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VERSITA

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Preliminary malacological investigation of the loess profile at Šarengrad, Croatia

Communication

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Abstract: More than 3 400 specimens of 51 mollusc species were identified in a loessy-alluvial section at Šarengrad village in Croatia. This section provides one of the most diverse collections of mollusc species in the lower Danube. The malacological data from this profile suggests that this section developed during the last interglacial-glacial cycle.

Keywords: Loess profile • Quaternary malacology • Šarengrad • Croatia

1. Introduction

Quaternary sediments are prevalent in Eastern Croatia and include predominantly alluvial, marshy, and lucustrine sediments that are typically covered with aeolian material. The Basic Geological Map of Croatia (scale 1:1000 000) and publications provide detailed descriptions of the different types of quaternary sediments present. At least six paleosols, ranging in age from the Middle to Upper Pleistocene, are intercalated in the loess sections from Eastern Croatia [1]. Geochemical, sedimentological, and geochrological analyses of these paleosols have been used to reconstruct the environmental and climactic changes that occurred in Eastern Croatia during the Middle to Late Pleistocene [2].

Loess deposits are thickest in the "loess plateaus" of Eastern Croatia and on the Fruska Gora hills. Aeolian sediments were also deposited in lakes, pools, and shallow marshes. These low-lying loess/paleosol sequences were undercut and eroded by the Danube river resulting in excellent exposures in steep cliffs up to 30 m high.

The Šarengrad loess profile is located in the easternmost part of Croatia, 500 m to the east of Šarengrad village centre (N: 45°13′53.97″ E: 19°17′49.23″) on the northern foreground of Fruska Gora hills. Due to financial and temporal constraints, the research team was only able to sample between 9 and 22 meters of the approximately 23 m high profile.

The Quaternary malacological investigations of the loess profile at Šarengrad were completed in conjuction with the Croatian-Hungarian bilateral project in spring 2008. The main goal of this project was to correlate the loess profiles in SW-Hungary with the profiles in East-Croatia using analagous analytical methods to obtain malacolog-

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ical analyses of Šarengrad and Zmajevac.
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Table 1. The identified mollusc species in the loess profile.

Viviparus contectus (Millet, 1813)	*Pupilla* cf. *bigranata* (Rossmässler, 1839)
Valvata cristata (O. F. Müller, 1774)	*Vallonia costata* (O. F. Müller, 1774)
Valvata piscinalis (O. F. Müller, 1774)	*Vallonia pulchella* (O. F. Müller, 1774)
Bithynia tentaculata (Linnaeus, 1758)	*Vallonia tenuilabris* (A. Braun, 1843)
Bithynia leachii (Sheppard, 1823)	*Chondrula tridens* (O. F. Müller, 1774)
Lymnaea stagnalis (Linnaeus, 1758)	*Ena montana* (Draparnaud, 1801)
Stagnicola palustris (O. F. Müller, 1774)	*Punctum pygmaeum* (Draparnaud, 1801)
Galba truncatula (O. F. Müller, 1774)	*Discus ruderatus* (A. De Fèrussac, 1821)
Planorbarius corneus (Linnaeus, 1758)	*Vitrina pellucida* (O. F. Müller, 1774)
Planorbis planorbis (Linnaeus, 1758)	*Vitrea crystallina* (O. F. Müller, 1774)
Anisus leucostoma (Millet, 1813)	*Aegopinella ressmanni* (Westerlund,1883)
Anisus spirorbis (Linnaeus, 1758)	*Nesovitrea hammonis* (Ström, 1765)
Anisus vortex (Linnaeus, 1758)	*Euconulus fulvus* (O. F. Müller, 1774)
Gyraulus albus (Müller, 1774)	*Cochlodina laminata* (Montagu, 1803)
Gyraulus crista (Linnaeus, 1758)	*Clausilia dubia* (Draparnaud, 1805)
Pisidium amnicum (O. F. Müller, 1774)	*Clausilia pumila* (C. Pfeiffer, 1828)
Succinea oblonga (Draparnaud, 1801)	*Helicodiscus* cf. *singleyanus* (Pilsbry, 1889)
Succinea putris (Linnaeus, 1758)	*Helicopsis striata* (O. F. Müller, 1774)
Oxyloma elegans (Risso, 1826)	*Perforatella bidentata* (Gemelin, 1788)
Cochlicopa lubricella (Porro, 1838)	*Trichia hispida* (C. Linnaeus, 1758)
Columella columella (Martens, 1838)	*Trichia striolata* (C. Pfeiffer, 1828)
Vertigo antivertigo (Draparnaud, 1801)	*Trichia edentula* (Draparnaud, 1805)
Vertigo pygmaea (Draparnaud, 1801)	*Arianta arbustorum* (C. Linnaeus, 1758)
Orcula dolium (Draparnaud, 1801)	*Pupilla triplicata* (G. Studer, 1820)
Granaria frumentum (Draparnaud, 1801)	*Sphaerium rivicola* (Lamarck, 1811)
Pupilla muscorum (C. Linnaeus, 1758)	

