Cent. Eur. J. Geosci. • 5(4) • 2013 • 465-479
DOI: 10.2478/s13533-012-0153-4

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Central European Journal of **Geosciences**

Mollusc-based paleoecological investigations of the Late Copper – Early Bronze Age earth mounds (kurgans) on the Great Hungarian Plain

Research Article

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Received 19 September 2013; accepted 13 November 2013

Abstract: The malacological material of the mound bodies (kurgans) of the Great Hungarian Plain indicates a mixed vegetation of dry and humid environments, developed on a mosaic of alkaline and chernozem soils in the period of the construction of the kurgan. The malacofauna that evolved in the upper soil horizon of the mound indicates the extremely dry environmental conditions of steppes, charaterized by the dominance of thermoxerophilous species. Dominant species of this kurgan are *Chondrula tridens, Helicopsis striata, Granaria frumentum* and *Cepaea vindobonensis*. The species composition shows that there are differences in the malacofauna of the Danube-Tisa Interfluves region compared to that of the lowlands east of River Tisza, indicated by the higher dominance of *Granaria frumentum* and *Helicopsis striata* in the former region. Following the construction of the kurgans an island-like, dry habitat developed on their surface, covered by black soil and populated by a steppe fauna, the composition of which is comparable mostly with the mollusc fauna of loess steppes and forest steppe, irrespectively of the floodplain or wind-blown sand character of the original surface.

Keywords: Holocene • malacofauna • kurgan • steppe • forest steppe

1. Introduction

In Hungary and, in the Carpathian Basin the first investigations in Quaternaery malacology were carried out by the royal geologist Heinrich Wolf in the 1860s [36]. Following this, further studies were made by Henrik Horusitzky (1870-1944) and Tivadar Kormos (1881-1946), of the Department of Agrogeology, Royal Geological Institute, Budapest, followed by the inventories of Kálmán Czógler (1884-1952) from Szeged and Mihály Rotarides (1893-1950). These experts processed material from loess layers collected within the Carpathian Basin, as well as from the Holocene layer and material from archaeological sites. With respect to the malacological study of Hungarian kurgans near Szeged, the work of Kálmán Czógler, founder of the Malacological School of Szeged was highly influential. Czógler had processed material collected at Neolithic dwelling mounds (so called *tells*) [1], and con-

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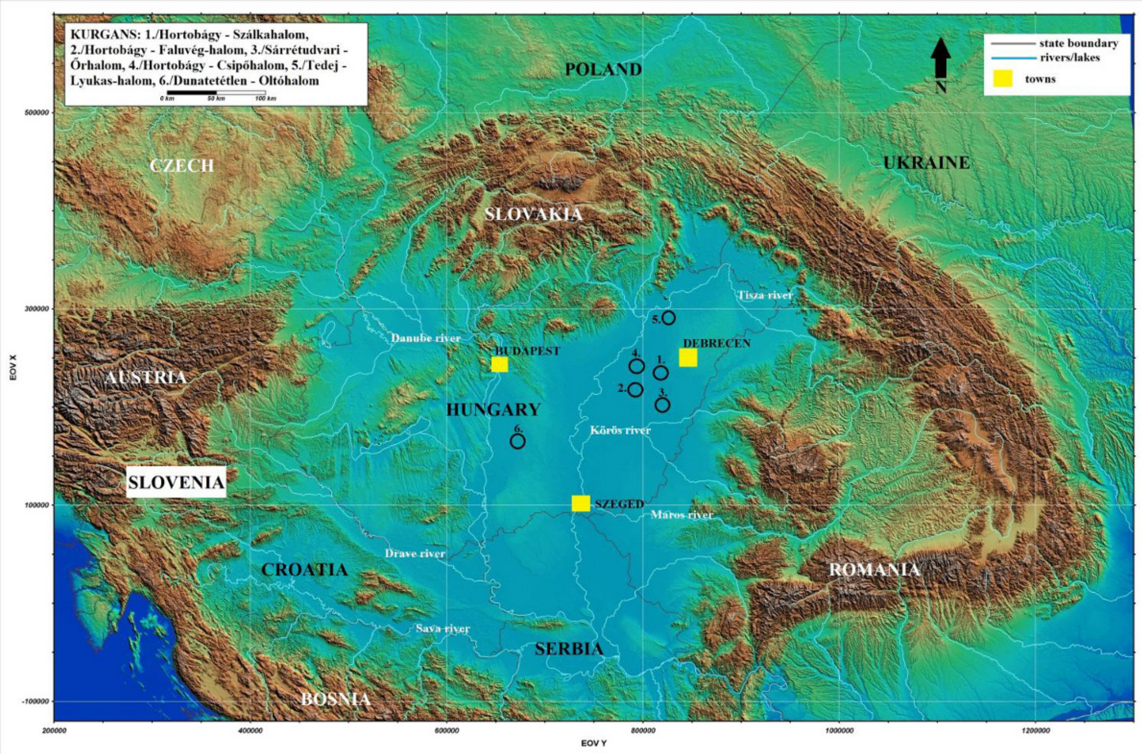

Figure 1. Location of the studied kurgans.

cluded that such anthropological sites from the Holocene high cultures are well worth investigating from a point of Quaternary malacology.

In spite of all this, archaeological sites were not inventoried by any malacologist until the 1980s. Even though the pioneers of Quaternary malacology, Andor Horváth from 1954 and by Endre Krolopp from 1958 onwards had processed material from several archaeological sites, their studies excluded kurgans. As Hungarian malacologists gradually organised themselves into a school of Quaternary malacology, amongst them Levente Fűköh specialised in Mollusca faunas of Holocene layers and especially those of archaeological sites from 1977 onwards [2].

Here we adopt the approach applied by Hungarian archeologists [3] that separates late Neolithic and early Bronze Age dwelling mounds (tells) from the man-made earth-pyramids built at the end of the Copper, beginning of the Bronze Age, in the Iron Age and Migrations Period mounds used for burial purposes. The latter are called kurgan (a word of Turkish origin), or, synonimously, in their Hungarian common name „kunhalom" (=Cumanian mound – [4]). The first investigation into the malacofauna of Hungarian kurgans was carried out in the Hortobágy region, on a kurgan called Szálka-halom. The first drillings were made in the winter of 1987/1988, followed by the wet-screening of mollusc shells from the sediment material, its identification and detailed analysis [5]. This study was part of a thorough Quaternary malacological and landscape evolution investigation of the first Hungarian national park, involving isotope geochemical and sedimentary geological studies of several sites within this characteristically alkaline region [6–10].

