Pleistocene malacofauna of the Požarevac Danube Area
(NE Serbia)

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Abstract. The results of recent analyses of loess samples from the localities: Čirikovac, Klenovnik, Novi Kostolac, Zatonje and Kisiljevo, confirm the idea that malacological associations identify biotope characteristics. Using palaeontological analyses, 25 species of gastropods were identified. Statistical analyses, tables and histograms based on ecological indices separate malacological associations: forest and species living mainly in woods, but also in mesophilous places and both damp and dry biotopes, steppe, open biotopes, mesophilous and hygrophilous species. Based on the current literature on the Požarevac Danube Area, the species Vertigo pygmaea in Čirikovac and Columella columella in Klenovnik were recorded for the first time. Based on the following species: Succinella oblonga, Cochlicopa lubrica, Granaria frumentum, Vallonia costata, Vitrea crystallina, Pupilla muscorum, etc. it could be concluded that loessoid eolian sediments have their origin in the arid climate during the Pleistocene.

Key words: Pleistocene, gastropods, palaeoecology, loess, loessoid sediments.

Introduction

The Požarevac Danube Area is located along the right bank of the Danube River, from the mouth of the Velika Morava River to the city of Golubac. In the geomorphologic sense, this area belongs to Morava lowland and the Mlava valley, with an average altitude of 85–110 m (Fig. 1).

The relief of the area is composed of low-level lake terraces, desiccated by fluvial erosion. Fluvial erosion has had a huge effect as is evident by the broad fluvial planes and wide river valleys. Erosion significantly reduced the Pliocene lake coverage, and moved it from the recent Danube valley further to the south, which was sometimes left in the form of fold belts (i.e., the Požarevac fold belt).

Quaternary eolian sedimentary loess and quicksand cover 97 % of the Požarevac Danube Area, being the most extensive in this geographic region. Quicksand is limited to the immediate beach areas and lies along a distance of 5–6 km from the Danube River, while loess is stretches further to the south, up to 34 km from the river. In the Požarevac Danube Area, loess sediments were, at the time of their formation, represented by one continuous cover, which was later, as a result of erosion, lowered, and broken into several separated parts:
a) The nearest region between Velika Morava and Mlava rivers and from Požarevac to Kostolac constitutes the “Požarevac fold belt”; b) Loess sediments between Mlava and Pek rivers follow the banks of the Danube River; from Ram to Pek River, loess outcrop at the lowest terrain between the villages Zatonja and Kisiljeva up to 100 m altitude, and to the highest terrain, where loess covers Tertiary relief from the village Topolovnik to Pek River; c) Loess from Pek to the town of Golubac has the smallest geographic distribution and is situated at the base of loessoid sand, which according to its morphology and higher absolute altitude could not belong to the Požarevac Slope.

The Holocene is represented with the formations of lower river terraces, fluvial and slope sequences. In the Ram Danube Area (south of Ram, Topolovnik, Kumane, Biskuplje and Kličevac), eolian loessoid sands are well distributed and positioned over the Older Pleistocene sediments of the “Kličevac Formation”. The loessoid sediments of the Smederevo–Ram Danube Area are often changed into deluvial formations, composed of gravel which indicates repeated sedimentation through rinsing processes.

Literature on this subject is numerous and includes: UOVIĆ (1889, 1893), CVIJIĆ (1924), STEVANOVIĆ (1949), MARKOVIĆ-MARIJANOVIĆ (1951), MILOJEVIĆ (1960), Mladenović (1973), Malešević et al. (1980), Rakić (1980), Dimitrijević & Knežević (1988), Stevanović et al. (1992), etc.

Material and methods

Quaternary malacofauna was collected from sediments in two ways: as individual specimens (visible to the naked eye) and in bulk samples of 3 kg. The specimens visible to the naked eye were collected individually.

During the mechanical processing and extraction of individual fossils from the loess sediments, hand tools, such as trowels, knives and brushes, were used. The taxonomical determination of the “naturally prepared fossils” was done depending on the degree of preservation, on the genus or species level. The extracted fossil snails with preserved sculpture were studied and prepared again in the laboratory. The restoration of the broken shell fragments was made by glue and polish. Employing table lenses, the extremely fragile and tiny specimens were “quickly” transferred in order to preserve the shell specimens. In order to perform the identification of macrofauna with stronger shells, when it was necessary to determine the elements of oral aperture, regularity and structure, these specimens were washed with 3% H₂O₂.