2. Sampling methods

Samples were collected from a cleaned profile according to the following Quaternay malacological sampling method: 1 dm^3 (about 2.5 kg) was collected from every 25 cm of the profile [3, 4]. Samples were wet screened using a screen of 0.5 mm mesh. A total of 52 samples were collected. The retrieved shells were taxonomically identified [5–10] (see Table 1).

The abundance and dominance values of taxonomically identified specimens were noted for each profile. In addition, charts were prepared depicting the specimen and percentage distribution of individual species with depth. The individual species were segregated into paleoecological and biogeographical groups based on ecological requirements specific to each species such as preferred temperature, humidity and vegetative cover [11–13]. Fluctuations in the abundance and dominance values of individual paleoecological and biogeographical groups with depth are depicted in each profile with charts and tables prepared using the Psimpoll software package of Bennett [14].

Climatic reconstructions were completed using the malacothermometer method. This method is based on recent regional geographic patterns of 11 dominant gastropod species from a composite malacofauna. For selected gastropod species, optimal climatic conditions, including the minimum and maximum temperatures needed for gastropod activity of each species, was determined using data from meteorological stations [12, 15–17]. Prior to sampling, the research team cleaned the profile and described the layers using Munsell Soil Color Charts.

3. Environmental and stratigraphic description

The profile is located on the east side of a valley that leads to the southern portion of the Danube river (see Figure 1). An interesting biogeographical feature of the valley from a malacological perspective was the collective presence of modern and fossil specimens of the Pontic *Pomatias rivulare* and Atlanto-Mediterranean *Pomatias elegans*. This is the first time these two species have been documented in coexistence in the Lower Danube area of Croatia.

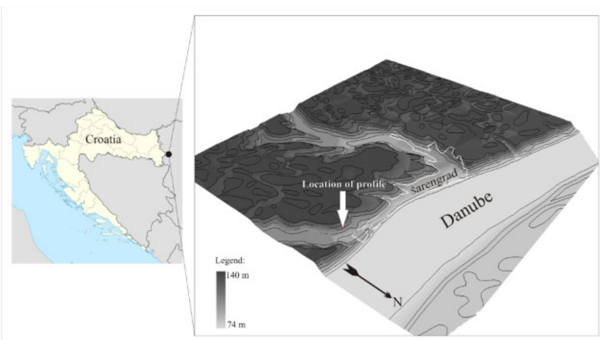

Figure 1. Location of the loess profile at Šarengrad (white line shows the extension of Šarengrad village).