This preliminary investigation was followed by the drilling analysis of the Faluvég-halom kurgan (Hortobágy), and the malacological processing of the material, as part of a larger project to study the evolution of the Hortobágy alkaline grasslands [11]. A similar study was carried out at the Szent Imre-halom in the Jászság region [11]. In 1992, as requested by archeologist Ibolya Nepper Módyné of the Déry Museum from Debrecen, a site visit and sample collection resulted in the development of the reconstructed digital surface model based on the excavations and earlier earth removals, leaving only half of the original mound of Őr-halom in Sárrétudvari (Fig. 12- 14 in [12]). Malacological studies were supported by high-resolution stratigraphic sedimentological, pedological and micro-morphological analyses [13].

The most recent malacological study in the Hortobágy region was carried out as part of Attila Barczi's kurgan investigations, at Csípő-halom, where drilling analyses were carried out (Sümegi in [14, 15]). The investigation of the mounds in Hortobágy, Jászság and Sárrét (Fig. 1) was complemented by the stratigraphical and malacological studies of the illegally excavated Lyukas-halom at Tedej immediately after reporting the illegal activites, to answer the call of archeologist professor Pál Raczky [35]. A more recent request from archeologist Rozália Kustár resulted in the malacological analysis complementing sedimentological and geochemical studies of the Oltó-halom (Danube-Tisa Interfluves region, drilling analysis). The latter studies were financed by the Ministry of Environment and Water [16].

As the chronological identification of the Szent Imre-halom in the Jászság is rather dubious, the present study only includes the results of quarter-malacological studies of kurgans originating from the end of the Copper and beginning of the Bronze Age (Szálka-halom, Faluvég-halom, Csípő-halom, Hortobágy region; Őr-halom, Sárrétudvari, Bihar region; Oltó-halom, Dunantetétlen, Duna-Tisza-köze region) (Fig. 1).

2. Methods

For the excavations of the kurgans and their malacological sampling several methods were applied. The simplest and most up-to-date mass sampling could only be implemented in kurgans that had been opened beforehand. Sections of the illegally excavated Lyukas-halom at Tedej and that of the Őr-halom at Sárrértudvari, which were significantly damaged by earlier excavations and soil removals were cleaned and sketches of the two kurgans layers were drafted. Having used simple tools like scaffolding and ladders 2.5 kilograms of sediment sample was taken every 25 or 10 cm (as suggested by Krolopp [17]. Organic matter and carbonate content of the sediment samples were analysed according to Dean [46], while granularity was identified by hydrometric analysis [18].

At intact mounds drilling exploration methods were applied using different size drill bits. The main objective at Szálka- and Faluvég-halom was to explore Holocene soils covered and fixed by the mounds themselves, therefore a 25 cm long drill was used [19], while at Csípő- and Oltó-halom a twist-drill was used each 5 cm, to geological mapping standards. With the twist-drill, 5 continuous samples, taken every 5 cm were merged into one 25 cm sample. Each quarter-malacological study used a total of 1 kg sediment sample from the drillings.

A 0.5 mm mesh size sieve was used for washing and draining the sediment, and the reamining silt was checked for Mollusca shells. Identification work was carried out based on [20–25]. Paleo-ecological categories used are based on recent ecological findings of [21,23,26,27,28] and on distribution data published by Bába [30, 31] and Klemm [32], also referring to the paleo-ecological categories based on their works [8].

3. Results

3.1. Szálka-halom (Hortobágy)

Kurgans studied are presented here in the order of data processing, starting with the Szálka-halom, located in the eastern part of Hortobágy region (N: 47° 34′ 35″, E: 21° 14′ 40″) where drilling took place in the winter of 1987-1988. The mound is situated on a 90 m altitude residual surface of a Pleistocene river bank covered by infusion loess, reaching 95.1 m above see level. Such river banks of the region have a typical northeast-southwest orientation. The mound is surrounded by a temporally waterlogged Ice Age backswamp to the West and by an almost completely silted up Ice Age riverbed to the East (Fecskerét, Nyírőlapos).

The development of the bedrock and the geomorphological constitution of the area formed a surface of different altitudes (Fig. 2) on the otherwise flat looking landscape. Therefore the level of the water-table, vegetation and soils are primarily determined by micro-geomorphological characteristics. That is, a hydroseries was formed starting from the highest point situated on the top of the mound to the lowest one located at the bottom of the ancient riverbeds [8]. This geomorphological hydroseries was influenced by recent anthropological activities: the southern side of the mound had already been eroded in 1987 by excavations and two dirtroads, while the top of the mound shelters a geodetic reference point. Undisturbed sections of the original structure could only be found in the northern side of the kurgan. Although anthropogenic disturbance and grazing degraded the original loess grassland (*Salvio nemorosae*) vegetation of the mound, still, valuable species are present there such as *Phlomis tuberosa*, *Salvia austriaca*, *Stipa capillata*, *Agropyron pectiniforme* and *Thalictrum minus*. Remains of this vegetation can be found in the surrounding area of the mound, covering the 90 m. a.s.l. Ice Age river banks to their edges (Fig. 3). Ditches around the former river banks are covered by alkaline, salt tolerant vegetation (*Achilleo–Festucetum*, *Artemisio-Festucetum*, *Puccinellietum limosae* and *Bolboschoenetum maritimi)*. Loess grassland and chernozem soils (Szálka-halom, Kajla-hát) are patchily distributed, alternating with alkaline vegetation and soils (Fig. 3). On the least disturbed northern side of the Szálka-halom, a 5 m drill core was taken at 94.5 m altitude, and the iden-

Figure 2. Geological map of the Szálkahalom kurgan *1. Infusion loess, 2. Clayey silt, 3. Marshy sediment*.

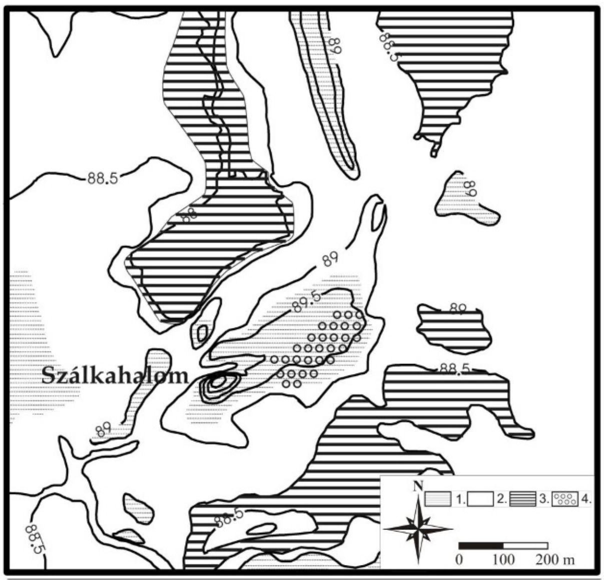

Figure 3. Vegetation map of the Szálkahalom kurgan *1. Loess steppe (Salvio nemorosae), 2. Alkaline steppe* (*Achilleo–Festucetum,Artemisio-Festucetum),3. Alkaline marsh (Puccinellietum limosae, Bolboschoenetum maritimi),4. Robinia pseudo-acacia*.

