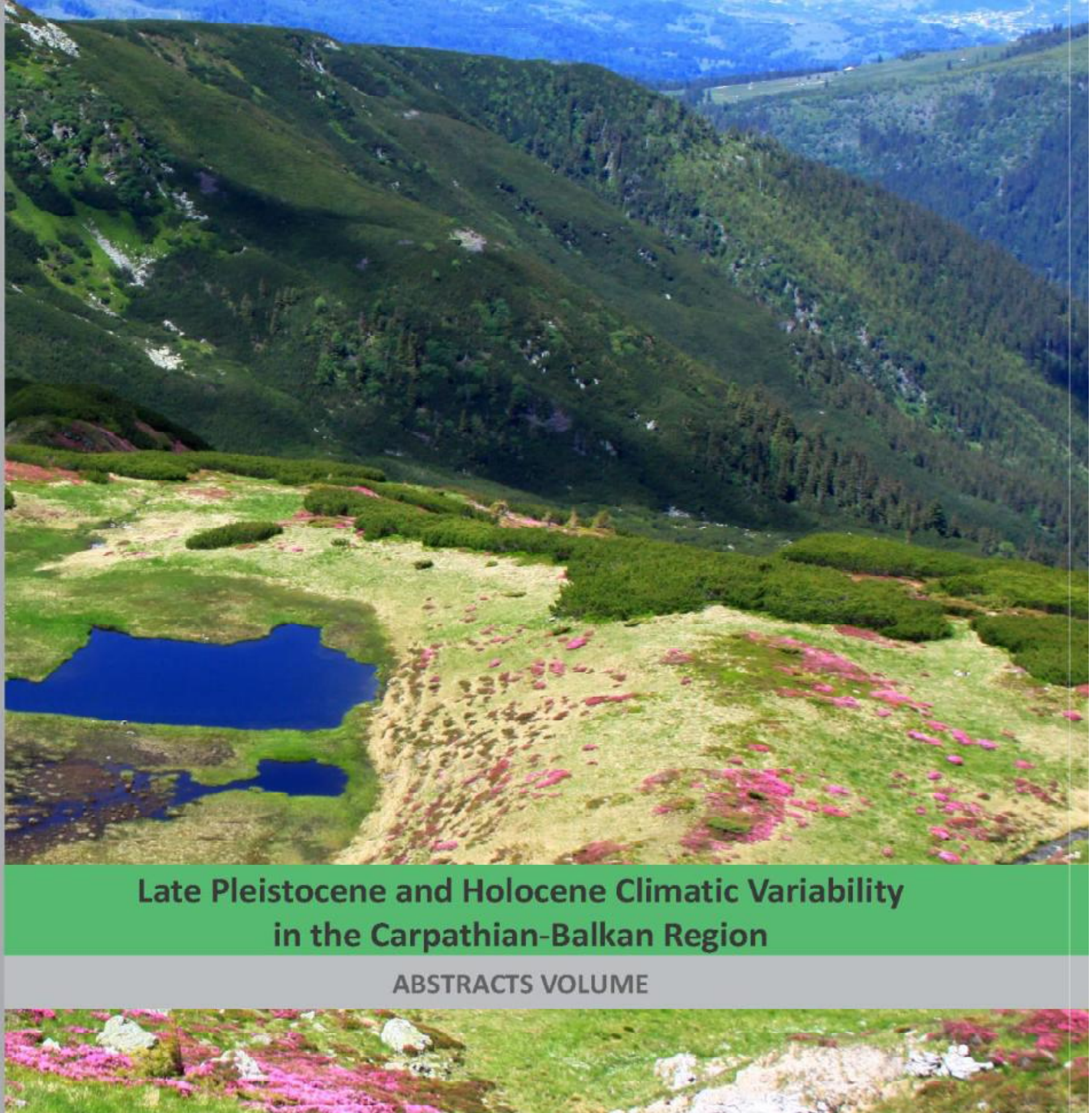
Nov. 2014

PN-II-RU-TE-2012-3-0386

Editor
Marcel MINDRESCU

Associate editor
Ionela GRADINARU



Late Pleistocene and Holocene Climatic Variability in the Carpathian-Balkan Region

ABSTRACTS VOLUME

Ştefan cel Mare University Press

Late Pleistocene and Holocene climatic variability in the Carpathian-Balkan region. Abstracts volume