The profile is bounded by farmed gardens and vineyards. The cliffs surrounding the valley arec overed with acacia groves including *Euonymus verrucosus,* italian honeysuckle (*Lonicera caprifolium*), hellebor (*Helleborus odorus*), black bryony (*Tamus communis*), black elder (*Sambucus nigra*), stinging nettle (*Urtica dioica*), greater celandine (*Chelidonium majus*), goosegrass (*Galium aparine*) and wood avens (*Geum urbanum*) and various other deciduous trees consisting of black locust (*Robinia pseudoacacia*), walnut tree (*Juglans*), silver lime (*Tilia tomentosa*), field maple (*Acer campestre*), field elm (*Ulmus minor*), manna ash (*Fraxinus ornus*).

The bedrock within the 23 m profile comprises dark yellow, non-fossiliferous, slightly calcareous fine to very fine sands between the depths of 23-22 m (see Figure 2). This unit is overlain by a yellowish-brown, non-fossiliferous horizon of sand and silt with moderate carbonate content of fluvial origin from 22-20.62 m. From 20.62-17.87 m, the underlying horizon transforms into greyish-yellow silts and clay containing carbonate and iron nodules and numerous mollusc shells. Also fluvial in origin, this horizon must have been deposited during reduced energy conditions. The thickness of the alluvial sequence is about 3 m. The alluvial silts and clays are overlain by light yellowish-brown infusion loess between the depths of 17.87-14.73 m.

A 2 m thick double paleosol complex developed on this infusion loess layer. The B and BC horizons of the paleosol were marked (10 YR 4/6-5/6) by the appearance of a clear carbonate accumulation zone in the lower portion (14.73-12.20 m). The double paleosol complex is overlain by a homogenous, highly fossiliferous 8 m thick loess deposit (10 YR 6/4). Only the lower 3 meters of the aeolian loess layer were sampled due to technical limitations. The upper 2-5 m of the profile consists of a double paleosol complex. The two paleosol layers within this double complex correspond to independent pedogenetic events.

4. The mollusc fauna

The studied profile yielded 3 450 specimens of 51 mollusc (34 terrestrial, 17 freshwater taxa) species. The identified taxa were divided into ecological groups based on their temperature and habitat preferences (see Figure 3). Despite the low number of identified specimens, some general conclusions can be made regarding the composition of the studied fauna. When comparing the results from the profile examined in this study to findings from similar studies at Sebian sites near Fruska Gora hills [19–22], it is apparent that this profile provides one of the most plentiful examples of malacofauna in the Lower Danube area. This profile can be divided into 5 malacological horizons (see Figure 4).

The first malacological horizon developed between the depths of 22-17.75 m. This section includes only sporadic fragments of freshwater taxa representing the paleocommunity of the freshwater terraces of the Danube river. No chronosratigraphical markers were identified. However, the lack of cryophilous taxa indicates warm climatic conditions for the formation of this zone.

The second zone was identified between the depths of 17.75 and 15 m, providing a statistically evaluable mollusc fauna. The dominance of numerous moving-water

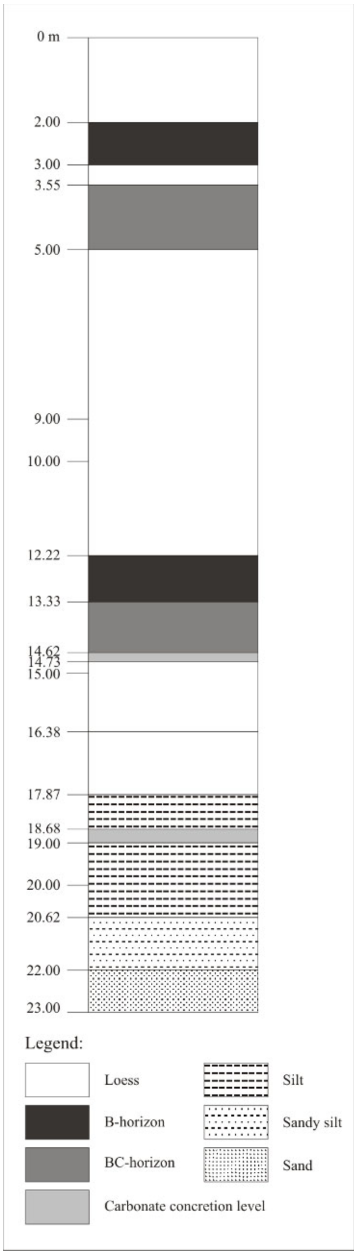

Figure 2. A sketch of the loess profile.