tified layers are listed in Table 1. From the core samples of Szálka-halom a few hundred specimens of 25 mollusc taxa were identified (Table 2). This makes Szálkahalom the most diverse Hungarian kurgan that has been explored to date. The relative species richness of this location could be due to the fact that the site is embedded in an infusion-loess bedrock which preserved representatives of terrestrial and aquatic species that became extinct at the end of the Ice Age. Sediment analysis showed that builders of the mound reached the bedrock, thus mixed loess material from the bedrock containing fossil mollusc shells with the chernozem soils hauled to create the mound at the end of the Copper, beginning of the Bronze Age. As a result, the kurgan contains shells from several time periods and from different environments. Following the exclusion of the 9 extinct and 6 aquatic species not native to the terrestrial sediments of the kurgan, the remaining 10 species represented by some 200 specimens characterize a mollusc fauna more similar to those of other studies on kurgans and recent fauna of loess grasslands and forest steppe of the Hungarian Great Plain [33, 34]. In the Holocene the following 10 species populated the surroundings of the kurgan: *Vertigo pygmaea, Granaria frumentum, Pupilla muscorum, Pupilla triplicata, Vallonia costata, Vallonia pulchella, Chondrula tridens, Vitrea crystallina, Limacidae* and *Cepaea vindobonensis*. Among these, the xeromesophilous, carbonate grassland tolerant *Pupilla triplicata* species was present at several locations on the Hungarian Great Plain at the beginning of the Holocene [6, 8], but later its range was reduced to carbonate-rich open vegetation habitats at higher altitudes. Even though *Vitrea crystallina* is present on the Hungarian Great Plain, it is recently found in riparian gallery forests and sandy oak forests providing a shadier and humid environment compared to the surrounding areas of the kurgan, where live specimens have not been found up to now. All the other recent taxa are xerothermophilous or xeromesophilous snail species and typical of recent loess grasslands of the Hungarian Great Plain [33, 34]. Dominant species amongst the shells identified were *Chodrula tridens* and *Cepaea vindobonensis*. As showed by the mollusc fauna, the area had a denser and taller loess grassland than the present day vegetation cover, dominated by one-meter tall herbaceous species (*Phlomis tuberosa, Salvia austriaca*) creating potentially higher relative humidity levels than today.

Based on the changes of the malacofauna and sedimantary geological characteristics, it seems possible that the Szálka-halom was built in two different time periods phases. In the first phase, only chernozem type soils from the superficial layers were incorporated into the mound, while in a later phase, bedrock was piled on the top of the original mound to increase its size. The surface of the mound had gone through a soil formation process, thus in this still evolving soil horizon a malacofauna typical of loess grasslands was identified. Chernozem soils formed before the end of the Copper, beginning of the Bronze Age (under the kurgan), and those evolved later (on the top of the kurgan) are characterized by the same species,

Table 1. Strata of the Szálka-halom kurgan, Hortobágy region [5].

Stratum	Depth (m)	Organic matter (%)	Carbonate (%)	Characteristics
1. Chernozem A	0 – 0.3	6.5 – 7.2	2.2 – 2.5	Shot by roots, friable, contains snail shells
2. Chernozem B	0.3 – 0.7	6.1 – 6.3	2.5 – 2.9	Carbonated patches, precipitates and sporadic snail shells
3. Mound body 2	0.7 – 1.5	1.8 – 6.2	3.0 – 5.5	Chernozem soil mixed with infusion loess containing mollusc remains, including shells of aquatic snails and bivalve
4. Mound body 1	1.5 – 4.0	6.2 – 6.6	2.1 – 2.2	Chernozem soil containing shells of terrestrial snails
5. Paleosol A	4.0 – 4.25	5.5 – 6.0	1.6 – 1.7	A horizon of chernozem with snail shells
6. Paleosol B	4.25 – 4.50	4.6 – 5.4	1.8 – 2.1	Chernozem B horizon with mollusc shells characteristic of the bedrock
7. Bedrock	from 4.50 m	0.2 – 0.6	6.5 – 9.8	Infusion loess with remarkable snail and bivalve fauna

although *Pupilla triplicata* and *Vitrea crystallina* is still present in the buried soil.

3.2. Faluvég-halom (Hortobágy)

In the winter of 1990, the archaeological site (parcel id.: Hortobágy, 01859) of the kurgan called Faluvég-halma was also drilled, and at the same time other boreholes were drilled for geological mapping purposes nearby. According to the III. Military Mapping Project of the Austro-Hungarian Monarchy in 1875, also to the 1945 Hungarian military map, as well as to the 1911 and 1938 surveys by Lajos Zoltai, archaeologist from Debrecen, this kurgan reaches 95 m a.s.l. [47].

According to the results of our drilling and the geological mapping the infusion loess covered kurgan is located on the 90 m altitude bank of an Ice Age river serving as a channel today. At the time of the drilling the surface of the kurgan was damaged by ploughing. There are two dirt roads leading through its body, and during the 20th century water regulation activities the eastern and north-eastern part of it was also damaged. As a result of this anthropogenic activity both its horizontal and vertical extension was significantly reduced compared to its original dimensions. Due to its use as cropland for many years and the growth of weeds it was impossible to reconstruct the original vegetation of the kurgan.

Table 3 lists the layers identified from the 4 m deep drill core from the northern part of the seriuosly damaged Faluvég-halom kurgan at a 92-93 m altitude. Due to the damaged and ploughed surface of this mound the exact relationship between the soil on the surface of, and the sediment in the kurgan could not be clarified, but still its structure and fauna shows remarkable similarities to the Szálka-halom kurgan (Table 2). Regarding its structure this similarity refers to an at least two-phase construction, since in the first phase (Mound body 1) the soil material layed on the fix-positioned chernozem-like soil did not contain infusion loess, whereas in the stratum closer to the surface (Mound body 2), infusion loess patches and strips were found.

From the drilling material of the Faluvég-halom kurgan some 200 specimens (most of the shells were broken) of 12 mollusc taxa had been identified (Table 4) Compared to the Szálka-halom kurgan there are both analogies and remarkable differences in the fauna. The mollusc fauna of the infusion loess bedrock is much less diverse than that of Szálka-halom. Two characteristic species of the mollusc fauna evolved at the end of the Ice Age, but were extinct by the beginning of Holocene on the Hungarian Great Plain, *Valvata pulchella* and *Anisus leucostoma*. Representatives of the aquatic fauna, some taxa of *Planorbidae* and *Pisidium* populate the neighbouring Árkus Channel, which was created by inland water regulations work in a former Ice Age river bed. Aquatic species, including those that became extinct by the end of the Ice Age were found not only in the infusion loess bedrock, but also in the topmost sediment, proving that in a later phase (or phases?) of the kurgan's construction, the builders had reached the infusion loess bedrock under the chernozem soil formed during the Holocene on the Ice Age river bank. Regarding the terrestrial fauna *Trichia hispida*, extinct by the early Holocene, and *Vitrea crystallina* that are characteristic species of lowland gallery and sandy oak forests around wetlands, were found exclusively in the bedrock.

