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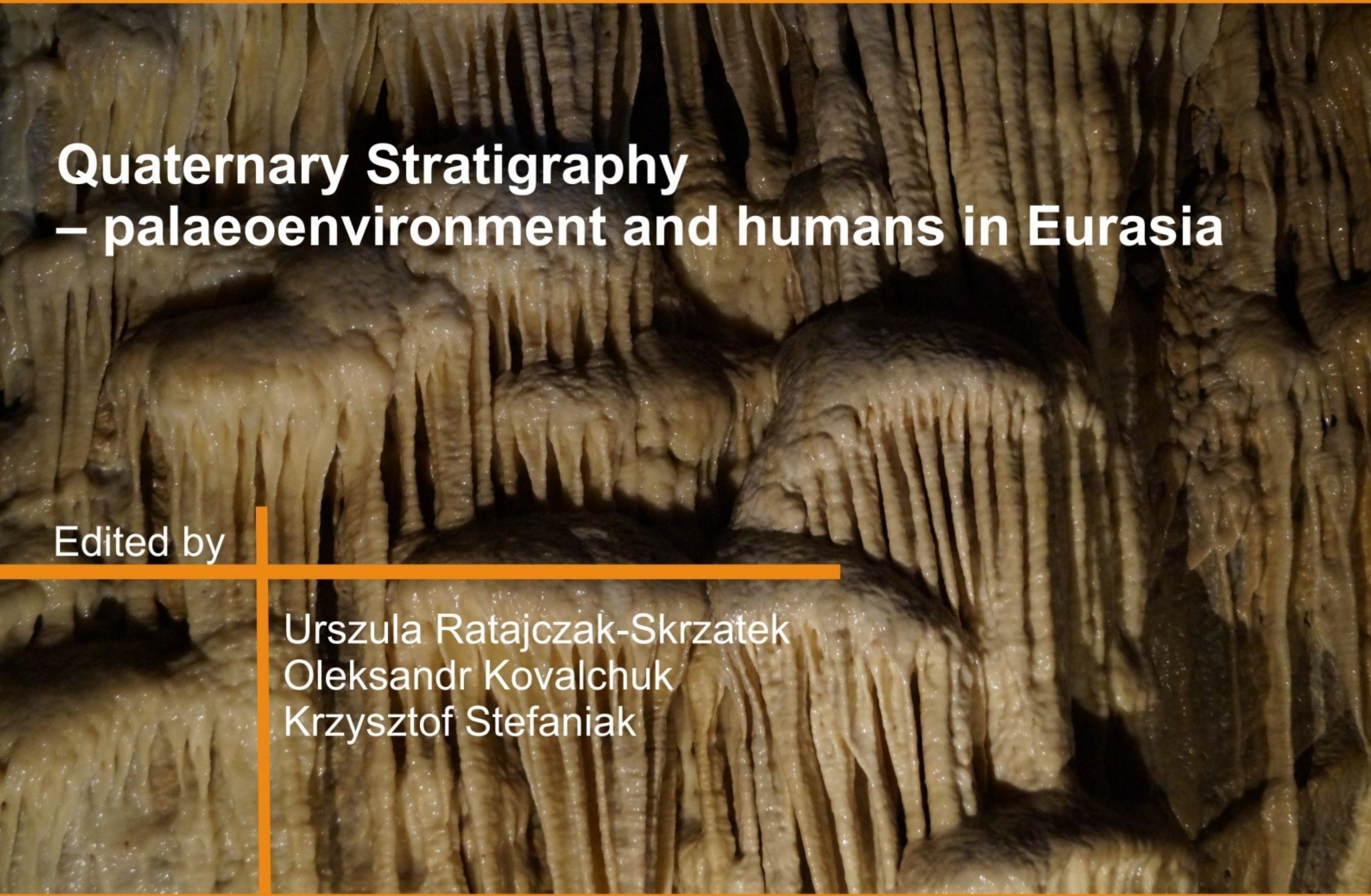
## Conference Proceeding

INQUA-SEQS
Poland, 2021



# Quaternary Stratigraphy – palaeoenvironment and humans in Eurasia

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Uniwersytet Wrocławski

RESEARCH UNIVERSITY
EXCELLENCE INITIATIVE
Ministry of Science and Higher Education

# INQUA SEQS 2021

## Conference Proceedings

**Wrocław, Poland, 13th December 2021**

Quaternary Stratigraphy

– palaeoenvironment and humans in Eurasia

Uniwersytet Wrocławski

**Cover design:** Urszula Ratajczak-Skrzatek

**Cover image:**. The stalactite cascade in the Niedźwiedzia Cave in Kletno (Poland).

Photo by Urszula Ratajczak-Skrzatek

**ISBN:** 978-83-942304-2-5 (Polish Geological Society)

*Materials are published with the maximal preservation of the authors text.*

**Supporting Organizations**

INQUA – SEQS Section on European Quaternary Stratigraphy

INQUA – SACCOM Commission on Stratigraphy and Chronology

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Polish Academy of Sciences (PAS)

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Polish Geological Society

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**Please cite this book as:**

Ratajczak-Skrzatek U., Kovalchuk O., Stefaniak K. (eds.), 2021. Proceedings of INQUA SEQS 2021 Conference, Wrocław, Poland. University of Wrocław & Polish Geological Society, 119 p.

# PREFACE

In 2021, we organized the SEQS-INQUA conference "Quaternary Stratigraphy - palaeoenvironment and humans in Eurasia" for the second time. We hoped it would take place in a traditional form. The conference program was to include plenary sessions in the Śnieżnik Massif (the Sudetes), field sessions in the Sudetes caves, in the Karkonosze Mts, and in the Kraków-Częstochowa Jura. Unfortunately, restrictions implemented due to the Covid-19 pandemic once again thwarted our plans and we had to cancel the conference. At first we thought about giving up on holding the conference in any other form. However, after consultations with the authorities of INQUA and Section on European Quaternary Stratigraphy (SEQS), as well as considering the many requests from a large number of potential participants, we decided to organize a virtual meeting this year, in December. The interest to take part in the proposed form of the conference has again exceeded our expectations. At present, at least 90 participants have applied proposing 34 oral presentations and 26 posters.

Here we present a book of abstracts and the conference program. We hope that our virtual conference will only be an introduction to a direct meeting to which we are looking forward to be held next year in Russia.

On behalf of the Organising Committee
Krzysztof Stefaniak

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# INQUA SEQS 2021

## Conference Proceedings

### Wrocław, Poland, 13th December 2021

# ABSTRACTS

# CLIMATE CHANGE 7–2 KA BP AND ITS IMPACT ON SETTLEMENT PHASES AT THE BRŠADIN SITE IN EASTERN SLAVONIA, CROATIA

**Katarina Botić[1], Leszek Marks[2], Fabian Welc[3], Jerzy Nitychoruk[4], Anna Rogóż-Matyszczak[4], Marcin Szymanek[5], Monika Czajkowska[5]**
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***Keywords:*** *Holocene, freshwater malacofauna, soil chemistry, archaeological record, southern Carpathian Basin*

The Bršadin – Pašnjak pod selom site is located in the easternmost part of northern Croatia (southern Carpathian Basin), south of the village Bršadin and on the former bank of the Vuka River which flows into the Danube about 10 km east (Fig. 1). During the course of water regulation at the end of the 19$^{th}$ / beginning of the 20$^{th}$ century, the site underwent major interventions with new regulation of the river, severing the southern part of the archaeological site and possible levelling of what could have been a multi-layered settlement. Today the site consists of several oval elevations, probably as a result of this large-scale landscape change. The eastern elevation was sampled in spring 2016 when the first geological profile (Br 1) of 2.8 m was obtained by drilling directly through the cultural layers of the north-eastern part of the site (Fig. 1). The second profile (Br 2) of 2.3 m was collected in the depression between two elevations and composed of natural layers (Botić 2017).

Archaeological excavations were carried out in 2016, 2018 and 2019 in two test trenches (S1 and S2), where stratified remains of the Late Neolithic settlement were explored and non-stratified material from various younger periods was found. Eleven radiocarbon dates for the Late Neolithic period were obtained on unarticulated animal bones ranging from 5931±44 BP to 5764±48 BP (between 4940–4710 cal BC and 4720–4490 cal BC) (Botić 2020). The formation of a Late Neolithic settlement on the edge of the river bank just after the 5000 BC, and not earlier, may indicate arid conditions in the region of eastern Slavonia, comparable to global conditions at ~7.1 ka BP. The site was continuously occupied in later periods, two of which are Late Eneolithic / Early Bronze Age (c. 2600–2300 BC), corresponding to the period before 4.2 ka BP, and the Late Iron Age / Early Roman Period (c. 1st century BC – 1st century AD), during the climate stability of the Roman Optimum. These last two periods were also radiocarbon dated in Br 1 and Br 2 records (Fig. 1).

Br 1 profile consists of several layers of human occupation, indicated also by high values of magnetic susceptibility (0.0 – 1.8 m), while Br 2 is composed of natural layers. Silty clay predominates in the Br 1 profile, while Br 2 consists of silt, silty sand and fine sand with mollusc and ostracod remains. The faunal assemblage from Bršadin indicates a shallow overgrown water body in the vicinity of the site. According to ecological tolerance of ostracods, mean July and mean January temperatures of 15 – 23ºC and -8 – 3ºC can be expected, respectively. Some deterioration of the conditions for fauna development might have occurred in the uppermost part of Br 2. A significant decrease in the shell abundance may correspond to the period before 4.2 ka BP.

Geochemical analysis was used to describe paleoredox environmental conditions. Generally low TOC in Br 1 corresponds with P contents (sharp peak at 0.7 m and some fluctuations at 0.8 – 2.7 m depth). At 0.5 – 0.8 m depth there is a good correlation of Ca and S, suggesting presence of $CaSO_4$, and the lower part, the curves of Ca and inorganic C are similar, suggests presence of $CaCO_3$. Al, Ti, K, Fe, V, Li, Ni and REE, characteristic for terrigenous delivery, show two phases, with higher contents at 0.5-1.8 m and lower at 1.8-2.7 m depth. In Br 2, contents of Al, K, Fe, Ti, V, Zn, Li, Y, and

REE increase gradually from the bottom, reaching the highest concentration at 0.5 m depth and then drop rapidly. Most geochemical proxies indicate anoxic conditions that are connected with terrigenous delivery. U/Th ratios indicate mostly suboxic to anoxic conditions (Jones and Manning, 1994) but dysaerobic ones in Br 2 at 1.8–2.1 m depth. Th/U ratios in both profiles indicate dysaerobic conditions. Combined environmental and archaeological data suggest a possible correlation between climate change and settlement strategies of past populations. At present, at least three phases can be distinguished (7.1 ka, ~4.2 ka and 2 ka).

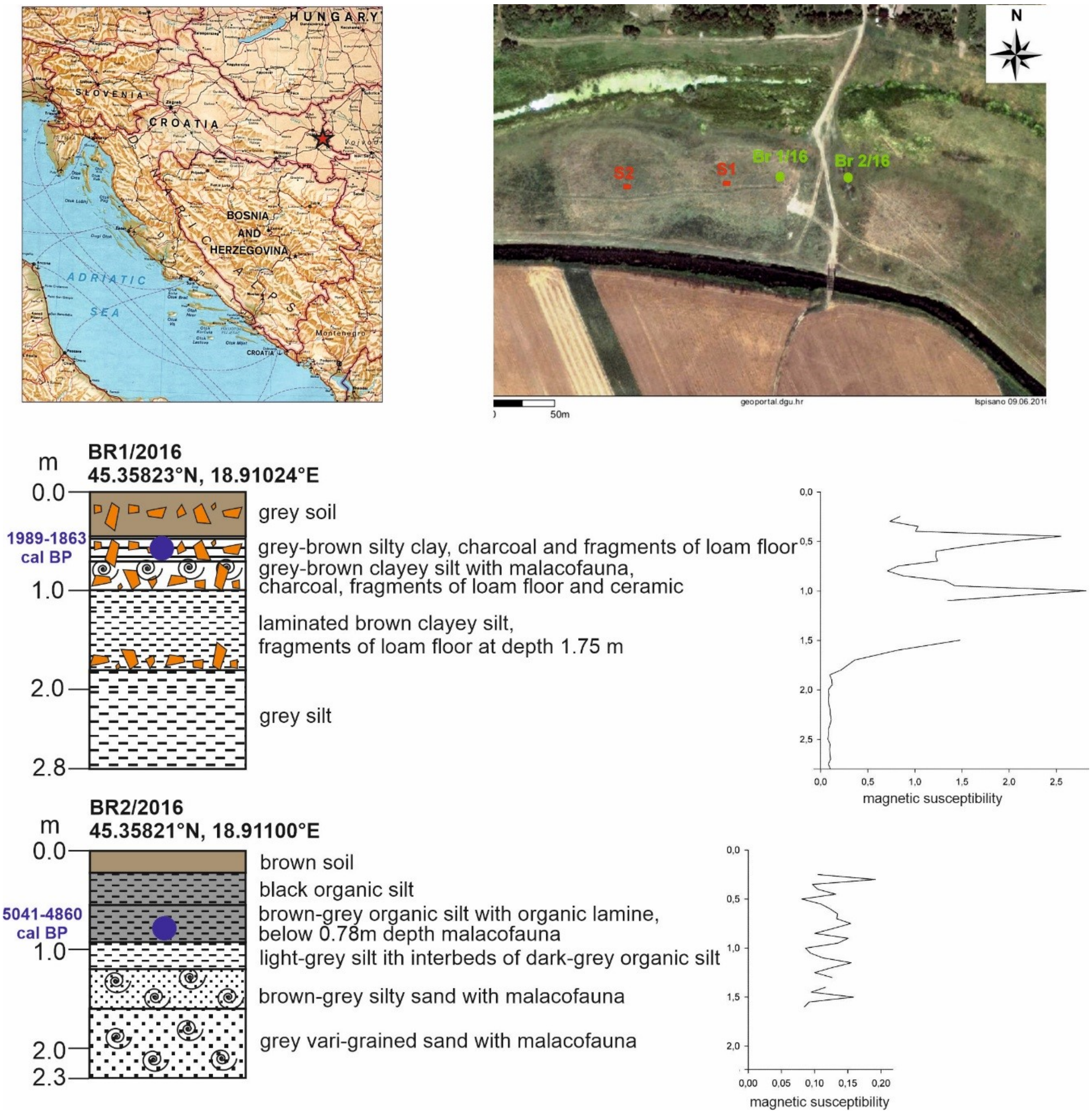


**Figure 1.** Bršadin – Pašnjak pod selom site, location of geological cores (in green) and of archaeological probes (in red). Drilling sections BR 1 and BR 2 with magnetic susceptibility curves

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# PHOSPHATIC FEATURES AS A HINT FOR TACKLING HUMAN IMPACT TO THE DEPOSITIONAL PROCESSES AT OBISHIR-5 SITE (KYRGYZSTAN)

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***Keywords:*** *micromorphology, phosphorous, human activity, site formation, Obishirian*

Obishir-5 is located on the northern slope of the Alay mountain range just at the southern border of the Fergana Valley in Central Asia. Obishir-5 is a Stone Age site of the Obishirian culture. Known since the mid-20$^{th}$ century, it has been recently re-excavated by a joint Russian-Kyrgyz research team. On the northern margin of a small intermontane basin called Aydarken valley, the site is just in front of two rock shelters at the toe of a steep cliff built in limestone (Devonian). An eponymic stream Obishir flows just in front of the site. Obishir-5 is located on a slope and the Quaternary sequence is represented by diamicton-like layers characterized by coarse clasts mainly coming from the disintegration of the limestone cliff and other colluvial/alluvial processes. In the open-work structure of the coarse material, finer particles eventually infiltrated. Although the material is quite consistent throughout the entire sequence, six stratigraphic layers were distinguished within the profile (layers from 0–top to 5–bottom) of which layers 5 and 4 have loess-like features whereas layers 3 and 2, that rest upon, were interpreted as colluvial/alluvial deposits. Interestingly, from layer 3 and up above a second processes might have been relevant in the formation of the site, that is the contribution of human activity. To confirm the hypothesis that human activity was involved in the site formation, and how and when this contribution occurred, here we present micromorphological and geochemical phosphate-related features. Phosphorous (P) is present in soil and its average value for normal soil environments is 0.05% (Lindsay et al., 1989). The major source of soil phosphate comes from animal inputs such as guano, animal dung and coprolites (Karkanas et al., 2018). Anthropogenic activities such as human waste, animal husbandry and agriculture add P to the soil (Karkanas et al., 2018).

The average amount of total %P within the profile is 0.27 at Obishir-5 and the profile showed a peak coinciding with layer 2 (Table), possibly indicating a former ground surface eventually buried. To verify the possible nature of P in the sediments we applied micromorphological analyses. We observed that the presence of bone fragments occurred from layer 3 upward, and that frequency and size increased going upward reaching a peak coinciding with layer 2 (Table). Whereas coprolites were observed mainly in layer 2 and layers up above (Table). Interestingly, bone fragments and coprolites are associated with other components such as charcoal fragments, char material, snail shell fragments, ash, and burnt bones which are all elements associated with human activity. In layers 5 and 3 we observed secondary phosphate minerals (e.g., leucophosphite). In layer 3 secondary phosphate minerals are associated with ashes, charcoal fragments, char material, bone fragments and snail shell fragments. In literature, phosphate minerals are generally associated with severely altered anthropogenic combustion features and presumably indicate diagenesis processes.

To conclude we can assume that, on the basis of geochemistry and micromorphology, the most intense human activity at Obishir-5 is connected with layer 2, although archaeological traits were recorded in each layer below. The layer-2 human activity impacted the sediments by increased P accumulation, which originated from the deposition of bone wastes and firing. The progressively lower amount of both P content and phosphatic features downward the sequence is rather a record of post-depositional processes, such as diagenesis of phosphates and mechanical mixing of sediments, than of less intense human activity. Presence of secondary phosphates in the lower part of the sequence points toward illuviation of P from layers above.

**Table**. Phosphorous content and micromorphological features distribution in Obishir-5 profile.

| Layer | Archaeology | %P | bones | burnt bones | coprolites | woody charcoal fragments | char material | ash | secondary phosphates | shell fragments |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | Recent | 0.32 | + | + | + | + | + | + | – | + |
| 1 | Bronze Age – Middle Ages | 0.28 | + | + | ++ | ++ | + | – | – | + |
| 2 | Obishirian | 0.38 | ++ | ++ | ++ | ++ | ++ | ++ | – | ++ |
| 3 | Obishirian | 0.14 | + | + | + | + | + | + | + | + |
| 4 | Upper Palaeolithic | 0.10 | + | – | – | – | – | – | – | – |
| 5 | Upper Paleolithic | 0.08 | – | – | – | – | – | – | + | – |

+ few; ++ common; – not observed

*This study was supported by the National Science Centre, Poland, grant number 2018/29/B/ST10/00906.*

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# THE PALAEOLITHIC PEOPLING OF ARCTIC SIBERIA: THE ENVIRONMENTAL BACKGROUND OF THE MIS 3 INTERSTADIAL

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***Keywords:*** *Arctic, Pleistocene, mid-Last Glacial, ecosystem, fossil fauna, human adaptation*

The Palaeolithic dispersal in high latitudes has been long a matter of discussion. There is solid evidence on the presence of the Middle Palaeolithic people in northern Eurasia at several stages of the Middle and Late Pleistocene. The extension of occupation into the interior and coastal arctic regions of the (sub) arctic Siberia was a continuation of the geographic spread of early people, presuming biological adaptations to the tundra-steppe and forest-tundra habitats.

The climatically mild mid-Last Glacial interstadial (60/55–24 ka BP) is considered to be the most suitable time interval for the Pleistocene inhabitation of the Siberian North (Koltyakov et al., 2017). The earliest 14C-dated cultural finds together with fossil biota are found in the exposed stratified Late Pleistocene cryogenic geo-contexts. The enclosing and genetically diverse (lacustrine, alluvial, colluvial, aeolian) formations points to the changing landscapes and the past climate-driven (sub)arctic ecosystem restructuring with meandering channels, thermokarst depressions and lakes analogous to the present ones in North Yakutia.

The affluent palaeoenvironmental records of ancient wood, plant remains, pollen and coprolites retrieved from frozen grounds along with rich fossil fauna (Lazarev, 2008) report on woodland and parkland habitats during the first half of the interstadial ~50–38 ka BP and a broad ecological diversity. The overall evidence points to the rather favourable conditions particularly during the early MIS 3 in spite of switching warm and cold climate oscillations. The palaeo-biota uniformly indicate a high natural diversity under the conditions of increased mean annual temperature as well as humidity.

Milder climates comparing to the present ones are reported across the broad territory of East Siberia from the lower Lena to Chukotka, corroborating the broad-leaf vegetation records from fossil-peat cryolithic contexts in polar tundra in the lower Taz Basin, NW Siberia. The chronologically equivalent bio-stratigraphic archives point to much warmer summers with the MAT up to 0.5–2.0 ºC higher than today. Shrub- and herbs-dominated frigid tundra with alder and dwarf birch, and xerophytes herbaceous grasslands were the principal biotopes of the (sub-)arctic lowlands towards the end of the mid-last glacial (~30–24 ka BP) within the mammoth steppe (Ukraintseva, 2013). Continental aridity and low temperatures are witnessed by massive sand accumulations.

Cultural inventories made from mammal bones and mammoth ivory provide witness of the co-existence of the Palaeolithic people and the Pleistocene megafauna. The spread of the early hunters-gatherers beyond the Arctic Circle mirrors the long-term favourable conditions with the onset of the MIS 3/Karga Interstadial. The geographic distribution of the archaeological sites pre-dating ~40 000 years provides clear proof of the pre-LGM peopling of the Russian Arctic from the Northern Urals to the easternmost North-East Siberia (Fig. 1). The age of the uncovered sites implies the presence of the pre-modern humans (Homo sapiens neanderthalensis) in the polar areas during the mid-Last Glacial and possibly prior that time. The emerging picture of the late Middle Palaeolithic occupation in the Siberian Arctic, predating at least by 15 000 years the presently oldest arctic Upper Palaeolithic settlement represented by the RHS Site dated to 31.6 ka BP, pushes for the change of the traditional paradigm of early peopling of the high-latitude Eurasia (Chlachula et al., 2021).

Behavioural and cultural interactions with the Neanderthal gene-flow into the modern human populations most likely applied for the eastern Russian Arctic as well. Under the long-term moderate MIS 3 climates, and the existing territorial physiographic and palaeoecological situation, there was no physical (geomorphic and environmental) barrier to prevent a further spatial dispersal of the prehistoric people eastwards into present-day Alaska and NW Canada (Chlachula, 2019) within the close (<2000 km) geographic limits from the easternmost regions of North Siberia.

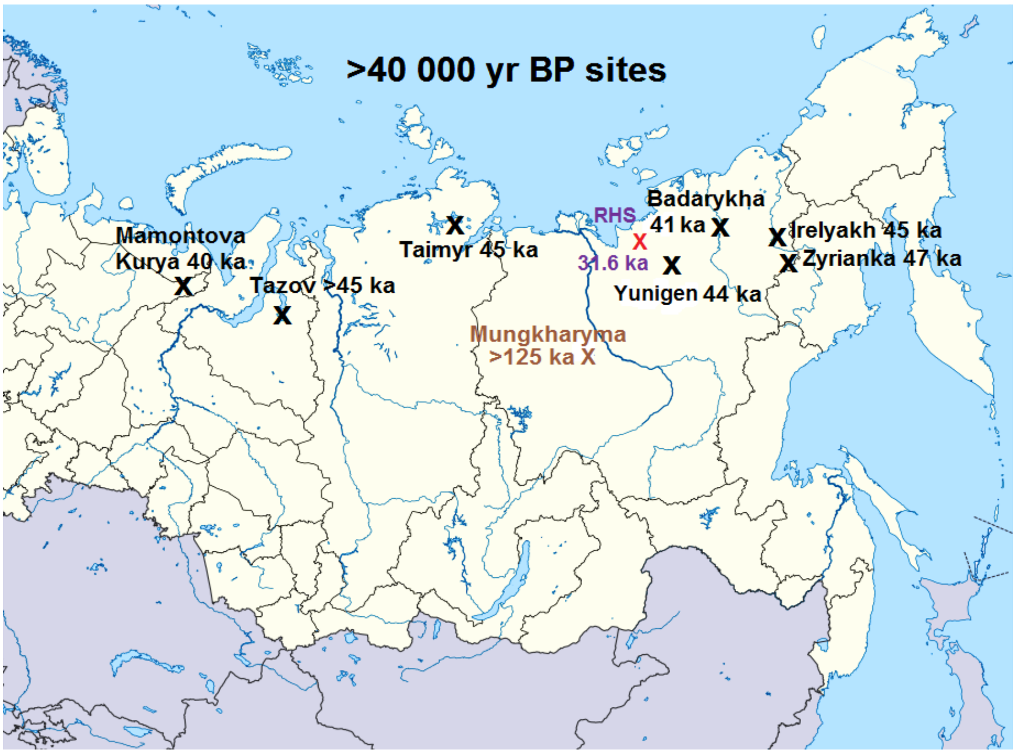


**Figure 1.** Geographical location of the pre-40 000 yr-old archaeological sites in the Russian Arctic and sub-Arctic; the Middle Palaeolithic Mungkharyma (the Viluy River Basin) and the Upper Palaeolithic Yana RHS site (the Yana River valley). The $^{14}C$ dates on the cultural records and biota from the stratified MIS 3 geo-contexts.