The fossil material was identified under binocular lenses, using the comparative collection of fossil and recent molluscs from the Collection of Natural History Museum, Belgrade, collected by Petar Pavlović, as well as foreign literature (Brohmer et al. 1962; Grossu 1956, 1993; Frank 2004; Ložek 1964; Kerney et al. 1983, 1999; Šilejko 1984; Krolop & Šumeji 1993, 2000; Sōos 1943, 1959; and Pfeifer 2000).

During the preparation of the histogram, ecological valences for species were used according to Ložek (1964). In the text, the percent representation is shown in parentheses after the name of the species. The statistic processing of the results is shown Table 1 and in the histogram in Fig. 7. The material was inventoried and labeled under the Inventory number K 6306-6402 and kept in the collection of the Natural History Museum, Belgrade.

Results and discussion

Čirikovac

According to the Basic Geological Map (Malešević et al. 1980), on the “Kostolac (Požarevac) fold belt”, between Požarevac and Čirikovac, deluvial-proluvial sediments (dpr) lie discordantly over the Pontian sediments – “Kličevac Formation”. The major components of the “dpr” are gravels, sand and silty-sands up to 10 m thick, while in the base is loessoid sandy-clayey-silts, 5 m thick (Fig. 2), in which a diverse land fauna of the Upper Pleistocene was identified: Pupilla sterri (Voith), Chondrula tridens (Müller) and Granaria frumentum (Drapparnd); species of open habitats: Pupilla muscorum (Linné), Vertigo pygmaea (Drapelau) and Vallonia pulchella (Müller); the mesophilous species Trochulus hispidus (Linné) and hygrophilous species: Sucinella oblonga (Drapelau) and Catinella cf. arenaria (Bouchard-Chantereaux) (Pl. 1, Fig. 7). The top level of this profile is composed of fossil soil, 0.5 m in thickness. From the loessoid sands, the only fossil-bearing layer, the warmth-loving Trochulus striolatus (Pfeifer) (Pl. 1, Fig. 9) was recorded as the only representative of forest-mesophilous species (24%). It inhabited

Fig. 1. Geographical position of the sites (blacks stars) with fossil macrofauna.
moist forest habitats and high grasses, along the ecotone boundary belt between forest and grasslands. A colder climate is indicated by steppe fauna (41.4%): *Pupilla sterri* (0.64%), *Chondrula tridens* (33%) and *Granaria frumentum* (7%), while species inhabiting open biotopes: *Pupilla muscorum* (6%), *Vertigo pygmaea* (2%), *Vallonia pulchella* (5%) and mesophilous *Trochulus hispidus* (16%) were weakly represented.

One of the most common representatives of the genus *Vertigo*, *V. pygmaea* (Pl. 1, Fig. 5) was recorded only at the locality of Čirikovac. It occurs in association with species inhabiting open habitats, as well as those living in forests. In the Late Pleistocene, *V. pygmaea* became more common in the sediments originating in cooler and moister periods (KROLOPP & SÜMEGI 1993). From the genus *Vertigo*, *V. pygmaea* is one of a few typical of loess formations (KROLOPP & SÜMEGI 2000).

### Klenovnik

A profile of the Pleistocene sediments was discovered close to Klenovnik on the road to Kostolac, after the right turn towards the school. These sediments lie over Pontian gray coarse-grained quartz sands, 2.5 m thick. The profile (Fig. 3) shows brown silty sands (1.0 m thick), overlaid by reddish sandy clays (1.5 m thick).
and light brown silty sands a (2.5 m thick). The exposed profile is covered with silty sands with a low humus content, 0.5 m thick.

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Fig. 3. Detailed view of the upper part of the section from Klenovnik.

