in dating.

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In loose, soft limestones well-preserved shells may often be found. The cleaning of these may involve long, hard work and the shells generally get injured in spite of the most careful work. Consequently, material suitable for a quantitative evaluation is difficult to obtain from loose or friable travertines. This is inconvenient in determining the age or environment.

Malacological studies are most important in the case of fauna embedded in soft fine-grained sediments (calcareous mud, sand or lacustrine chalk). These often contain masses of well-preserved molluscs. The shells may easily be extracted in order to acquire malacological material for quantitative evaluations. I proposed a method in the early 1950s. A measured sample of five to ten kilogrammes was taken for washing. It was washed through a sieve with a mesh of 0.8 mm (KROLOPP 1995). The dried result was then sorted and found to contain fauna in its original composition and suitable for a quantitative evaluation.

Palaeosols intercalating travertine deposits may also contain rich mollusc fauna. The preparation and evaluation may be similar to those mentioned above. Unfortunately, most palaeosols do not contain mollusc shells because humic acids may dissolve them during diagenesis.

Studies can be completed by evaluating post-travertine events. Travertines may be overlaid by younger loess, or sandy layers. These also may contain molluscs. Rich fauna may occur in fissures of the travertine deposits. These fauna may help in evaluating the age of travertines ("*ante quem* dating").

Fine-grained sediments within travertines, as mentioned before, often contain rich aquatic and terrestrial fauna. The complete list of given localities could contain as many as 80 to 100 species (KROLOPP 1990), while the number of species of all Hungarian Pleistocene localities is 208 (KROLOPP 2003). Consequently a malacological study of travertines can make a huge contribution to our knowledge about the whole Hungarian Pleistocene mollusc fauna, regarding its taxonomy, stratigraphy, and palaeoecology.

The main goal of the malacological studies of Quaternary travertines is, as always, biostratigraphy and reconstruction of the environment.

Biostratigraphy

Conidering the importance of quaternary fauna for biostratigraphy, it is clear that the evolution of most vertebrates, especially of rodents is much quicker than that of molluscs. Consequently, vertebrate fauna have a priority in Quaternary stratigraphy. In travertine deposits, however, vertebrate fossils occur only sporadically and this increases the importance of molluscs in this respect. The malacostratigraphical scheme (KROLOPP 1983) proposed for the Hungarian Pleistocene may serve as a base for the chronology of travertine deposits (*Fig. 1*).

Based on the mollusc fauna, it was possible to date many Hungarian travertine deposits more accurately in accordance with other stratigraphic methods. The location of some important localities in NW Transdanubia is shown in *Fig. 2*. Their malacostratigraphic ranges are displayed in *Fig. 1*.

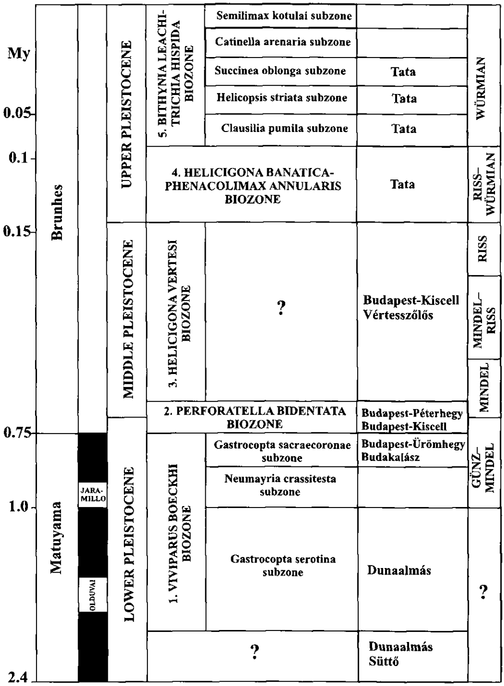

Fig. 1 The stratigraphic division of the Pleistocene based on malacofauna (not time-proportional) and the stratigraphic position of the travertine localities mentioned in the article

1. ábra. A pleisztocén malakosztratigráfiai tagolása (nem időarányos) és a cikkben szereplő travertínó lelőhelyek rétegtani besorolása

The reconstruction of the palaeoenvironment

It is well-known that molluscs are sensitive to environmental changes. Consequently, most palaeoecological data for Pleistocene deposits have been based on mollusc fauna. The theoretical and practical basis of such studies was the fact that most Pleistocene mollusc species are still living, thus their ecological demands may be determined by zoological observations.

There are two important fields of the environmental reconstruction of travertines, using molluscs:

- Reconstruction of the aquatic sedimentary environment,
- Reconstruction of the broad environment.