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# THE RELATIONSHIP BETWEEN THE ENVIRONMENT AND CULTURE ON THE EXAMPLE OF THE BIŚNIK CAVE

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***Keywords:*** *Biśnik Cave, stone tools, Pleistocene*

The current article aims to capture the relationship between the elements of natural environment around the Biśnik Cave, reconstructed during the research, and the remains of the culture of its inhabitants, present in the obtained archaeological sources. The research has provided abundant material both of natural and cultural character. This allows the formulation as well as an attempt at verification of the hypothesis that diverse cultural behaviour, such as the location and size of campsites or the diversity of flint inventories in particular layers may be linked with the environment in which the layers were deposited in the cave. Consequently, data of natural (lithological, geochemical, palaeozoological and palaeobotanical) and cultural (typological-technological, functional and spatial) character have been analysed and compared, with reference to artefacts from several layers with cultural levels (Fig. 1). The following interglacial layers: 19, 15 and 14 and glacial layers: 18, 12, 11 and 7 have been selected from the stratigraphic sequence of the cave, which attest diverse environments. This allowed the analysis of the phenomena which occurred in the area of the central part of the Polish Jura in the period between MIS 8 and the beginning of MIS 3, i.e. c.a. 200 000 years (Cyrek et al., 2010, 2014; Krajcarz et al., 2014).

Three types of criteria were applied for the analysis. The first one referred to the spatial distribution of cultural remains (hearths, artefact clusters) within the cave, the second one - to the technology and taphonomy of flint artefacts, whereas the third one – to the elements of natural environment, such as climate, landscape, flora, fauna or lithology of sediment.

The analysis has revealed that in warm periods (layers 11, 14 and 15), inhabited zones included the main chamber (Fig. 2), the area under the overhang, and occasionally the side chamber and side shelter (Cyrek et al. 2016). In the cold periods (layers 7 and 18) the area of inhabitation was the main chamber. Other sections of the cave were rarely penetrated (layer 7). The main place, where campsites were set up in all periods, was the area of the main chamber in the vicinity of the entrance, which is confirmed by the location of almost all hearths (Fig. 3). Similar numbers of hearths, clusters of artefacts and sizes of inventories in particular layers attest a comparable frequency and intensity of the cave inhabitation, both in the glacial and interglacial climatic conditions. Taking into account the number of the clusters of flint artefacts and animal bones, it seems that these are remains of short-lived campsites set up by small groups of hunters. The analysis of bears' teeth with reference to the season of death (Krajcarz et al. 2012), indicated the animals' increased mortality in winter during the hibernation, which may mean that people inhabited the cave in summer.

A relatively high percentage of retouched tools in particular assemblages and the results of traseological research indicate a household/hunting character of campsites, especially as the most numerous tools in each analysed assemblage include side-scrapers, denticulate-notched forms with a considerable number of points and knives. The hunting function of campsites is additionally reinforced by shed reindeer antlers, which underwent processing. The traces of such activity were discovered in the Interplenivistulian layer 7 (Mazza et al., 2021).

It should be underlined that all analysed cultural levels are characterised by technological similarity, despite different climatic conditions. It involved a dominant role of the Levallois method during the processing of local Jurassic flint. There were differences, however, in the percentage of particular types of tools. The most significant differences refer to points, which dominated in layers 19 and 12 and were almost completely absent in other layers, as opposed to the number of side-scrapers and denticulate-notched tools, which were always present with small differences in frequency. Apart from side-scrapers, knives are the most characteristic Middle-Palaeolithic tools in the analysed levels. They seem to have evolved from unifacial knives found in the warm layer 19, through partially bifacial knives unearthed in the cold layer 18, to completely bifacial ones found in warm layers 14, 15 and a cold layer 7, where they are a prevalent types of tools. In this case, the change of the form of flint knives resulted from technological-cultural tradition linked with the economic requirements of the dwellers. The latter was connected with the elements of the environment surrounding the cave.

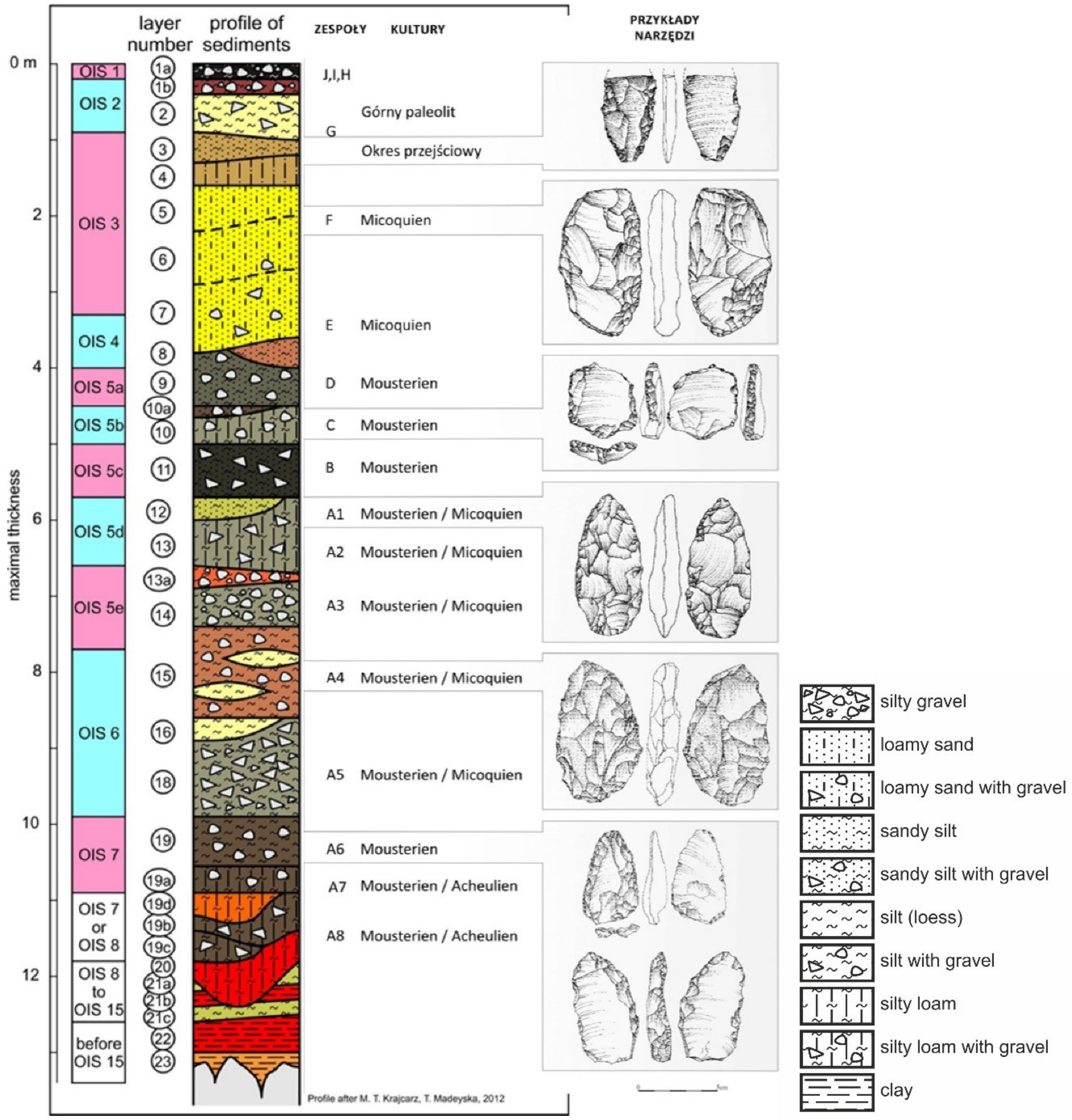


**Figure 1.** Biśnik Cave. Stratigraphy, cultural assemblages, and characteristic artefacts

It should be pointed out that no direct convincing relationships were discovered between the assemblage of flint tools and climatic conditions. However, it should be highlighted that the analysed inventories were scarce, which to some extent impedes the accuracy of interpretation.

Palaeozoological and palaeobotanical data attest a mosaic and diverse character of landscape in the vicinity of the cave, during the Middle Polish interstadial (layers 19, 18 and the lower part of layer 15), Eemian interglacial and the early Vistulian (upper part of layer 15, layer 14, layers 12 and 11). The landscape was dominated by open areas with the stable presence of forested areas. Consequently, during a long period between MIS 8 and the initial chase of MIS 5, palaeoecological conditions near the Biśnik Cave could have been similar. This is also confirmed by similar climatic indicators, such as air temperature, humidity and the length of vegetation season (Socha, 2014).

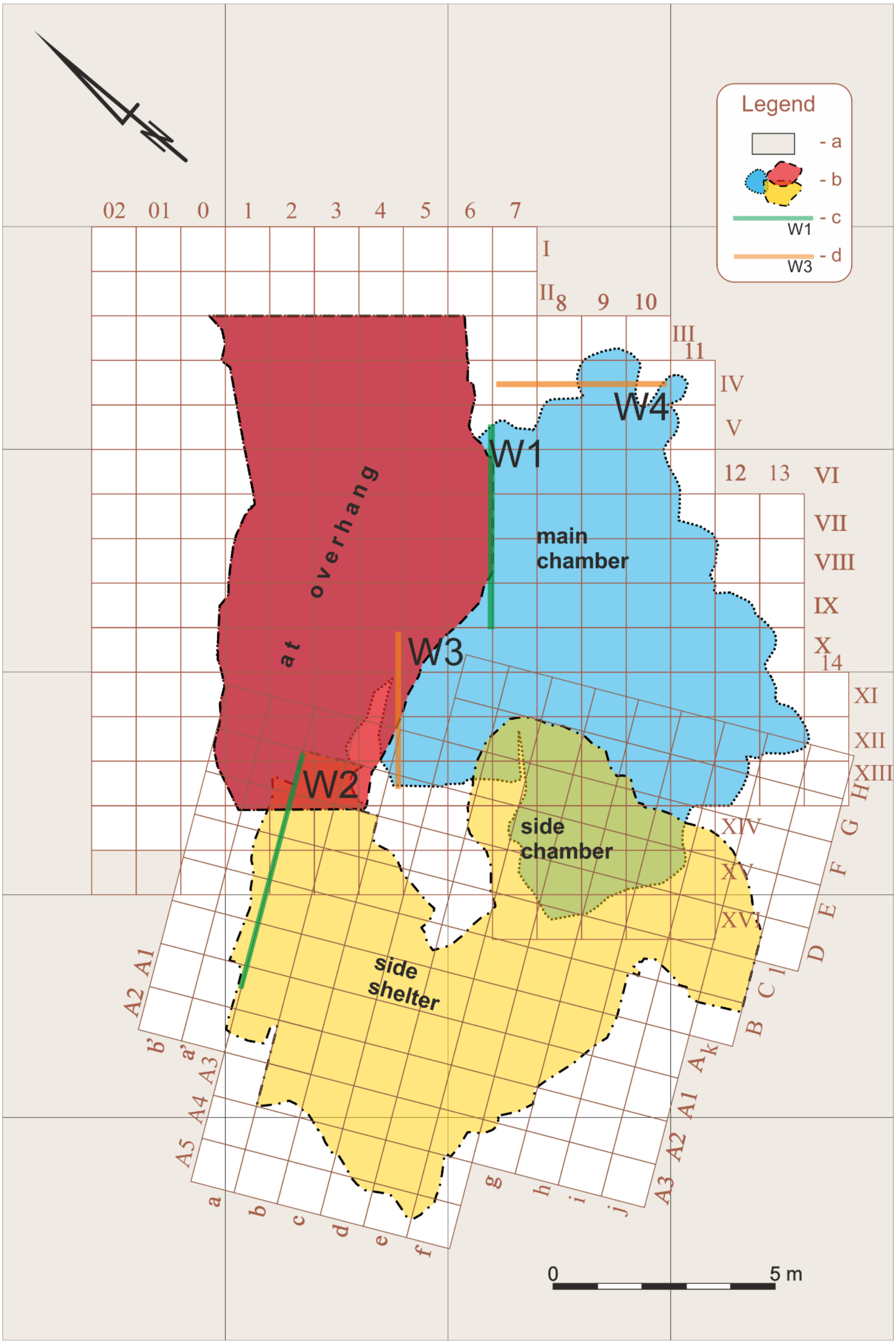


**Figure 2.** Biśnik Cave. Cave division:
a - rock, b - cave components, c-d - location of modern and fossil entrance holes

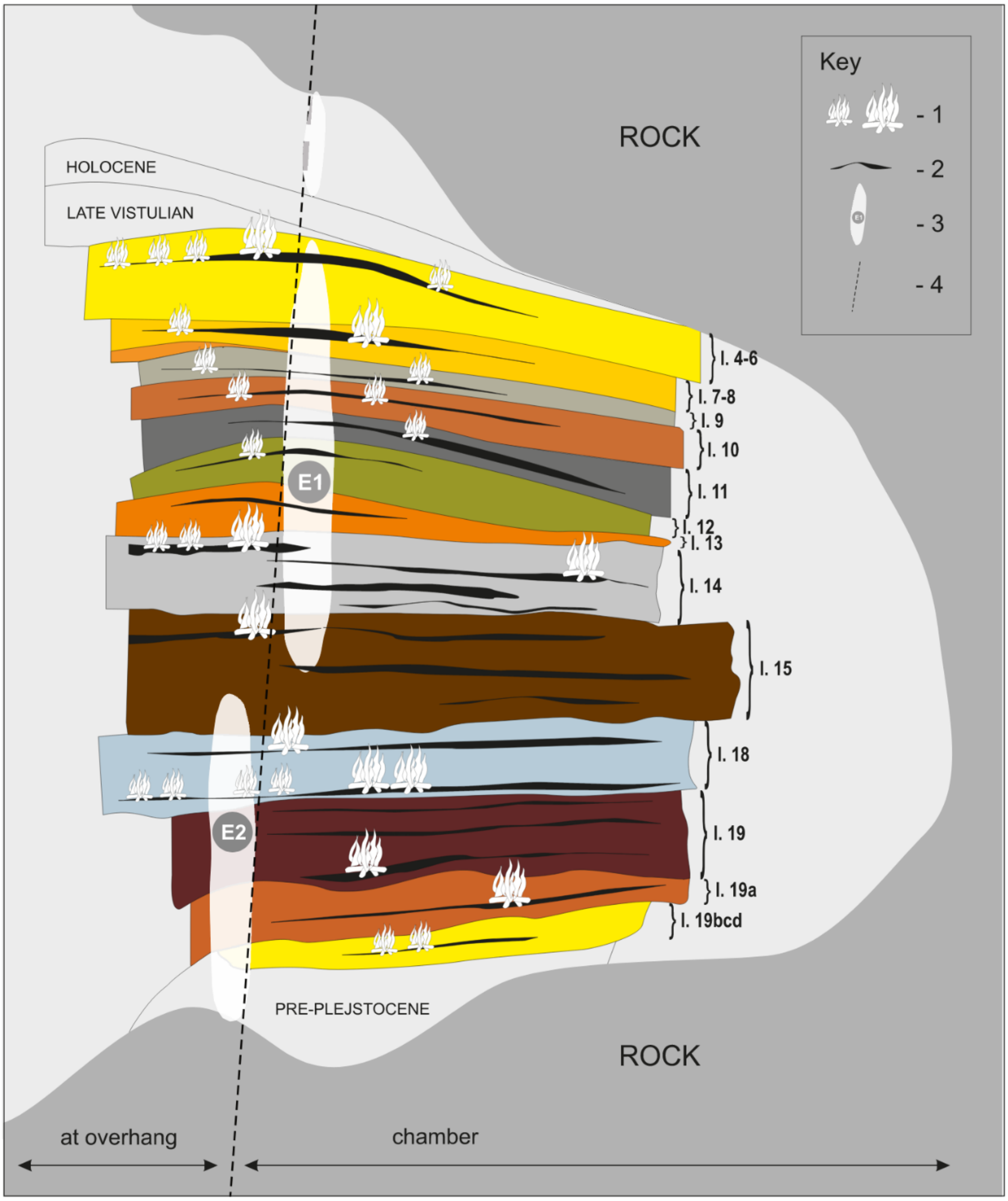


**Figure 3.** Biśnik Cave. Location and stratigraphy of hearths:
1 - hearths, 2 - cultural levels, 3 - modern entrance holes, 4 - boundary between chamber and overhang

In the whole Middle Pleistocene animals connected with forest or forest-steppe (bison priscus, red deer, straight-tusked elephant, elk and a roe deer) were present in the layers described as glacial. The reindeer and woolly rhinoceros were found in the interglacial sediment. The results of isotope and molecular research (Krajcarz et al., 2010) have revealed that almost invariably there was a forest, more or less compact (coniferous or mixed) in the valley at the foot of the cave. The permanent access to flowing or stagnant water at the foot of the cave was an important factor in attracting hunted animals - between several and several dozen taxa of large herbivorous mammals. The circumstances ensured the cave's attractiveness for the Palaeolithic settlement, which is confirmed by at least 18 levels of the cave inhabitation, with over 4000 flint and bone artefacts (Cyrek et al., 2014).

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# TOOTH ENAMEL MORPHOLOGY OF SELECTED PLEISTOCENE-HOLOCENE HORSES OF UKRAINE

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***Keywords:*** *Pleistocene, Holocene, teeth*

The presented results of research on the ultrastructure and chemical composition of the enamel of premolars and molars, as well as incisors of selected groups of equines from Pleistocene and Holocene sites. The material came from the extinct forms of *Equus gmelini*, *Equus latipes*, *Equus hydruntinus*, partly *Equus suessenbornensis*, as well as modern *Equus caballus* from the Holocene sites, *Equus przewalskii* and Polish konik. A detailed analysis of the tooth enamel morphology depending on the enamel types (I, II, III), function and environmental conditions was performed.

For this purpose, the methods of measuring enamel structural elements (IPM - inter-prismatic matrix and prisms - PE) were used, with subsequent data processing using statistical methods. For their characterization, the "K" index (PE to IPM ratio) was additionally introduced in various enamel types, as well as the "PII" index ("K" ratio of the first type of enamel to "K" of the second enamel type), referred to as the inversion index. The obtained results were analysed using a comparative-evolutionary approach, an in-depth analysis of the structure and chemical composition of the enamel in relation to functionality, as well as the determination of possible directions in the evolution of the structure. The research was carried out from the point of view of the significant role of enamel as an integral part of the functionally comprehensive digestive system, taking into account the principles of evolutionary morphology and adaptation processes. The data on the dependence of the enamel morphology on the food was found, and it is noticeable in individuals coming from relatively wide time intervals, e.g., the Late Pleistocene and the present day (low PII coefficients in *Equus gmelini*, *E. latipes*, and *E. hemionus*). On the other hand, the differences in the forms of *E. caballus* from the Holocene are usually within the limits of the permissible variability of the feature.

Based on the obtained data, it was established that the basic trends in the evolution of enamel in small forms from the tarpan group (*Equus gmelini*, *E. hydruntinus*, *E. przewalskii* and Polish konik) are the strengthening of the first and second types of enamel over time, increasing the thickness of PE prisms and reducing the thickness of IPM. Another direction is the more and more complicated (down to decussation) structure of the waves of prisms in the transition zone (TZ) between the first and the second types. Comparison of the results of cluster analysis (dendrograms) on the basis of data on the structure of tooth enamel as a morphological feature in its entirety shows justified similarities in the structure of comparable forms, while distinguishing *E. hydruntinus* in the group of small horses "tarpan" and *E. latipes* in the group "*caballus*".

In conclusion, the enamel morphology is to some extent species-specific, shows variability and taxonomic differences. As a morphological feature, it can be used to identify taxa, especially extinct forms. The similarities and differences in structure are mainly related to geological age, food, function; they may indicate the nature of adaptation genesis and conclude about possible related forms.

# FROM THE LATE PLEISTOCENE TO THE PRESENT: CHANGES IN THE FAUNA OF SMALL MAMMALS IN THE NORTH OF THE MIDDLE URALS

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***Keywords:*** *small mammals, Makhnevskie caves, Late Pleistocene, Holocene*

The submountain part of the Urals (the north-east of the Perm Territory, Russia) is famous for its unique area that contains the Makhnevskie Caves rock mass (59° 26′ N 57° 41′ E). The deposits in these caves were formed at the beginning of the Late Pleistocene (MIS 5e, Makhnevskaya Ledyanaya), in the middle of the Late Pleistocene (MIS 3, Makhnevskaya-2 Cave) and in the Middle Holocene (MIS 1, Bolshaya Makhnevskaya Cave). At present, most of the area surrounding the cave complex is represented by second-growth mixed forest with *Picea obovata* and *Betula pendula*; the forest was re-established through succession processes developed in the area occupied by the original dark coniferous forests destroyed by clear-cutting during the first half of the 20th century.

The studied cave deposits belong to different taphonomic types. The narrow corridor in the Makhnevskaya-2 Cave and the remote grotto in the Makhnevskaya Ledyanaya Cave were used by large predatory mammals as a temporary shelter; in addition, the above grotto was a natural trap for small mammals (the entrance to it started with an abrupt drop). The Bats' Grotto in the Bolshaya Makhnevskaya Cave was most likely a natural trap (mammals got into the grotto through the hole in the ceiling); besides, the massive bat die-off occurred in the grotto. The total volume of materials related to small mammals and studied in the deposits of these caves includes more than 120,000 teeth and jawbones. Among the identified taxa, a special place is taken by *Crocidura* sp., *Hystrix brachyura*, *Dryomys nitedula*, *Apodemus flavicollis*; all these mammals were first discovered in the form of fossil remains in the north-eastern area of the Middle Urals. In addition, teeth of rodents were found in the Late Pleistocene sediments of the caves, assigned to the genera *Terricola* and *Chionomys*.

The palynological data and taxonomic composition of mammals' fauna (Tabl.) reveal that broadleaf forests were well represented in the vicinity of the rock mass area at the beginning of the Late Pleistocene (Fadeeva et al., 2020). Among rodents, taiga species such as *Myopus schisticolor*, *Microtus agrestis*, *Craseomys rufocanus* and *Myodes rutilus* prevailed. Most of the insect-eating mammals were represented by forest inhabitants – *Sorex isodon*, *Sorex caecutiens* and *Sorex araneus*.

In the middle of the Late Pleistocene, most of the area was occupied by periglacial forest-tundra-steppe and inhabited by three dominant species of small mammals (*Dicrostonyx torquatus*, *Lasiopodomys gregalis* and *Lemmus sibiricus*). The species composition of insectivores had changed – the fauna of that period was dominated by *Sorex tundrensis*, a representative of open landscapes.

Judging by the abundance of bone remains belonging to small forest mammals such as *Myopus schisticolor*, *Craseomys rufocanus*, *Sorex isodon*, *Sorex caecutiens* and *Sorex araneus*, the over-the-cave vegetation in mid-Holocene deposits was represented by dark coniferous tree species with the well-developed moss-and-lichen understory. At present, the caves are surrounded by second-growth forests with a lot of deadwood. It has been found that *Myodes glareolus* prevails considerably (90%). The adjacent areas (floodplain mixed forests) are also characterized by the dominance of this rodent species; *Microtus arvalis* and *Sorex araneus* are also well represented. *Alexandromys oeconomus* is well represented within meadow formations. This comprehensive study of the specific local natural area makes it possible not only to compare the species compositions through the evolutionary changes, but also to specify the boundaries of occurrence and morphological characteristics of some fossil mammalian species found in cave deposits. Biostratigraphic differences have been found in dental enamel characteristics (thickness, enamel differentiation coefficient (SDQ)) of *Arvicola amphibius* during three periods of time (Fadeeva et al., 2021).