However a few specimens of *Pupilla triplicata*, a species already extinct from the Hungarian Great Plain had been identified in the bedrock, in the early Holocene soil covering the bedrock, as well as in the soil material (Phase 1 with no infusion loess) of the mound body. Unfortunately without radiometric dating (AMS) it is impossible to decide whether the shells in the sediment of the kurgan originated from the redeposited material of the early Holocene soil, or that this species had still populated the

Table 2. Mollusc fauna in the strata and bedrock of Szálka-halom (††= species extinct at the end of the Ice Age on the Hungarian Great Plain, †= species extinct during the Holocene on the Hungarian Great Plain, * = species still present in the area) 1. A horizon of the chernozem soil covering the surface of the kurgan, 2. B horizon of the chernozem soil covering the surface of the kurgan, 3./ Layer 2 of the mound body, 4./ Layer 1 of the mound body, 5./A horizon of the fix positioned paleosol at the base of the kurgan, 6./B horizon of the fix positioned paleosol at the base of the kurgan, 7. Bedrock (infusion loess)

Species/stratum	1.	2.	3.	4.	5.	6.	7.
Aquatic snails	0	0	+	0	0	+	+
Valvata pulchella††	0	0	+	0	0	0	+
Bithynia leachi††	0	0	+	0	0	+	+
Lymnaea palustris	0	0	+	0	0	+	+
Lymnaea glabra††	0	0	0	0	0	0	+
Planorbis planorbis	0	0	+	0	0	+	+
Planorbarius corneus	0	0	+	0	0	+	+
Anisus spirorbis	0	0	+	0	0	+	+
Anisus leucostoma††	0	0	+	0	0	+	+
Gyraulus laevis	0	0	0	0	0	0	+
Terrestrial snails	+	+	+	+	+	+	+
Succinea oblonga	0	0	+	0	0	0	+
Columella columella††	0	0	+	0	0	0	+
Vertigo geyeri††	0	0	0	0	0	0	+
**Vertigo pygmaea*	+	+	+	+	+	+	0
Vertigo substriata††	0	0	0	0	0	0	+
**Granaria frumentum*	+	+	+	+	+	0	0
**Pupilla muscorum*	+	+	+	+	+	+	+
Pupilla triplicata†	0	0	0	+	+	+	0
**Vallonia costata*	+	+	+	+	+	0	0
**Vallonia pulchella*	+	+	+	+	+	+	+
**Chondrula tridens*	+	+	+	+	+	0	0
Vitrea crystallina	0	0	+	+	+	+	+
**Limacidae*	+	+	+	+	+	+	+
Trichia hispida††	0	0	+	0	0	0	+
**Cepaea vindobonesis*	+	+	+	+	+	0	0
Bivalve	0	0	+	0	0	0	+
Pisidium	0	0	+	0	0	0	+

soil surface at the end of Copper, beginning of the Bronze Age and they were moved into the mound body during its construction.

If the latter idea could be proven, it would mean that *Pupilla triplicata*, a species characteristic of a xeromesophilous and carbonate-rich environment, but today distributed only in the hilly parts of Hungary, started to disappear from the lowland in the second half of the Holocene, during the Bronze Age (4^{th}-3^{rd} millennia BC). According to the up-to-date information and relevant data this process may have occured much earlier (6^{th}-5^{th} millennia BC).

The composition of the fauna found in the earth-pyramid of the kurgan, based on the presence of *Pupilla muscorum, Pupilla triplicata, Vallonia pulchella, Chondrula tridens* and *Cepaea vindobonensis* indicates that the early Holocene soil surface could be covered by a loessy steppe vegetation dominated by tall herbaceous species. Comparing the fauna of the soils covering the kurgan and that on the surface of the bedrock it is quite obvious that both mollusc faunas were dominated by xeromesophilous species, being the most characteristic elements of the recent lowland loess steppes [33, 34]. Shells of *Chondrula tridens* dominated the soil stratum on the top of the kurgan, while *Pupilla muscorum* is already missing here.

According to the changes in the composition of the mollusc fauna and also to the sedimentary geological characteristics it is supposed that the Faluvég-halom kurgan was built in two distinct periods of time or at least in two phases. During the first phase only surface chernozem like soil material was built into the mound, while as part of the second, heightening phase the bedrock was damaged and moved onto the already existing smaller kurgan. The topmost stratum of the mound has been going through a still-ongoing soil formation process, in which a mollusc fauna characteristic of loess steppes was identified. Chernozem soils under and on the top of the kurgan are dominated by the same species, while in the buried soil *Pupilla triplicata* and *Pupilla muscorum* was still present. The most dominant species of the mollusc fauna of the kurgan material is *Chondrula tridens*.

3.3. Csípő-halom (Hortobágy region)

This kurgan was explored in the framework of a research programme targeting the study of the evolution of Hungarian kurgans. Upon the request of Attila Barczi, the project manager, several borehole drillings were arranged [35] with a self-designed and constructed drilling assembly, which was designed according to the relevant standard of the Geological Institute of Hungary, but constructed individually based on a two-armed Styl drill [7].

Results of the studies on the vegetation around the drillings, as well as the stratigraphical, pedological and sedimentary geological analyses have already been published by [14, 15, 37, 38].

In our drill core snails were found in the soil buried under the mound body and in its bedrock, in the topmost startum which had gone through a soil formation process, and also from two sites around the kurgan. The drilling settled centrally on the top contained species of the dry steppe (*Chondrula tridens*, *Cepaea vindobonensis*) from

Table 3. Strata of the Faluvég-halom kurgan, Hortobágy region [5].

Stratum	Depth (m)	Organic matter (%)	Carbonate (%)	Characteristics
1. Ploughed soil A horizon	0.0 – 0.4	3.5 – 4.2	1.2 – 1.5	Shot by roots, friable, contains snail shells, heavily disturbed
2. Ploughed soil B horizon	0.4 – 0.8	4.1 – 5.1	1.5 – 1.9	Carbonated patches, precipitations, disturbed, contains snail shells
3. Mound body 2	0.8 – 1.4	1.8 – 6.2	3.0 – 3.5	Chernozem like soil mixed with infusion loess
4. Mound body 1	1.4 – 2.0	3.2 – 3.6	2.1 – 2.2	Chernozem soil containing shells of terrestrial snails
5. Paleosol A	2.0 – 2.5	4.5 – 6.2	1.6 – 1.7	Chernozem like soil with snail shells
6. Paleosol B	2.5 – 3.0	4.2 – 4.4	1.8 – 2.1	Chernozem B horizon bedrock with a few mollusc shells
7. Bedrock	3.0 – 4.0	0.2 – 0.4	4.3 – 5.6	Infusion loess with sporadic snail and bivalve fauna