In the silty sands, a diverse gastropod fauna composed of species confined to certain habitats was discovered. The forest species were few in numbers: Discus ruderatus (FÉRUSSAC) (6.25 %), Cochlodina laminata (MONTAGU) (0.7%) and Aegopinella nitens (MICHAUD) (6.94%). The mesophilous species of forest biotopes: Vitrea crystallina (MÜLLER) (2.78%) and Trochulus striolatus (13.20%) belong to species living in conditions of mesic forests. The forest-steppe zone was replaced by steppe, with the characteristic species Chondrula tridens (29.86%) and Granaria frumentum (9.72%). The species of open spaces, inhabiting biotopes ranging from wetland meadows to steppe: Pupilla muscorum (4.16%), Columella columella (MARTENS) (0.7%) (Pl. 1, Fig. 3), Vallonia costata (MÜLLER) (1.38%), Vallonia pulchella (MÜLLER) (3.47%), were replaced by mesophilous species: Euconulus fulvus (MÜLLER) (2.08%), Punctum pygmaeum (DRAPAŃAUD) (3.47%) (Pl. 1, Fig. 10), Trochulus hispidus (7.64%), Cochlicopa lubrica (MÜLLER) (3.47%), and species of screen forests and rocks: Clausilia dubia (DRAPAŃAUD) (2.78%), Orcula dolium (DRAPAŃAUD) (1.38%).

In the region of the Požarevac Danube Area, the species Columella columella was recorded only at this locality. It is a species typical of loess formations, indicating the existence of specific cold tundra areas in Upper Würm, but was also present in the more hygrophilous parts of the steppe (SUMEGI & RUDNER 2001). It commonly appears in association with other characteristic loess species, such as Sucinella oblonga, Vallonia tenuilabris, etc.

In these sediments, land fauna of a steppe association was best represented (39.58%), a certain indication that they were formed by wind-blown particles being laid upon the already formed accumulative plain. Such a cover of aeolian dust is connected with the last glaciation or Würm in a broader sense.

Novi Kostolac

In the vicinity of the coal pit Novi Kostolac, at the surficial pit Drmno, Pontian sediments (Fig. 4) are represented with fine to coarse gravels bound with clay 2 m thick, yellowish, slightly silty sands 1 m thick. Overlying these sediments are sandy loessoid silty sands 5 m thick with a rich association of Pleistocene molluscs: Forest species include Discus ruderatus (3.69%) and Aegopinella nitens (3.69%). Mesophilous species of a forest biotope are: Vitrea crystallina (1.84%), Trochulus striolatus (8.3%) and Arianta arbustorum (LINNÉ) (2.3%) (Pl. 1, Fig. 12). The following interval of cold winters and a fairly dry vegetation period during the summers caused the appearance of the most common steppe species Chondrula tridens (25%), Granaria frumentum (6.45%) and Pupilla sterri (0.92%) of interstadial stage. The mesophilous species: Pupilla muscorum (8.75%) and Vallonia costata (11.5%) were especially important in areas characterized by open

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Fig. 4. Detailed view of the upper part of the section from Novi Kostolac.
steppe biotopes. The species *Vallonia costata* is highly tolerant, a so-called species of “transition zones” between open and woodland habitats (KROLOPP 1995). The mesophilous species: *Punctum pygmaeum* (4.6%), *Trochulus hispidus* (7.83%), *Cochlicopa lubrica* (3.2%) replaced the species of screen forest biotopes: *Clausilia dubia* (5%), *Orcula dolium* (3.69%).

The humidity from tree leaves or from moist soil was suitable for life of hygrophilous species, such as *Sucinella oblonga* (2.76%). According to the malacological results from the analyzed locality, the appearance together of warmth-loving, cold-loving and mesophilous fauna is obvious evidence that the loess series was deposited during several phases of stadial and interstadial.

**Zatonje**

At the road Ram–Biskuplje, on the right bank of the Danube, at the exit from the village of Zatonje, a profile of sandy sediments, about 12 m thick occurs, which consist of eight determined layers (Fig. 5). The thickest, fifth layer included the fauna of steppe biotopes: *Chondrula tridens* (31.3%), *Granaria frumentum* (28.13%). The species *Sucinella oblonga* (11.45%) in most of the European loesses is typical snail assemblages of loess steppe. Three ecological groups were present, mesophilous species: *Eaconulus fulvus* (3.13%) (Pl. 1, Fig. 8), *Punctum pygmaeum* (8.33%), *Trochulus hispidus* (1.04%); species of open biotopes: *Pupilla muscorum* (8.33%), *Vertigo alpestris* ALDER (2.08%) (Pl. 1, Fig. 2), *Vallonia costata* (2.08%) and species inhabiting forest detritus and rocks: *Clausilia dubia* (3.13%) and *Orcula dolium* (6.25%).