*This study was funded by RFBR and Perm Region, project number 19-44-590001.*

**Table**. The list of fossil and modern small mammal species.
The nature reserve "Makhnevskie caves" (the North of the Middle Urals, Russia)

| Species/Period | MIS 5e | MIS 3 | MIS 1 | Modern time |
|---|---|---|---|---|
| *Erinaceus* sp. | + | - | - | - |
| *Talpa* sp. | + | - | + | + |
| *Crocidura* sp. | + | - | - | - |
| *Sorex minutus* Linnaeus, 1766 | + | + | + | + |
| *Sorex caecutiens* Laxmann, 1788 | + | + | + | - |
| *Sorex isodon* Turov, 1924 | + | - | + | + |
| *Sorex tundrensis* Merriam, 1900 | | + | - | - |
| *Sorex araneus* Linnaeus, 1758 | + | + | + | + |
| *Sorex minutissimus* Zimmermann, 1780 | + | + | + | - |
| *Neomys fodiens* Pennant, 1771 | - | - | - | + |
| *Myotis mystacinus* Kuhl, 1817 | - | - | + | - |
| *Myotis brandti* Eversmann, 1845 | - | - | + | - |
| *Myotis daubentoni* Kuhl,1817 | - | - | + | - |
| *Myotis dasycneme* (Boie, 1825) | + | - | + | - |
| *Plecotus auritus* (Linnaeus, 1758) | + | - | + | - |
| *Eptisicus nilssonii* (Keyserling & Blasius, 1839) | + | - | + | - |
| *Ochotona* sp. | + | + | + | - |
| *Sciurus vulgaris* Linnaeus, 1758 | + | + | + | - |
| *Spermophilus sp.* | - | + | - | - |
| *Hystrix brachyura* Linnaeus, 1758 | + | - | - | - |
| *Dryomys nitedula* (Pallas, 1778) | + | - | - | - |
| *Sicista betulina* (Pallas, 1779) | + | + | - | - |
| *Cricetus cricetus* (Linnaeus, 1758) | - | + | - | - |
| *Cricetulus migratorius Pallas, 1773* | - | + | - | - |
| *Lemmus sibiricus* (Kerr, 1792) | - | + | - | - |
| *Myopus schisticolor* (Lilljeborg, 1844) | + | - | + | - |
| *Craseomys rufocanus* (Sundevall, 1846) | + | + | + | + |
| *Myodes glareolus* (Schreber, 1780) | + | + | + | + |
| *Myodes rutilus* (Pallas, 1779) | + | + | + | + |
| *Dicrostonyx torquatus* Pallas, 1778 | + | + | - | - |
| *Lagurus lagurus* Pallas, 1773 | - | + | - | - |
| *Arvicola amphibious* (Linnaeus, 1758) | + | + | + | - |
| *Microtus malei* Hinton, 1907 *(*cf. *Chionomys* sp.*)* | - | + | - | - |
| cf. *Terricola* sp. | + | - | - | - |
| *Alexandromys oeconomus* (Pallas, 1776) | + | + | + | + |
| *Alexandromys middendorffii* Poljakov, 1881 | - | + | - | - |
| *Lasiopodomys gregalis* (Pallas, 1779) | + | + | - | - |
| *Microtus agrestis* (Linnaeus, 1761) | + | + | + | + |
| *Microtus arvalis* c.l. | - | + | - | + |
| *Micromys minutus* Pallas, 1771 | - | - | - | + |
| *Apodemus uralensis* (Pallas, 1811) | + | - | - | + |
| *Apodemus sylvaticus* (Linnaeus, 1758) | + | - | + | - |
| *Apodemus flavicollis* (Melchior, 1834) | + | - | - | - |
| *Mus* sp. | - | + | - | - |
| NISP – number of identified specimens | 6 290 | 109 004 | 7 578 | 515 |

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# PLEISTOCENE SMALL MAMMAL FAUNAS OF THE IMANAY CAVE

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***Keywords:*** *small mammals, Imanay Cave, South Urals, Pleistocene*

For its unique faunistic finds, the Imanay Cave (53°02' N, 56°26' E) found in the Bashkiria National Park (Meleuzovsky District, Republic of Bashkortostan, Russia) stands out among the caves located in the southern part of the South Urals. The cave deposits contained fossil remains of at least 11 large cave lions (*Panthera* ex gr. *fossilis-spelaea*) and fossil remains of more than 110 small cave bears (*Ursus* ex gr. *savini-rossicus*), which are dated by radiocarbon to the Briansk interstadial period (MIS 3) (Gimranov and Kosintsev, 2020). The cave deposits contained artifacts dating back to the Middle Paleolithic (Gimranov et al., 2021). The study of the fauna of small mammals was based on deposits of 13 reference horizons (the depth of 0–120 cm) of the 1 square meter excavated area.

The taxonomic identity was identified for 15,430 teeth and jawbones mandibles of mammals representing four orders: Eulipotyphla, Chiroptera, Lagomorpha and Rodentia. The fossil bone remains were heavily fragmented and mainly represented by isolated teeth. Based on the proportions of teeth representing six taxa such as *Lasiopodomys gregalis*, *Lagurus lagurus*, *Ochotona* sp., *Craseomys* sp., *Myodes* sp., *Sorex* sp. (the aggregate proportion of their teeth in the deposits averages 74.7–92.1%), the faunas of small mammals from the Imanay Cave can be divided into two types.

The first type of the fauna is typical of horizons 1–3 (0–30 cm) of the excavation site. *L. gregalis* is the dominant species in the faunas of this type, while *Ochotona* sp. is the co-dominant taxon; the average proportions of red-toothed shrews' and red-backed voles' teeth exceeded the average proportion of steppe lemmings' teeth. The second type of the fauna was discovered in lower horizons 4–12 (30 –120 cm). The dominant species was the same as in the fauna of the first type, i.e. *L. gregalis*, though with a higher degree of dominance. *L. lagurus* was the codominant species. The average proportion of steppe lemmings' teeth was higher than the proportions of red-toothed shrews' and red-backed voles' teeth. By its species composition, the cave fauna of small mammals has much in common with fossil faunas from the Late Pleistocene and Middle Holocene deposits in other locations in the southern part of South Urals (Danukalova et al., 2011). According to radiocarbon dating of postcranial skeletal bones of small mammals, the cave deposits were formed in the Late Glacial (13 255±60 IGAN 9116 (depth 50-60 cm); 17 100±50 IGAN 9117 (depth 100-110cm)).

Both fauna types demonstrate well-represented and quite uniformly distributed groups of all morphotypes of first lower molars of the narrow-skulled vole (*Lasiopodomys gregalis*), which are characterized by a pronounced dominance of teeth belonging to the "gregaloid" morphotype (>50%) and a small number of teeth (up to 8.6%) of complex structures ("microtid" morphotype). The dominance of the "gregaloid" morphotype has been found only in the species' teeth samples in deposits dating to Middle Pleistocene and the first half of the Late Pleistocene in the South Urals (Smirnov et al., 1990; Fadeeva et al., 2019; Yakovlev, 2020; etc.), in the sample from the Semeyka site dating to Middle Pleistocene and located in Western Siberia (Smirnov et al., 1986).

The first lower molars of *Lasiopodomys* (*Stenocranius*) *gregaloides* were found in sediments including the second type of fauna. In the sample of first lower molars of steppe lemmings from the fauna of the second type (horizons 4–12), the archaic ("transiens") morphotype accounts for 28.0–57.9%, while the advanced ("lagurus") morphotype accounts for 6.3–36.0%. In the samples from horizons 3 – 1 (the fauna of the first type), teeth with the "transiens" morphotype account for 40%, while teeth with the "lagurus" morphotype account for 20–40%. The proportions of morphotypes m1 of steppe lemmings from the fauna of the second type from the Imanay Cave are similar to those from the Middle Pleistocene site of Gunki in the East European Plain (Markova, 1974). In addition, most of the first lower molars [n=4] of *Arvicola* representatives, which were found in deposits of the Imanay Cave, have enamel of the "mimomys" type (SDQ > 100). Such morphometric and morphotypical characteristics of three rodent species are stratigraphic markers of the Middle Pleistocene – the beginning of the Late Pleistocene. Based on the radiocarbon dating, most of the deposits in Imanay Cave were formed during the Late Glacial (MIS 2). However, the morphological features of the teeth of some rodent species found in these deposits are characteristic of more ancient periods (the end of the Middle Pleistocene– the first half of the Late Pleistocene (MIS 6-MIS 4)). Thus, we suggest the existence in the end of the Late Pleistocene of refugia of the rodent populations with archaic teeth characteristics in the Ural Mountains.

*This study was supported by the grant Russian Science Foundation (Project № 20-74-00041).*

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# TAPHONOMIC ANALYSIS OF *CRASEOMYS* VOLE REMAINS FROM THE LATE PLEISTOCENE AND HOLOCENE CAVE DEPOSITS OF THE RUSSIAN FAR EAST

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***Keywords:*** *Craseomys, dental characters, taphonomy, Late Pleistocene, Holocene, the Russian Far East*

Preservation assessment (damage, fragmentation, roundness or staining) is widely used in taphonomic analysis both to clarify the conditions of deposits accumulation (site formation processes) and to understand the site stratigraphy (Smirnov et al., 1986; Andrews, 1990).

It was shown that the main factor of accumulating small mammal assemblages from different sites is a predation by avian or mammalian predators (Andrews, 1990; Fernández-Jalvo et al., 2016). However, damage to the bones and molars involved different agents such as digestion, abrasion and corrosion have different origins (predation, transport) (Fernández-Jalvo et al., 2016).

We studied the dental characters of *Craseomys rufocanus* as the most numerous species of small mammal assemblages from the Late Pleistocene and Holocene deposits of the Tetyukhinskaya cave (the Middle Sikhote-Alin, Russia Far East) and considered the possibilities of using them for taphonomic analysis. It is assumed that the accumulation of bone remains in the Tetyukhinskaya cave occurred as a result of the vital activity of predators (small mustelids, badgers and owls) that used the cave as a dwelling or temporary shelter (Borodin et al., 2018; Tiunov and Gusev, 2020).

In order to test this hypothesis a taphonomic method provided by Andrews (1990) and later by Y. Fernandez-Jalvo et al. (2016) was used. The 1$^{st}$ lower, 3$^{rd}$ upper molars and incisors were available for study and classified into four stages according to the intensity and grades of digestion (Fernández-Jalvo et al., 2016). The obtained results and the fact that the percentage of molars with different degrees of digestion varies, it can be assumed that there could be several potential agents forming taphocenosis – these were nocturnal birds of prey from both category 2 and 3. These could be a Great grey owl and European eagle owl, which are found in the vicinity of the Tetyukhinskaya cave. The grades of damage by mammalian predators are almost always high, and we assumed that they could not be the main source of accumulation of vole remains.

The burrowing activity of predators as well as the post-depositional processes of the layers could led to repeated redeposition of bone remains of different deposits. It extremely complicated the taphonomic structure and stratigraphy of the cave deposits. Color of bone is the indicator, which depends primarily on host sediments and the residence time in the strata (Smirnov et al., 1986; Strukova et al., 2006). To identify the presence of redeposition of the cave deposits and mixing of layers, the color of molars was analyzed. Despite that there may be several different agents and processes that staining molars, we categorized by color rather than agent.

It was revealed that both in the upper and in the deeper layers there are *C. rufocanus* molars from different color groups – both light and very light, dark, and black. The presence of different color group in layers indicates significant assemblage heterogeneity but we assumed that dark and black ones belong to Late Pleistocene deposits, while very light molars belong to Holocene. It's consistent with the published data of small and large mammal fauna, and the AMS-dating from the cave (Kosintsev et al., 2020; Borodin et al., 2018). In addition, that confirms the assumption that the sediments of this cave were accumulated by several agents for a long period of time and can be dated to a wide range during MIS2-5 (Kosintsev et al., 2020).

*This study was performed within the framework of state contract with the Institute of Plant and Animal Ecology, Ural Branch of the Russian Academy of Science, and partly financially supported by the Russian Foundation for Basic Research (projects no. 19-04-00966).*

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# LATE PLEISTOCENE CHRONOSTRATIGRAPHY OF A LOCAL INTERFLUVE SEDIMENT SINK BASED ON 3D-MODELLING (BORISOGLEBSK UPLAND, CENTRAL EUROPEAN RUSSIA)

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***Keywords:*** *kettle hole, watershed, glacial upland, infill, incision*

Late Saalian glacial uplands with hilly or kame and kettle topography covered by a loamy mantle of varied thickness are widespread at the centre of the Russian Plain. A local gully system called Puzhbol at the NE part of the Borisoglebsk Upland has been studied since the early 1960-s when several peat exposures were discovered on its sides (Novenko et al., 2005). It has been used since as one of the main reference sections for reconstructing the postglacial landscape history of the entire Central European Russia (Rusakov et al., 2015). Yet the interpretation of origin and timing of the related sedimentary and erosional events remained controversial, especially due to several hiatuses in the Weichselian deposition sequence. 3D-modelling of a local sediment sink on the left gully side was based on a new series of vertical and horizontal cross-sections and cores up to 7 m deep. Supplementary cores have shown the previously missing part of the section consisting of a stratified loamy thickness above the basal peats. Coupled with grain size, LOI, and spore-pollen analyses and $^{14}C$ dating of organic-rich deposits, it allowed revealing the fuller structure, stratigraphy, and chronology of the Late Pleistocene landscape and geomorphic change of the key site. That local section represents an infill of the MIS 6 glacial kettle hole that was initially occupied by a shallow stagnant water body in the Early Eemian, right after or even during the degradation of a small dead ice block (Shishkina et al., 2019). That shallow pond-like lake had generally persisted until the Late Weichselian time (MIS 5 - MIS 2) periodically drying up and transforming into a forested bog during the interglacial and interstadials and reverting back during the colder stages of the Weichselian.

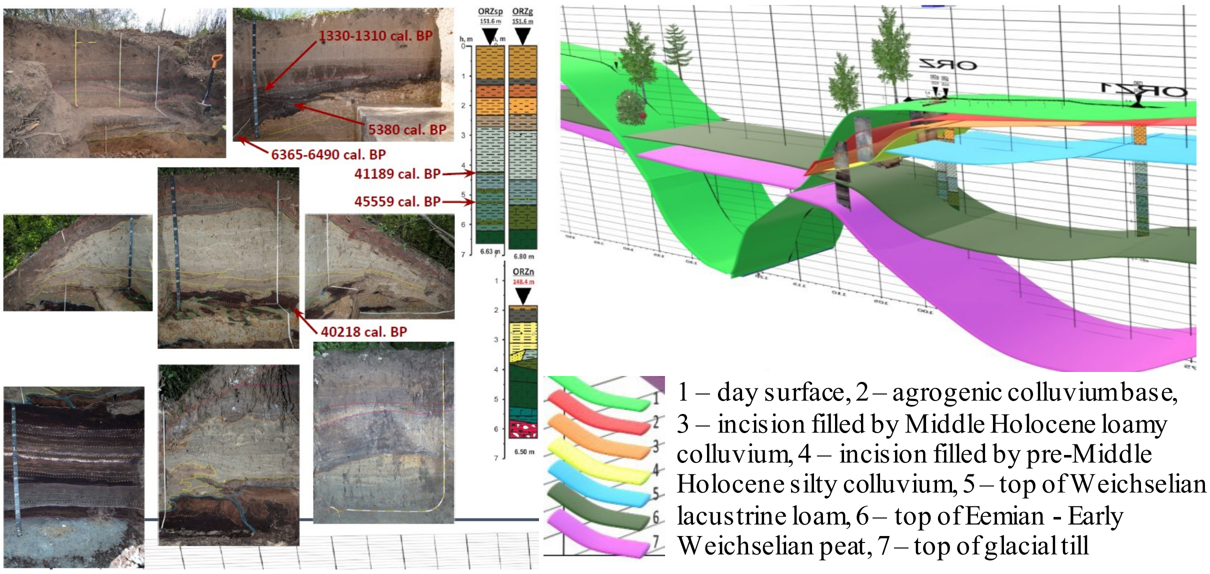


**Figure 1.** Cross-sections and cores of the ORZ key site at the left side of the Puzhbol Gully and 3D model of its incision-infill episodes

The Late Pleistocene to Holocene transition was associated with the most dramatic environmental changes and abrupt fluctuations. Response in the local morphodynamics first involved activation of slope mass movement followed by a gully incision reaching the site by regressive head knickpoint retreat. The observed sediment record provides evidence of at least 4 incision-infill cycles of linear erosion landforms of the Late Glacial to the Late Holocene age.

The first incision into the gradually undulating surface composed of the lacustrine and colluvial loams and its subsequent infill by stratified silty colluvium occurred not later than 6.5 cal. ka BP (Belyaev et al., 2020). It is fixed by the next incision phase infilled by pedosediments of reworked humic, eluvial and sub-eluvial horizons of the upper slope soils enriched by pyrogenic charcoal. The third incision stage can be linked to regressive growth of the main gully head and its branches (ca. 1.4 cal. ka BP) triggered by the onset of cut-and-burn agriculture practices determining conditions favourable for active deposition of agrogenic colluvium. Modern gully incision was preceded at least by another infill phase and occurred between 1941-1968 AD.

That sequence of erosional and depositional episodes demonstrates a rather drastic and recent evolution of the initially watershed landscape due to a progressive incision of a local gully. The latter has partially erased the sedimentary record of a quite prolonged lacustrine stage during the Weichselian concealing the full extent of postglacial levelling of the interfluvial topography.

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# INTERGLACIALS AND GLACIALS OF THE LATE MIDDLE PLEISTOCENE IN THE MIDDLE DNIEPER AREA (UKRAINE)

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***Keywords:*** *palaeopedocomplex, palaeocatena, pollen, palaeofauna, candidate for DATESTRA*

Assemblages of small mammals and the pollen succession are reliable indicators of the terrestrial equivalent of MIS 11, though neither of them cannot be detected in the majority of loess-palaeosol sections in Ukraine. The problem of palaeopedological identification of a unit corresponding to MIS 11 had been apparent for some time. The identification of palaeosols that are correlatives of MIS 9 and MIS 7 is even more crucial in the area of the Dnieper glaciation, where the sedimentary sequences were subjected to abrasional and erosional processes. In order to solve these problems, a step-by-step facial and palaeopedological recording and correlation of the sections have been done, starting from the key site where a palaeontological relation to MIS 11 had been reliably proved – the locality of Gun'ky, on the right bank of the River Psel. It is the reference site for the Likhvinian (Holsteinian) interglacial (Markova, 1982, 2018; Chepalyga, 1980; Rekovets, 1994; Velichko, 1997; Gozhik, 2006; Krohmal, Rekovets, 2010). The assemblages of small mammals and molluscs of the Likvinian (Holsteinian) have been determined in a 'gyttja' (oxbow humiferous deposits) and overlying alluvial sands. The pollen succession obtained from the lower part of 'gyttja' and underlying marls show the early appearance of *Carpinus* and the regular occurrence of small percentages of pollen of *Picea* and *Abies* (Gubonina, 1980) that is typical for the Holsteinian.

Later studies (Gerasimenko, 2004) have demonstrated the occurrence of pollen of highly thermophilous plants (*Juglans regia*, *Carya*, *Ostrya*, and, most importantly, *Pterocarya*) in a limited interval within the oxbow lens. Pollen of *Juglans* and temperate climate broad-leaved trees occur in the overlying marls, below a thin humiferous soil (infilled with large carbonate concretions) that caps the Holsteinian alluvial deposits. Several bones of small *Ursus* (including a femur) and Bovidae have been recently discovered immediately above the oxbow lens. The bear bones, found earlier below the lens, have been related to *Ursus spelaeous rossicus* Boriss. (Veklitch, 1968).

The Upper and Middle Pleistocene stratigraphy above the Holsteinian is very complete, with the till of the Dnieper glaciation as a reliable marker. The Luvisol overlying the Dnieper deposits, which are correlated with Saalian, has been related to the Mikulinian/Eemian (Velichko, 1997) and to Kaydaky unit (Veklitch, 1968). Two soil units, represented by well-developed pedocomplexes, exist between the Holsteinian alluvium and the Saalian glacial deposits. The lower soil unit is separated from the Holsteinian by loess and alluvial deposits formed during a cold stage, under steppe with small patches of boreal trees. The two described soil units are traced in the same stratigraphical position in this terrace succession over several kilometres (including the area near Lamane village). The oxbow lens is replaced here and there by alluvial soils. The surface of the alluvium was affected by erosional processes during the next cold stage, e.g. loesses of the post-Holsteinian cold stage have variable thicknesses or they are replaced by gully alluvial deposits in palaeodepressions. Soil genetic types and the microstratigraphy of the soil units change significantly depending on the palaeorelief.

Thirty-five excavations have been cut along the outcrop in order to trace facial changes and palaeocatenas of the Late Middle Pleistocene soils in the Holsteinian terrace. On the higher points of the terrace surface, the two palaeopedocomplexes merge together in one succession, though a dense net of frost wedges (1,5 m long and 0,1-0,2 m wide in their upper part) opens from the surface of the lower pedocomplex, and shorter 'humus tongues' distorted its bottom. The frost wedges are filled with loess, and frequently only separate pinnacles of the material of the upper soil are seen in the sections. Downslope, in the direction of the ancient ravine which cut the surface of the Holsteinian alluvium, a loess unit (up to 1,7 m thick) appears, separating the two pedocomplexes. Frost fissures filled with this loess cut into the top of the underlying soil, and another generation of even larger frost fissures (2,7 m long, 0,8 m wide in the upper part) which are filled with material of the Chernozem, dissect its lower border. Thus, a cold period with loess accumulation occurred between formation of these two soil units. Their stratigraphical position allows the upper pedocomplex to be regarded as the terrestrial equivalent of MIS 7, the lower as correlative of MIS 9, the loess between them is a correlative of MIS 8, and the loess below the lower pedocomplex corresponds to MIS 10. In the stratigraphical framework of the area, these are named, respectively, the Potyagaylivka (soil), Oril (loess), Upper Zavadivka/Sanzhary (soil), Middle Zavadivk/Lamane (loess) and Lower Zavadivka/Zavadivka *sensu stricto* (soil) units (Gerasimenko, 2004). On the higher parts of the palaeorelief, the Potyagaylivka unit consists (from bottom to top) of Luvisol, Chernozem (its lower boundary is strongly distorted by deep wedges, filled with humus) and Gleyic Cambisol (gleying being due to the impact of the subsequent glaciofluvial processes). Lower in the palaeorelief, this pedocomplex is separated from the Dnieper glaciofluvial deposits by loess-like beds, and the upper soil is a brown-coloured Cambisol. High in the palaeorelief, the Sanzhary pedocomplex consists of a lower Chernozem and an upper reddish-brown Chromic Cambisol. Downslope, the rubification of the upper soil gradually became less, and the lower Chernozem turns into Phaeozem of a greater thickness. In the lower slope of the palaeogully, Luvic Phaeozem and then Albic Gleyic Luvisol appears at the bottom of the Sanzhary pedocomplex. In the gully bottom, the Luvisol of the Potyagaylivka unit is replaced by an Albic Luvisol, and two Albic Gleyic Luvisols form the lower part of the Sanzhary pedocomplex.

In the sections of the higher terrace of the River Psel (e.g. at the Zamozhne site), the alluvial complex is constituted in a different way, and it is overlain by Early Middle Pleistocene soil units with different genetic soil types to those of the Late Middle Pleistocene. The uppermost of these pedocomplexes has features typical of the Lubny soil unit − as seen at the reference sites of Vyazivok and Kaydaky (Veklitch, 1968) − which is correlated with MIS 13. Below the till and loess of the Dnieper unit, the Potyagaylivka and Sanzhary pedocomplexes are very similar to those described on higher positions in the profile of the Holsteinian terrace at Gun'ky. At Zamozhne, they are separated by the Oril loess and a cryoturbation level. Between the Sanzhary and Lubny pedocomplexes, there is a 3 m-thick Tyligul loess, related to MIS 12 at Vyazivok (McCoy et al., 2001). The Zavadivka (*sensu stricto*) soil unit, located beneath the Sanzhary unit (MIS 9) and the thin Lamane loess (MIS 10), thus, corresponds to MIS 11, and here it is well-developed in a soil facies. It includes an upper Chernozem (0,6 m thick) and a very thick Ferric Ochric Luvisol, which differs from the above-mentioned Luvisols by its very bright yellow-brown colour and the presence on ped surfaces of the most abundant colloidal films. Here Zavadivka soils do not have the hydromorphic features that are typical for this pedocomplex at its reference sites in the Middle Dnieper area, and this clearly demonstrates that the Zavadivka soil formation occurred under a warm and humid climate, that allowed the growth of highly mesophilous and thermophilous trees, whose pollen are typical for the Holsteinian.

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# MIDDLE PLEISTOCENE PALEOLANDSCAPES RECONSTRUCTION OF THE PRE-ALTAI PLAIN BASED ON SMALL MAMMAL'S DATA

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***Keywords***: *small mammals, paleolandscapes, Middle Pleistocene, Pre-Altai Plain.*

Southern Siberia is an interesting region to study reasons of extinction of many Pleistocene mammoth fauna species. It is assumed that such an extinction could have occurred due to an environment change from open steppe landscapes towards more closed forest and forest-steppe landscapes in the Late Pleistocene – Holocene. Fossil complexes of microtheriofauna can serve as a good tool to understand this process. Small mammals are good paleolandscape indicators due to the significant number of specialist species. We analyzed small mammal's complexes of the second half of the Middle Pleistocene on the Pre-Altai Plain territory from Solonovka, Petropavlovskoe, and Malinovka-4 localities. For comparison, we used data on recent captures of small mammals in the Pre-Altai Plain (Makarov, 2016) and the adjacent territory (Dupal, 2004). For developing paleolandscape reconstructions and analyzing modern communities of small mammals, we used bioclimatic discriminant analysis with some changes (Hernández Fernández, 2001). Unlike the original method, we used a different classification of climatic zones inhabited by small mammals (Markova et al., 2019), but the principle itself remained the same. First, we determined the total number of climatic zones occupied by species, then for each species and the climatic zone in which this species lives, introducing a climatic restriction index (CRI). This index is calculated by the formula $CRIi = 1/n$, where $n$ is the number of climatic zones inhabited by the species, and $i$ is the climatic zone $i$ in which the species occurs. The sum of all CRIi for each species is equal to 1. Then comes the determination of the bioclimatic component (BC) according to the formula $BCi = (\Sigma CRIi)\ 100/S$, where $i$ is the climatic zone $i$, and $S$ is the number of species in a given area or faunistic complex. BCi reflects proportion that the climatic zone occupies in the bioclimatic spectrum of the faunal complex. From this, it is possible to determine in what landscape-climatic context the faunistic complex existed.

Bioclimatic discriminant analysis of faunistic associations from the Solonovka, Petropavlovskoe, and Malinovka-4 localities revealed predominance of the steppe, forest-steppe, and semidesert parts of bioclimatic spectrum (BS). Thus, the steppe, forest-steppe and semi-desert zones account for 88% of BS in the Malinovka-4 locality, 80% in the Petropavlovskoe locality and 82% in the Solonovka locality. For comparison with the fossil community of the second half of the Middle Pleistocene, we used data on recent captures of small mammals from Petropavlovskoe area (Altai region) and from area of Kaminnaya cave (Altai mountain). Since no remains of species from Muridae family were found in the fossil communities, representatives of this family from modern captures were not taken into account in the assessment of changes in landscape and climatic conditions. During analysis a significant difference in the fossil fauna of the second half of the Middle Pleistocene and the modern fauna of this region was revealed. If in fossil complexes the steppe, forest-steppe and semi-desert zones are accounted for an average of 83% of BS, then in modern communities these zones account for only 46% in the area of the village Petropavlovskoe and 37% in the Kaminnaya cave.