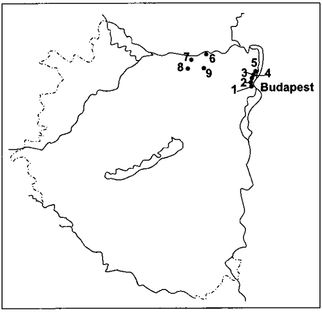

Fig. 2 The most important travertine occurences in the area of NW Transdanubia. 1 Budapest–Vár-hegy, 2 Budapest–Kiscell, 3 Budapest–Üröm-hegy, 4 Budapest–Péter-hegy, 5 Budakalász, 6 Süttő, 7 Dunaalmás, 8 Vértesszőlős, 9 Tata

2. ábra. Az északnyugat-dunántúli jelentősebb travertínó előfordulások helye. 1. Budapest–Vár-hegy, 2. Budapest–Kiscell, 3. Budapest-Üröm-hegy, 4. Budapest–Péter-hegy, 5. Budakalász, 6. Süttő, 7. Dunaalmás, 8. Vértesszőlős, 9.Tata

Palaeoecological data for the aquatic mollusc fauna

The main ecological factors for aquatic molluscs are: temperature and chemistry of the water, speed of currents, depth, and vegetation. As the bulk of Hungarian travertines were deposited from lukewarm or warm karstic springs, the best application of malacological studies is the reconstruction of paleo-water-temperatures.

Zoological studies have demonstrated that in hot springs a significant mollusc fauna might live in temperatures up to about 25 °C (Issel 1901; Starmühlner 1957). However the number of species, decreases significantly near to this temperature limit. Above this value – i.e. up to about 35 °C – only some ecologically highly tolerant species live. Furthermore some termophilous forms of other species appear, adapted to high temperatures. These latter differ in size or shell morphology from the more usual species.

In the NW part of Transdanubia (W region of Budapest, Budakalász, Süttő, Dunaalmás, Vértesszőlős, Tata, *Fig.* 2) in the compact hard layers of Pleistocene travertine only a few mollusc species were found. These are forms of high ecological tolerance. In many cases there are no molluscs in these layers. This fact, however, does not point unequivocally to a water temperature above 35 °C; other factors also may cause an absence of the fauna. Other data must also be taken into consideration (Korpás 2003).

Loose, friable travertine layers of the same region yield slightly more rich aquatic mollusc assemblages. These point to water temperatures of about 25 °C. This was valid in the case of some travertines from Budapest-Kiscell, Dunaalmás, Vértesszőlős and Tata.

Mollusc fauna in fine-grained sediments (calcareous mud, calcarenite, oolite) are generally rich in the number of species. One may conclude that the water temperature was probably between 20–25 °C. Such a temperature was inferred for the lime-mud layer at Üröm-hegy, Péter-hegy, Vár-hegy, Kiscell (Budapest) as well as for Dunaalmás, Vértesszőlős and Tata (*Fig.* 2). There are local particularities, as well. At Budakalász, the species *Fagotia acicularis* was represented by distinctly, ornamented specimens. Here the water temperature might have been as high as 25–27 °C. The same range of temperature was inferred for the lower part of the lime-mud layers at Üröm-hegy, where two species of aquatic snails lived. One of species was characterised by a shell that was significantly different from those living in cold water. The upper part of the lime-mud layer reflects the shoaling and cooling of the spring pond. Earlier this pond was deeper and quite big (the remains of *Hippopotami* have even been found here). The higher number of mollusc species point to a water temperature of around 18–20 °C.

Experts in malacology recognised very long ago that there is a relationship between water temperature and shell size. In hot waters we find small specimens of species which generally lived in waters of changing temperature. An increase in water temperature causes a decrease in shell size. In the outflows of geysers in Iceland STARMÜHLNER (1957) produced data about the shell sizes of the snail *Radix peregra* and the water temperatures; the latter also point to the above-mentioned relationship.

Bithynia tentaculata specimens living in thermal waters in Hungary are small-sized (*Bithynia tentaculata* f. *thermalis*). Fossil specimens from lime-mud in a travertine sequence of Budapest–Kiscell are slightly bigger than the mentioned extant ones. The size distribution curves of these, and as others from normal surface waters (about 14 °C) have been estimated and also for populations living in thermal springs (24 °C). From these data a palaeo-water temperature of 22.4 °C could be calculated (*Fig.* 3) for the Kiscell spring-waters.