Table 4. Mollusc fauna in the strata and bedrock of Faluvég-halom [5], *(††= species extinct at the end of the Ice Age on the Hungarian Great Plain, †= species extinct during the Holocene on the Hungarian Great Plain, * = species still present in the area) 1. A horizon of the ploughed chernozem soil covering the surface of the kurgan, 2. B horizon of the ploghed chernozem soil covering the surface of the kurgan, 3./ Layer 2 of the mound body, 4./ Layer 1 of the mound body, 5./A horizon of the fix positioned paleosol at the base of the kurgan, 6./B horizon of the fix positioned paleosol at the base of the kurgan, 7. Bedrock (infusion loess)*

Species/Stratum	1.	2.	3.	4.	5.	6.	7.
Aquatic snails	0	0	+	0	0	+	+
Valvata pulchella††	0	0	+	0	0	0	+
**Planorbis planorbis*	0	0	+	0	0	0	+
**Planorbarius corneus*	0	0	+	0	0	0	+
**Anisus spirorbis*	0	0	0	0	0	0	+
Anisus leucostoma††	0	0	+	0	0	+	+
Terrestrial snails	+	+	+	+	+	+	+
**Pupilla muscorum*	+	+	+	+	+	+	+
Pupilla triplicata†	0	0	0	+	+	+	+
**Vallonia pulchella*	+	+	+	+	+	+	+
**Chondrula tridens*	+	+	+	+	+	0	0
Vitrea crystallina	0	0	0	0	0	0	+
Trichia hispida††	0	0	+	0	0	0	+
**Cepaea vindobonesis*	+	+	+	+	+	0	0
Bivalve	0	0	+	0	0	0	+
**Pisidium*	0	0	+	0	0	0	+

the buried soil. In this part of the Hortobágy region the humic content of the soil is 2.3%, the pH is slightly alkaline, the traceable lime content is 0.5%, showing characteristics of good quality black soils, although the Na^+ content (3794 mg/kg) indicates a slightly alkaline character [37]. According to the snail fauna the soil of the bedrock of the kurgan evolved in a steppe environment. The extremely low number of species and individuals is probably related to the dry environment, which is the most important limiting factor on the terrestrial mollusc fauna [27].

The material from the drill cores settled around the kurgan contained species that occur in a slightly more humid, or periodically changing environment (*Vertigo pygmaea*, *Helicopsis striata*, *Chondrula tridens*, *Vallonia pulchella*, *Cepaea vindobonensis*). Buried soils buried are quite similar to the above, although the Na^+ content (4163 mg/kg) and the pH is a bit higher (pH HOH 9,4; pH (KCl) = 8,2). In the bedrock of these soils there is an increased lime content (13%) but a decreased Na^+ and humic content [37]. On the margin of the kurgan an obviously more humid and periodically changing micro-environment had developed with a more species-rich fauna, including species tolerating alkalization and a more salty environment (e.g. *Vertigo pygmaea*).

Species found in at a distance to the kurgán (*Planorbis planorbis*, *Anisus spirorbis*, *Oxyloma elegans*, *Chondrula tridens*, *Cepaea vindobonensis*) indicate water-side, alkaline and steppe like environments. Soils sampled here are chernozem meadow soils covering higher micro-elevations, surrounded by temporarily wet and mosaic-like alkaline geomorphological formations. The presence of aquatic species like the salt-tolerating *Anisus spirorbis* indicates the former existence of small, temporary water-bodies around the river bank on which the kurgan was built. Like in the case of Szálka-halom and Faulvég-halom kurgans, these sites could be the source of the mollusc fauna, containing water-tolerating and terrestrial meadow elements, found in the mound body.

In the topmost horizon of the mound body species indicating the driest environment appeared (*Helicopsis striata*, *Chondrula tridens*, *Cepaea vindobonensis*). Morphologically (underground animal passages, lime dynamics, etc.) the soil itself corresponds to the B horizon of a high quality black soil, which is confirmed by laboratory results.

The mollusc fauna of the good quality soil covering the kurgan unambiguosly confirms that the construction of the kurgan had created an island-like habitat with steppe vegation developed on a dry, good quality black soil, surrounded by a mosaic of alkaline and meadow soils covered by their characteristic vegetation. It is the mollusc fauna of the black soil on the surface of the kurgan which is comparable most of all to the original and fixed soil of the river bank on which the kurgan was built.

Therefore, the soil on the bedrock of the Csípő-halom kurgán can be considered as a black soil developed in a steppe environment. According to the composition of the mollusc fauna, development of significant forest-like vegetation in the sorroundings of the kurgan was hardly possible either before, or following its construction. This malacological analysis fully supports the suggestion that there was no significant natural afforestation at the beginning of the Holocene in the Hortobágy, and in the neighbouring Hajdúság regions [6, 10, 39–42]. The malacological data also confirm that the alkalization process had started and most probably was continuously going on from the end of the Pleistocene in the area studied [6, 7, 10, 41, 43, 48], where, depending on the morphological features and micro-relief differences, a mosaic of alkaline, meadow and black soils had developed. Dominant species of the kurgan material were *Vertigo pygmaea*, *Chondrula tridens* and *Cepaea vindobonensis*.

3.4. Őr-halom (Sárrétudvari, Bihar region)

During the summer of 1992, as requested by the archeologist Ibolya Módyné Nepper we joined the excavation project of this kurgan. Standard samples were taken at every 25 cm from the almost completely half-cut mound body for pedological, sedimentary, micro-morphological and malacological analysis. Based on the results the structure of the kurgan built in two phases has been modelled (Table 5), including the development of its digital terrain model [13]. Archaeologists have already published the stratigraphical and morphological data [12] that is why only results of the quarter-malacological analysis are provided here. This kurgan is located on an 87 m altitude bank along a Pleistocene river. The recent waterflow (Körtvélyesi-ér) occupying the former river-bed was regulated in the 20th century. The Ice Age river bank is constituted by infusion loess containing quite small amount of mollusc shells. The infusion loess was covered by a meadow (hydromorphic) soil characterized by well-developed soil horizons, with a polihedron structure and brownish-black colour, which contains significant amount of bog iron and also mollusc shells with sporadically dissolved surface (pseudomorphous shells). The kurgan was constructed on the surface of the meadow soil, A and B horizons of which were built in the mound during the first construction phase.

Significant amounts of limonite was detected in the material of the first contruction layer, although according to the micro-morhphological examination [13] this was not in the form of bog iron, but filling in pores and veins as a secondary matrix. The amount of limonite present gradually decreases towards the surface. The second construction phase could be easily detected in the half-cut kurgan, separated from the first one with a characteristic stratum (Sümegi, 1992). In the second phase, besides the meadow soil significant amounts of infusion loess were built into the mound body creating an almost 5 m high kurgan (Table 5). Based on the evolution of the sedimentary material it is probable that there was a third construction phase as well, but it is not suitable for detailed analysis, since its sedimentary material covers the surface of the mound and went through a soil formation process.