Ştefan cel Mare University Press

Pollen and lithological data from the Bukovynka Cave deposits as recorders of the Late Pleistocene and Holocene climatic change in the eastern foothills of the Carpathian Mountains (Ukraine)

Gerasimenko N. [1], Ridush B.[2] and Korzun Ju.[3]

[1] Taras Shevchenko National University of Kyiv, Ukraine, n.garnet2@gmail.com

[2] Yuriy Fed'kovych National University of Chernivtsi, Ukraine, bridush@chnu.edu.ua

[3] Taras Shevchenko National University of Kyiv, Ukraine, korzunj@gmail.com

The study of clastic sediments of the Bukovynka Cave shows biotic and climatic changes during the Middle Pleniglacial (the Trapeznyi Chamber), Late Glacial and Holocene (the Sukhyi Chamber) in the south-eastern part of the Ukrainian Carpathians. The artesian Bukovynka Cave is located near the village of Stal'nivtsi (the Chernivtsi region), in the Prut River basin. It is developed in the Miocene gypsum strata. The Quaternary clastic infilling of the cave, as well as mammal taphonomy has been previously studied in the Trapeznyi Chamber (Vremir et al., 2000; Ridush, 2004; Ridush et al., 2012), whereas palaeomagnetic research and its palaeoenvironmental implication has been provided for the Sukhyi Chamber (Bondar and Ridush, 2014). The results of pollen and grain-size studies of clastic deposits in both chambers, supported by mammal finds, are presented in this paper. In the Chernivtsi region, the pollen study has been previously performed (without ^{14}C-dating) on the Upper Pleistocene loess-paleosol section of Snyatyn and on the Onut site of the Holocene flood-plain deposits of the River Prut (Artyushenko et al., 1982).

39 samples from the cave sediments have been processed for grain-size analyses using the 'pipette' technique by Kachinsky (1965). In order to get pollen from clastic sediments, the following technique has been applied: heating with 10% HCl and 10% KOH, cold treatment with HF, disintegration in a solution of $Na_4P_2O_7$ and separation in heavy liquid (CdI_2 and KI) with a specific gravity 2.2. The abundance and good preservation of pollen show that the cave chambers turned periodically into sedimentation traps. Mammal bones are also mostly well preserved. Re-deposited pollen are abundant in the Trapeznyi Chamber but occur very rarely in the Suchyi Chamber. The present-day vegetation near the cave is a meadow-steppe surrounded by *Carpinus-Quercus* forest. The high proportion of *Pinus sylvestris* pollen in the surface soil samples (30-40%) does not correspond to the limited role that pine has in the modern vegetation. On the basis of this fact, pine pollen in the cave deposits are also regarded as over-represented because of its ability to travel farther on the wind than other pollen and its better preservation in rocks.

The Middle Pleniglacial. The section of the Trapeznyi Chamber (1 m thick) represents the following succession of sediments (from the bottom to top): fluvial, colluvial, zoogenic and aeolian ("cave loess"). The ^{14}C-date 41,300±1,100/1,300 BP (VERA-2529) obtained on the bone of *Crocuta spelaea* from the zoogenic bed indicates the Middle Pleniglacial age of these deposits. Light-grey fluvial sediments at the bottom of the section are characterized by a high content of sand (36-45%) and pollen spectra which are dominated by arboreal pollen (AP). In the AP, mainly boreal trees (*Pinus sylvestris, P. cembra, Picea abies, Abies alba, Larix* and *Juniperus*) are represented. Pollen of broad-leaved taxa also occur in noticeable numbers (*Carpinus betulus, Quercus robur, Fagus sylvatica, Corylus avellana, Ulmus* and *Fraxinus*), and their pollen percentges increase (up to 10%) from the bottom to the upper part of the fluvial bed. Thus, these deposits were formed during ***an interstadial*** with wet and relatively warm climate. The beginning of the interstadial was cooler: arcto-boreal spore plants (*Diphazium alpinum, Botrychium boreale* and *Cryptogramma*) grew in small numbers, whereas later on, *Lycopodium annotinum*, Polypodiaceae and Bryales absolutely dominated among spores. At the end of the interstadial, the admixture of broad-leaved trees in the conifer forest also became larger that clearly shows the progressive warming but, nevertheless, the climate was much cooler than nowadays.