Application of the bioclimatic method revealed predominance of open landscape zones in the bioclimatic spectrum of microteriofauna for the second half of the Middle Pleistocene. At the same time, the analysis of modern fauna showed a difference, expressed in an increase in proportion of closed landscapes. Through bioclimatic method, it became possible not only to carry out a more detailed paleolandscape reconstruction based on the small mammal's remains, but also to express the difference in the bioclimatic spectrum of fossil and modern faunas.

*The research was supported by the grant of the president of the Russian Federation for young scientists (project No. MK-74.2021.1.5).*

**Table 1**. Bioclimatic spectra of small mammal's localities of the Altai and Pre-Altai plain. 1 – arctic desert, 2 – tundra and forest-tundra, 3 – taiga, 4 – mixed and deciduous forests, 5 – forest-steppe, 6 – steppe, 7 – semi-desert, 8 – desert, 9 – mountain forests, 10 – alpine meadows, 11 – mountain steppe

| Localities | Bioclimatic component (BCi=(ΣCRIi)100/S) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| Solonovka | | 3.330 | 5.000 | 6.660 | 21.640 | 36.640 | 23.310 | | 1.660 | 1.660 | |
| Petropavlovskoe | | 4.162 | 3.125 | 5.200 | 21.850 | 37.475 | 20.812 | | 5.200 | 2.075 | |
| Malinovka-4 | | 4.757 | | 2.371 | 21.400 | 42.829 | 23.786 | | 2.371 | 2.371 | |
| Modern fauna (Petropavlovskoe) | | 4.757 | 22.614 | 21.414 | 15.457 | 17.843 | 13.086 | | 2.371 | 2.371 | |
| Modern fauna (Kaminnaya cave) | | 5.550 | 26.383 | 24.983 | 18.033 | 12.483 | 6.933 | | 2.767 | 2.767 | |

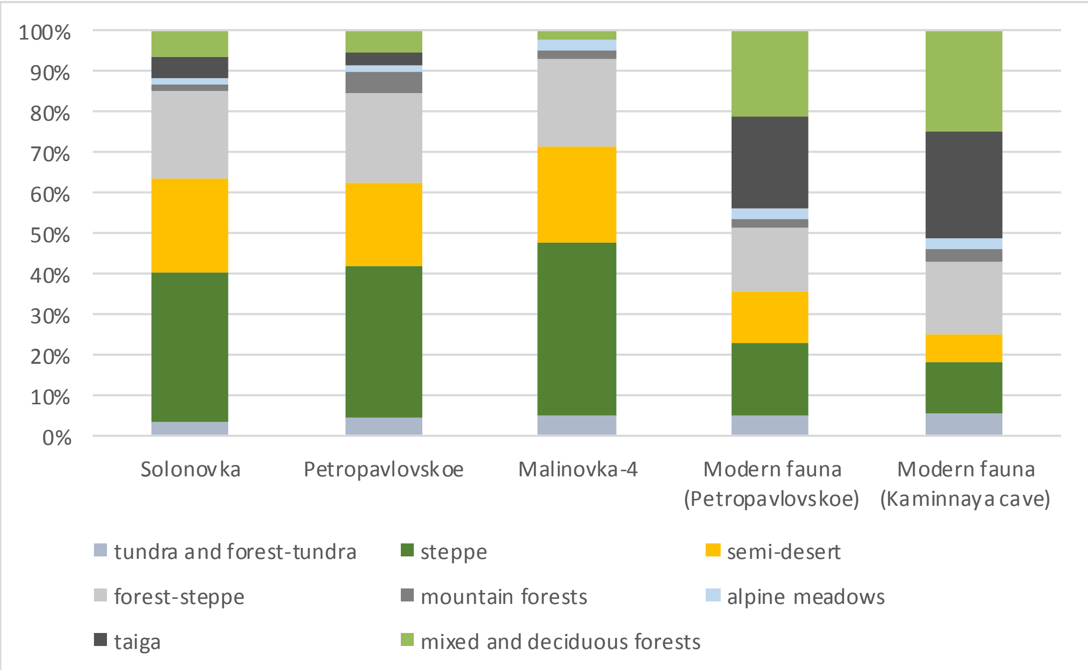


**Figure 1**. Visualization of bioclimatic spectra of small mammal's localities of the Altai and Pre-Altai plain

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# CLIMATIC OSCILLATION DURING MIS 11 BASED ON PALYNOLOGICAL RECORD FROM KRĘPA SITE (EASTERN POLAND)

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***Keywords:*** *Climate oscillation, palaeoclimatic record, MIS 11, palynology*

The Holsteinian Interglacial represents a long (~ 15 – 16 ka) and warm interglacial, which is widely correlated with Marine Isotope Stage 11c (MIS 11c; Kukla, 2003, Nitychoruk et al., 2006). In Polish record, Holsteinian is correlated with Masovian Interglacial (Marks et al., 2018).

Vegetation succession during Masovian Interglacial in Poland has been described basing on palynological records from numerous sites, mostly concentrated within eastern part of the country. Although the main outline of the succession is well-defined, some details still requires further studies, such as short climatic oscillations. Despite numerous palaeobotanical studies, the record of such events during Masovian Interglacial is still considered scarce. The main reason behind this is insufficient sampling resolution used for palynological analysis, which resulted in omitting the centennial-scale climatic events record. Material from Krępa drilling (South Podlasie Lowland) has been selected to thoroughly study such events.

Lacustrine biogenic sediments at Krępa site were drilled in a depth interval 7.65 – 21.80 m and consist mostly of gyttja, peat and silts. To provide sufficient resolution, 5 cm sampling interval was chosen. The palynological record of the Krępa core contains the entire MIS 11c succession, although the first (*Betula* phase) and last (*Pinus* phase) stages are particularly short due to sediments condensation. Both major climatic oscillations, i.e., Older Holesteinian Oscillation (OHO) and Younger Holesteinian Oscillation (YHO; Koutsodendris et al., 2010) can be distinguished within succession. In Krępa, OHO is characterised by high pollen values of pioneer taxa, mainly *Betula* and *Pinus* and significant retreat of temperate and thermophilous taxa.

The period preceding the older oscillation is particularly interesting. The record from Krępa suggests spread of *Carpinus* in the forests before climate cooling. Changes in vegetation during YHO indicate only slight decrease of summer temperatures, but the change in annual precipitation had more significant impact on vegetation. It inhibited growth of *Carpinus* broadleaf forests, whereas development of *Abies*-dominated communities was favoured.

An additional regressive episode has been identified at the end of the mesocratic stage. It can be related to the oscillation described as YHO in Brus and Ossówka (Hrynowiecka and Pidek, 2017; Nitychoruk et al., 2018). Due to the high condensation of the sediments, the record of this event is poor, nevertheless the observed spread of pioneer taxa suggests climate cooling.

Outside major oscillations, two short regressive episodes have been described during the mesocratic stage. Similar events have been described so far only from Skrzynka locality in Eastern Poland (Górecki et al., 2021). According to revised stratigraphy of Polish Middle Pleistocene (Marks et al., 2018; Hrynowiecka et al., 2019) subsequent sediments following MIS 11c succession represent substages *a* and *b* of the MIS 11 interglacial.

Pollen record suggests presence of multiple cooling periods, which are characterised by rapid decline of *Pinus* as well as by increase of *Betula*, *Juniperus* and herbs pollen values.

The last part of the Krępa succession is represented by very stable conditions without significant changes in vegetation. Moreover, pollen concentration is on low level, which might suggest the absence of dense vegetation. During this period, the palaeolake was most likely surrounded by cold steppe or sparse shrub tundra. We believe that the uppermost sediments might have originated during MIS 10 glaciation.

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# NEW FINDS OF THE FOSSIL GENUS REPRESENTATIVES OF *TONOMOCHOTA* (LAGOMORPHA, OCHOTONIDAE) IN THE KORYDORNAYA CAVE (JEWISH AUTONOMOUS REGION, FAR EAST OF RUSSIA)

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***Keywords:*** *Ochotonidae, Tonomochota, teeth, cave, Russia*

Recent finds of representatives of a new ochotonid genus *Tonomochota* (*T. khasanensis, T. sikhotana, T. major*) in the cave deposits of the Primorsky Territory (Tiunov, Gusev, 2020) allowed us to take a different look at the biodiversity of fossil Ochotonidae in the Far East of Russia. It was proposed that their range was limited to the mountainous areas of the sea coast. The analysis of the fossil material from the Koridornaya Cave (EAO) showed that the range area of the genus representatives of *Tonomochota* was much wider.

The Koridornaya Cave is located in the south-eastern spurs of Lesser Khingan Ridge, in the southern part of the Pompeevsky Ridge on the right bank of the Stolbukha River (N 48° 00', E 130° 59'). During excavations of the cave, Late Pleistocene and Holocene bone remains of large and small mammals were found in its sediments (Tiunov, Vinokurova, 2019; Voyta et. al., 2020).

The ochotonidae bone remains in the form of various fragments of jaws and isolated teeth were found throughout the depth of the deposits. The ochotonid identification was verified by the most informative first lower premolar tooth ($p_3$) (N=41). As the depth of the deposits increased, the premolar teeth had a color from light to completely black.

Dark colored teeth appear at a depth of 80-100 cm. A roe deer metacarpal bone from the layers underlying the *Beremendia* remains (depth is approximately 110–120 cm) was 14 C-dated by the AMS method to ca. 49,435 yr BP. AMS analyses of the roe deer metacarpal bone (IGANAMS-7598) were performed using equipment from the Research Resource Centre of the Laboratory of Radiocarbon Dating and Electronic Microscopy of the Institute of Geography, Russian Academy of Sciences (Moscow, Russia), and the Centre for Applied Isotope Studies of the University of Georgia (CAIS; Georgia, USA). (Voyta et. al.,·2020).

Twenty four ochotonid premolars from the Korydornaya Cave have cement in the labial folds of anteroconid. Cement is one of the main distinguishing features of ochotonidae of the *Tonomochota* genus. The rest of the teeth on an additional fold of the anteroconid $p_3$ had no cement and belonged to *Ochotona hyperborea*. The teeth with cement on the folds of the anteroconid were divided into two groups according to the ratio of the width and length of the tooth.
According to the results of the discriminant analysis which was based on morphometric features of the occlusal surface $p_{3,}$ the species belonging to two species of ochotonids was confirmed: *O. hyperborea* and *T. khasanensis*, eleven teeth were in advance assigned to the new species *Tonomochota* sp., that requires further research (Fig.). At present, they are the first finds of ochotonidae of the *Tonomoshota* genus outside the Primorsky Territory.

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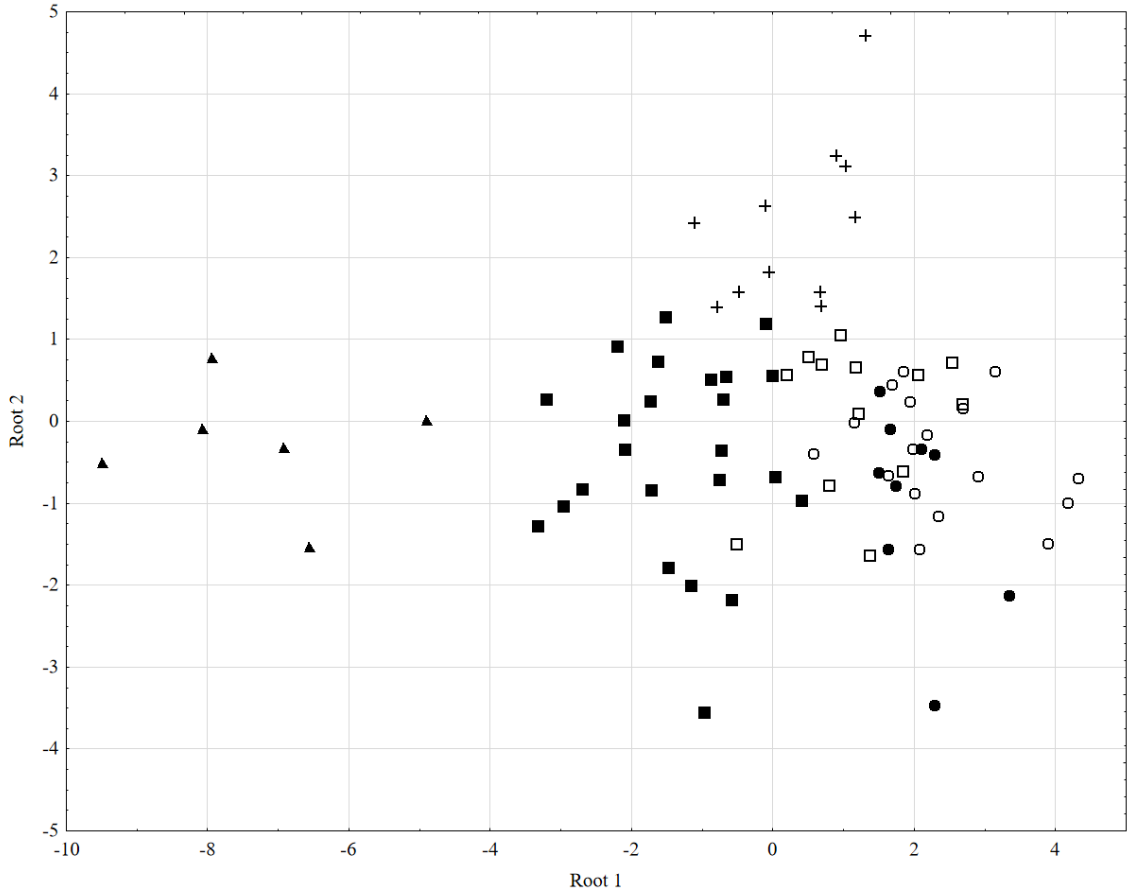


**Figure**. Scatter plot for the nine morphometric measurements of the teeth ($p_3$). Open circles – *Ochotona hyperborea* from Korydornaya Cave; solid circles – *O. hyperborea* from Sukhaya Cave; open squares – *Tonomochota khasanensis* from Korydornaya Cave; solid squares – *T. khasanensis* from Sukhaya Cave; solid triangles – *T. sikhotana* from Sukhaya Cave; crosses – *Tonomochota* sp from Koridornaya Cave

# SEDIMENTATION GAPS DOCUMENTED IN THE EEMIAN (MIS 5E) RECORD IN THE PROFILES FROM THE PUZNÓWKA AND ŻABIENIEC PALAEOLAKES (CENTRAL POLAND)

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***Keywords:*** *Eemian interglacial (MIS 5e); Sedimentation gaps; Climate changes; Palaeobotanical analysis; Central Poland*

Palynological and lithostratigraphic studies covered the sediments of several fossil lake reservoirs in the vicinity of Puznówka and Żabieniec on the Garwolin Plain in Central Poland (Żarski, 2020). The recognized pollen succession represents the Eemian interglacial correlated with Marine Isotope Stage 5e (MIS 5e), and the record also includes late-glaciation sediments (Late Saalian, MIS 6). The results present the palynological data from three profiles from the Puznówka site, of which the Pu-0 profile revealed the highest thickness of the Eemian sediments and probably comes from the deeper part of the reservoir than the other two profiles (signed Pu-19 and Pu2-19).

The analysis of the Żabieniec site included: 1. The pilot core Ża0 (Żabieniec 0) extracted from the deepest palaeolake, for which also the analysis of plant macroremains was performed; 2. cores Ża1 (Żabieniec 1) and Ża2 (Żabieniec 2) from two neighbouring smaller lakes; and 3. core Ża19 (Żabieniec 19) sampled near the pilot core Ża0, which was characterised by a large thickness of organogenic sediments and therefore particularly suitable for high-resolution pollen analyses.

Lithostratigraphic and palaeobotanical diagrams of the profiles from the Puznówka and Żabieniec sites revealed the presence of Regional Pollen Assemblage Zones (RPAZs) according to Mamakowa (1989), detailed Local Pollen Assemblage Zones (LPAZs) according to Kupryjanowicz and Granoszewski (2018) and records of changes in sediments associated with the evolution of these lakes. Special attention was paid to the Middle Eemian RPAZ 4 and 5 (i.e. *Corylus* and *Carpinus* phases) of the climatic optimum, for which records of several thermophilic taxa were found (e.g. megaspores of *Salvinia natans*, seeds of *Aldrovanda vesiculosa*).

In Pu-19 and Pu2-19, the record of interglacial succession ends in the period of the climatic optimum. The presence of all seven levels (E1-E7 RPAZs) in the Pu-0 profile and the presence of incomplete record were revealed in profiles Pu-19 and Pu2-19 (E1-E5 and E1-E4 RPAZs, were represented, respectively). In the Pu-0, special attention was paid to the transition between E5 and E6 RPAZs, which suggests the presence of a sedimentation gap. The analysis showed the absence of the E5c and E5d sub-zones in Pu-0 and possibly also the E6a RPAZs. It can be assumed that in the case of the shallow parts of the Eemian lake in Puznówka (profiles Pu-19 and Pu2-19) at the end of the hazel phase (E4 RPAZ), the lake was already very eutrophic, shallow, and overgrown with water fern *Salvinia natans* (fragments of microsporangium tissue with microspores) and nympheids. The longest record of the Pu-0 profile also indicates the rapid shallowing of the lake and the formation of a peat bog (including numerous Cyperaceae pollen and Filicales spores from the beginning of the E5 RPAZ). In this respect the pollen diagrams from the Puznówka site are similar to the ones from the neighbouring Żabieniec site (Pidek et al. 2021a).

Based on the research of Eemian lakes in northern Podlasie, Kupryjanowicz (2008) indicated a probable decrease in the groundwater level at the end of the Eemian hornbeam phase. It is a phenomenon recorded in many Eemian palaeolakes in Poland, which could have been caused by a decrease in precipitation and groundwater level as well as a decrease in climate humidity. Such a picture is in line with the reconstruction of the Eemian interglacial climatic conditions using modern pollen analogues (Pidek et al., 2021a) and with the picture of the evolution of the Eemian lakes in central Poland presented by Roman et al. (2021). It should be emphasized that there are reservoirs in the immediate vicinity that functioned as lakes throughout the interglacial period. An example is Lake Kozłów in the Garwolin Plain (Pidek et al., 2021b). In these cases, local environmental factors play a major role in the survival of the lake or its transformation into a peat bog.

*Research financed by the National Science Centre in Poland project No. 2017/27/B/ST10/01905.*

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# CHRONOSTRATIGRAPHY AND PERIGLACIAL PHENOMENA OF ZAPRĘŻYN LOESS-PALEOSOL SEQUENCE - TRZEBNICA HILLS

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***Keywords:*** *Late Pleistocene, loess-paleosol sequence, periglacial phenomena, Trzebnica Hills*

Loess can be simply defined as terrestrial silt sediment of aeolian genesis (e.g. Smalley and Jary, 2004). Due to its lithological and structural features loess-paleosol sequences (LPS) are exceptional source of palaeoclimate data constituting an indirect record of changing environmental and climatic conditions prevailing during loess deposition and early diagenesis.

Loess in Poland is a part of the northern European loess belt (NELB) stretching from the southern part of Great Britain, through Belgium, Netherlands, northern France, Germany, Poland, Ukraine and Russia (Różycki 1991). The NELB was created in the extraglacial zone of the Fennoscandian ice sheets. The LPS in this region were strongly influenced by periglacial processes and environments (Lehmkuhl et al., 2021).

The Zaprężyn LPS (λ = 17°11'52''E, φ = 51°14'44''N, 165 m.a.s.l.) is situated in an inactive sandpit within the southern morphological edge of the Trzebnica Hills – the northernmost loess region in SW Poland (Fig. 1). The area is cut by small denudation valleys of the general N-S course. Loess cover (5-6 m thick) is resting on fluvioglacial sands of the Warthanian stadial.

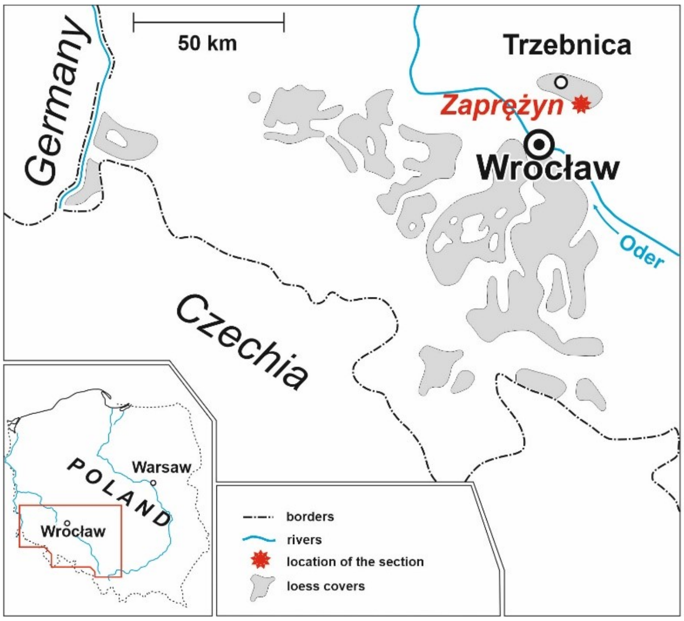


**Figure 1.** Location of the Zaprężyn LPS on the background of loess distribution in SW Poland.

The Zaprężyn LPS was initially described by Śnieszko (1995) and Szponar (1998). First comprehensive description and interpretation of the Zaprężyn LPS was published by Jary (2007) and then supplemented by Jary et al., (2016). On the basis of lithological data and three $^{14}C$ AMS-ages he designated five lithopedostratigraphic units developed during the Late Pleistocene and Holocene: two loess units (L1LL1, L1LL2 – the names of the stratigraphic units acc. to Marković et al., 2015) and three polygenetic fossil soils sets (S0, S1 and L1SS1). In the lower part of the Zaprężyn LPS the S1 pedocomplex (MIS 5) was formed. It consists of the weak illuvial horizon, the eluvial horizon and accumulation horizon. In the lower part of the accumulation horizon, slightly undulating concentrations of charcoals have been preserved. The morphological features of the S1 pedocomplex in SW Poland are very similar, hence this chronostratigraphic interpretation seems to be reasonable.

The problem of chronostratigraphic interpretation of the Zaprężyn LPS arises for the younger part of the section. The new OSL dating results done in Bayreuth and Gliwice laboratories contradict the $^{14}C$ AMS ages. OSL ages suggest, that in Zaprężyn LPS only L1LL2 unit and upper part of loess L1LL1 unit have been preserved. The loess unit L1LL2 is relatively well developed with 2-3 tundra-gley paleosols. The L1LL2 loess unit is dissected by ice wedge pseudomorphs confirming the presence of the permafrost conditions in this area during the lower pleniglacial. Taking into account the OSL ages the permafrost decay has occurred at the beginning of the middle pleniglacial. The results of OSL dating confirmed the presence of the unconformity within the upper part of Zaprężyn LPS. This can be interpreted as a proof of extremely hard climatic conditions during the Last Glacial Maximum caused by proximity to the ice sheet margin (60 km).

The Zaprężyn LPS confirms the hypothesis about the presence of a considerable climatic gradient between the northern and southern part of the SW Poland as well as meridional changes of periglacial climate conditions during the Last Glacial period (Jary, 2009, Jary and Ciszek, 2013).

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# UNCERTAIN TAXONOMICAL POSITION OF *VULPES* CF. *PRAEGLACIALIS* (KORMOS, 1932) FROM LOWERMOST LAYERS OF BIŚNIK CAVE

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***Keywords:*** *taxonomy, morphology, intermediate, ancestor, lineage*

Biśnik Cave (50°25’35”N 19°39’56”E; 406-410 m a. s. l.) is a multi-layered site located in the central part of Kraków-Częstochowa Upland, and excavated since 1992. The cave is formed by several interconnected chambers and rock shelters, originally almost completely filled with deposits. The layers in the locality are numbered downwards, and the oldest levels 19ad-19 are dated on 370-300 kyr. The fauna from these horizonts included some late Middle Pleistocene elements, like *Canis lupus lunellensis* Bonifay, 1971, *Cuon alpinus priscus* (Thenius, 1954), *Ursus deningeri* (von Reichenau, 1904), *Panthera spelaea fossilis* (von Reichenau, 1906), *Cervalces latifrons* Johnson, 1874 or *Capreolus priscus* Soergel, 1914.

Among them, an abundant fox material has been found. It is represents by almost all skeletal elements, only the complete skulls are missing. Despite the relative abundance of these materials, some material still was not formerly described and their taxonomical position remain uncertain. Since the remains of the red fox *Vulpes vulpes* (Linnaeus, 1758) were determined and recognised, second fox from layers 19ad and 19 still remain a part of mystery. Bones hold the intermediate features between the late *Vulpes praeglacialis* and early *Vulpes lagopus* (Linnaeus, 1758). Recently it was recognised as one of the latest record of *V. praeglacialis* in Europe.

# NATURAL AND ANTHROPOGENIC ENVIRONMENT CHANGES IN ŚWIŚLINA VALLEY – CASE STUDY FROM DOŁY BISKUPIE SITE (POLAND)

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***Keywords:*** *Świślina valley, sedimentation, loess, metallurgical activity, anthropogenic muds*

The study area is located in the Świślina River valley at Doły Biskupie. It is the NE part of the Mesozoic margin of the Holy Cross Mts., where the Triassic sandstones and shell limestones, marls and clay mudstones are covered with a thick layer of the Pleistocene loess (Fig. 1). The Świślina River basin is located in an area where the Prehistoric metallurgy developed (bloomerys), and later, in the Middle Ages and modern times, in the Old Polish Industrial District area (Orzechowski 2007, 2013).