More than one thousand specimens of 20 snail and bivalve taxa have been identified in the half-cut kurgan (Table 6). Compared to the Hortobágy region kurgans the proportion of aquatic and water-side species is higher, due to the fact that taxa tolerating shallow and temporary water-cover or water-side environments (*Lymneidae*, *Planorbidae*, *Succinidae, Carychium minimum*) dominated both in the bedrock and in the meadow soil on the top of it. It is clear that aquatic species dominate the material used during the two phases of kurgan construction, when the bedrock was used for building purposes. Besides the recent aquatic and hygrophilous species, three others, *Valvata pulchella*, *Bithynia leachi* and *Trichia hispida* were identified from the infusion loess, but they become extinct at the end of the Ice Age. Shells of these species were also found in the infusion loess material of the second construction phase. On the surface of the kurgan, constructed from the bedrock infusion loess and from the water-affected meadow soil, an island-like dry habitat had developed, which was completely different from the surrounding floodplain habitat. In this dry environment plants (*Agropyron pectiniforme*) and animals (steppe snails) characteristic of steppes could establish populations. This suggestion is reinforced by the presence of a characteristic xeromesophilous mollusc fauna (*Pupilla muscorum, Vallonia pulchella, Vallonia costata, Chondrula tridens, Cepaea vindobonensis*) in the black soil covering the kurgan surface. All these species are characteristic of recent lowland loess steppes [33, 34], the appearence of their populations in a foodplain environment was a result of human activities, which had constructed a dry biotope, emerging from the surrounding wetland like an island. The same reason is accountable for the development of the black soil

Table 5. Strata of the Őr-halom kurgan, Sárrétudvari, Bihar region [13]

Stratum	Depth (m)	Organic matter (%)	Carbonate (%)	Characteristics
1. Chernozem soil A horizon	0.0 – 0.25	6.5 – 7.4	2.1 – 2.6	Shot by roots, friable, contains snail shells, heavily disturbed
2. Chernozem soil B horizon	0.25 – 0.50	4.9 – 6.2	3.5 – 3.9	Carbonated patches, precipitates, disturbed, contains some snail shells
3. Mound body 2	0.50 – 1.75	1.8 – 6.2	3.0 – 3.5	Hydromorphic soil material mixed with infusion loess, containing some limonite
4. Mound body 1	1.75 – 4.25	3.2 – 3.6	2.1 – 2.2	Hydromorphic soil material containing significant amount of limonite patches and sporadic snail shells
5. Paleosol A	4.25 – 4.50	3.5 – 4.2	1.6 – 1.7	Meadow (hydromorphic) soil, aquatic and coastal snail shells
6. Paleosol B	4.50 – 4.75	1.2 – 2.5	1.8 – 2.1	B horizon of a meadow soil, with significant amount of limonite patches and shell pseudomorphs
7. Bedrock	4.75 – 5.0	0.2 – 0.4	4.3 – 5.6	Infusion loess with sporadic snail and bivalve fauna

Table 6. Mollusc fauna in the strata and bedrock of the Őr-halom *(††= species extinct at the end of the Ice Age on the Hungarian Great Plain, * = species still present in the area), 1. A horizon of the meadow soil covering the surface of the kurgan, 2. B horizon of the meadow soil covering the surface of the kurgan, 3./ Layer 2 of the mound body, 4./ Layer 1 of the mound body, 5./A horizon of the fix positioned paleosol (meadow soil) at the base of the kurgan, 6./B horizon of the fix positioned paleosol (meadow soil)at the base of the kurgan, 7. Bedrock (infusion loess)*

Species/Startum	1.	2.	3.	4.	5.	6.	7.
Aquatic snails	0	0	+	+	+	+	+
Valvata pulchella††	0	0	+	0	0	0	+
Bithynia leachi††	0	0	+	+	+	+	+
**Lymnaea palustris*	0	0	+	+	+	+	+
**Planorbis planorbis*	0	0	+	+	+	+	+
**Planorbarius corneus*	0	0	+	+	+	+	+
**Anisus spirorbis*	0	0	+	+	+	+	+
Anisus leucostoma††	0	0	+	0	0	+	+
Terrestrial snails	+	+	+	+	+	+	+
Carychium minimum	0	0	+	+	+	+	+
Succinea oblonga	0	0	+	+	+	+	+
**Succinea putris*	0	0	+	+	+	+	+
**Oxyloma elegans*	0	0	+	+	+	+	+
**Pupilla muscorum*	+	+	0	0	0	0	0
**Vallonia pulchella*	+	+	+	+	+	+	+
**Vallonia costata*	+	+	0	0	0	0	0
**Chondrula tridens*	+	+	+	+	+	0	0
**Vitrea crystallina*	0	0	0	0	0	0	+
**Perforatella rubiginosa*	0	0	+	+	+	+	+
Trichia hispida††	0	0	+	0	0	0	+
**Cepaea vindobonesis*	+	+	0	0	0	0	0
Bivalve	0	0	+	0	0	0	+
**Pisidium*	0	0	+	0	0	0	+

on the kurgan surface, surrounded by a completely different floodplain environment. Pedological and malacological analyses are comparable with the vegetation studies of the kurgan surface, since the black soil formed on the top of the mound and the snail species of dry, steppe-like habitats correlate with the loess-grassland developed on the surface of the kurgan [13]. *Chondrula tridens* was the dominant species of the mollusc fauna explored in the kurgan material.

Lyukas-halom (Tedej)

In September 2002, based on a civil notice, the seriously damaged Lyukas-halom kurgan nearby to Tedej was visited with Pál Raczky, professor of archaeology. Following the official report of the illegal activity, as requested by Prof. Raczky, sedimentological, micro-morphological and malacological studies were started in 2002. A central and a marginal profile had been established on the almost half-cut body of the mound from which 2.7 kg sediment samples were taken for malacological analysis at every 10 cm. Profiles were complemented with drill cores: a 7 m malacological sample was taken from the central core, and a 5 m one from the marginal profile. Stratigraphical and sedimentological studies clearly indicate three construction phases – since three soil surfaces went through a soil formation process in the past. The mound is erected on the transitional chernozem-meadow soil covering the bedrock. According to the malacological analysis no difference could be identified among the mollusc fauna of the three construction phases. For this reason mollusc material from the mound body is presented and evaluated together (Table 7). Five hundred specimens of 19 snail and bivalve taxa constituted the mollusc fauna extracted from 0.3-tons of material. Based on the amount of sedimentary material processed, the mollusc fauna can