In the gray, fine-grained quartz sands with small lenses of sandy silts (Fig. 5), the fauna of a forest biocenosis was also recorded: *Cochlodina laminata* (5.21%), *Aegopinella nitens* (1.04%), as well as that of mesic forest biotopes: species *Vitrea crystallina* (15.63%) (Pl. 1, Fig. 11) and *Fruticicola fruticum* (MÜLLER) (1.04%). The species *Vertigo alpestris* was recorded for the first time at the open profile of the locality Zatonje. It is characteristic only for the Upper Pleistocene (Würm), including loess (but it is not typical) (KROLOPP & SÜMEGI 2000). This petrophilous species may be locally an indicator of forest and shrub habitats, during cold and moist climatic periods. According to the collected fauna, the hypothesis of MARKOVIĆ-MARIANOVIC (1951) on a multi-phase nature of land loess is supported. Additional proof are the limestone rock plates 1 cm thick, which appear serially in the water wells of the village Zatonje at a depth of 21 m. The other layers are not fossil-bearing.

**Kisiljevo**

Between the villages Kisiljevo and Biskuplje, discordantly over Miocene sediments, lay the Lower Pleistocene deluvial folds of the “Kličevac Formation”, composed of gravel, sands, silts and tufa (RAKIĆ 1980). In the broader area of the village Kisiljevo toward Topolovnik, the sands are joined in inundation layers by various silts, which are, especially at the surface, of alluvial character and transformed into a loessoid or fluvial horizon 5 m thick (Fig. 6). It contains Holocene malacofauna of a forest biotope: *Discus ruderatus* (0.21%), *Cochlodina laminata* (0.21%), *Aegopinella nitens* (11.36%) (Pl. 1, Fig. 4); and mesophilous fauna *Trochulus striolatus* (26.06%), *Arianta arbustorum* (0.44%), *Fruticicola fruticum* (4.68%). This fauna was included in the formation of a biocenosis belonging to the forest-steppe type, which later became less diverse and turned into some kind of steppe. The species: *Chondrula tridens* (2.23%), *Granaria frumentum* (15.82%) (Pl. 1, Fig. 1) and *Cecilioides acicula* (0.44%) showed that the steppe conditions were maintained for some time. The species *Pupilla muscorum* (1.56%) and *Vallonia costata* (5.35%) confirm the existence of a common feature of steppe adaptations and life in open terrains. The mesophilous species are *Punctum pygmaeum* (0.89%), *Trochulus hispidus* (15.82%) and *Cochlicopa lubrica* (9.58%), while *Orcula dolium* (3.79%) (Pl. 1, Fig. 6) and *Sucinella*
oblonga (1.56%) represented transitional forms of these and neighbouring associations.

### Conclusions

By analyzing the abundances of malacofauna from loess sediments of the Požarevac Danube Area, several biotopes were recognized (Fig. 7): forest, open areas within forest biotopes, steppe, open biotopes, forest-mesophilous areas and moist biotopes.

Forest and forest-mesophilous species are abundant with 32%; the most common species is *Trochulus striolatus* (Čirikovac, Klenovnik, Novi Kostolac and Kisljevo). The “warmth-loving forms” also belong to this group, and they appear mostly in the relatively warmer phases of the late Würm.

Steppe fauna is abundant with 28.78%, with species *Chondrula tridens* and *Granaria frumentum* present at all localities. The steppe species lived in intrazonal biotopes (forest valleys, flooded forests along rivers, etc.), while some of them are representatives of mesophilous groups. The steppe climate was characterized by cold and arid winters and humid summers; the succession of “cold-loving forms” and “warm-loving forms” indicate that the loess was deposited in three Würm stadials, while the basal part was deposited during the Ris–Würm interglacial. The majority of these dry, grass, steppes represented the biogeography area of the Pannonian–Dakian steppe, suggesting diluvium origin (MATVEJEV 1961).