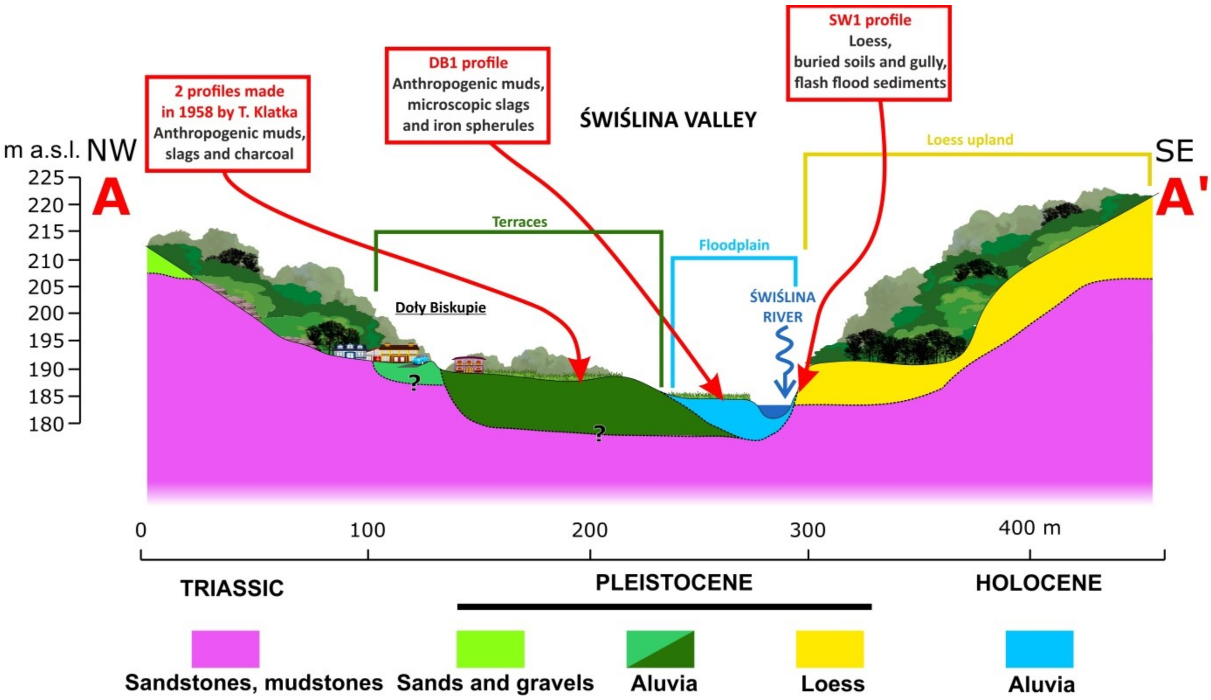


**Figure 1.** The geological cross-section of the Świślina valley in Doły Biskupie site and location of three profiles made in loess upland, terrace and floodplain area

In the studied section, the valley has steep slopes. A two steps are marked in the valley bottom as wide terrace raised 9-11 m above the river level (a.r.l) and narrow 4.5-5.5 m high flood plain (Fig. 1). Both levels are built of fine-fraction sediments (anthropogenic muds), grain size similar to loess, in which numerous traces of metallurgical activity in the form of slags with a diameter of up to 25 cm were found. These traces indicate very young age and anthropogenic genesis of these sediments accumulation, related to the metallurgy activity (Klatka, 1958).

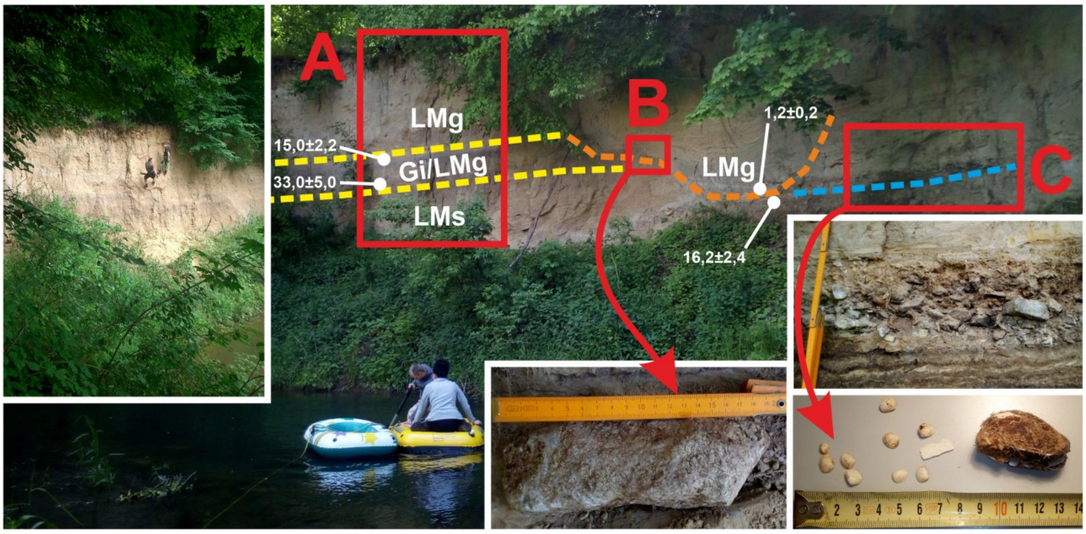


**Figure 2.** The SW1 profile (photo P. Przepióra, 2014, 2020) in right-bank of the river with OSL datings (in ka): A - buried soil complex marked in yellow, B - buried gully filled with loess and limestone boulder in the bottom marked in orange, C - lens of non-rounded limestone fragments and malacofauna marked in blue

The loess outcrop (SW1 profile) is several meters wide (Fig. 2). To the left is a complex of two buried soils (GI/LMg)(33.0±5.0 ka; UJK-OSL-132, 15.0±2.2 ka; UJK-OSL-131). On the right side of the outcrop, a buried gully filled with a series of young loess (16.2±2.4 ka; UJK-OSL-130) is visible. In the most extreme, right-site part of the outcrop, at a height of approx. 2 m a.r.l. the lens of non-rounded limestone fragments with a maximum diameter of 10 cm is preserved (1.2±0.2 ka; UJK-OSL-129). This layer is about 25 cm thick, and in its highest part, there are undamaged shells of *Unio* and other malacofauna species (Fig. 2). The coarse sediments are remnants of catastrophic flows (flash flood) from the last millennium. In the DB1 profile of the floodplain, on the lag deposits (poorly rounded gravels) there are overbank sediments, silts with an admixture of sands where the numerous microscopic iron balls (spherules) was found (Kalicki et al., 2021a, b). They occur only in the upper and middle part of the profile, above the distinct sandy flood layer. This confirming that the sediments above were redeposited from the upper part of the catchment where only the Prehistoric and Medieval metallurgical activity was confirmed i.a. large slags in the sediments in the site area (Klatka, 1958). The microslags are an excellent marker of metallurgical activity and are helpful in the interpretation of the processes, genesis and age of alluvia at the studied site.

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# PRELIMINARY RESULTS OF PALAEOGEOGRAPHIC STUDIES BASED ON THE ANALYSIS OF SEDIMENTS PALEORESERVOIR NEAR SUWAŁKI (NE POLAND)

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***Keywords***: *lake deposits, geochemical composition, palynology, Late Glacial*

A few km north-east of Suwałki (NE Poland) there is an extensive, irregularly shaped depression. It consists of several larger reservoirs connected by constrictions. Most of its area is covered with peat bogs. The basin is drained to the south-east by a small of Kamionka stream flowing to Krzywe Lake. From the north, this depression contacts the flat and undulating moraine plateau. From the east and west they are limited by sandurs (outwash). In its southern part there is a vast island of a ground moraine, probably cut by meltwater into several smaller islands (Weckwerth et al., 2019). The first identification of biogenic sediments of the analyzed site took place before the World War II (Ołtuszewski, 1937) The *Via Baltica* expressway will lead through the western part of the depression. It caused necessity a detailed geological research of this depression by numerous drillings and discovered that in the central part of this basin there was as much as 20.5 m of biogenic sediments, mainly gyttja. As a result of the rapidly progressing road works and the destruction of the peat bog, it was not possible to collect biogenic sediments from the place of the greatest thickness. Using the GEOPROPBE and a manual probe, two intact biogenic sediment profiles were drilled (OS - 10.40 m, OS2 - 5.94 m), and a third one from a small outcrop in the marginal part of the peat bog (OS1 – 2 m).

So far, palaeobotanical (palynological, diatomological, Cladocera) and geochemical (elemental composition of the sediments, $CaCO_3$ content, etc.) have been performed in the collected sediments.

In the near future, $^{14}C$ AMS dating of selected plant remains and determination of stable oxygen and carbon isotopes are planned. The results from OS profile are very interesting. The core was collected in the central part of the reservoir and 10.40 m of biogenic sediments was obtained here. The top was an embankment (2.45 m), then a thick gyttja layer (8.25 m), below there is silt (0.3 m), and clay (0.5 m). Sands and gravels were found under the limnic sediments. The embankment sediments were not investigated. The analyzed lake sediments were deposited from the Late Glacial into the Subatlantic period in the Holocene. The silt and clay sediments come from the Late Glacial and the gyttja represents the Holocene. Gyttja is highly carbonate, the content of CaCO3 ranges from 25 to 96%. The current pH of the sediments was from 6 to 7.5. In the vertical profile, a fairly large variation in the composition of the main and trace elements is observed, as well as the calculated geochemical indices. The TOC content is variable and ranges from 0.3 in the floor to 26. The sediments under the gyttja are characterized by an even higher pH, a similar abundance in calcium carbonate and a very low TOC content (0.4-1.5%). They contain more lithophilic elements in their composition.

The conducted palynological analysis shows that the functioning of the water reservoir near Suwałki began in the Oldest Dryas, when the area was overgrown by vegetation of open communities dominated by *Artemisia*, *Helianthemum nummularium*, Poaceae, Amaranthaceae, and Ranunculaceae. Slight warming of Böling resulted in high *Pinus* pollen values, which may indicate the development of rare interstadial pine forests in close proximity to the discussed reservoir. Re-cooling of Older Dryas resulted in the withdrawal of these communities and their replacement mainly with herbaceous and shrub vegetation (*Hippophaë rhamnoides*). Another warming - Alleröd, led to the development of rare pine and birch forests interstadial communities with numerous sea buckthorn. The gradual cooling of the Younger Dryas brought the domination of open communities with *Juniperus*, *Salix* and *Hippophaë* *rhamnoides* and steppe-tundra with Poaceae, *Artemisia* and *Betula nana*. The Holocene began with Preboreal warming, which caused the spread of pioneering birch forests first, then *Corylus*-dominated Boreal forests with moist *Ulmus* and *Alnus* riparian forests, and Atlantic deciduous forests with *Tilia cordata*, *Corylus* and *Quercus*. The reservoir gradually became shallower, transforming from the deeper one with numerous *Pediastrum* and *Botryococcus* (LG), to shallow and eutrophic, overgrown with Nympheids (At), which is confirmed by the Cladoceran analysis. Subboreal change in humidity conditions led to a significant withdrawal of riparian forests and an increase in the importance of the *Quercus* and *Corylus* communities with the significant role of *Picea Abies*. The reservoir was getting shallower. Human impact on the environment in the Subatlantic period caused deforestation, surface runoff, increased importance of *Pinus sylvestris* and the emergence of crop indicators, incl. *Secale cerale*, *Triticum*, *Centaurea cyanus*.

*The above research results are presented thanks to the grant of the National Science Center (2018/31/B/ST10/00976) "Geomorphological evidence and palaeogeographic implications of catastrophic floods and glacial charges of the southern sector of the Scandinavian late Vistulian ice sheet (MEASSIS)" and the funds of Nicolaus Copernicus University in Toruń as part of the Emerging Filds "Global changes in the environment".*

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# RECONSTRUCTION OF THE ICE-DOMES AND ICE-FLOWS OF BARENTS-KARA ICE SHEET DURING MIS2-6

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***Keywords:*** *glaciations, paleogeographic reconstructions, paleoglaciological modelling, Barents-Kara ice sheet*

The land surface of the Barents-Kara Sea region may have been eroded to a subaerial platform before the Quaternary (for the past 420 cal ka BP) due to both tectonic uplift and sea-level lowering erosion processes (Musatov, 1996; Nikiforov et al., 2018; Shpolyanskaya, 2019). The Barents Sea was then further eroded into its present form by the following action of ice sheets (Riis, 1992; Lasabuda et al., 2021). The previous reconstructions of the Barents-Kara ice sheet have indicated total grounded ice coverage of the Barents shelf by a 2.0-2.5 km thickness ice domes (Grosswald, 1988; Lindstrom, MacAyeal, 1989; Tushingham, Peltier, 1991; Grosswald, Hughes, 1995). The theoretical creature of this ice sheet is based on two suppositions about the glacial setting (Siegert, Dowdeswell, 1995).

The first assumption is: the Barents Sea was covered by standing sea ice, thickened due to a relatively low rate of basal melting to form an ice shelf that afterward grounded over the Barents shelf (Hughes, 1987). The model more frequently proposed implies an ice sheet when (Grosswald, 2009) thorough freezing of adjacent seas is required, with the subsequent advance of the formed ice sheet onto the continent.There are many ways to calculate the freezing of water bodies. Modifications of the well-known Stefan problem empirical dependences of ice thickness on the sum of negative air temperatures are usually employed (Sheinkman et al., 2020). The maximum thickness of the modern pack-ice cover in the Arctic is 3–4 m. Given the relatively small amount of precipitation, there is a slow rate of accumulation of snow over the ice; however, the snow layer itself weakens the freezing effect beneath it and, moreover, thickening of the ice-and-snow stratum due to precipitation at its top is compensated by thawing at its bottom. Logically, for ice to rest on the seafloor, the entire water column must freeze through. Let us take the conditions of the modern typical thermochron with the average depths of the Barents and Kara Sea being about 100 m (while more than 400 m at maximum) and the average annual air temperature at the respective latitudes being only two times lower compared to the present-day values (Kutzbach et al., 1998). According to the stepwise solution of the Stefan problem (Sheinkman, Plyusnin, 2015), the maximum possible ice thickness that could form during a typical cryochron is several tens of meters, whereas thorough freezing of the sea requires the sum of negative temperatures to be lower by more than an order of magnitude, if not, even more, compared to the present-day value, and, obviously, such cold conditions in the region are fundamentally inaccessible. The second assumption, in excess of Late Pleistocene was available during the glacial cycle for the ice-sheet build-up to have occurred (Denton and Hughes, 1981) such as the Greenland ice sheet. Authors found (Kashdan, Sheinkman, 2021), based on paleoglaciological modeling, that a significantly smaller ice sheet may have formed over the north-eastern and south-eastern sector of Barents Sea if either of these two assumptions were incorrect.

However, there are few available data to assess the validity of these two assumptions for glaciations prior to the Late Weichselian. Therefore, in order to ascertain the maximum possible dimensions of the ice sheet, the numerical ice sheet model was run for at least MIS2-6 of model time, accounting for a sea ice-induced ice shelf. The ice sheet reached a steady state over the modem submarine bedrock topography of the Barents Sea within MIS2-6 of model time. The ice sheet had an ice dome over the northern Barents Sea near Nordaustlandet, 0.9-2.2 km thickness, and local ice domes over the central Barents Sea 0.6-0.9 km thickness. The ice sheet was drained mainly by ice streams within Bjornoyrenna, Storfjordrenna, and the relatively small flows at the northern and eastern margin of the Barents Sea. The authors considered stochastic simulations to show the verification and validation of the model, a subaerial platform was applied as the bedrock input. The resulting ice sheet had a simple parabolic profile with a maximum thickness of 0.9 km for the central ice dome, 0.6 km for local ice domes, and a few noticeable areas with relatively high ice velocities near the ice shelf. The underlying bedrock configuration thus controlled geometry of ice flows and ice dynamics of ice sheet during MIS6.

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# GIANT SHORT-FACED HYENA *PACHYCROCUTA BREVIROSTRIS* (CARNIVORA, HYAENIDAE) FROM LOWER PLEISTOCENE OF CRIMEA (TAURIDA CAVE)

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***Keywords:*** *Pachycrocuta brevirostris, lower Pleistocene, Crimea*

Giant short-faced hyena *Pachycrocuta brevirostris* (Gervais, 1850) was the largest known Hyaenidae Its appearance in the beginning of Early Pleistocene of Europe, called '*Pachycrocuta* event' coincides with major changes in large mammal faunas (Croitor, Popescu, 2011). The last appearance of *P. brevirostris* in Eurasia was in the middle Pleistocene, ~0,5 Ma (Marciszak et al., 2021). *P. brevirostris* was adapted to dismembering large carcasses and transporting them to a den (Palmqvist et al., 2011). This means that short-faced hyenas could have competed with early *Homo* for large ungulate carcasses. There is evidence that early humans and short-faced hyenas scavenged off each other (Espigares et al., 2013). On this basis, it is suggested that presence of *P. brevirostris* was one of the limiting factors of early Homo activity.

We studied dentition of *P. brevirostris* from Taurida cave (Crimea). All studied finds come from the main bonebearing layer and have an age 1.8-1.5 Ma (Early Pleistocene, Late Villafranchian) (Lopatin et al., 2019; Vislobokova et al., 2020). About 70 isolated teeth, two large fragments of skulls of P. *brevirostris*, one almost complete skull, several lower jaws of adults and juvenile individuals, numerous elements of the postcranial skeleton, as well as large number of hyena coprolites were found in southern corridor of the cave. Many bones of large ungulates were found here with hyena bite marks. All of this suggests that Taurida cave was used by *P. brevirostris* as a den. Morphometric characteristics of 51 adult teeth were examined. Morphometric data of *P. brevirostris* from other Eurasian localities was used for comparison. Short-faced hyenas from Taurida cave have a singular set of dental morphometric features which combines primitive and advanced features. P3 and p3 are quite large and robust; p2 and p3 do not have anterior accessory cusps and m1 talonid only has 1 central cusp. All of these features are considered advanced in *P. brevirostris* evolution. At the same time short-faced hyenas from Taurida have some primitive features: P3 still retains an anterior accessory cusp, P4 is relatively small and its parastile is shorter than the protocone, p4 is shorter than m1. This combination of primitive and advanced features could be explained by the fact that *P. brevirostris* from Taurida cave might have a transitional morphotype between earlier and later forms of Eurasian *P. brevirostris*. This hypothesis is also supported by the fact that migrations of short-faced hyenas from Asia could have gone through the territories adjacent to Crimea.

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# SUBSISTENCE OF THE IVOLGA TOWN OF XIONGNU EMPIRE

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In the process of excavation of the Ivolga Town of Xiongnu Empire we obtained very interesting data, we collect shells of molluscs and bone remains of different wild vertebrates, obtained palynological specimens (Khenzykhenova et al., 2020).

Multidisciplinary investigations were performed, including palynological and archaeozoological studies. Palynological data reflects the palaeovegetation of the region and shows the abundance of forested landscapes in the past. The fauna was made of molluscs (7 taxa), fishes (14 taxa), amphibians (3 taxa), reptiles (1 taxon), and wild mammals (18 taxa).

The species composition and environmental data show the mosaic character of landscapes surrounding the ancient settlement: taiga and forest, steppe and forest-steppe biotopes, as well as meadows in the Selenga valley with the prevalence of open steppe spaces. In the era of the Xiongnu Empire, the climate was less arid than it is now.

The contained of the charred macro botanical remains is numerous in the Ivolga archaeobotanical collection and the analysis of it is still continuing. Therefore, we have totally analyzed 16 samples. They represent all phases of settling of this excavated area.

A total more than 3000 seeds/fruits and 1600 fragments of chaff have been obtained from 16 samples. Seeds/fruits belong to cultigens of 5 species – *Hordeum vulgare* var. *nudum*, *H. vulgare var. vulgare*, *Triticum aestivum, Panicum miliaceum* and *Setaria italica*. The broomcorn seeds millet caryopses are dominant among all seeds.

Seeds of other cultural plants are not so numerous: caryopses of foxtail millet, caryopses of 6-row hulled barley, caryopses of 6-row naked barley and seeds of barley, which we were not able to distinguish between these species. In the Poznań Radiocarbon Laboratory were obtained six reliable grain dating for the first time.

# GEOLOGICAL STRUCTURE AND LOWER-MIDDLE PLEISTOCENE FOSSIL FAUNA OF NAGORNOE 1 SECTION (ODESSA REGION, UKRAINE)

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***Keywords:*** *fossil mollusks, herpetofauna, small mammal, correlation, Pleistocene*

The Nagornoe 1 geological section (lat: 45°25'04"N, long: 28°26'47"E) has been studied by O. I. Krokhmal in 1990 on the cliff of east shore of the Kagul Lake in the deposits of V terrace of the Danube River in the south-west of Nagornoe village. O. I. Krokhmal studied the small mammal fauna and V. Yu. Ratnikov described the fossil herpetofauna (Ratnikov & Krokhmal, 2005), the freshwater mollusks were investigated by P. F. Gozhik (Gozhik, 2006), brackish-water mollusks and ostracods were given in the monograph (Mikhailesku & Markova, 1992) and article (Krokhmal & Dykan, 2006).

The Nagornoe 1 section includes from top to bottom the following layers: **1** – modern soil, **2** – loesslike loam, **3** – reddish-brown paleosol, **4** – sands and aleurites greenish-gray with the shells of freshwater ostracods *Ilyocypris bradyi, Ilyocypris gibba, Ilyocypris caspiensis (*syn. *I. bella), Cypria candonaeformis, C. nagorniensi, C. longa, Cyprideis torosa* and others. **5** – sands of gray, clayey, horizontal and cross-bedding, with gravelstones and diverse fauna of molluscs and small vertebrates (locality Nagornoe 1, I). Ostracods are presented *Ilyocypris gibba, Candeniella subellipsoida, Cypria* elongate, *Ilyocypris brady, Potamocypris tschaudae.* A reach fauna of freshwater mollusks together with *Didacna baericrassa* has been collected: *Dreissena polymorpha, Theodoxus danubialis, Th. fluviatilis, Viviparus tiraspolitanus, V. kagarliticus, V. zsigmondyi, V. rhodensis, V. aethiops, Fagotia nagorensis, Microcolpia longus, Unio tiraspolitanus, U. pictorum, Crassiana hassiae, C. bodamica, Potomida litoralis, P. kinkelini* and others. Locality has also produced 75 bone fragments of the herpetofauna representing seven families: *Triturus cristatus*, *Bombina bombina*, *Pelobates fuscus*, *Pelobates* sp., *Bufo raddei*, *Bufo* (*bufo*) sp., *Bufo* sp., *Rana ridibunda*, *Rana* (*esculenta*) sp., *Rana* (*temporaria*) sp., *Rana* sp., Anura indet., *Lacerta* cf. *agilis*, Colubrinae indet., *Natrix natrix*, *Natrix* sp., Serpentes indet. Taxonomic composition of small mammal: *Sorex* cf. *runtonensis* (1), *Sorex* cf. *subaraneus* (1), *Crocidura* sp. (2), *Talpa* cf. *fossilis* (2), *Desmana* sp. (2), *Ochotona* sp. (1), *Spermophilus* sp. (31), *Allactaga* sp. (1), *Spalax* sp. (1), *Cricetus* sp. (2), *Allocricetus* sp. (1), *Apodemus* sp. (1), *Ellobius* sp. (5), *Clethrionomys* ex gr. *glareolus* (3), *Prolagurus posterius* (2), *Eolagurus luteus* (1), *Mimomys intermedius* (8), *Arvicola mosbachensis* (50), *Stenocranius gregaloides* (2), *Terricola arvalidens* (34). **6** – grayish-green clay, **7** – sands light gray with gravel and rare molluscs *Viviparus, Dreissena, Theodoxus* and others, as well as rare bones of small mammals *Ochotona* sp. (1), *M. intermedius* (21), *Villanyia petenyii* (2), *Allophaiomys pliocaenicus* (1) and *Terricola arvalidens* (1) (locality Nagornoye 1, II), **8** – sands light gray, interbedded with clay, **9** – sands light gray from fine- to inequigranular, with lenses of gravel, with horizons of millstone grit and gravelstones in the form of slabs. In lenses of gravel with cross-bedding of channel-type the freshwater mollusks *V. tiraspolitanus, V. kagarliticus, Dreissena polymorpha, Theodoxus danubialis, Fagotia esperi, Lithoglyphus naticoides* and rare small mammal *M. intermedius* (14), *S. gregaloides* (4) has been collected (locality Nagornoye 1, III). **10** – sands light gray, diagonal and horizontal bedded with interbedded of gravelite. Molluscs are presented *Theodoxus transversalis, Viviparus* cf. *tiraspolitanus, Lithoglyphus* sp., *Bithynia* sp. and others. **11** – gravel with interbedded ferruginous clays and greenish-gray sand with gray sandstone, with bones *Ochotona* sp. (1), *Spalax* sp. (1), *Prolagurus* cf. *ternopolitanus* (1), *M. intermedius* (3), *Allophaiomys deucalion* (3) (locality Nagornoye 1, IV).

The stratum of liman sediments of the terrace (the layers 4-8) has normal magnetization of the Brunhes orthozone (Mikhailesku & Markova, 1992).

Locality Nagornoe 1, I (MIS 13, Interglacial Noordbergum, Lubny, late Tiraspol faunistic complex). The species *I. caspiensis* is part of the biostratigraphic subdivision "*Ilyocypris caspiensis-Leptocythere caspia* complex zone". The zone is identified in the sediments of the fifth terrace of the

Danube river and belongs to the upper Early Neopleistocene. Molluscs from the bone-bearing deposits of the Nagornoye-1 section (layer 5) are represented by typical Tiraspol species *Viviparus tiraspolitanus, V. kagarliticus, V. acerosus, P. littoralis, P. kinkelini, Unio tiraspolitana, U. pictorum, Fagotia nagorensis* and many others. Tailed amphibians are represented by the species *Triturus cristatus*. This is the second find of a crested newt in a fossil state in Ukraine.