Table 7. Mollusc fauna in the strata and bedrock of the Lyukas-halom, Tedej *(††= species extinct at the end of the Ice Age on the Hungarian Great Plain, * = species still present in the area), 1. A horizon of the black soil covering the surface of the kurgan, 2. B horizon of the black soil covering the surface of the kurgan, 3./ Layer 3 of the mound body, 4./ Layer 2 of the mound body, 5./ Layer 1 of the mound body, 6./ A horizon of the fix positioned paleosol (meadow soil) at the base of the kurgan, 7./ B horizon of the fix positioned paleosol (meadow soil) at the base of the kurgan, 8./ Bedrock (infusion loess)*

Species/Stratum	1.	2.	3.	4.	5.	6.	7.	8.
Aquatic snails	0	0	+	+	+	+	+	+
Valvata pulchella††	0	0	0	0	0	0	0	+
**Lymnaea palustris*	0	0	+	+	+	+	+	+
**Planorbis planorbis*	0	0	+	+	+	+	+	+
**Planorbarius corneus*	0	0	+	+	+	+	+	+
**Anisus spirorbis*	0	0	+	+	+	+	+	+
Anisus leucostoma††	0	0	0	0	0	0	0	+
Terrestrial snail species	+	+	+	+	+	+	+	+
Carychium minimum	0	0	0	+	+	+	+	+
Succinea oblonga	0	0	0	+	+	+	+	+
**Succinea putris*	0	0	+	+	+	+	+	+
**Oxyloma elegans*	0	0	+	+	+	+	+	+
**Pupilla muscorum*	+	+	+	+	+	+	0	0
**Vallonia pulchella*	+	+	+	+	+	+	+	+
**Vallonia costata*	+	+	+	+	+	+	0	0
**Chondrula tridens*	+	+	+	+	+	+	+	0
**Perforatella rubiginosa*	0	0	0	0	0	+	+	+
Trichia hispida††	0	0	+	+	+	+	+	+
Monacha cartusiana	+	0	0	0	0	0	0	0
**Cepaea vindobonesis*	+	+	+	+	0	0	0	0
Bivalve	0	0	+	+	+	+	+	+
**Pisidium*	0	0	+	+	+	+	+	+

be characterized by an extremely low number of individuals, which together with the dissolved, pseudomorphous shells found suggest that following the construction of the kurgan dynamic chemical processes, including carbonate dissolution and aggregation had occured. Theabsence of shells in certain strata of the kurgan could have been the result of these postgenetic processes.

A few specimens of *Valvata pulchella*, *Anisus leucostoma* and *Trichia hispida*, species that become extinct from the Hungarian Great Plain by the end of the Pleistocene, were identified in the infusion loess bedrock. Shell fragments of these species were found in the sedimentary material of the kurgán as well, indicating that the bedrock material was also exploited and mixed into the construction material of the earth-pyramid. Besides the extinct specimens, a dominance of mollusc species preferring aquatic, hygrophilous and water-side environments was found.

Mollusc shells were found in the chernozem like hydromorphic soil on the surface of the infusion loess. However most of the pseudomorphous shells and shell dissolution traces were detected in this stratum, too. According to the shell fragments of species preferring aquatic and hygrophilous environment in the original, but buried soil layer, soil formulation should have been influenced by temporary water cover. Shells of xero- and mesothermophilous species found in the mound body are characteristic of the soils developed between the kurgan construction phases on the kurgan surface, as well as those occuring in the soil of the bedrock of the kurgan and in the bedrock itself, testify to the mixed character of the sediment material, as well as the soil formation processes in between the different kurgan construction phases.

Monacha cartusiana, dominant species of the mollusc fauna of the stratum series of the kurgan, was found in the marginal profile only. This species migrated to and distributed in the Carpathian Basin during the last two millennia, probably as a consequence of Celtic deforestations [49]. Its occurrence on the Hungarian Great Plain is confirmed between the 2^{nd} B.C. and 1^{st} century A.C. [44], and its shells were found in many Sarmatian archaeological sites. It is a faunal element characteristic of wet meadows, which are recently found in the margin of the former, already ploughed, alkaline grassland called Lyukas-szik north of the kurgan. Based on its presence the soil covering the kurgan probably indicates a more recent, maybe Imperial Period (Sarmatian) intervention on the surface of the kurgan. An alternative explanation is that rodents had subsequently stored shells of this species into the chernozem soil covering the kurgan. Contrary to this characteristic, the fauna of the black soil covering the surface of the kurgan consists of xeromesophilous and xerothermophilous snail species.

Malacological material of the Lyukas-halom kurgan has remarkable analogies with the mollusc fauna of the Hortobágy and Bihar region kurgans. The identical bedrock, evolvement of the buried paleo-soil and the dry steppe environment created by the construction of the kurgan resulted in an analogous fauna development of the kurgans east of River Tisza in the Carpathian Basin. However, two differences are considered to be significant: Firstly, *Pupilla triplicata* was not found in the Lyukas-halom kurgan, and secondly, *Monacha cartusiana* which migrated to the Carpathian basin during the last two millennia, was identified in the most recent soil surface covering the mound. This suggests the idea of Sarmatian intervention during the Imperial Period, which had influenced the most recent soil formation of the kurgan. Predominant species of the mollusc fauna found in the mound body are *Chondrula tridens* and *Cepaea vindobonensis*.

3.5. Oltó-halom (Dunatetétlen, Danube-Tisa Interfluves region)

Based on the geodetic reference point (N: 46° 47'46.38", E: 19° 09'42.58") on the top of this kurgan called Ottó-, or in its more popular name Oltó-halom, the height of the mound is 102.7 m a.s.l. In 2008 archaeological, geological and malacological studies have been implemented here, supported by Rozália Kustár archaeologist, and Zoltán Oroszi, nature conservation experts [45].

Several drill cores have been undertaken both in the N-S and E-W directions on the kurgan. The kurgan was seriously damaged and became deformed due to animal grazing during the last couple of thousands of years, a recent sand-mine and illegal motocross activities.

According to the cross-section outlined by the drilling results (Fig. 4), two different sand layers, both accumulated in the site by natural processes are identified: a sand stratum of fluvial origin forming the general bedrock, covered by an another wind-blown sand layer, which evolved by aeolian processes and formed sand dunes in some places. For the construction of the kurgan a higher wind-blown sand elevation (sand dune or *jardang*) had been selected by the Copper Age communities, on the top of which the earth-pyramid was erected. At the central part of the kurgan the earth-pyramid was settled on the wind-blown sand layer, although in several marginal locations a red-brown layer, referring the more intensive water movements, or to the formation of a brown forest soil could be identified under the mound. The absence of a continuous red-brown horizon at the central position (Fig. 4) of the sand surface raises questions. This horizon is probably missing here probably due to human; like the possible construction of a centrally positioned funeral chamber, or that this layer is simply degraded from the highest relief surfaces following the deforestation of the area. Based on the drilling samples, the material of the mound was found to be extremely mixed, partly composed of chernozem like soil, but alkaline patches and sediment could indicate the former presence of alkaline soils as well. Most of the sediment built into the kurgan originates from the A horizon of different soils, rich in organic matter, but significant amounts of carbonate-rich B horizon material was also built into the mound body. According to the drill core analysis, the kurgan was erected in one phase, since homogenous layers separating different soil layers referring to more construction phases could not be identified.

