

The flood basins, favored by the roughness of the landslide body, are usually higher than the lateral accretion deposits and frequently remained as meander islands. This situation has geomorphological logic because in these areas sedimentation occurred only during floods, and in adjacent areas with active bed erosion, constant degradation and deepening occurred.

It is clear from the above that there is a need for a continuation of dating and geophysical and archaeological surveys for the precise geomorphological evolution of the studied area. The present results, however, bring quite a lot of clarity and guide future study directions.

The finding that fairly rapid incision has occurred in recent centuries can be related to both the changes induced by the expansion of habitation in the medieval period and the climatic changes of this period. The identification of agents with which medieval and modern sedimentary deposits can be dated more precisely is an obvious need.

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Late Pleistocene mollusk fauna in terrace deposits of the Zeleniv section (Northern Bukovyna, Ukraine)

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1. Introduction

Cyclical climate changes in past at the regional and local scales are well recorded in the terrace deposits. Therefore, their study allows us to detail knowledge about the nature development in the region, to trace the cyclical changes in natural conditions during the deposits' formation, to find out their genesis, etc.

Unlike the Dniester valley, the age and dismemberment of the river terraces in the pre-Carpathian part of the Upper Prut remains studied insufficiently. There are still not many sections with strong and fully

dissected subaerial strata. It is mainly due to the poorly preserved terraces, which are strongly deformed by landslide processes, especially on the right bank of the Prut River. There is also practically no mention of sections of terraces with remains of large mammals' fauna and mollusks.

However, mollusk shells are the most common paleofaunal remains in the Quaternary sediments. They are present in almost all genetic types of sediments, are paleoecological indicators of the natural environment, and therefore allow us to restore the development of natural conditions, processes, and individual properties of paleolandscapes. The similarity of the landscape and ecological conditions of Pleistocene mollusk fauna to modern ones allows us to establish the natural conditions at different stages of the Pleistocene and trace the evolution of paleolandscapes. Since terrestrial mollusks (especially stenobiontic species) have limited opportunities for dispersion and are vulnerable to changes in natural conditions, they are one of the most representative groups of organisms for bioindication purposes and well reflect changes in natural conditions.

2. Investigated area

A section of the terrace of the Prut River was found near the confluence of the Brusnytsia River. The Prut River valley here is quite well-developed and terraced. A typical feature is its asymmetry - the right bank here is steep, and the left bank is gentle. Such a structure of the river valley can be traced almost throughout Pre-Carpathian. The primary topography of the right bank has been disturbed by landslides, so not all terrace levels can be traced here.

The studied 23-meter exposure is in a ravine, on the northeastern outskirts of the Zeleniv Village (Chernivetska Oblast), about 200 m upstream from the mouth of the ravine (right side). The relative altitude of the studied terrace surface above the incision of the Prut River is about 40 m; the roof of the channel alluvium is 21 m, and the terrace basement is 17 m. This site is unique for the region due to the well-preserved section of the terrace deposits and the paleontological remains found in them. A preliminary overview of the fauna on the site and its vicinities was presented at the symposium [Ridush et al., 2016]. More details about the geomorphological position of the object and current research results are covered in work [Ridush et al., 2021].

3. Methods

The sampling of subfossil shells was provided according to the methods described in the works by V. Bondarchuk [1933, 1937], I. Danilovskyi [1941], I. Melnychuk [1972], V. Lozhek [1964], M. Kunitsia [1974, 2007], with the improvement by the authors: monolithic sampling considering microstratigraphy, facial variability of sediments and taphonomical conditions).

The taxa identification was carried out mainly by conchiological and conchiometric parameters of mollusk shells. Statistical processing was carried out according to the method of identification and calculation of shells' fragments according to V. Lozhek [1964], S.V. Aleksandrowich and V.P. Alexandrowich [2011].

4. Results

In general, the sediments in the section are represented by channel, floodplain, and subaerial strata. Faunal remains of large mammals, sometimes with traces of processing, are associated with the layer of the floodplain alluvium, represented by sands, sandy loams, and sometimes gleyic. The developed Upper Paleolithic flints and mollusk shells were also found. According to the biostratigraphical dating of the remains of mammoths, the layer corresponds to the end of the Vytachiv Stage (MIS 3) - the beginning of the Bug Stage (MIS2). The main part of the Bug Stage in the section is represented by rhythmic interlaying of sand, sandy, loam, and dusty layers and interlayers, often with signs of glaying, ferrugination, solifluction micro deformations [Ridush et al., 2016], cryodesiccation cracks. Sediments in the section lie at a slight angle.