The described sandy deposits are overlain by a thin loamy bed with high content of large silt particles (61%). The AP percentages become lower (67%) at the expense of an increase in spores. The AP include only few taxa of boreal trees (*Pinus sylvestris, P. cembra* and *Picea abies).* This indicates a significant cooling as compared to the preceding climatic phase. A sparse conifer forest existed with arcto-boreal spore plants in its ground cover. This time span was ***a stadial*** with cold but relatively wet climate.

During the next climatic phase, established on the basis of pollen data, two lithological units were formed: grey-brown colluvial sandy loams (up to 33% of sand particles) and zoogenic horizon (8 cm thick). The latter is a clastic sediment with a great number of not-disturbed bones and abundant coprolites of *Crocuta spelaea* (so-called "hyena den"). Pollen have been extracted directly from coprolites, as well as from the sediments. During the described time span, forests spread more extensively than during the preceding stadial, but open areas also existed as it is indicated by a great diversity of herbal pollen. Forests consisted mainly of boreal trees (*Pinus sylvestris, P.cembra, Picea abies*, less frequently – *Larix* and *Juniperus*), but an admixture of broad-leaved taxa existed: *Carpinus betulus, Quercus robur, Fraxinus, Corylus avellana* and, especially, *Ulmus* (6% of its pollen). The ground cover of forests included club-mosses (*Lycopodium annotinum, Diphazium complanatum* and *Huperzia*), ferns and green mosses. A few arcto-boreal species of Lycopodiaceae still grew (*Lycopodium dubium* and *Diphazium alpinum*). Open areas were covered by mesophytic steppe, though some xerophytes (*Ephedra distachya*) occurred. It was a relatively warm forest-steppe climate of an interstadial which, according to the dating, represents ***the last part of Moershofd***. The latter is dated between 55 and 40 kyr BP and it includes several interstadias and stadials (Hammen, van Der, 1995). The described interstadial was drier than the preceding one. The pollen data are in good correspondence with palaeofaunal assemblage from the zoogenic horizon which includes both animals of open landscapes and forest species (*Coelodonta antiquitatis, Crocuta spelaea, Ursus spelaeus, Equus caballus latipes, Bison priscus*, *Megaceros giganteus, Sus scrofa* and *Vulpes vulpes*).

The last unit of the section ("cave loess") is enriched in large silt particles, and it has the lowest AP percentage in the section. The AP composition is poor: *Pinus sylvestris, P. cembra, Picea abies* and single pollen grains of *Abies alba* and *Corylus avellana* (only in the lower part of the unit). The non-arboreal pollen (NAP) include sedges and mesophytic herbs. High percentages of spores and, particularly, those of arcto-boreal plants are typical for this unit: *Diphazium alpinum* (up to 17%), *Lycopodium dubium* (up to 13%), *L. lagopus* (up to 9%). Thus, there existed vegetation which resembled periglacial forest-tundra. This cold time span might be related to ***Hasselo stadial*** (40-38 kyr BP).

The Late Glacial. In the Sukhyi Chamber section (2.35 m thick), the ^{14}C-date 10,730±60 BP (Poz-46240) marks the beginning of the Younger Dryas (Ridush et al., 2012). Below the level with this date, at the bottom of the section, there are sediments of fluvial origin (81-91% of fine sand). Diverse AP prevail in them. Despite boreal trees (*Pinus sylvestris, P. cembra, Picea abies, Abies alba, Alnus, Betula)* being strongly dominant, a few pollen grains of broad-leaved taxa (*Ulmus, Acer, Corylus*) also occur. Pollen of wet-loving coniferous trees (*Picea, Abies, P. cembra*) indicate that the climate was rather humid. This is confirmed by the pollen diversity of mesophytic herbs. The predominance of Cichoriaceae in the NAP was evidently controlled by the strong disturbance of soils around the cave during this time. The simultaneous presence of pollen of cold-loving *Pinus cembra* and broad-leaved species shows that the vegetation was of an interstadial type. These deposits most likely were formed during the ***Alleröd***, but as well they could belong to some earlier interstadial. The climate was cooler and wetter than nowadays. Pollen of *Pinus cembra* and *Corylus avellana* also occur in the Alleröd deposits in the Central Ukrainian Carpathians (Chumak, 2012). The early appearance of broad-leaved taxa might indicate existence of their refugia in the Southern Carpathians.