In the wind-blown sand bedrock only extremely fragmented, dissolved and polished shell remains of the

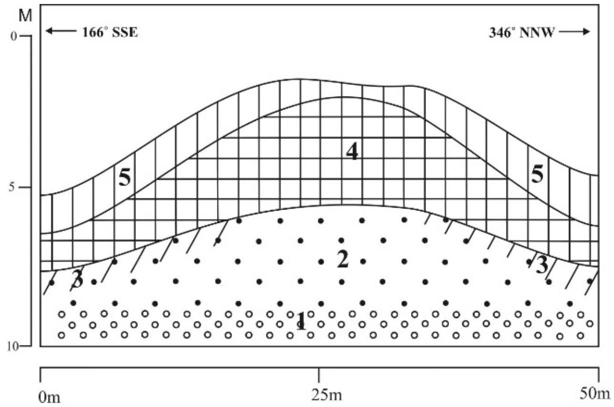

Figure 4. Geological cross-section of the Oltóhalom kurgán at Dunatetétlen *1.Fluvial sand (alluvial fan material), 2.Wind-blown sand, 3.Reddish-brown layer, 4.The sediment and soil material of the body of the Oltó-halom kurgan, 5. The uppermost, recent soil of the body of the Oltó-halom kurgan.*

aquatic *Lymnaea* genus were found. Based on these characteristics of the shell fragments it is suggested that this material is derived from the bedrock of the wind-blown sand of fluvial origin. Besides the representatives of this taxon being alien to the facies, only snails preferring an environment characterized by mild and dry growth seasons (*Helicopsis striata, Cepaea vindobonensis* és *Chondrula tridens*) could be found, indicating conditions of wind-blown sand formation process (Table 8). In the red-brown soil horizon (brown forest soil?) covering the wind-blown sand only shells of *Vallonia pulchella* preferring a subhygrophilous and penumbral environment, but with a wide ecological tolerance spectrum, and shells of *Cepaea*

Table 8. Malacological analysis of the drilling material of the Oltó-halom kurgan $*$ = *species stil present in the area, 1. A horizon of the black soil covering the kurgan surface, 2./ Sediment constituting the mound body, 3./ Red-brown soil layer covering the wind-blown sand bedrock, 4./ Wind-blown sand bedrock*

Species/Startum	1.	2.	3.	4.
Lymnaea sp.	0	0	0	+
**Anisus spirorbis*	0	+	0	0
**Oxyloma elegans*	0	+	0	0
**Vertigo pygmaea*	+	+	0	0
**Granaria frumentum*	+	+	0	0
**Chondrula tridens*	+	+	0	+
Vallonia pulchella	0	+	+	0
**Helicopsis striata*	+	+	0	+
**Ceapaea vindobonensis*	+	+	+	+
Helix pomatia	0	+	0	0

vindobonensis, a species characteristic of forest steppes were identified. Besides these species requiring significant vegetation cover, no other species characteristic of steppe environment were found. For this reason it is suggested that in the period of the formation of this buried surface there could be a significant vegetation cover in the area. Based on the low number of shells found no additional conclusions can be made.

From the shell material of the mound body *Anisus spirorbis*, a species tolerating small alkaline water-bodies was found, supporting the results of the geochemical analyses (Sümegi, 2008), which indicates that alkaline sediment material could have also been moved into the kurgan body. Thermoxerophilous (*Chondrula tridens*, *Granaria frumentum*, *Helicopsis striata)* and mesophilous species (*Vertigo pygmaea*) with a wider tolerance spectrum predominate this horizon suggesting that most of the kurgan material was derived from soils evolved in a steppe environment and covered by non-arboreal, herbaceous vegetation. On the other hand *Oxyloma elegans*, characteristic of wet meadows and a water-side environment was also found in this layer, indicating that a smaller part of the mound body was exploited from a humid environment, the latter is also indicated by the presence of *Vallonia pulchella*. The former, more significant vegetation cover is indicated by the high number of individuals of *Cepaea vindobonensis*, characteristic species of tall grasslands and forest steppes, as well as by the presence of *Helix pomatia*, preferring shady, more afforested habitats.

The malacological material of the mound body indicates a mixed vegetation of dry and humid environments, developed on a mosaic of alkaline and chernozem soils in the period of the construction of the kurgan. The malacofauna developed in the upper soil horizon of the mound indicates the extremely dry environmental conditions of steppes, charaterized by the dominance of thermoxerophilous species. Composition of the mollusc fauna can be well synchronized with the results of archaeological-geological, sedimentological and pedological analyses. More detailed conclusions could have been made with an archaeological exploration of the kurgan, including the excavation and sampling of its surface strata.

The dominant species of this kurgan are *Chondrula tridens, Helicopsis striata, Granaria frumentum* and *Cepaea vindobonensis*. The species composition indicates that besides the remarkable analogies, there are also differences in the malacofauna of the Danube-Tisa Interfluves region compared to that of the lowlands east of the River Tisza, indicated by the higher dominance of *Granaria frumentum* and *Helicopsis striata* in the former region.

4. Summary

Although the malacofauna of the kurgans studied demonstrate local and regional differences, to the species composition can also reflect their former environment.

The environment surrounding the kurgans studied is mosaic-like both in terms of soils and their vegetation, meaning that steppe, forest steppe, alkaline and water-influenced biotopes could be identified around almost all of them. Following the construction of the kurgans an island-like, dry habitat developed on their surface covered by black soil and populated by a steppe fauna, the composition of which is comparable mostly with the mollusc fauna of loess steppes, irrespectively of the floodplain or wind-blown sand character of the original surface. *Chondrula tridens* and *Cepaea vindobonensis* are the two flagship species of all kurgans, but xeromesophilous and xerothermophilous species like *Vertigo pygmaea*, *Pupilla muscorum* and *Helicopsis striata* are common elements of the associated malacofauna.

Secondly, most of the malacofauna extracted from the sedimentary material of the kurgans is composed of shells of mollusc species that lived earlier than the end of the Copper, beginning of the Bronze Age, and were embedded into the original soil under the kurgans, or into the bedrock. As a consequence of this, in some cases it was not possible to verify whether certain species are from the substrate (soil layer on the bedrock) or they simply lived in the region when the kurgan was erected there. Of these species *Pupilla triplicata* - extinct from the Hungarian Great Plain during the Holocene - seems to be the most important, since besides its presence in the early Holocene, the idea of its survival until the 3^{rd} millenia BC is also suggested, but in the absence of dating information this hypothesis cannot be confirmed at the moment.

The presence of *Monacha cartusiana* within the Carpathian Basin during the last two millennia is also significant, as it implies a possible disturbance of the surface of the kurgans in the Imperial Period, or afterwards.

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