The most indicative in the stratigraphic sense is the find of the remains of the Mongolian toad *Bufo raddei*, which inhabited the territory of Eastern Europe until the beginning of the Middle Neopleistocene. In the small mammal fauna presents the ancient root-toothed voles of *Mimomys* as well as archaic steppe lemmings of *Prolagurus* genus. The genus *Mimomys* is represented by *M. intermedius* and the genus *Prolagurus* is represented by *P. posterius* (A/L=51,0-54,0, C/W<15). The archaic water vole *Arvicola mosbachensis* (L=3,36 mm, SDQ=136,4, SZQH=2,47) is the most characteristic for this fauna. Voles represented mainly by *Microtus gregaloides* and *Microtus arvalidens*. Such species composition is very characteristic to Nagornskaj association of small mammal (Krokhmal, 2014a), described in reference section Nagornoe 1 in Lower Danube River basin (Krokhmal & Rekovets, 2010). Rich Nagornoe 1, I small mammal and mollusk locality could be correlated with Lubny Interglacial and MIS 13. This locality is also very important because it contain the brackish-water and freshwater mollusk fauna of Late Chauda basin.

Locality Nagornoe 1, II (MIS 17, thermomere Cromerian "type", Martonosha, typical Tiraspol faunistic complex). Neopleistocene voles are represented by species *M. intermedius* (L=3,226 mm, SDQ=142,86, SZQH=2,59) and *T. arvalidens*. Species *Allophaiomys pliocaenicus* and *Villanyia petenyii* undoubtedly redeposited (Krokhmal, 2014a).

Locality Nagornoe 1, III (MIS 17, thermomere Cromerian "type", Martonosha, typical Tiraspol faunistic complex). Numerous remains of *M. intermedius* as in locality Nagornoe 1, II are present (Mikhailesku & Markova, 1992).

Locality Nagornoe 1, IV (MIS 41-53, Waalian, Kryzhanivka, Odessa faunistic complex). The presence of *Prolagurus* cf. *ternopolitanus* and *A. deucalion* (A/L=41,17, B/W=29.07, SDQ=113,7) indicates to the Early Eopleistocene (Krokhmal, 2014b).

The subaquatic sediments of the Nagornoe 1 section (beds 4-11) are overlain by the Zavadovka (Holsteinian) Interglacial paleosol.

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# NEW AND REVISED MAGNETOSTRATIGRAPHIC AND $^{40}$AR/$^{39}$AR AGE CONSTRAINTS ON THE AKCHAGYLIAN STAGE OF THE CASPIAN SEA (LATE PLIOCENE – EARLY PLEISTOCENE)

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***Keywords:*** *Integrated stratigraphy, Caspian Sea, Akchagylian, Early Pleistocene*

The reorganisation of the global climate in the late Pliocene linked to enhancement of the Atlantic Ocean Thermohaline Circulation (AOTC), instigated a transition to glacial-interglacial cyclicity in the Quaternary. Enhancement of the AOTC amplified atmospheric precipitation over the Eurasian interior strengthening Northern Hemisphere Glaciation. Increased rainfall on the vast Russian Plain drained into the endorheic Caspian Sea, which makes the Caspian geological record highly potential for tracing atmospheric precipitation changes. Two major palaeohydrological events in the Caspian Sea, the Akchagylian transgression and the Akchagylian marine incursion, led to a five-fold enlargement of the Caspian Sea surface area and transformed the basin palaeoecology enabling active interregional faunal dispersals. The Akchagylian Stage still lacks an unequivocal age model with two age constraints – the "long Akchagylian" (3.6–1.8 Ma) and the "short Akchagylian" (2.7–2.1 Ma) standing on magnetostratigraphic studies of geological records in Turkmenistan and the Kura Basin, respectively. The age discrepancies also exist within the Kura Basin, where the fossil mammal-bearing Kvabebi locality with Akchagylian marine fauna was magnetostratigraphically dated at 3.2 Ma. In this paper, we try to resolve the age contradictions for the Akchagylian Stage. We revisit the Kvabebi (Georgia) and Kushkuna (Azerbaijan) sections of the western Kura Basin and provide new magnetostratigraphic and $^{40}$Ar/$^{39}$Ar age constraints on these marginal Akchagylian deposits. Moreover, we revise the magnetostratigraphy of 25 geological records from the eastern (Turkmenistan) and western (the Kura Basin) coasts of the Caspian Basin and propose a new unified age model for the Akchagylian Stage with following paleoenvironmental intervals: 1. Intrabasinal Akchagylian freshwater-mesohaline transgression at 2.95±0.02 Ma; 2. Akchagylian marine incursion through establishment of a Caspian-Arctic connection (2.75–2.45 Ma); 3. Akchagylian–Apsheronian boundary highlighting a Caspian-Black Sea connection at 2.13 Ma. The sudden expansion of the Caspian Sea at 2.95±0.02 Ma potentially correlates to the interglacial intensification of the AOTC between 2.95 and 2.82 Ma. The new ages constrain a much shorter (2.95–2.1 Ma) Akchagylian than in previously mentioned regional geological time scales (3.6–1.8 Ma) and strongly appeal to reconsider the ages of numerous archaeological and mammalian sites in the Caspian region.

# SEDIMENTARY CHARACTERISTICS OF BAER KNOLLS DEPOSITS IN THE VOLGA RIVER DELTA

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***Keywords:*** *Late Pleistocene, Caspian Sea, Underwater bedform accumulation, Khvalynian time, stratigraphy, sedimentology*

Baer knolls (BK) are elongated ridge and depressions often close to the sub-latitudinal orientation sometimes spatially isometric that are widespread in the entire Northern Caspian Region up to 0 m a.s.l. (the upper limit of the Late Khvalynian sea transgression). Several opinions on the origin and time of formation of BK exist. Researchers interpret the material composing a particular landform, the features of its spatial distribution and orientation very differently. The aeolian opinion is the most popular among the scientific community. The relevance of this research is in studying BK as landforms dated back to the stage of the Late Khvalynian transgression as the key to restoring the history of the Caspian Sea and environmental features that existed on its shores during the Late Pleistocene — Holocene transition. The research objective is detailed studying of the internal structure of BK and their lithological features for a more reliable interpretation of their genesis. The main problem is incomplete and often ambiguous data. This article aims to revise previous interpretations of various researchers on the proposed genesis by receiving new data based on modern methods as a supplement to an earlier publication (Badyukova, 2018). For the first time, ICP-AES analysis is performed in this article for sediments from several Baer knolls at the Volga Delta. BK consists of two lithological formations based on chocolate clay. We divided Baer knoll strata into lithofacies 1 (LF1), lithofacies 2 (LF2) strata and chocolate clays as a basement (CC) (Fig.1).

Four radiocarbon dates from Yaksatovo, Dolgiy, and Sarai-Batu knolls in the Volga Delta range from 16.4 to 13.8 ka cal B.P. Results demonstrate that deposition LF3, and LF2 correspond to the period from Oldest Dryas cold event to Bølling-Allerød warm stage.

Chocolate clay (CC) and Volga alluvium were significant sources of material for the knoll formations. Nonetheless, for lithofacies 1, it was also sandy material lying below the CC. BK have been formed during the transition of Late Khvalynian and Early Holocene time. The BK material cannot be attributed to the aeolian genesis because of lithological characteristics. According to sedimentological data, the formation of the knolls took place in brackish subaquatic conditions, where a low-energy current occurred. Simultaneously with the accumulation of sandy material and interlayers of redeposited shells, there was a background deposition of clay particles. Thus, BK are analogues of river bedforms appearing as the result of turbulent flow, like ripples and river dunes.

*This research was supported by a grant from the Russian Science Foundation (№ 20-77-00068).*

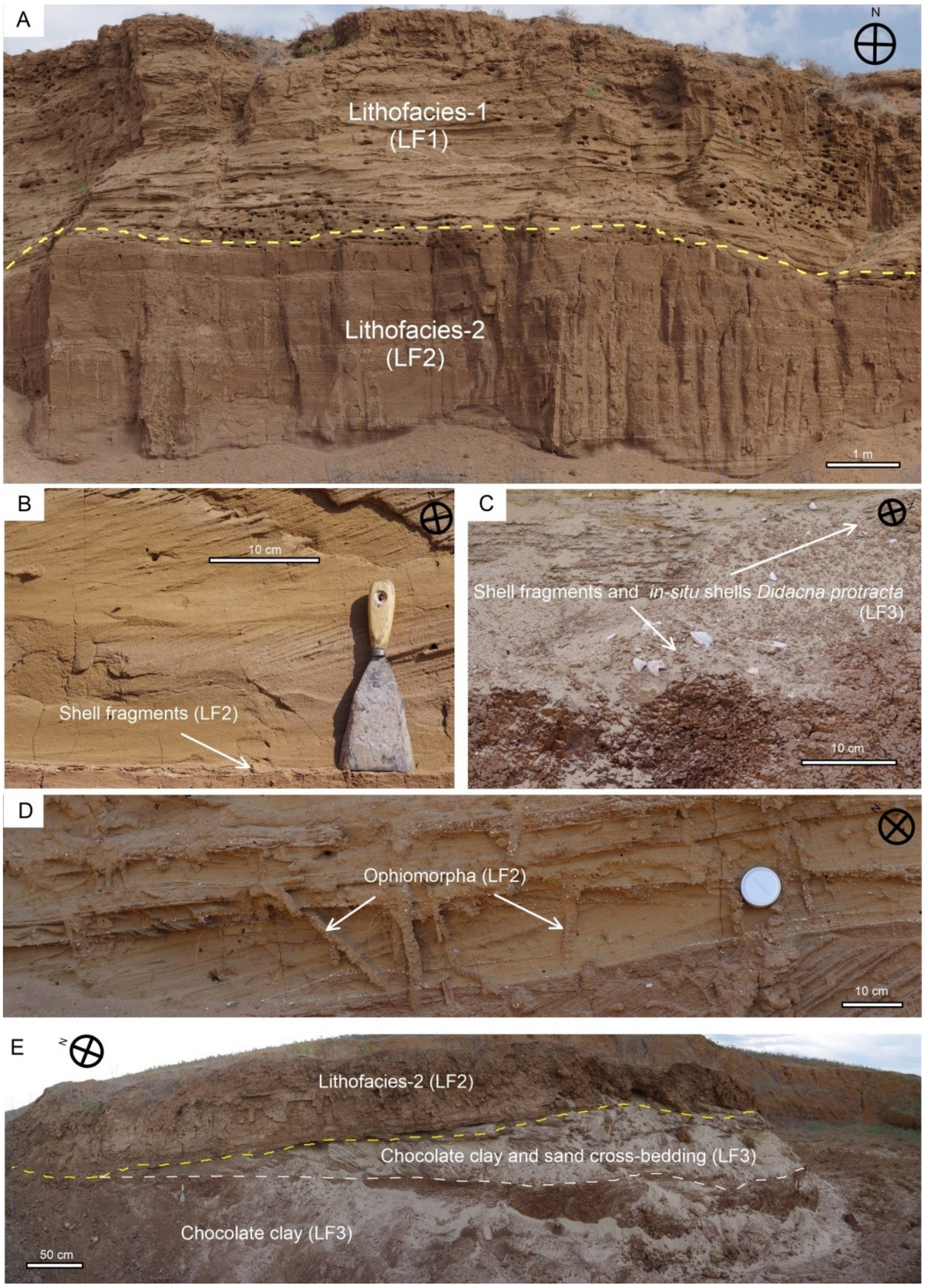


**Figure 1**. Sedimentary architectures and lithofacies of Baer knolls. (A) Yaksatovo knolls erosional contact between LF1 and LF2. (B) Cross-lamination sand and compacted coarse sand layer with shell detritus (LF1). (C) Mollusc shells *Didacna protracta, Dreissena rostriformis* in sand lenses (LF3). (D) *Ophiomorpha* burrows presented in LF2 in Nartovo knoll. (E) Dolgiy knolls cross-lamination of sand and chocolate clay and erosional contact between LF2 and LF3.

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# THE TIMING AND SEDIMENTARY FACIES OF EARLY KHVALYNIAN STAGE IN THE LOWER VOLGA RIVER REGION (NORTHERN CASPIAN LOWLAND)

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***Keywords:*** *Caspian Sea, Late Pleistocene, sedimentology, stratigraphy, radiocarbon dating*

The history of the Caspian Sea region is inextricably linked with transgression and regression events during the Quaternary. Early Khvalynian basin was one of the largest in the history of the Caspian Sea during the Late Pleistocene, which predetermined the development of the modern environment in this region (Svitoch, 2014). In the maximum stage of transgression, the coastline has reached the height of 45-50 m asl (Fedorov, 1957) with an area up to 950,000 km$^2$ (Varuschenko et al., 1987). Evolution of the Early Khvalynian basin took place in several stages, which correspond to an altitude of sea-level terraces 45-50, 30-32, 20-22 m asl respectively (Fedorov, 1957).

During the Early Khvalynian stage on the north-west of the basin unique sediments, predominated by clay (chocolate clay) were deposited (Pravoslavlev, 1908). Chocolate clay is widespread and covers the area of the Middle and Lower Volga River Valley, the Ural River Valley, Saikhin-Botkul-Baskunchak lakes, and system of Sarpa lakes (Fedorov, 1957, Yakhimovich et al., 1986). The chocolate clay contains silt and sand layers with mollusk shells *Didacna protracta, D. ebersini, Dreissena polymorpha, Dreissena distincta, Monodacna caspia, Hypanis plicatus*, etc. (Yanina, 2012). The occurrence of chocolate clay is sporadic and depends on bed morphology features. Their thickness is varying from 1.5 m in the flat area to more than 12 m in paleodepressions. In this research, we provide a comparison result of sedimentological analysis and 80 radiocarbon dating of the khvalynian deposits obtained from sections in the Lower Volga River region.

Seven lithofacies (LF1-LF7) are recognized based on lithology, color, fauna in studied sections in the Lower Volga River region. According to radiocarbon dates, the age of the Early Khvalynian stage in the Lower Volga Region is varying between 25-12.6 cal ka BP. The chocolate clay deposition in the Lower Volga region corresponds to an interval between 16.4-12.7 cal ka BP.

The most density of the radiocarbon dates is between 14.1-13.5 cal ka BP. The interval between 14.5-14.1 cal ka BP is characterized by the absence of mollusc shells and the deposition of massive chocolate clay. Comparison radiocarbon data of mollusc shells and lithofacies characteristics of Khvalynian sediments reveal a certain pattern with the main late Pleistocene climatic events and allow us to reconstruct the depositional history during the Last Glacial Maximum to Younger Dryas at the Lower Volga River region.

*This research was supported by a grant from the Russian Science Foundation (№ 20-77-00068).*

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# THE PALEOECOLOGY OF LARGE MAMMALS OF MINUSINSK DEPRESSION IN LATE PLEISTOCENE BY STABLE ISOTOPES DATA

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***Keywords:*** *Late Pleistocene, mammoth fauna, Siberia, paleo-diet, stable isotopes*

Paleo-dietary reconstruction through the analysis of stable isotope ratios in skeletal, dental and soft tissue remains is one of the most productive modern methods of studying various aspects of ancient humans and animals life. The many research groups all over the world studying this subject (Bocherens et al., 2015; Jürgensen et al., 2017; Kuitems et al., 2019; Rey-Iglesia et al., 2021; and others). The stable isotope data of various elements are used for paleo-dietary reconstructions. However, the most important among them is the nitrogen and carbon isotope ratios, as elements directly related to the trophic level of animals. Not only the diet of animals, but also climatic conditions can have a huge impact on isotopic indicators. Passing by these factors can lead to erroneous conclusions about fossil animal's diet. Therefore, for correct reconstructions, it is necessary to study changes in time specifically in relation to specific populations, and it is necessary to identify the "isotopic baselines" for different regions (Britton et al., 2012).

The Minusinsk depression is located in the south of Central Siberia and is bounded on three sides by the Eastern and Western Sayan (east and south) and Kuznetsk Alatau (west) mountain structures. Thus, the Minusinsk depression seems to be a very convenient object for characterizing the "isotopic baselines" of fossil animals, since it is a conditionally "isolated" ecosystem with natural boundaries. The authors obtained new data and summarized published data of nitrogen and carbon isotope ratios on 11 species of Late Pleistocene large mammals from this region. It's *Crocuta spelaea*, *Panthera spelaea*, *Mammuthus primigenius*, *Equus ferus*, *Coelodonta antiquitatis*, *Rangifer tarandus*, *Megaloceros giganteus*, *Bison priscus*, *Ovibos moschatus*, *Saiga tatarica* and *Ovis ammon*. Most currently obtained data for *Rangifer tarandus* – 7 specimens (Iacumin et al, 2000.), *Coelodonta antiquitatis* – 6 (Rey-Iglesia et al, 2021; authors data) and *Mammuthus primigenius* – 5 (authors data). For other species, the stable isotopes ratio is known for 1 or 2 specimens. Most of the data was obtained for animals dated to LGM. Available comparative data on reindeer, mammoths and woolly rhinos showed some differences in the isotopic ratios in comparison with other regions of Siberia.

The $\delta^{13}C$ and $\delta^{15}N$ isotope ratios for woolly mammoths of Minusinsk depression LGM were slightly different from mammoths in north of the Eastern and Central Siberia (Kuitems et al., 2019). To the Minusinsk depression mammoths the $\delta^{15}N$ values were slightly lower, and the $\delta^{13}C$ values were higher than in the northern populations. The LGM rhinos of the Minusinsk depression were close to the post-LGM rhinos of Eastern Europe and the Urals, in contrast to other rhinos in Southern and North-Western Siberia (Rey-Iglesia et al., 2021). This is especially noticeable for $\delta^{15}N$ and, to a lesser extent, for $\delta^{13}C$. The isotope values of the LGM reindeer in the Minusinsk depression are very different from the post-LGM reindeer in the Kansk-Rybinsk basin. Despite the close location (130 km to the northeast) of the regions, these populations of reindeer differ greatly in terms of $\delta^{15}N$, which are about 2 points higher in the reindeer of the Minusinsk depression (Iacumin et al., 2000).

Currently available data of $\delta^{13}C$ and $\delta^{15}N$ isotope ratios do not yet allow us to assess how stable the noted characteristics of the Minusinsk depression animal's populations. Nevertheless, these data make it possible to characterize in the most general form the "isotopic baselines" of the Late Pleistocene mammoth fauna of the region. The obtained data clearly indicate that during LGM in the Minusinsk depression the animals living conditions could be markedly different from the living conditions of the same species in other regions of Siberia. Further studies of $\delta^{13}C$ and $\delta^{15}N$ isotope ratios for fossil mammals of the region will make it possible to better characterize the paleogeographic setting in the Pleistocene of Southern Siberia.

*This work was supported by the Russian Science Foundation (the grants No 21-77-00029, https://rscf.ru/en/project/21-77-00029/).*

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# AEOLIAN FORMS OF THE RELIEF OF THE NADYM OB AREA AND FACTORS OF THEIR FORMATION

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***Keywords:*** *aeolian forms of the relief, holocene, Nadym Ob area, dune*

Sand massifs are a common element of landscapes in many regions of the world. The modern relief of Western Siberia is the result of a combination of different processes: permafrost, aeolian and etc. The main factors influencing the development of aeolian processes are: features of the geological structure, climatic conditions, including prevailing winds, as well as vegetation and soil cover. Modern forms of aeolian relief are represented mainly by dunes and manes.

This study examines the territory of sand swelling, located in the subzone of the northern taiga of Western Siberia, in the valley of the river Nadym. In August 2017-2018 expeditionary studies were carried out 30 km from the city of Nadym, on a sandy massif stretched from west to east by 1 km, from north to south by 2 km, up to 12 m high (Malikova, 2020). On the studied territory of the second above-floodplain terrace, aeolian formations are distributed, which form sandy massifs (Zemtsov, 1976). Among which there are ancient and modern dunes (Volkov, 1976). The activation of aeolian processes was influenced by human economic activities: sand extraction, transport, pipelines, road construction and etc. therefore, the Late Holocene aeolian landforms are poorly fixed.

In order to study the features of the distribution of sand massifs, the methods of remote sensing were used. The classification of Markov (Markov, 1955) and Fedorovich (Fedorovich, 1983; Leontiev and Rychagov, 1988) was used distinguish aeolian landforms. Analysis of highly detailed satellite images and field research materials showed the spread of various forms of aeolian relief on the territory of the Nadym Ob region. The following relief forms were identified: 1-fixed longitudinal hollow-ridged dunes, 2-overgrown blow-out hollows, 3-roll-shaped dune, 4-rake-shaped blow-out hollow, 5-rake-shaped dune, 6-dune bars, 7-complex blow-out hollows, 8- complex of complex arcuate dunes, 9-complex roll-shaped dunes, 10-large circular dune, 11-inter-ridge blowing hollow, 12-parabolic dunes, 13-peripheral ramparts, 14-semicircular large dunes with polygonal vein cracks.

Wind direction and strength are the main factors in dune formation. The spatial distribution of the dunes within the sand blowingfits well with the directions and strength of the prevailing winds. The most active movement of the dune occurs in summer, therefore, almost all aeolian forms are concentrated in the southeastern part of the sand blowing, where sand moves under the action of northerly and northwestern winds. Despite the fact that the winds of the southern rumba are close in strength and intensity to the northern winds, most of these winds occur during the cold season. For this reason, the dunes remain practically immobile during the winter season. The frozen and snow-covered sand is not subject to waving, and therefore accumulative relief forms are practically not observed in the northern parts of the territory.

The modern period of dune formation began after 1500 AD (Zykina et al., 2017). Since that time, the aridization and the strength of the northerly winds have intensified, which has become the reason for the expansion of the dune, which continues to the present. Strengthening of the northerly winds is confirmed by the location of the highest dunes in the southeastern part of the swell.

To assess the deflationary potential of the region, the climate factor (C), proposed by Lyubtsova (Lyubtsova, 1997), calculated by the formula:

$$C = 102v3 / (H / T + 10) 2,$$

where C is the climate factor; v is the average annual wind speed, m / s; H is the annual amount of precipitation; T is the average annual temperature. For the calculations, the data of meteorological observations from the meteorological station Nadym airport from 1955 to 2020 were used. (www.gismeteo.ru, Sizov, 2015).

The greatest intensity of deflation was observed in the 70s and 90s. XX century, when the climate factor reached C = 2.78. At present, it has decreased to the minimum values for the entire observation period (C = 0.001). What speaks about the cyclical nature of climatic fluctuations. During the observation period in this area, deflation was moderate and strong, but in the last decade, there has been a tendency towards a decrease in deflation. This is probably due to an increase in temperature and precipitation in the study area in recent years (Malikova, 2021).

Study of large sand blowingin the Nadym River valley, using remote sensing methods, made it possible to clarify and detail the features of the aeolian landforms of the study area. On the basis of archival and modern satellite imagery, a highly detailed analysis of the formation processes of aeolian landforms has been carried out. Use tiles heights helped identify microdepressions and mark landforms imperceptible at spaceshots and 3D-visualization allowed to most clearly show the results.

*The study was carried out within the framework of the state assignment of the IGM SB RAS and RFBR grants 19-05-00513 and 20-05-00801.*

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# RADOCHOWSKA CAVE (SUDETY MTS, SW POLAND) – ONE OF THE EUROPEAN CAVES WITH BEAR CULT?

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***Keywords:*** *assemblages, bear cult, Late Pleistocene, Holocene, taphonomy, lost*

Radochowska Cave (50°21’31”N 16°49’9”E; 468-460 m a. s. l.; kat. no. S - 3.1). The locality is known more than 300 years (Kahlo 1757), however the exploration of its sediments was started only in 1933 by P. Heinrich who made it available for tourists. Systematic excavations were carried out by J. Frenzel in 1935 and by L. Zotz in 1936. The deposits of this 265 m-long cave are represented by brown and grey loams with limestone rubble. L. Zotz found also “Palaeolithic artefacts” made of quartzite. The excavations in 1983 were taken as results of the German works. New profiles outside the cave were uncovered, and the analyses excluded the presence of the Palaeolithic man. Unfortunately, most of the bone remains from the pre-war studies were lost and thus only a small part could be re-examined. Late Pleistocene fauna (MIS 3-2): *Microtus* sp., *Microtus arvalis, Canis lupus spelaeus* (Figure 1)*, Cuon alpinus europeaus, Ursus ingressus, Ursus arctos priscus, Mustela erminea, Mustela nivalis, Panthera spelaea, Panthera pardus* (Figure 1)*, Megaloceros giganteus, Equus ferus*. Most of the faunal remains were dated back to MIS 1: *Myotis* sp., *Myotis myotis, Plecotus auritus, Rhinolophus hipposideros, Lepus europaeus, Lepus* sp., *Oryctolagus cuniculus, Apodemus* sp., *Arvicola terrestris, Castor fiber, Microtus arvalis, Myodes glareolus, Canis lupus lupus, Vulpes vulpes, Ursus arctos arctos, Meles meles, Martes martes, Mustela putorius, Mustela erminea, Mustela nivalis, Lynx lynx, Felis silvestris, Alces alces, Cervus elaphus, Capreolus capreolus, Bison/Bos* sp. and *Sus scrofa* (Frenzel 1936, 1937; Pax 1937; Zotz 1939; Bieroński et al. 1985, 2009; Marciszak et al. 2016, 2020; 2021a, 2021b).

**Figure 1.** The leopard *Panthera pardus* cornered by one of his main Late Pleistocene competitors, the cave wolves *Canis lupus spelaeus*. Drawing by W. Gornig.