The overlying layer, dated to the ***Young Dryas*** on the *Ursus arctos* bone, is represented by light loams with a high content of large silt ('loess') particles (76-79%). Their formation obviously occurred through the strong input of aeolian dust. Pollen of wet-loving *Abies alba, Picea abies* and warmth-loving broad-leaved trees disappear or occur rarely, whereas the pollen frequencies of cold-resistant *Pinus cembra,* shrubs (*Juniperus*, Malaceae, Rhamnaceae) and NAP increase. Arcto-boreal forms of Lycopodiaceae indicate that the climate was cold and dry. Nevertheless, birch-pine forest continued to exist, as it is also confirmed by presence of *Ursus arctos* bones.

The Holocene. In the Sukhyi Chamber, the Holocene sedimentation started with formation of a layer of fluvial origin (90% of sand particles) above the Young Dryas deposits. The appearance of pollen of diverse broad-leaved taxa (*Carpinus betulus, Quercus robur, Ulmus*, *Fraxinus*) indicates the ***Mid Holocene*** age of these sediments. Obviously, the Early Holocene deposits were removed by erosion. Judging from the further increase in pollen diversity of warmth-loving taxa (*Fagus sylvatica, Tilia cordata, T. platyphyllos* and *Cornus* appear), the overlying reddish-brown loam belongs to the Mid Holocene optimum. High humidity is indicated by re-appearance of pollen of *Abies* and *Alnus,* and an increase in Ericaceae and Polypodiaceae. The climate was wetter and warmer than nowadays. The next phase is represented by dark-brown loam with dominance of large silt particles (77-79%), fragmented bones and coprolites. The pollen diversity of broad-leaved trees decreases (*Ulmus* prevails), as do the frequencies of wet-loving Ericaceae and Polypodiaceae. Asteraceae and Cichoriaceae pollen prevailed over mesophytic herbs. This indicates an increase in aridity, which is also confirmed by presence of undisturbed bones of the steppe rodent *Marmota bobak*. Areas of open-steppe landscapes existed around the site. Dry phases occurred in Ukraine during the end of Late Atlantic and in the Middle Subboreal (Gerasimenko, 1997).

The succeeding phases are represented by a thin sand bed and the overlying dark, coarse silt loam. The distinctive palaeomagnetic event, recorded in the loam, is correlated with the 2800 BP excursion of the Ukrainian Holocene magnetostratigraphic framework (Bondar, Ridush, 2014), i.e. with the end of the Late Subboreal. The climate of the ***Late Subboreal*** was humid (Artyushenko et al., 1982; Gerasimenko, 1997). In the Sukhyi Chamber, the increase in precipitation is marked by the appearance of *Picea, Abies*, Ericaceae, Polypodiaceae, and the increase of pollen of mesophytic herbs and broad-leaved taxa (*Carpinus, Quercus, Tilia* and *Corylus*). In the Central Ukrainian Carpathians, the *Abies* pollen culmination also occurred in the Late Subboreal (Chumak, 2012). The appearance of Cerealia pollen indicates the beginning of intense agricultural activity which evidently happened during the Late Bronze Age.

Above the 2800 yr BP marker, the layer of sandy loams occurs (19-20% sand particles and 62-69% coarse silt) which is characterized by a further increase in pollen diversity of wet-loving plants (*Abies, Picea*, *Pinus cembra*, *Alnus, Fagus, Carpinus* and Cyperaceae). This is an indication of a rise in precipitation and decline in temperature during the beginning of the ***Early Subatlantic***. In Eastern Europe, this time span (2600-2300 BP) was cool and wet (Khotinsky et al., 1991). The overlying dark-brown loam is marked by the maximum pollen frequencies of broad-leaved trees and bushes, as well as an increase in coarse silt particles (73-81%). The climate during formation of this layer was warm and relatively arid. In Ukraine, two very warm phases occurred between 2000 and 1000 yr BP: the end of Early Subatlantic and the ***Middle Subatlantic*** (Gerasimenko, 2007).