Accordingly, younger sediments are wedged closer to the headwaters of the ravine. Therefore, sediment research and sampling were carried out in several geological clearings. A total of 32 main and additional samples were taken at the Zeleniv section.

The mollusk fauna of the beginning of the Bug Climatolithic is mainly represented by species of mesophytic meadows. The species composition is dominated by *Succinea oblonga* (Drap.). Few *Vallonia tenuilabris* (Al. Br.), *Pupilla sterri* (Voith), *Vertigo parcedentata* (Sandb.), as well as isolated finds of *Vallonia pulchella* (Müll.), *Helicodiscus singleyanus* Pilsbry, fragments of *Vallonia* sp., *Pupilla* sp., *Clausiliidae* and *Helicoidea*. In the ecological composition, the part of mesophiles is the highest (for the account of the eurythermic *Succinea oblonga* (Drap.). The part of species that prefer open biotopes is high. These are representatives of the genera Valloniidae, Pupillidae and the species *Vertigo parcedentata* (Sandb.). The presence of cryophilic species in the fauna (*Vallonia tenuilabris* (Al. Br.) and *Vertigo parcedentata* (Sandb.)) testifies to intervals of significant cooling of the climate, which were characteristic of certain phases of the beginning of the Bug Stage.

In the sediments of the Bug Stage, a layer of the older pedosediment (Zl_{2a}) re-deposited by a mud-debris-flow, is present in the section, which is similar in characteristics to the Kaidaky paleosol (MIS5e). The species composition of mollusks from this layer is quite rich. Taxa representing open biotopes (*Pupilla muscorum* (L.)) and mesophytic meadows (*Succinea oblonga* (Drap.)) are dominant. High proportions of *Pupilla bigranata* (Rossmässler), *Vallonia tenuilabris* (Al. Br.), *Columella edentula* (Drap.). Such taxa as *Acicula polita* (Hartmann), *Pupilla bigranata* (Rossmässler), *Clausilia dubia* (Draparnaud), *Cl. pumila* C. Pfeiffer, and *Carpathica calophana* (Westerlund) in the sediments of the Zeleniv section are found only in this pedosediment. Most of them (except for *Pupilla bigranata*) are shade-loving species. So, at that time, in the studied part of the Upper Prut valley, forest landscapes were also common in addition to open meadows.

Shells of mollusks from the extremely cold chronointerval of the Bug Climatolithic (LGM, Zl₇) were found in only one of the six selected samples. They are represented by the taxa: *Succinea oblonga* (Drap.), *Vallonia excentrica* Sterki, *Trichia hispida* (L.) and *Pupilla* sp., but their number is too low for paleoecological reconstructions. At the same time, in the inner canyon part of the neighboring Middle Dniester valley, even in the LGM sediments, we find at least the eurybiont taxon *Succinea oblonga* (Drap.), characteristic of this region. According to the molluscan fauna and the sediments in the Zeleniv section, which here are represented by thin-layered, fissured loess, formed mainly under nival conditions, we established that during the coldest phases of the Bug Stage, in the Upper Prut valley, the landscapes were similar to periglacial semi-desert or desert. At the same time in the Middle Dniester valley, an extreme impoverishment of the mollusk species composition can be traced, but the region remains to be a refugium.

A detailed analysis of the of mollusks ecological assemblage at the site, based on samples selected considering the microstratigraphy and facial variability of sediments, allows us to trace the following succession of phases in landscape-climatic changes (Fig. 1):

Zl₁ – mesophytic meadows were characteristic; local proluvial processes were activated in the area;

Zl₂ – increased part of open biotope species; hygrophilous and shade-loving species appeared;

Zl₃ – open biotopes also prevailed; loess accumulation began;

Zl₄ – humidification increased (due to hygrophilic species); the part of cryophiles increased; phase of active loess accumulation;

Zl₅ – the part of cryophiles decreased, but a small amount of xerophiles appeared and the part of hygrophiles increased;

Zl₆ – humidification gradually increased; the proportion of hygrophiles was highest at the end of the phase;

Zl₇ – the climate became extremely cold, close to periglacial semi-desert or desert.