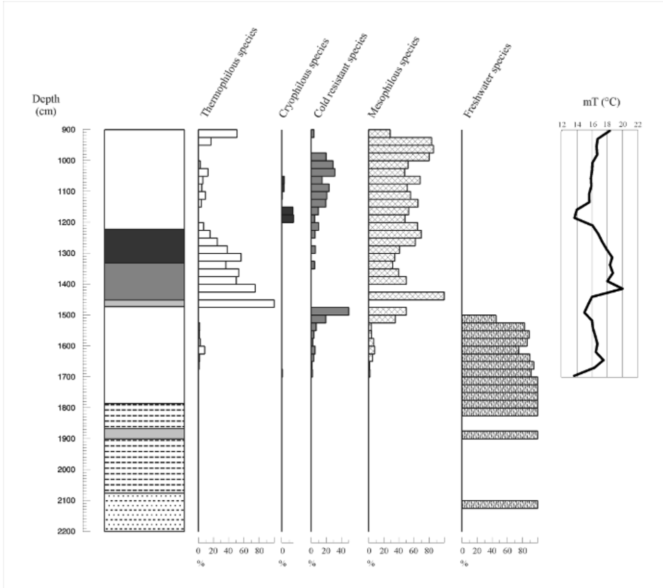

Figure 3. The dominance relationships of the different ecological groups in the mollusc fauna.

forms (*Valvata piscinalis, Sphaerium rivicola, Pisidium amnicum*) univocally indicates a fluvial setting. The percentage of rheophilous *Bithynia tentaculata* is exceptional. However, several ditch and slum species preferring still or gently moving water conditions were also identified (*Valvata cristata, Planorbis planorbis, Anisus vortex, Anisus spirorbis*). The proportion of cryophilous elements (*Bithynia leachii, Anisus leucostoma*) was secondary in this zone. In comparision to the first zone, this zone contained an abundance of thermophilous elements (*Viviparus contectus, Bithynia tentaculata, Anisus spirorbis, Pisidium amnicum*). This zone yielded numerous paleoecologically important species and chronospecies [3–5]. The collective presence of *Ena montana, Helicodiscus* cf. *singleyanus, Viviparus contectus* and *Pisidium amnicum* indicate that this zone must have developed during an interglacial period of the Middle Pleistocene. However, the communal presence of such forms as *Cochlodina laminata* and *Granaria frumentum* with other chronospecies suggests a somewhat younger phase of the Middle Pleistocene, probably the terminal part of the Riss-Würmian interglacial (approx. 100 000 years).

The next zone was identified between the depths of 15-12 m and can be divided into two prominent phases based on mollusc fauna. The first stage, corresponding to a transitional loess horizon, is hallmarked by the complete disappearance of freshwater elements and the advent of cold resistant, mesophilous grassland elements (*Pupilla muscorum, Trichia hispida, Trichia striolata, Nesovitrea hammonis, Euconulus fulvus*). The appearance of these mesophilous grassland elements marks the development of a loess steppe fauna and a short-term cooling in the area characterized by the disappearance of the former woodlands and the development of a parkland grassland setting. This short-term cooling was followed by a prominent warming leading to the cessation of dust formation and intensification of pedogenesis, as recorded by the paleosol horizon between the depths of 14.73 and 12.22 m.