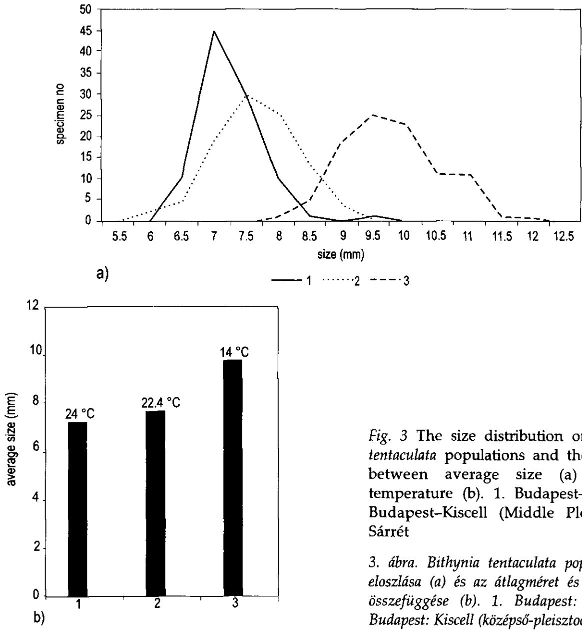

Fig. 3 The size distribution of the *Bithynia tentaculata* populations and the relationship between average size (a) and water temperature (b). 1. Budapest–Malom-tó, 2. Budapest–Kiscell (Middle Pleistocene), 3. Sárrét

3. ábra. Bithynia tentaculata populációk méreteloszlása (a) és az átlagméret és vízhőmérséklet összefüggése (b). 1. Budapest: Malom-tó, 2. Budapest: Kiscell (középső-pleisztocén), 3. Sárrét

From the aquatic mollusc fauna of the lime-mud layers it is possible to draw other conclusions about the sedimentary environment. For example a high species diversity indicates a varied environment with abundant, lush vegetation. A strong current influences the shell growth in a similar way to the water temperature. From the ratio of lung (pulmonate) and gill (branchiate) snails it is possible to calculate the oxygen content of the water. Evidently, these data need to be evaluated in a complex way – i.e. data from various localities must be considered.

Reconstruction of the broad environment

The broader environment influences the deposition of travertine as well. For a reconstruction the terrestrial molluscs of the layer can be used.

The most important environmental factor is the climate. Terrestrial snails are all under the influence of microclimatic conditions. It is these conditions which need to be reconstructed first. However, it is evident, that the microclimate is influenced by macroclimatic conditions. From the terrestrial molluscs of a travertine deposit suppositions can be made about the climate. If mollusc fauna change in the sequence, this may reflect climatic changes.

For terrestrial gastropods the most important climatic factors are temperature and humidity. These influence the qualitative and quantitative composition of the fauna mainly through the vegetation, albeit not directly. Consequently, those materials, which can be evaluated quantitatively are of special importance. Such fauna are primarily those preserved in lime-mud layers.

It is apparent that the environment of different travertine deposits is highly variable with respect to climate and vegetation. This is not only due to their differing settings but also to their different ages. However, some general observations can be mentioned.

In the travertine deposits of NW Transdanubia, from compact and loose, friable rocks there was absolutely no malacological sign of a cool climate. Thus it is plausible that all these deposits were formed in climates similar to the present

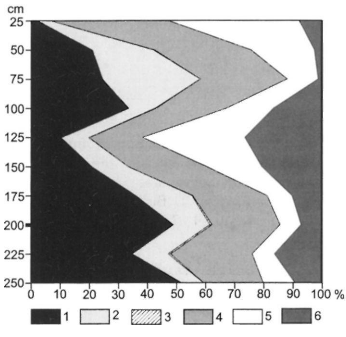

Fig. 4. Changes in the specimen number of the malacological groups formed with regards to the ecological needs of the individual species for the Budapest-Péterhegy site. 1 xerothermophylous species, 2 species favouring warm and humid conditions, 3 outliers, 4 hygrophylous species, 5 cold-resistant hygrophylous species, 6 cold-resistant xerophylous species

4. ábra. A Budapest: Péter-hegyi lelőhely ökológiai igények szerint csoportosított csigafaunájának egyedszámarány változásai. 1. xerotherm fajok, 2. melegigényes higrofilek, 3. nem besorolhatók, 4. higrofilek, 5. hidegtűrő higrofilek, 6. hideg- és szárazságtűrők one, or even under warmer climates, at least those deposits that contain mollusc shells which can be distinguished. Only some fauna indicate a climate cooler than the present one. These were found in lime mud layers at Tata and Budapest–Kiscell, as well as in a loess-layer intercalating a travertine at Vértesszőlős (KROLOPP 1969, 1990). A climate warmer than the present one could be detected at Tata, Vértesszőlős, Budakalász and at some localities in Budapest. These climates may have been more arid or sometimes more humid than the one of today.

From a quantitative analysis of terrestrial snail fauna of travertine sequences the nature and trend of changes in the environment can be deduced, especially changes, primerily in the climate. Such details could help in dating the sediments (ecostratigraphy). *Figure 4* illustrates the changes in the proportion of specimens belonging to ecologically-grouped species, (with respect to the travertine sequence at Péter-hegy, Budapest). The diagram indicates a lower Pleistocene climatic change, when a period of cooling was followed by a dry hot period.

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