Environmental changes in the Bukovyna Upland during the last interglacial – early glacial (founded on the study of clastic deposits of the Tovtry cave)

Yulia AVDIEIENKO[1*], Natalia GERASIMENKO[1], Bogdan RIDUSH[2]
[1] *Taras Shevchenko National University of Kyiv, Kyiv, Ukraine*
[2] *Yuri Fed'kovich National University of Chernivtsi, Chernivtsi, Ukraine*
* Corresponding author: Yulia Avdieienko. E-mail: korsunj@gmail.com

KEYWORDS: pollen, lithology, palaeovegetation, Western Ukraine

Introduction

Results of pollen and lithological studies of clastic deposits from the Tovtry cave show vegetational and climatic changes during the last interglacial and early glacial in the south-eastern part of the Bukovyna piedmont of the Ukrainian Carpathians. The Tovtry cave is located in the Bukovyna Upland, in the cliff of the tributary of the Dniester River valley (220 m a. s. l.). The modern vegetational zone here is *Carpinus-Quercus* forests, but local vegetation is a mesophytic steppe with some pine patches. The cave is a vertical well worked out in the Neogene gypsum strata (Ridush, 2013).
The regional type locality of the last interglacial and early glacial is the Kolodiiv peatbog (Gurtovaya, 1983; Bezusko et al., 2011), situated much closer to the mountains than the Tovtry site. The pollen study of the last interglacial palaeosols and early glacial deposits in the Middle Dniester valley has been intensely carried out (Bolikhovskaya, 1995; Bolikhovskaya, Pashkevich, 1982; Komar, 2012; Gerasimenko *et al*., 2016). Sub-terrain deposits of these units were studied at Tovtry first, and they included the grain-size analysis (Avdieienko, 2015, 2019).

Results

Field study of the Tovtry cave lithology and their sampling (depths 1.10 – 4.10 m) has been fulfilled by B. Ridush, grain-size studies by Avdieienko (2015, 2019). Those pollen zones (PZ) have been identified in the Tovtry cave deposits that allows the reconstruction of the vegetation development and climate change in this area (Table 1). The Quaternary Stratigraphic framework of Ukraine (Veklitch et al., 1991) is used for the cave deposits stratigraphy, with the following indices: kd – Kaydaky unit formed during the warm stage, ts – Tyasmyn unit formed under cold environments, pl – Pryluky unit formed during the alternation of cool and warm spells. The sub-division of the corresponding time units into phases follows (Rousseau et al., 2001; Gerasimenko, 2006).
Last interglacial vegetational development in the Bukovyna Upland. Pine woodlands (including *Pinus cembra*) with admixtures of spruce and birch marked the pre-temperate phase of the last interglacial. Elm and oak dominated the woodlands during the telocratic optimum but the appearance of *Juglans* both on plateau (the cave deposits) and in the Dniester valley (Bolikhovskaya, 1995) is a particular feature of this vegetation. Later on, hazel and alder became abundant as typical for vegetational succession of the last interglacial. Nevertheless, cooler and more arid phase with the reduction of arboreal vegetation, and particularly broad-

leaved species, has been revealed between the two optima of the last interglacial. The mesocratic optimum was characterized by an extension of hornbeam woodlands. On the contrary to the Dniester valley, *Juglans* did not grow on the plateau at this time. Fir appeared at the end of this phase as typical for the last interglacial succession. The post-temperate stage of the interglacial was marked by the shrinkage of woodlands and disappearance of broad-leaved species (pine and birch dominated).

Table 1. The phases of vegetational development and climate change founded on the Tovtry cave data

Depth, m	Pollen zone (PZ)	Periodization	Vegetation and climate
1,1-1,2	12	pl_3	Mixed forest (*Pinus sylvestris*, *P. cembra*, *Ulmus sp., Carpinus betulus, Fagus sylvatica, Betula* sp.). The second interstadial of the early glacial, temperate climate
1,3	11	pl_2	Sparse pine forest (*Pinus sylvestris, P. cembra*), with admixtures of *Betula* sp. and *Juniper* sp. The second stadial of the Early Glacial, boreal climate
1,4-1,7	10	pl_1	Mixed forest (*Pinus sylvestris*, *P. cembra*, *Carpinus betulus, Ulmus sp., Tilia cordata, Qvercus robur).* The first interstadial of the early glacial, temperate climate
1,8-2,00	9	ts	Boreal light forest (*Pinus sylvestris*, *P. cembra, Betula pendula, B. pubescens, Alnus glutinosa*) with arcto-alpine elements of vegetation, arcto-boreal climate. The first stadial of the early glacial
2,1-2,2	8	kd_{3c}	Forest-steppe: forest from *Pinus sylvestris, P. cembra,* arboreal *Betula*, and mesophytic steppe, boreal climate
2,3-2,5	7	kd_{3b2}	Mixed pine-spruce forest, an increase in *Betula pendula* and *B. pubescens,* cool-temperate climate.
2,6	6	kd_{3b1}	Broad-leaved forest with domination of *Carpinus betulus*, the late (mesocratic) optimum of the last interglacial. The appearance of fir at the end.
2,7-2,8	5	kd_2	Forest-steppe: pine forest (*Pinus sylvestris, P. cembra)* with *Picea* sp. and Juniperus *sp.*, and mesophytic steppe, boreal climate
2,9	4	kd_{1b2}	Broad-leaved forest (*Quercus robur, Corylus avellana*), hygrophytic vegetation (*Alnus glutinosa*, Cyperaceae), temperate climate
3,0-3,3	3	kd_{1b1}	Mixed forest with a significant role of broad-leaved trees (*Ulmus sp., Quercus robur*, a few *Juglans* sp.*),* the early (telocratic) optimum of the last interglacial
3,4-3,5	2	kd_{1a}	Pine forest (*Pinus sylvestris, P. cembra*), admixtures of *Picea* sp.*;* boreal climate
3,6-4,1	1		