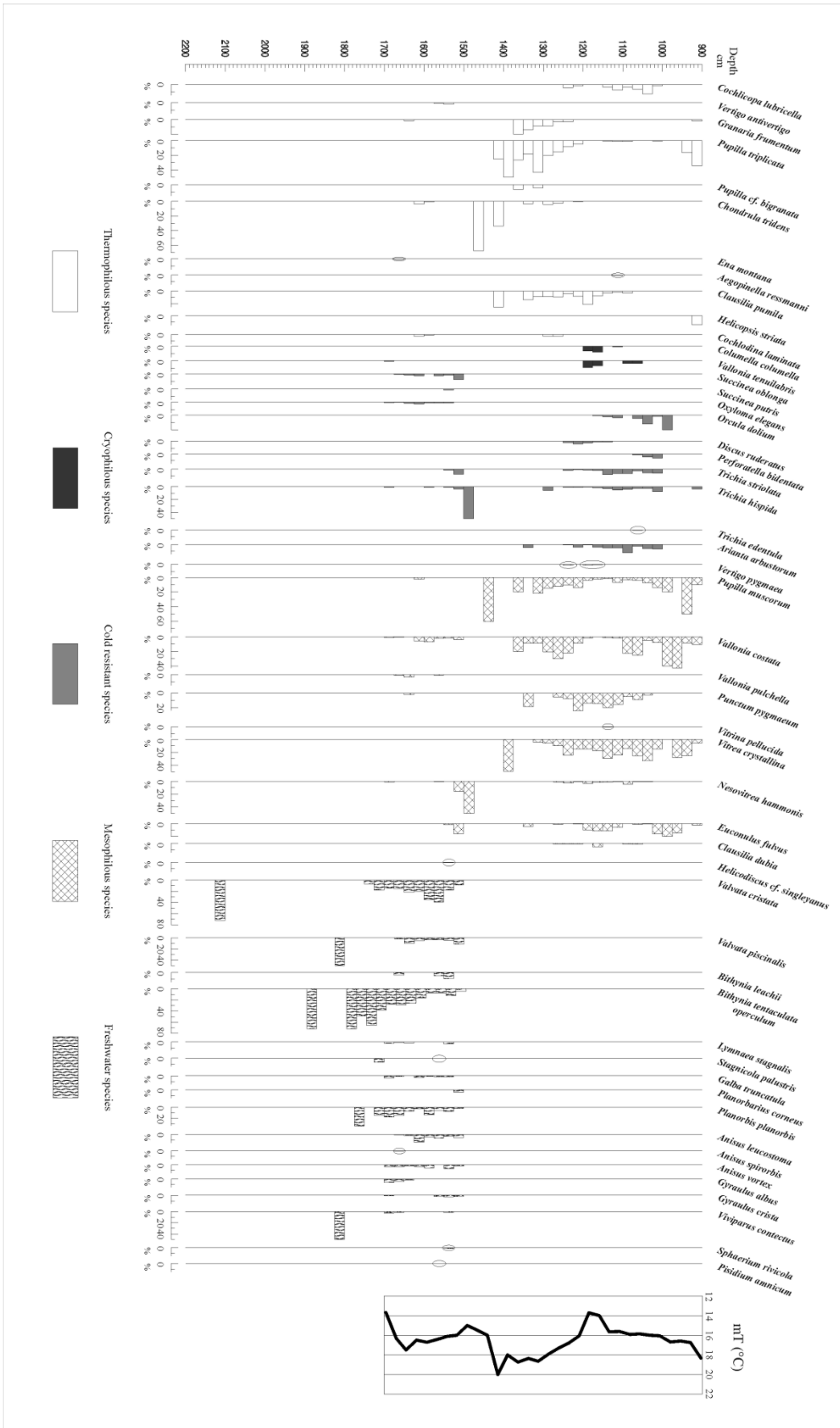

Figure 4. The dominance relationships of the mollusc species from the profile with malacothermometer data.

This interpretation is supported by the presence of mollusc fauna and the occurrence of thermophilous grassland and woodland elements implying the formation of an open-parkland setting. The dominant elements of this fauna are those of *Granaria frumentum*, *Pupilla triplicata*, *Pupilla* cf. *bigranata*, *Clausilia pumila*, *Vallonia costata* and *Vitrea crystallina*. Pedogenesis must have taken place between 70 and 60 ka in the Early Würmian area.