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# POŁUDNIOWA CAVE - FIRST MID-MIDDLE PLEISTOCENE SITE FROM STUDETY MTS (SILESIA, SW POLAND) AND THEIR BIOSTRATIGRAPHIC SIGNIFICANCE

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***Keywords:*** *mid-Middle Pleistocene, Sudety Mts, Poland, Quaternary remains, bones*

Południowa Cave (50°57'17"N 15°55'23"E; 620 m a. s. l. (German names Kitzelhöhle, Kitzelloch, Kitzelberghöhle, Kitzelkirche, Teufelskeller). The cave is already known more than 500 years. It was found during quarrying, and destroyed in 1970s. The cave was developed into an elongated, L-shaped corridor. The first research was organized there in 1904, however, complex excavations were carried out only in 1930s. Deposits are represented by a mixture of yellow clays, intercalations of quartz gravels, red clays of terra-rossa type and limestones covered by brown clays. It seems that at least three or even four different faunal assemblages were found there. The oldest faunal element is represented by the rodent *Baranomys loczyi* and *Mustela pliocaenica*, being the only Pliocene finds from Sudeten caves. Second fauna is dated back to mid-Middle Pleistocene, and consists of the following taxa: *Sorex* sp., *Rhinolophus* aff. *ferrumequinum*, *Arvicola* cf. *mosbachensis*, *Myoxus glis*, *Pliomys coronensis*, *Mimomys* sp., *Pliomys episcopalis*, *Lycaon lycaonoides*, *Canis mosbachensis*, *Vulpes vulpes*, *Ursus deningeri*, *Ursus arctos suessenbornensis*, *Ursus thibetanus*, *Gulo schlosseri*, *Meles meles atavus*, *Martes vetus*, *Mustela strandi*, *Mustela praenivalis*, *Panthera spelaea fossilis*, *Homotherium latidens*, *Panthera gombaszoegensis*, *Acinonyx pardinensis intermedius*, *Felis* cf. *silvestris*, *Pachycrocuta brevirostris*, *Capreolus* sp. The third assemblage is dated back to the Late Pleistocene (MIS 3), and contains the remains of *Glis glis*, *Arvicola* sp., *Canis lupus spealeus*, *Ursus spelaeus* ssp., *Martes martes*. Finally, the youngest fauna, dated as MIS 1, is represented by *Arvicola* sp., *Apodemus* sp., *Lepus* sp., *Cricetus cricetus*, *Ursus arctos arctos*, *Meles meles*, *Martes martes*, *Capreolus capreolus*. Within the Middle Pleistocene Revolution (MRP), this site provides valuable data from the Sudety Mts, since in the locality presence of old forms like lycaon, jaguar or cheetah together with new arrivals like lion or brown bear were found. Especially interesting are possible relationships and impact of new species for the extinction of ancient carnivores.

# PALAEOENVIRONMENTS OF THE CENTRAL RUSSIAN PLAIN BY THE SMALL MAMMAL FAUNA FROM BYKI 7 LATE PALAEOLITHIC SITE (SEIM R. BASIN)

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***Key words***: *small mammals, Late Palaeolithic, Byki 7 site, central Russian Plain, Seim R. basin*

Byki 7 Late Palaeolithic site is located on the south-western slope of the Central Russian Upland ($51^0$38′N, $35^0$ 30′E, Fig. 1) on the ancient dune above the floodplain of the River Seim left bank (the Desna R. basin), Kursk Region. Archaeological studies at the site are for many years conducted under the leadership of N.B. Akhmetgaleeva (2015). Geological deposits have been studied by Yu. N. Gribchenko and E.V. Voskresenskaya and the group of A.V. Panin (Inst. of Geogarphy RAS) (Akhmetgaleeva et al., 2010, 2020b). N.D. Burova investigated large mammals' remains (Akhmetgaleeva and Burova, 2020a). Small mammals' remains were handed over in 2019 to A.K. Markova for identification. Byki 7 site is a multilayer one and includes the following cultural layers: Ia, Ib, Ic, I, II. The C14 dates for cultural layers were calibrated with OxCal 4.4.0 software and fall between 22 – 17 cal BP. The number of all remains of small mammals (Lagomorpha and Rodentia) is ~ 1,800. About 800 remains were identified on the species level. Small mammal remains were found in Ia, Ib and I cultural layers. Most of them were found in Ia and Ib layers (Table 1).

**Table 1**. Small mammal species from the Byki 7 site (cultural layers Ia and Ib)

| Species | Cultural layer 1a | | Cultural layer 1b | |
|---|---|---|---|---|
| | N | % | N | % |
| **Lagomorpha – lagomorphs** | | | | |
| *Ochotona pusilla* Pallas – steppe lemming | 75 | 35,55 | 120 | 41,20 |
| **Rodentia – rodents** | | | | |
| *Marmota bobac* – marmot bobac | 1 | 0,47 | | |
| *Spermophilus* sp. – ground squirrel | 12 | 5,68 | 1 | 0,34 |
| *Spalax microphthalmus* – Russian mole rat | 8 | 3,79 | 2 | 0,68 |
| *Ellobius talpinus* – Northern mole-vole | 3 | 1,42 | | |
| *Cricetus cricetus* – East European hamster | 8 | 3,79 | | |
| *Lemmus sibiricus* – Siberian lemming | 13 | 6,16 | 15 | 5,10 |
| *Dicrostonyx torquatus* – collared lemming | 14 | 6,64 | 15 | 5,10 |
| *Lagurus lagurus* – steppe lemming | 4 | 1,90 | | |
| *Microtus (Alexandromys) oeconomus* – root vole | 3 | 1,42 | 6 | 2,04 |
| *Lasiopodomys (Stenocranius) gregalis* – narrow-skull vole | 70 | 33,18 | 130 | 44,18 |

The remains of only 2 species (*Ochotona pusilla* and *Lasiopodomys (S.) gregalis*) were found in the cultural layer I. The analysis of the Late Pleistocene small mammals' fauna from the cultural layers of Byki 7 site allowed identifying the prevailing of steppe species. Tundra mammals (collared and Siberian lemmings) are represented by a small amount of remains. The steppe pika and narrow-skulled vole are the dominants. Forest species are absent. The site location is within the boundaries of the modern forest-steppe zone. The modern faunal assemblage includes forest, meadow and steppe species. The analysis of small mammals from the cultural layers of Byki 7 site allows reconstructing the unique structure of this fauna formed under the influence of the Late Valdai Glaciation. This fauna belongs to the so called mixed or no-analogue faunas widely distributed in the period of Late Valdai (= Vistulian) Glaciation. Compared to other faunas of Late Palaeolithic sites of the Russian Plain, only very few remains of subarctic species were found at Byki 7. Such specific feature of Byki 7 fauna may be explained by its location at a significant distance from the border of the Valdai ice sheet.

The periglacial steppes were reconstructed by small mammal data from Byki 7 site for the central Russian Plain.

*This study was carried out within the framework of the theme of the Institute of Geography RAS no. 0148-2019-0007.*

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# SAALIAN GLACIATION IN WESTERN POLESYE REGION (BORDER AREA OF POLAND, BELARUS AND UKRAINE)

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***Keywords:*** *Saalian ice sheet limit, western Polesye, key sites, Bug lobe, neotectonic movements*

The landscape of the at the Polish-Belarusian-Ukrainian border was created by varied glacial, glaciofluvial, fluvial, lake-marshy and karst processes but it is generally monotonous and flat. Morphogenetic transformation of this area was connected with Cainozoic tectonic movements and reactivation of faults in the Quaternary bedrock (Dobrowolski et al., 2000).

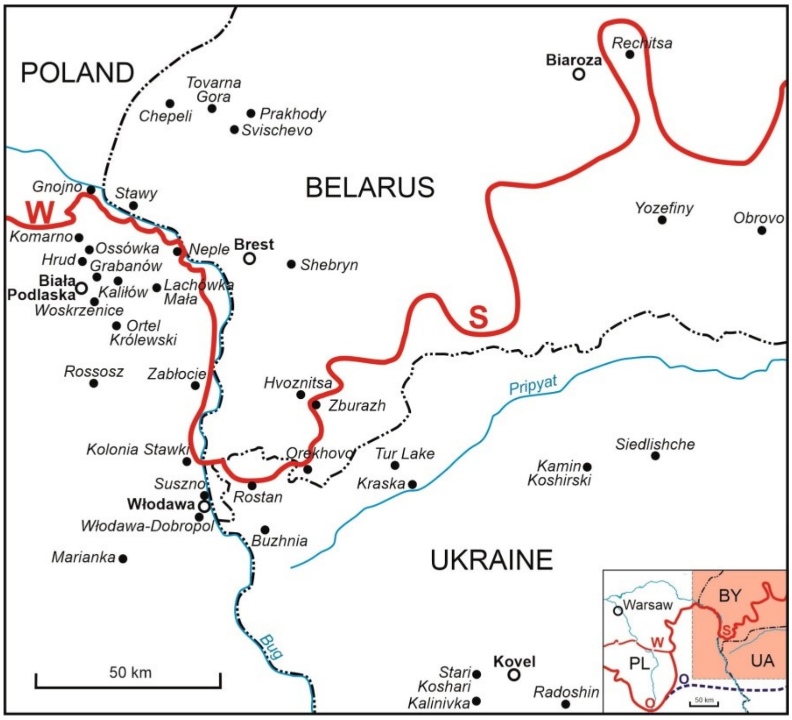


**Figure 1**. Maximum extent of the Saalian Glaciation in western Polesye (borderland of Poland, Belarus and Ukraine): W – Warta Stadial S – Sozh Stadial; examined Mid-Pleistocene sites are in italics. In the inserted sketch the maximum Saalian limit (O – Odranian) and its previously postulated limit (dashed blue line)

A crystalline basement in northern Polesye is quite deep-seated, glacial landforms are rare and river valleys wide, with extensive floodplains and river channels incised to 10-15 m (Dobrowolski and Harasimiuk, 2002). In southern Polesye the basement occurs at smaller depth whereas the Quaternary sequence is reduced and located at higher altitudes. Activity of tectonic processes in western Polesye is overlapped by compensative glacioisostatic movements of the Earth's crust that steered behaviour of the advancing ice sheets and intensity of glacial deposition (Marks et al., 2018). Based on varied thickness of Cainozoic sediments, a magnitude of neotectonic uplifting was estimated at 280 m since the Oligocene, that is 0.01-0.013 mm annually (Palienko, 1992; Makhnach et al., 2001). These regional conditions influenced remarkably both ice sheet advances and a deglaciation, favouring development of glaciofluvial plains at the land surface. Most glacial marginal landforms in the Polesye were considered to reflect parallel fractures in the bedrock (cf. Zalesskiy, 1978). Shallow occurrence of the Cretaceous carbonate rocks enabled development of cover karst features and of lakes in karst depressions (Zalesskii et al., 2014). A reduced sequence of the Quaternary deposits in western Polesye and a limited access the border area has been a series problem in the past in stratigraphic correlation of deposits and determination of ice sheet extents. Ice sheet limits were previously connected with Sozh/Warta Stadial and Odranian/Pripyatian/Dnieperian (Saalian), Krzna and Sanian 2/Berezinian/Oka (Elsterian) glaciations, correlated in turn with MIS 6, 8 and 12. In the Volhynian Polesye of the Ukraine the Odranian/Pripyatian/Dnieperian (Saalian) ice sheet maximum limit was located in the vicinity of Kovel (Fig. 1Lindner et al., 2007). Deposits of 4 glaciations were distinguished, referred to MIS 6, 8, 12, 16), although in any site no more than 2 tills were identified (Rühle, 1937; Karaszewski and Rühle, 1976; Lindner et al., 2007). The studies in the border area of Poland, Belarus and Ukraine have been carried through since 2018 within the frames of the research project 2017/27/B/ST10/00165, funded by the National Science Centre in Poland. Based on examination of several dozen of key sites in western Polesye, glacial deposits were correlated with 2 glaciations only (MIS 6 and 12), regional key stratigraphic horizons were identified and the Saalian ice sheet limit was determined (Fig. 1). It founded a good background to revise a regional stratigraphy and to correlate it with the European stratigraphy. In the present Middle Bug Valley region to the south of Brest, the Bug lobe was found to advance during the Warta/Sozh Stadial of the Saalian. The runoff of glacial meltwaters and extraglacial waters during the Warta Stadial turned to the east, toward the Pripyat River valley and then, to the Dnieper River valley and the Black Sea.

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# THE DWARF *HIPPOPOTAMUS PENTLANDI* VON MEYER 1832 FROM 'FESSURA MALATACCA' (PALERMO, SICILY)

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*Hippopotamus pentlandi* is a dwarf hippopotamus species documented from more than 40 localities in Sicily and restricted to the late Middle and Late Pleistocene. Compared to the continental species, such as the extinct *H. antiquus* and the extant *H. amphibius*, the skull of *H. pentlandi* is characterized by a more developed occipital region, a more enlarged mastoid process and a shorter dental row (Caloi & Palombo, 1983; Caloi & Palombo, 1986). Unfortunately, during the $19^{th}$ and $20^{th}$ centuries, many Sicilian fossiliferous sites were exposed to illegal excavations that caused the completely loss of a large amount of hippopotamus fossil remains as well as their stratigraphic and taphonomic information. The 'falesia of Malatacca-Benfratelli' consists of nine small marine-modelled cavities located in the district of Palermo where fossil vertebrates were firstly reported in 1831 by Scinà. 'Fessura Malatacca', one of the smallest cavities of the 'falesia of Malatacca-Benfratelli' complex, mainly yielded remains of hippopotamus, *Ursus* cf. *arctos*, *Leithia melitensis* and *Sus scrofa*. This small cavity was completely depleted of all its content and some of its fossils were sold to the Natural History Museum of Milan (MSNM) by the Battaini & C Company in 1937 together with remains from Puntali Cave and Cannita Cave. The dwarf hippopotamus specimens here investigated, currently stored at the MSNM, include 9 teeth, three tali, two calcanei, 12 metapodials, and 5 phalanges. The calcanei are slender, the tali display an area for navicular and cuboid articulations bigger than in the extant African hippo and the metapodials are stockier than those of *H. amphibius*. Morphometrically the two m3s and the three tali collected from 'Fessura Malatacca' fall within the variability of *H. pentlandi* collected from other fossiliferous localities of Sicily (Fig. 1).

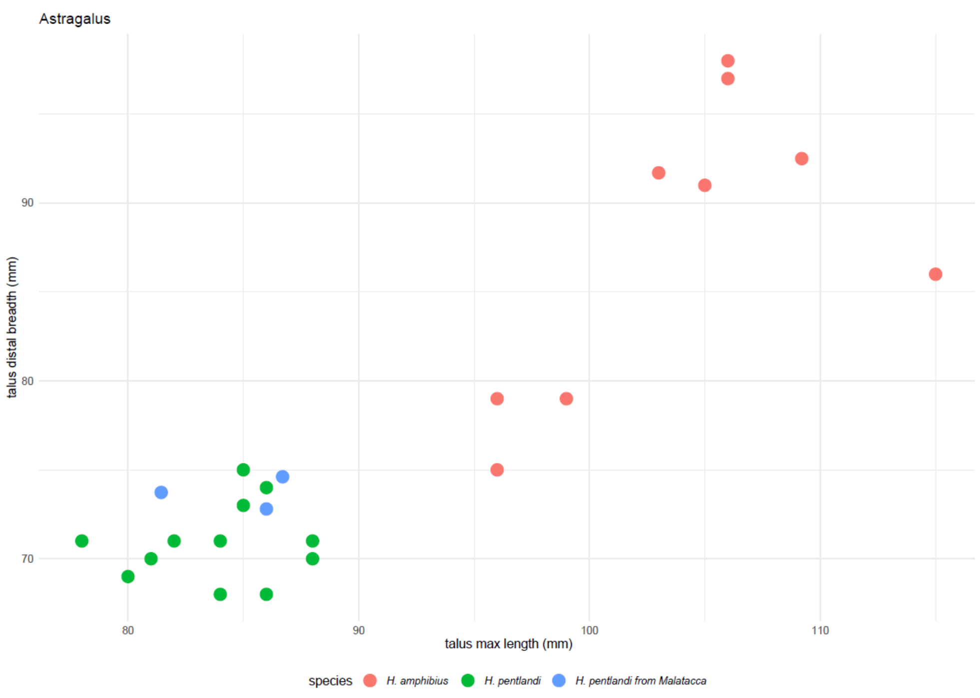


**Figure 1**. Length-distal breadth diagram (in mm) of talus in *H. pentlandi* (in green), *H. pentlandi* from 'Fessura Malatacca' (in blue) and *H. amphibius* (in orange). Measurements from literature

The characters observed in the postcranial elements possibly indicate a cursorial adaptation in *H. pentlandi* that could be linked with a shift to an environment that was probably more rocky than the mainland. The study of the material collected from the poorly known site of 'Fessura Malatacca' allows us to increase our knowledge about the Sicilian fossiliferous localities and it also provides new data about the dwarf *H. pentlandi*.

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# EXPERIENCE OF STUDYING OF ACCUMULATIVE COASTAL FORMS OF THE SEA OF AZOV AT THE EXAMPLE OF THE DOLGAYA SPIT (KRASNODAR TERRITORY, RUSSIA)

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***Keywords:*** *Sea of Azov, spit Dolgaya, Holocene, Late Pleistocene, sedimentation, geomorphology*

The Azov Sea is an inland body of water associated with the Black and Mediterranean Seas. The study of the Quaternary history of this reservoir allows us to trace in sufficient detail the dynamics of changes in the level and hydrology of the sea, the stages of starting and termination of water exchange between the Black and Caspian Seas, the characteristics of changes of the coastline, transformation of watersheds, etc. (Tesakov et al., 2007; Matishov et al., 2019). The coast of the shallow Sea of Azov is characterized by the presence of a series of sand-shell spits. We pay much attention to the comprehensive study of these accumulative forms, since they make it possible to trace a number of paleogeographic processes in the region. The studies carried out by us on the spits of the Sea of Azov coast include the following types of work: drilling with coring, study of alongshore currents and bottom topography in the coastal zone of the sea, absolute dating of sediments by the radiocarbon method and its malacological study, as well as the study of coastal swells that form these accumulative coastal forms (Matishov et al., 2020a, b, 2021).

One of the key research objects is the Dolgaya spit, which is the largest on the southern coast of the Sea of Azov. At the same time, its structure and development history remain unclear and require clarification. The total length of the system "spit - island part" is more than 30 km. The length of the spit proper on the right (eastern) bank exceeds 10 km, on the left - about 7 km. The width of its basal part reaches 3.75 km. The Dolgaya Spit actually separates the Taganrog Bay from the main part of the sea. It is exposed to the prevailing southwest and northeast winds.

Investigated by 13 holes, the upper part of the Dolgaya Spit's deposits is everywhere composed of shell material with an admixture of clay and loam. The thickness of the shell deposits increases from the base to the distal part of the spit from 4 to 7 m. About 20 species and supraspecific taxa of mollusks have been identified in the shell deposits of the spit's body. The most numerous are the shells of *Cerastoderma glaucum* (in different horizons their percentage is up to 76.5-96.1%), *Bittium reticulatum* (up to 1.5%), and *Tritia reticulata* (up to 1.5%). A preliminary analysis of the malacofauna from the examined outcrops, supported by the obtained data of absolute age dating (at $^{14}C$), suggests that the main part of the accumulative body of the spit was formed in the time interval from 1920 ± 110 (LU-9756) to 2500 ± 150 (LU-9757) years, during the Late Holocene Nymphaean transgression (Matishov et al., 2021). The reason of a large amount of shell material accumulation in the deposits of the Spit is the high productivity of the Sea of Azov basin. The total annual production of zoobenthos in the Sea of Azov is estimated at 19–20 million tons, that is, up to 2 $kg/m^2$ (Vorobyov, 1949). The shell rock stratum lies on a densely plastic gray loams, which in turn overlap brown clays and loams. In the distal part of the spit, at a depth of 18–20 m, they are underlain by Middle Pleistocene sands of freshwater genesis. Shells of mollusks are abundant in these sands: *Viviparus* sp., *Bittium* sp., *Lithoglyphus* sp., *Planorbis* sp., *Dreissena* sp., *Theodoxus* sp., *Cerastoderma* sp. and *Abra* sp. Finds of teeth of *Arvicola* cf. *mosbachensis* and *Microtus* cf. *gregalis* (primitive morphotype) allows to correlate these layers with the beginning of the Middle Pleistocene.

According to aerial and satellite images of the Dolgaya Spit, five generations of different age coastal swells can be distinguished, with a total amount of about 150. The oldest of them are located in the immediate vicinity of the base bank's part (the base part of the spit) and were formed more than 5 thousand years ago in the initial stage of development of the Ancient Azovian (=New Black Sea) transgression. Further formation of the accumulative of the spit's body occurred as a result of the successive attachment of coastal swells to it.

The main reason for the formation and further growth of the Dolgaya Spit was that intensively produced organogenic material from the center of the Sea of Azov was continuously supplied to its coastal zone. The largest source of sediment for the formation of the surface-underwater part of the Dolgaya Spit apparently existed in the southeastern part of the Sea of Azov in the area of Zhelezinskaya, Akhtarskaya, and Elenina banks. The area of these positive structures is about 100 $km^2$. The predominance of the southern currents in the Sea of Azov predetermined the vector of movement of organogenic sediments towards the Dolgaya Spit (Matishov et al., 2021).

The analysis of topographic maps and satellite images allows us to trace in detail the modern dynamics of the development of the spit for the period 1974-2020. It was noticed that the coast from the side of the Taganrog Bay is receding, and from the side of the Sea of Azov it is accumulative.

*The work was fulfilled in the framework of the grant of the Russian Science Foundation no. 20-17-00196.*

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# COOLING – WARMING CYCLES DURING MIS 3-2 IN THE RECORD FROM VARIOUS SEDIMENTARY ENVIRONMENTS; CASE STUDIES FROM WEICHSELIAN EXTRAGLACIAL ZONE (POLAND)

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***Keywords:*** *MIS 3 – 2, cooling – warming cycles, Poland*

Interpleniglacial related to MIS 3 (*ca.* 57 – 29 ka BP), separates two stadial periods, MIS 4 and 2. It lasted about 28-30 thousand years. In Central and Southern Poland, it is mainly represented by alluvial deposits, and to a lesser extent by lake or slope sediments. In Western and Central Europe, during the Interpleniglacial period, based on the radiocarbon and luminescence dates of sediments, several distinct warming phases (Derek/Oerel, Glinde, Moershoofd, Hengelo, Denekamp) were usually identified with forest or forest-tundra flora (*e.g.* Krzyszowski 1990, 1998; Manikowska 1996; Kasse *et al.* 1998; Houmark-Nielsen 2010; Marks *et al.* 2016; Dzieduszyńska *et al.* 2020).

The elaboration of the isotope curve of oxygen from the Greenland ice cores, NGRiP (Rasmussen *et al.* 2014) showed the existence of more warmings and coolings within MIS 3 (approx. 10-12). These were quick (counted in tens of years) as well as long-term changes (counted in hundreds or even thousands of years). So, they had the nature of extreme changes, but also gradual climatic oscillations. The aim of the research undertaken by our team is to verify the number of cooling and warming cycles in Interpleniglacial in Poland. We undertook an analysis of deposits of various sedimentary environments: fluvial, slope and lacustrine sediments from sites located in selected regions of Poland south of the Last Glacial Maximum (LGM). Our research will allow to find out, how the climate changes registered in the sediments are correlated with the changes recorded in the Greenland ice cores (Wachecka-Kotkowska *et al.* 2019; Michczyńska *et al.* 2021).

The study was based on the analysis of the set of radiocarbon and TL/OSL dates. The obtained results from the Central Poland for MIS 3 and MIS 2, complement the earlier data on palaeoenvironmental conditions from Southern Poland (*cf.* Gębica *et al.* 2015; Starkel *et al.* 2017). These data allow for a new interpretation of the role of local sedimentation conditions in river valleys of various size and the role of climatic fluctuations (oscillations) resulting from the location of the studied river valleys in the periglacial zone during the Interpleniglacial. In the periglacial zone the interaction between fluvial and slope environment was clearly expressed and periods of intensification of slope processes were correlated with climatic changes. The data from Poland showed a multiple of climatic fluctuations, although only 2-3 phases were found in small valleys and isolated depressions. About 33-30 thousand years ago, in the sediments of the valleys of Central Poland there was a sudden transition to climatic conditions with the features of the periglacial zone and the influence of continentalism. This transition should be combined with the expansion of the Scandinavian ice sheet. In southern Poland, the upcoming cooling was expressed by the intensification of loess accumulation (approx. 32-26 ka BP).

Due to the small amount of pollen data from MIS 3, the question of the degree of changes in the vegetation cover in Central and Southern Poland along with episodes of warming or cooling phases remains open.

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# OSL CHRONOSTRATIGRAPHY OF THE LATE PLEISTOCENE FLUVIO-AEOLIAN SUCCESSION IN CENTRAL AND SOUTH-EASTERN POLAND

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***Keywords:*** *luminescence dating, aeolian dunes, Last Glacial Maximum*

Fluvio-aeolian succession has been recognized in Poland, based on sedimentological and absolute dating methods. Appropriate correlation and dating of the aforementioned deposits are one of the crucial problems. Previous studies postulate asynchronous of sedimentary processes (Zieliński et al., 2015). Recent studies reveal different model of aeolian phases in Poland, where main dune-forming phases were detected in the Allerød interstadial (Moska et al., 2021).

To testify potential chronological differences four key sites from central and south-eastern parts of Poland were chosen. All key sites are located in the extraglacial zone of Last Glacial Maximum. Two of them are located in central Poland (Zarzecze and Kuźnica Kaszewska sites) and two in south-central Poland (Ostrowy Tuszowskie and Kamionka sites). Obtained OSL chronology is based on 34 dating results. Preliminary results confirm asynchronicity of depositional processes, particularly in fluvial and fluvio-aeolian complexes.