Early glacial vegetational changes development in the Bukovyna Upland. The appearance of cryophytes (*Lycopodium lagopus, Botrychium boreale* and a few *Betula nana*,), and the further reduction of woodlands, which included only boreal trees, indicates the subperiglacial climate, which existed during the Tyasmyn times (the first stadial of the early glacial). The existence of mixed forest with broad-leaved trees in its composition during the Early and Late Pryluky times proves that they represent warm interstadials, which climate was slightly cooler than nowadays. The two interstadials (pl_1 and pl_3) which are correlated

with the early glacial interstadials (MIS 5c and MIS 5a), were separated by a cooler and more arid phase, representing the second stadial of the early glacial.
Judging from the fact that well-stratified sites of sub-aerial deposits of the last interglacial and early glacial occurred in Bukovyna very rarely, the palaeovegetation and palaeoclimate information obtained from the corresponding sub-terrain deposits is very important for the reconstruction of the palaeoenvironments of the Middle Palaeolithic cultures which sites are frequent in the studied area.

Conclusions

The large changes in warmth and humidity caused the alternation of forest and forest-steppe vegetation types on the slopes of the Bukovyna Upland during the last interglacial and, particularly, during the early glacial. Nevertheless, the environments in this area never were as severe as in the rest of the plain area of Ukraine. Arcto-boreal species were typical only for the first early glacial stadial (rarely during the second one). During the stadials, patches of boreal woodland existed, and xeric steppe plants were not abundant (only *Ephedra distachya* was significant during some phases). On the contrary, moisture-loving Ericaceae, sedges and diverse ferns grew abundantly. A few broad-leaved species occurred during the post-temperate phase of the interglacial and during the second early glacial stadial, and the extension of broad-leaved trees during the interstadials was larger than in the rest of the plain area of Ukraine. All of this indicates a more humid climate of the studied area and more possibilities for the warmth-loving plants persistence on the southern slopes of the Bukovyna Upland.

References

Avdieienko Yu. 2015. Roslynnist' ta klimat ostann'oho mizhzledeninnya u karstovykh rayonakh Krymu ta Seredn'oho Prydnistrov'ya. *Physical Geography and Geomorphology*, 4(80): 102-109 (In Ukrainian).

Avdieienko Yu. 2019. Rekonstruktsiya zmin paleoheohrafichnykh umov pryluts'koho i tyasmyns'koho etapiv u Seredn'oho Prydnistrov'yi z metoyu vidnovlennya pryrodnoho seredovyshcha paleolitychnoyi lyudyny. *Physical Geography and Geomorphology*, 3 (95) (3): 62-68 (In Ukrainian).

Bezus'ko, L., Mosyakin, S., Bezus'ko, A. 2011. Zakonomirnosti ta tendentsiyi rozvytku pokryvu Ukrayiny u pizn'omu pleystotseni ta holotseni. Kyiv. Alterpres: 450 (In Ukrainian).

Bolikhovskaya N., Pashkevych G. 1982. Dinamica rastitel'nosti v okrestnostyakh stoyanki Molodovo I v pozdnem Pleistocene. Molodova I. Unikalnoe mustyerskoe poselenie na Srednem Dniestre, Moscow: 120-145 (In Russian).

Bolikhovskaya N., 1995. Evolutsia lessovo-pochvennoy formatsii Severnoy Evrazii (Evolution of loess-soil formation of Northern Eurasia). Moscow University Press, Moscow: 112-119 (In Russian).

Gerasimenko N., 2006. Upper Pleistocene loess-palaeosol and vegetational succession in the Middle Dnieper Area, Ukraine. *Quaternary International*, 147: 55-67.

Gerasimenko N., Ridush B., Korzun Yu. 2016. The Late Pleistocene vegetation history and ecosystem variability in the karst areas of Ukraine based on palaeontological study of cave deposits. *Georeviews.* PAGES: *Central and Eastern Europe Paleoscience Symposium*: from Local to Global. Cluj-Napoka, Stefan cel Mare University Press: 25-27.

Gurtovaya E. 1983. Flora i rastitel'nost na vostoke Sredney Evropy v mikulinskoye mezhlednikove. Izv. Academy of Sciences of the USSR. *Geographiya* 4: 78-86 (in Russian).

Komar M. 2012. Pollen analysis of the Upper Pleistocene loesses and palaeosols in the Yezupil and Halyc sites. *Loess i paleolit Nadniestrza Halyckiego (Ukraina). Studia geologica Polonica*, 119: 245-251, 357-358.

Rousseau D.-D., Gerasimenko N., Matviishina Zh., Kukla G., 2001. Late Pleistocene environments in Central Ukraine. *Quaternary Research* 56: 349-356.

Ridush B. 2013. Paleheohrafichni rekonstruktsiyi pryrodnykh umov pizn'oho kaynozoyu pivdnya Skhidnoyi Yevropy za rezul'tatamy doslidzhen' vidkladiv pecher. Doctor of Geography Sciences' thesis. *The Institute of Geography of National Academy of Science of Ukraine.* Kyiv. (In Ukrainian).

Veklitch, M. (Ed.), 1991. Stratigraphic framework of Quaternary in Ukraine. *Ukrainian Geological Committee*, Kyiv (In Russian).