The fourth zone (12-9.5 m) is marked by the disappearance of thermophilous, xerophilous grassland elements (*Granaria frumentum*, *Chondrula tridens*, *Pupilla* cf. *bigranata*) and a considerable decrease in the proportion of other thermophilous elements (*Pupilla triplicata*, *Clausilia pumila*). A significant increase in cold resistant (*Trichia hispida*, *Trichia striolata*, *Discus ruderatus*) and cryophilous elements (*Vallonia tenuilabris*, *Columella columella*) are observed in this part of the profile. Although the proportion of cryophilous elements is less prominent, their presence clearly indicates the onset of a cooling event (i.e. a stadial) within the Early Würmian glacial ca. 60-50 ka ago.

The transition in the faunal composition between the paleosol layer, corresponding to an interstadial phase, and the previous malacological zone and successive loess layers, representing this new zone and the deposits of a stadial, was by no means sharp and sudden. Although the proportions of thermophilous and cryophilous elements markedly changed at the paleosol/loess boundary in the samples as a whole, a more gradual and much smaller change was observed in the percentage of mesophilous elements suggesting a gradual transition between the horizons. There is a steady increase in the proportion of mesophilous and ecotone species dwelling at the boundary of woods and parklands such as *Vallonia costata*, *Vitrea crystallina*, *Punctum pygmaeum* within the transition zone of the paleosol/loess horizons. Furthermore several cold resistant woodland species also appear in this zone in progressively larger numbers (*Vitrina pellucida*, *Orcula dolium*, *Clausilia dubia*).

In the next zone between the depths of 9.5 and 9 m there is an expansion of various thermophilous elements like *Helicopsis striata*, *Pupilla triplicata*, *Granaria frumentum*, coeval with the appearance of mesophilous open parkland dweller elements. This is accompanied by the gradual withdrawal of cold resistant and cryophilous elements from the fauna indicating the inception of another warm period. The prominent arrival of mesophilous elements also refers to a decrease in humidity resulting in drier conditions, and a reduction in species numbers and dominance of xerophilous elements in this zone.

5. Discussion

Based on the composition of mollusc fauna, the Šarengrad profile displays a close relationship with other profiles of similar age from the southern part of the Carpathian Basin. In comparision, the profile of interest in this study yields a collective dominance of such taxa as *Aegopinella ressmanni*, *Cochlodina laminata*, *Clausilia pumila* that are different that those from other regions of the basin. Similarly, the proportion of the cryophilous *Vallonia tenuilabris* and *Columella columella* is secondary in our profile similarly to other profiles from Transdanubia [12] and the loessy island of Susak, Croatia [18]. This implies the emergence of unique environmental conditions in this part of the Carpathian Basin in accordance with findings of malacological studies implemented on other profiles in the region [12, 16, 17]. Our results suggest the development of a long-grass and short-grass grassland with scattered mosaics of parklands and lesser tundra-like patches in the southern part of the Carpathian Basin during the Pleistocene.

The general makeup of this environment was fundamentally different from other parts of the Eurasian loess belt. The local endowments resulted in a different evolutionary path of the mollusc fauna during the course of successive stadials and interstadials of the last glacial. The onset of a stadial was characterized by a positive shift in the humidity as a result of reduced temperatures, which had positive influences on the evolution of the mollusc fauna as seen by an increase in diversity values during the transition from interstadials to stadials.

The relatively narrow range of reconstructed mean July paleotemperature values suggest that the temperatures of the growth season must have been relatively balanced in this part of the Carpathian Basin during the shift from stadials to interstadials and vice versa. A major shift is noticeable only in the values of humidity, which fundamentally affected the evolution of the mollusc fauna in a positive direction increasing diversity. These processes were restricted to the southern part of the Carpathian Basin. The evolution of the mollusc fauna of the Northern and Western European areas were characterized by much lower temperatures [12].

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