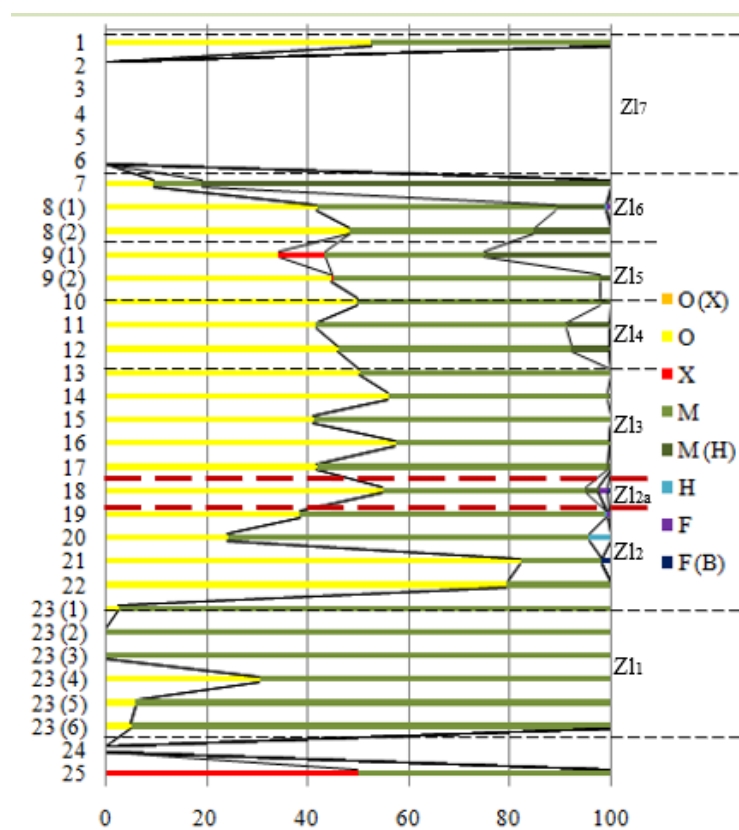


Figure 1. Variability of the Late Pleistocene environments according to the mollusk fauna in the terrace deposits of the Zeleniv section

Legend: 1-25 – sample numbers; Zl₁-Zl₇ – phases of the environment changes. Ecological groups [Alexandrowicz S., Alexandrowicz W. 2011]: O – species of open biotopes, M – mesophilic species, X – xerophilic species, H – hygrophilous species, F – shade-loving species, F (B) – species of shaded and partially shaded biotopes.

5. Conclusions

The approach we applied to the paleomalacological studies of the Late Pleistocene terrace deposits of the Prut allowed us to establish the following features:

- 1) the paleomicrorelief diversity of the studied area was reflected in significant differences in the stratigraphic and lithological-facial structure of the deposits;
- 2) in most cases, these changes in sediments correspond to a change in the species and, in part, ecological composition of the mollusk fauna. This made it possible to trace the short-term phasing of the development of paleogeographic conditions based on the change in the percentage of the mollusk's ecological groups;
- 3) there were significant differences in the natural conditions of the Upper Prut and Middle Dniester valleys during the Bug Climatic accumulation. Based on the study of the features of the sediments of this time in the Zeleniv section and the conclusions drawn from the mollusk fauna, we propose to consider the landscapes of the Bug Stage in the Upper Prut valley similar to periglacial semi-desert or desert.

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What can floodplain deposits of one of the last colonized catchments in central Europe tell us about Late Holocene climate and land-use changes?

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The Bečva River catchment (eastern Czech Republic) was colonized more than one millennium later than other Central and Western European catchments and thus present uniquely long record of natural factors affecting morpho-sedimentary evolution. The anthropogenic activity superseded natural factors as late as during 12th century AD. Since the Outer Western Carpathians where the studied river originates are highly susceptible to erosion, its sub-mountainous floodplain is well developed and its alluvial record well preserved. We used coring, geophysical sounding and lithological analysis of floodplain deposits supported by AMS dating to establish stages of Late Holocene floodplain evolution. We describe six stages from Late Atlantic up to the 20th century – during three stages accumulation prevails, incision prevails during two stages, and one stage is described as mixed. We successfully linked each morpho-sedimentary stage with major driving factor that changed in the catchment.