The open biotope consists of places of moist meadows and steppe. It is hypothesised that the S and SE winds in the southern parts, enabled the development of open biotopes for many species represented with 11.76%.

The mesophilous species were continually distributed along all of the studied profiles, they are represented with 24.92 %, and could live in fallen leaves and in relatively moist meadows.

According to some hypotheses (RAKIĆ 1977), the ecological conditions with more humid environment formed during the deposition of the oldest horizon, matching the penultimate phase of glaciations. Although the terrestrial fauna of gastropods had the widest distribution, it does not necessarily mean that the sediment was formed on land, because terrestrial forms could also indicate open grassland areas in the vicinity of water or moist ground. The presence of hygrophilous species (2.54%) may indicate that this loess was also occasionally flooded, but still not long enough to develop water fauna.

During the Riss–Würm interglacial, an analogous type of Balkan–Middle European ecological conditions was occasionally widely distributed in Europe. In the regional sense, the sediments of the “Kličevec Formation” of the Požarevac Danube Area can partially be correlated with similar sediments of the “Srem Formation” at the slopes of Fruška Gora Mountain and the “Zagajčka Formation” in Southern Banat (RAKIĆ et al. 1998).

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References


климу одликну ју хладно-суви зиме и жарка лета, смена заједница хладнољубиве и топлољубиве фау-не. Састав гастроподске фауна указује да је лесна серија формирана за време Рис-вирмског интер-глацијала и у три вирмска глаццијала. Већи део ових исушених, травнатих степа, сматра се да представ-ља биогеографско подручје подпрвици панон-ско-дакијских степа, што указује да су степе "дилу-вијалне старости" (Матвејев, 1961).

Отворене биотопе чине влажне ливаде и степе. Претпоставља се да је утицај J и ЈI ветрова у јужним деловима степа, омогућио развој отворених станишта за 11.76% присутних врста.

Мезофилне врсте континуирано се појављују у свим истраживаним профилима са укупно 24.92%, могу живети и у опалом лишћу и на умерено влаж-ним ливадама.

Постоје предпоставке (Ракић 1977) да су се еко-лошке карактеристике које указују на влажнију средину, одиграле за време депоновања најстаријег хоризонта, што би одговарало претпоследњој фази глаццијације. Иако је заступљена углавном сувозем-на фауна мекуца тј. гастропода, то не мора да значи да је седимент стваран на сувом. Копнене форме указују на отворене травнате пределе, који су били у близини воде, односно влажног тла. При-сустом хигрофилних врста (2.54%) може се прет-поставити да су се више пута формирале баре, али ипак недовољно дуго да би се развила водена фа-уна.

За време рис-вирмске интерглацијације, аналоги-ти балканско-средње-европских еколошких услово-ва био је повремено широко заступљен у Европи. У регионалном погледу седименти "Клиначке сери-јом" Пожаревачког подуна ваља, делимично се могу корелисати са сличним наслагама "Сремске серии" на падинама Фрушке Горе, и "Загајичком серијом" у Јужном Банату (Ракић 1998).

**Fig. 1.** Granaria frumentum (Draparnaud). Kisiljevo; × 8.

**Fig. 2.** Vertigo alpestris Alder. Zatonje; × 13.

**Figs. 3a, b.** Columnella columnella (Mantens). Klenovnik; × 13.

**Fig. 4.** Aegopinella nitens (Michaud). Kisiljevo; × 4.

**Figs. 5a, b.** Vertigo pygmaea (Draparnaud). Čirikovac; × 26.

**Fig. 6.** Orcula dolium (Draparnaud). Kisiljevo; × 8.

**Fig. 7.** Catinella cf. arenaria (Bouchard-Chantereaux). Čirikovac; × 8.

**Figs. 8a, b.** Euconulus fulvus (Müller). Zatonje; × 13.

**Figs. 9a, b.** Trochulus striolatus (Pfeiffer). Čirikovac; × 4.

**Figs. 10a, b.** Punctum pygmaeum (Draparnaud). Klenovnik; × 27.

**Fig. 11.** Vitrea crystallina (Müller). Zatonje; × 13.

**Figs. 12a, b.** c. Arianta arbustorum (Linne). Novi Kostolac; × 3.