The next unit is the light-coloured loam which also contains a large proportion of coarse silt (76-85%), but its pollen composition is quite different from that of underlying dark loam. Pollen of wet-loving plants disappears (with the exception of hydrophytes), and the NAP (particularly Chenopodiaceae, Asteraceae and Cichoriaceae) reaches its maximum. The dry and cool phase recorded in this unit corresponds, in our opinion, to the "***Little Ice Age"*** (700-200 yr BP). Above is a thin bed with 75% of sand grains which separates from the underlying unit a dark-brown loam with abundant coarse silt (68-77%). Based on pollen, frequencies and diversity of broad-leaved trees (including wet-loving ones) increased at this time, which possibly corresponds to the beginning of the ***modern warming***. The last unit is a thinly laminated loam with a large content of sand particles (20%). The increase in NAP and wind-blown pine pollen seen in the upper units obviously indicates an intense forest clearance in the area studied.

The obtained results show a good correspondence between palaeoenvironmental signals from lithological, pollen and palaeofaunal information recorded in unconsolidated sediments of the Bukovynka Cave and, thus, this demonstrates a great potential of these deposits as recorders of climatic changes. Pollen occurence of broad-leaved taxa during the Middle Pleniglacial and Late Glacial interstadials indicates the presence of their refugia in the South-Eastern Carpathians. The absence (or very low participation) of xerophytes in the vegetational cover during the Middle Pleniglacial is a special characteristic of this area in the mountain foothills.

References

Artyushenko, A.T., Arap, R.Ya., Bezys'ko, L.G., 1982. Istoria rastitel'nosti zapadnyh oblastey Ukrainy v chetvertichnom periode [Quaternary vegetational history of the western areas of Ukraine]. Kyiv: Naukova dumka, 135 p. (in Russian).

Bondar, K., Ridush, B., 2014. Rockmagnetic and palaeomagnetic studies of unconsolidated sediments of Bukovynka Cave (Chernivtsi region, Ukraine), Quaternary International, http://dx.doi.org/10.1016/j.quaint.2014.04.025

Chumak, N., 2012. On vegetation dynamics in the foothills of the Eastern Carpathians during the Late Glacial and the Holocene. Naukovy visnyk Chernivetskogo universytetu, 616, P. 53-56.

Gerasimenko, N., 1997. Environmental and climatic changes between 3 and 5 BP in Southeastern Ukraine In: Third Millennium BC climate change and Old World collapse. Berlin Heidelberg: Springer, P. 371-401.

Gerasimenko, N., 2007. Landshaftno-klimatychni zminy na teritorii Ukraini protyagom ostannikh 2,500 tys. Rokiv [Environmental and climatic changes in Ukraine during the last 2 500 years. In: Istorychna geografia: pochatok XXI stolittya]. Vinnytsa: Teza, P. 41-53 (in Ukrainian).

Kachinsky, N.A., 1965. Fizika pochvy [Soil physics]. Moskva: Vyshaya shkola, 332 p. (in Russian).

Hammen, Van Der., Th,. 1995. The Dinkel valley revisited: Pleniglacial stratigraphy of the eastern Netherlands and global climatic change. Mededeingen Rijsk Geologishe Dienst. – 52. – P.343-355.

Hotinsky N.A., Alyoshinskaya, Z.V., Guman M.A., 1991. Opornye razrezy golotsenovyh otlozheniy tsentra Russkoy ravniny [The reference site of the Holocene deposits of the centre of the Russian Plain]. Izvestiya AN SSSR, ser. geogr. 3, P. 30-41. (In Russian).

Ridush, B., 2004. Chetvertynni vidklady pechery Bukovynka ta yih paleogeografichne znachennya [Quaternary deposits of the Bukovynka Cave and their palaeogeographical significance]. Naukovy visnyk Chernivetskogo Universutetu, 199: Geografia, Chernivtsi, P. 105-115 (in Ukrainian with English abstract).

Ridush, B., Stefaniak, K., Marciszak, A., 2012. Complete skull of the brown bear Ursus arctos Linnaeus, 1758 from Bukovynka Cave (Ukraine) and distribution of the species in the latest Pleistocene and Pleistocene/Holocene boundary in southeast Europe. In: The 18th International Cave Bear Symposium, Program e Abstracts e Field trip guide. “Emil Racovita” Institute of Speleology, Bucharest, Romania, P. 61.

Vremir, M., Ridush, B., Codrea, V., 2000. The Late Pleistocene vertebrate taphocoenosis of Bukovinka Cave (Western Ukraine). In: Proceedings of the Joint Meeting of Friends of Karst, Theoretical and Applied Karstology and IGCP. Cluj-Napoca, Romania, P. 158-161.