*Presented results were obtained with the support of Polish National Science Centre, contract number: 2018/30/E/ST10/00616.*

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# SMALL MAMMALS OF «MIXED FAUNA» OF NOVGOROD-SIVERSKYI PALEOLITHIC SITE (CHERNIGIV REGION, UKRAINE)

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***Keywords***: Late Paleolithic, small mammals, paleoecology, SDQ, Ukraine

The Late Paleolithic site of Novgorod-Siverskyi (Chernihiv region) is located on the right bank of the Desna River. In 1933, the site was discovered in the sandstone-quartzite quarry. For paleontologists, the site is interesting of a large number of osteological remains of animals. In different years the fauna was studied by I.G. Pidoplichka, I.M. Gromov, L.I. Rekovets, L. Demay, L.V. Popova (Pidoplichka, 1934, 1941; Gromov, 1965; Rekovets, 1985; Popova, 2012; Demay and Stupak, 2021).

According to the faunal list of small mammals by Pidoplichka (1947) and Rekovets (1985), the micromammal community are represented by cold steppe, tundra and riparian species. Forest species are absent. This diversity of taxa belongs to the type of «mixed fauna» when xerophilous, tundra and coastal species live alongside steppe species. This taphonomic effect is confirmed by the difference in dates. There are two different dates for mammoth tooth (19 800 ± 350 BP, OxA–698) and mandible of *Dicrostonyx* sp. (15 340 ± 60 BP, GrA–41725).

In 2011, a new excavations were carried out by D. Stupak. During the works, two cultural layers were identified. Both layers contain fauna. The microteriofauna were found in the upper layer, which was redeposited [Demay, Stupak, 2021]. One part of the small mammals remains was redeposited by the Dnieper moraine. It comes from pellets. Another part is a mole-hill material [Rekovets, 1985; Popova, 2012]. Identified small mammal species include *Spermophilus* sp. (teeth, 1 piece), *Ochotona* sp. (teeth, 5 piece), *Dicrostonyx torguatus* (lower jaws, 2 piece), *Microtus gregalis* (m1, 1 piece), *Arvicola terrestris* (m1, 1 piece). Ground squirrels (*Spermophilus* sp.) and pika *(Ochotona* sp.) inhabit open steppe territories. Tundra lemming (*D. torguatus)* and narrow-skull vole (*M. gregalis)* inhabit cold and arid environment. Water vole (*A. terrestris)* reflects the presence of a relatively slow watercourse. The average value of the enamel differentiation coefficient (SDQ) m1 of water vole is 81,08%. It determines the relative age of the Novgorod-Siverskyi site by the Late Pleistocene. The paleontological remains of small rodents and lagomorphs confirm the conditions of the cold steppe environment of the glacial period of the periglacial zone.

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# MATHEMATICAL METHODS IN THE STUDY OF CAVE LIONS IN THE PLEISTOCENE OF THE WEST SIBERIAN PLAIN

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***Keywords:*** *Cave lion, Pleistocene, Western Siberia*

There is currently a discussion about the systematic position of the cave lion *Panthera spelaea*. Some researchers consider it an independent species, others designate *Panthera leo* as a subspecies of the modern African lion. The situation is complicated by the presence of the remains of an even older form of lion from the early Pleistocene-*Panthera fossilis* [4]. For a more reliable separation of these forms, we have applied some methods of statistical analysis of morphological data on fossil lions.

The initial data are measurements of the lower jaws of Panthera spelaea and Panthera fossilis from locations in the south-east of the West Siberian Plain. Materials from the collections of the TSU Paleontological Museum and articles [1, 2, 3] are considered. The study of the material was carried out using cluster and correlation analysis in the STATISTICA program. Cluster analysis is used to divide the source data into relatively homogeneous groups (clusters), they reflect the relationships between the analyzed data, due to the similarity in the distribution of individual elements. The purpose of correlation analysis is to identify estimates of the strength of the relationship between random variables (features) that characterize some real process.

The resulting dendrogram (Fig. 1) demonstrates two isolated groups using cluster analysis.

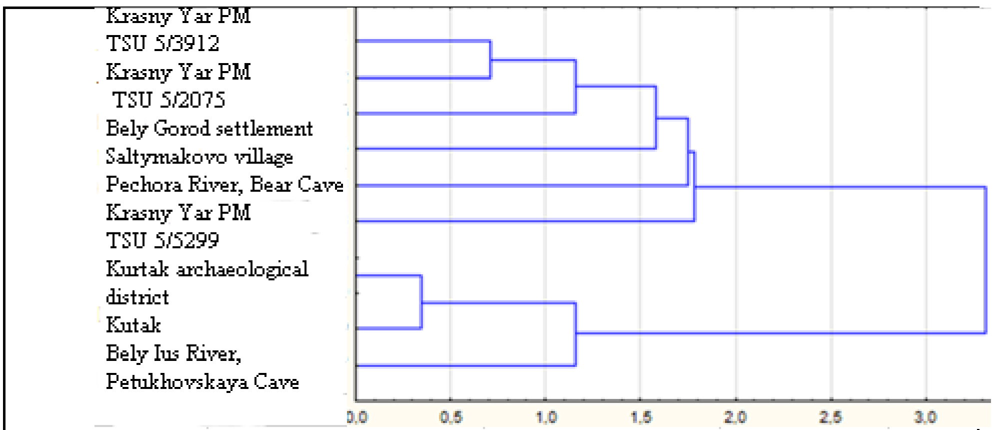


**Figure 1**. Dendrogram of cluster analysis of the mandibles of *Panthera spelaea* and *Panthera fossilis* from locations in the south-east of Western Siberia

The first group (Fig. 1) contains a relationship between the remains of *Panthera spelaea* from the locations: Krasny Yar PM TSU 5/3912, Krasny Yar PM TSU 5/2075, Bely Gorod settlement, Krasny Yar PM TSU 5/5299, Saltymakovo village, Pechora River, Bear Cave. The second group identifies a significant relationship between the remains of *Panthera fossilis* from the locations: Kurtak archaeological district, Kutak and Petukhovskaya Cave, Bely Ius River. The strongest relationship is observed in the first group: Red Yar PM TSU 5/3912 and Red Yar PM TSU 5/2075. In the second group: Kurtak archaeological district and Kurtak.

The dendrogram (Fig. 2) distinguishes two groups of features. The first group contains a relationship between: the maximum length from the incisor edge, the length of the dentition (c-m1), the length of the row of cheek tooth (p3-m1), the length of the dentition (from the incisors), the height in the area of p4, the height in the area of the diastema, the height of the m1, the length of p4, the length of m1, the width of p4, the width of C, the length of C. The second group contains a relationship between: length p3, width m1, length of the symphysis, width p3. Which makes it possible to identify distinctive features related to *Panthera fossilis.*

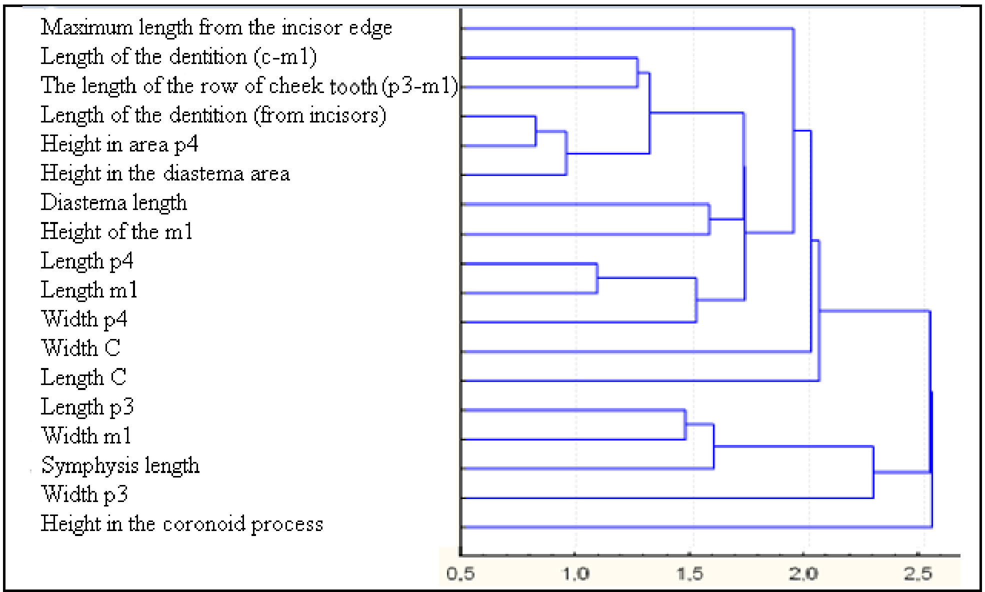


**Figure 2**. Dendrogram of cluster analysis of mandibles measurements

As a result of the work, we obtained a significant relationship between the remains of *Panthera fossilis* from the locations: Kurtak archaeological district, Kurtak and Petukhovskaya Cave on the Bely Ius River. Which allows us to put forward a hypothesis about the allocation of a separate species of *Panthera (Leo) fossilis.* The findings are extended to the available materials, due to the few finds of the remains of cave lions in Western Siberia.

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# MORPHOMETRIC ANALYSIS AND COMPARISON OF MOLAR TEETH AND THEIR ENAMEL THICKNESS IN TWO BOVIDS, *BISON* AND *BOS*, FROM POLISH CAVES

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Large Quaternary mammals are one of the most intensively studied organisms by paleontologists. Many of these species have descendants today in the form of modern mammals. By studying the history of evolution, it can help us understand the biology of species living today. One of the large systematic groups occurring over the years, but also today a subfamily of undoubtedly great natural importance is Bovinae Gray, 1821. This is a group of large herbivorous mammals inhabiting mainly forests. This subfamily includes 10 genera such as, for example, *Bison* (Hamilton-Smith, 1827) or *Bos* (L., 1758). The types of *Bison* sp. and *Bos* sp. are very closely related to each other, and the high morphological similarity causes difficulties in the determination of the fossil material, especially when it is highly fragmented or unsatisfactory. One of the methods of determining species affiliation is the morphometric analysis of the teeth of these species.

The material used in the research covers the teeth of *Bison* and *Bos* from the Middle Pleistocene until the present day. The examined remains come from six caves sites in Poland (Biśnik, Komarowa, Deszczowa, Mamutowa, Łokietka) and Bulgaria (Bacho-Kiro). During our study, 260 teeth were subjected to morphometric analysis. Then the material was compared and analyzed with the measurements of the specimens from the literature: the results of 17 archeological sites dated from middle Pleistocene to Holocene from the area of 8 Eurasian countries: Moldova, Denmark, France, Great Britain, Russia, Austria, Bulgaria and Spain. More accurate measurements of teeth than those performed so far (apart from measuring the width and length of the teeth and calculating the ratio of these measurements), i.e. the basic measurements were made during the analysis, based on specially prepared figures, of the occlusal surface and the thickness of the enamel. A total of 44 types of measurements were made, taking into account the basic dimensions of teeth and their parts, and 8 measurements of enamel thickness. Morphometric examinations of teeth of members of the subfamily *Bovinae* turned out to be differentiating both in terms of the type of tooth and its type/species. Moreover, the teeth of the members of the subfamily *Bovinae* have decreased over the centuries (from the Pleistocene to the Holocene), both in terms of general measurements of teeth and measurements of the occlusal surface and enamel. After analyzing the correlation of the measurements with the MIS stratigraphic age, that enamel measurements turned out to be more important than the measurements of the distance between the points on the occlusal surface. The lowest values of the L/W ratio among the juxtaposed species are achieved by domesticated forms of beef (*Bos primigenius f. taurus*) and representatives of the species *Bison schoetensacki*, while the highest representatives of the genus *Bos* sp. From the Bacho Kiro cave site in Bulgaria, regardless of the type of tooth. The largest ranges of variability in the values of basic teeth measurements are shown by representatives of the *Bos* sp. Species from the Bacho Kiro cave in Bulgaria, it is related to the lack of records of the layers from which the teeth come. In occlusal surface analysis and basic tooth measurements (apart from the L/W ratio), higher values are achieved by the fore-teeth. In order to obtain more accurate results, it would be necessary to analyse in the same way a larger amount of material from the Eurasian area, more diverse in terms of the stratigraphic age of the MIS. The above studies can be a key comparative basis for further analysis. In the future, it is worth correlating the morphometric measurements of teeth with the measurements of, for example, the skull and cervical vertebrae.

# LATE PLEISTOCENE MOLLUSCS AND SMALL MAMMALS FROM THE TETYUKHINSKAYA CAVE (SOUTH FAR EAST, RUSSIA): PRELIMINARY RESULTS

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Remains of Quaternary mammals and molluscs have mainly been found in caves and archaeological sites of the Southern Far East of Russia. Material for this study was obtained from palaeontological excavations in the Tetyukhinskaya Cave (44°35′N, 135°36′E) during 2012–2015 field campaign (Fig. 1).

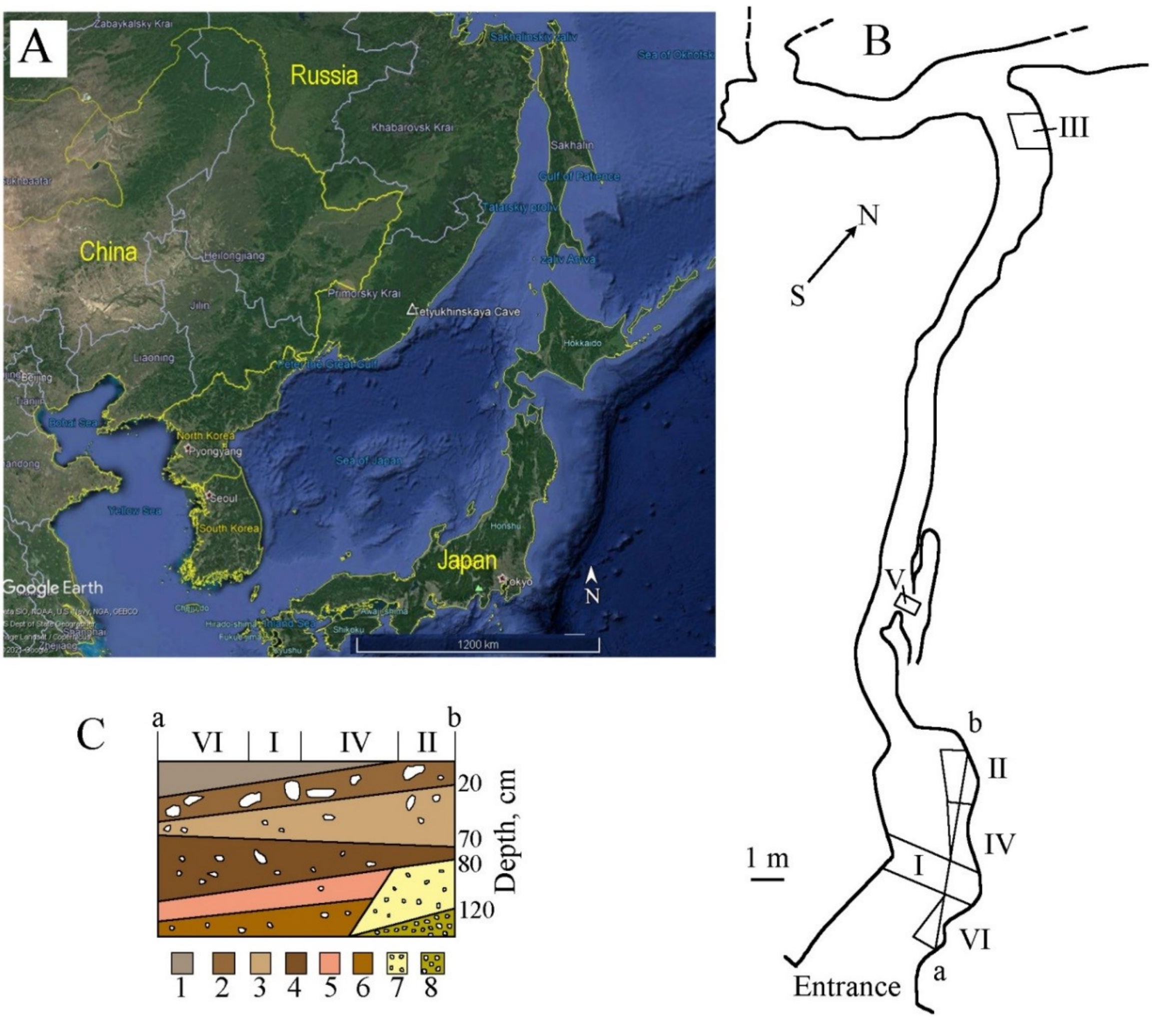


**Figure 1**. A) A map and location of the cave; B) Plan of the Tetyukhinskaya Cave; C) the section along the a/b line. Symbols: I–V – pit numbers; 1–8 – number of layers (layers description is given in the text).

Tetyukhinskaya Cave was originated in the Triassic limestone. It is located in the mid-part of the Sikhote-Alin' Ridge near Dalnegorsk City. The entrance of the cave is situated at an altitude of 410 m above sea level. The depth of the cave is 31.5 m; the length of its described part is 490 m.

Six pits were excavated by researches from Vladivostok in the unconsolidated deposits inside the cave; four of them were placed in the entrance grotto (Tiunov and Gusev, 2021). All pits in the entrance grotto were dug to the rocky bottom. Despite some disturbance of the deposits, the sequence of layers can be fairly well traced in the profiles of the pit walls. The excavation was carried out in arbitrary levels (spits), approximately 10 cm. All samples were wet-sieved (mesh size: 1 mm) and dried in the field, and later dry remnant with fossil remains was investigated in the laboratory. To date important intervals radiocarbon method was used.

Molluscs were defined using Prozorova et al. (2018) and Sysoev and Shileyko (2009); they are given in the systematic order according to Sysoev and Shileyko (2009).

Comparative morphological and morphometric methods were used in the specific diagnosis of small mammals bone remains. Fragments of the skull and lower jaws were used to identify the shrews; voles and lemmings were identified by the first lower molar (m1); mice of the genus *Apodemus* were identified by the second upper molar (M2); other rodents could be identified by any isolated teeth; pikas were identified by the third lower premolar (p3).

*Stratigraphy and chronology*. Eight lithological layers can be defined in the unconsolidated deposits of the cave: 1 – greyish-brown uniform medium loam; 2 – brown medium loam with large stones; 3 – brownish heavy loam with small stones; 4 – brown medium loam with small stones; 5 – yellowish-brown light loam with small stones; 6 – tan light loam with small stones; 7 – yellowish clay with small stones; 8 – dark yellow raw clay with small numerous limestone fragments.

Several radiocarbon dates were obtained from this site: using AMS 39874±133 BP (himalayan bear tooth; pit 2, depth 0.40-0.5 m, layer 3; NSK–850, UGAMS–21786) and 37673±950 BP (pit 1, depth 0.5-0.6 m, layer 3, rhinoceros tooth, NSKA–851; using $^{14}C$ 20215±1000 BP (mammal bones, layer 4, SPb–1057). These dates make it possible to correlate deposits with Marine Isotope Stages (MIS 3–2) and with chronological units starting from Late Pleistocene to Holocene.

*Molluscs*. All identified specimens belong to terrestrial molluscs. A total of 15274 shells were identified, which belong to 14 species (*Carychium pessimum* Pilsbry, 1902, *Cochlicopa lubrica* (Müller, 1774), *Vallonia patens* Reinhardt, 1883, *Vallonia pulchellula* (Heude, 1882), *Columella edentula* Draparnaud, 1805, *Vertigo* cf. *japonica* Pilsbry et Hirase, 1904, *Punctum ussuriense* Likharev & Rammelmeyer, 1952, *Discus depressus* (A. Adams, 1868), *Hawaiia minuscula* (Binney, 1841), *Perpolita petronella* (L. Pfeiffer, 1853), *Euconulus fulvus* (Müller, 1774 , Arionidae / Limacidae, *Karaftohelix maacki* (Gerstfeldt, 1859), *K.* cf. *middendorffi* (Gerstfeldt, 1859)), 12 genera (*Carychium*, *Cochlicopa*, *Vallonia*, *Columella*, *Vertigo*, *Punctum*, *Discus*, *Hawaiia*, *Karaftohelix*) from 10 families (Carychiidae, Cochlicopidae, Valloniidae, Pupillidae, Punctidae, Discidae, Zonitidae, Euconulidae, Arionidae/Limacidae, Bradybaenidae).

The biotopes of the studied species of molluscs are quite diverse: *Karaftohelix maacki* and *K.* cf. *middendorffi* live on well-watered forest floor. *Discus depressus* and *Euconulus fulvus*, form massive clusters on raw dead wood, where they usually feed on various mushrooms. These species, together with *Carychium pessimum*, *Cochlicopa lubrica*, *Vallonia patens*, *V. pulchellula*, *Columella edentula*, *Vertigo* cf. *japonica*, *Punctum ussuriense*, *Hawaiia minuscula*, *Perpolita petronella* also settle on overgrown slopes and turfs, in damp rock crevices, on scree and ledges.

*Mammals*. Analysis of the small mammal bone remains from the Tetyukhinskaya cave demonstrated that species of different mosaic landscape and ecological groups inhabited vicinities of the cave: there are taiga and mountain-taiga (*Sorex caecutiens, S. isodon, Sciurus vulgaris, Eutamias sibiricus, Pteromys volans, Clethrionomys rutilus, Myopus schisticolor*); deciduous and coniferous-deciduous forests (*Mogera robusta, Sorex unguiculatus, S. mirabilis, Petaurista tetyukhensis, Craseomys rufocanus, Apodemus penninsulae*); semi-open landscapes (*Ochotona hyperborea, Erinaceus amurensis, Rattus norvegicus*); open landscapes (*Tonomochota sikhotana, Crocidura lasiura, Micromys minutes, Apodemus agrarius, Tscherskia triton, Myospalax psilurus*), and intrazonal species (*Neomys fodiens*). The composition of the fauna of small mammals and molluscs indicates the wide distribution of mosaic landscapes where forests existed together with open and semi-open areas in Primorye during MIS 3–2 of the Late Pleistocene.

Mammal bone remains accumulated inside the cave because of the activity of predatory animals and birds, which used the caves as a dwelling or temporary shelter. The malacofauna complex is represented by species that lived in broadleaf and coniferous forests in a continental climate. Molluscs inhabited entrance part of the cave using organic matter for feeding. The continuation of the research will permit to compare our results with other regional and global data.

All the vertebra finds are kept at the Federal Scientific Center of the East Asia Terrestrial Biodiversity, FEB RAS (Vladivostok, Russia). Mollusc shells are storage at the Institute of Geology UFRC RAS (Ufa, Russia).

*The work was performed within the framework of the State Budgetary Theme No. 0246-2019-0118.*

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# QUATERNARY REMAINS OF EURASIAN JAGUAR *PANTHERA GOMBASZOEGENSIS* (KRETZOI, 1938) OF POLAND

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The Eurasian jaguar *Panthera gombaszoegensis* (Kretzoi, 1938) was found at 7 sites in Poland. The oldest record is that from Żabia Cave, while the youngest remains were found in Biśnik Cave (Marciszak 2014; Marciszak and Lipecki 2021). *P. gombaszoegensis* was the only pantherine cat during the Early Pleistocene Europe until the arrival of the Pleistocene lion *Panthera spelaea* (Goldfuss, 1810) and the leopard *Panthera pardus* (Linnaeus, 1758) (Hemmer 2003, 2004).

The Eurasian jaguar as an eurytopic species was widespread and well adapted to live in wetlands and open areas. The Eurasian jaguar was capable of hunting a wide range of prey and has achieved undeniable evolutionary success. The difference in the size of the jaguar's body is probably due to its geographic distribution, and it is conditioned by Bergman's rule (Seymour 1993). For almost 1 million years, the Eurasian jaguar has held a stable, high position in the carnivore palaeohierachy. However, during the latest part of the Early Pleistocene climatic and environmental changes strongly affected on the jaguar's prey spectrum, which caused changes in the distribution and density of the Eurasian jaguar population (O'Regan, 2002). However, the main factor responsible for the extinction of the jaguar in Europe was the emergence of significant competition from the immense steppe lion *Panthera spelaea fossilis* (von Reichenau, 1906). As its numbers increased then the range of the jaguar began to shrink significantly. The Eurasian jaguar was retreating, creating isolated populations that were ultimately dominated by the steppe lion. Jaguar finally became extinct between 330-300 ka.

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# UNDERSTANDING THE VARIABILITY OF EARLY PLEISTOCENE *STEPHANORHINUS* (MAMMALIA, RHINOCEROTIDAE): IMPLICATIONS FOR TAXONOMY AND PALAEOBIOGEOGRAPHY

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***Keywords:*** *morphology, morphometry, Stephanorhinus, Eurasia*

Isolated teeth and bones of rhinoceroses are sometimes difficult to identify at specific level because our poor knowledge on the high morphological variability of fossil and, often, of extant species. During the past, several studies have been devoted to highlight morphological and morphometric differences among the fossil Pleistocene species, but only a few of them considered the variability of the extant taxa, in particular *Dicerorhinus sumatrensis*, to support and interpret their results. *Dicerorhinus sumatrensis* is the closest extant relative of the Eurasian *Stephanorhinus*, as recently evidenced by molecular analyses, and it could provide useful data to better understand the variability in extinct Pleistocene Eurasian taxa.

*Dicerorhinus sumatrensis* is characterized by a relatively wide morphological variability in several features of the cranium, as evidence by Groves (1982). Normally, male individuals are somewhat larger than female and are characterized by wider nasal bones. By the way, relatively young male individuals could display narrow nasal bones, similarly to females. A few characters of the cranium are reliable documented in all specimens, e.g., the ventrally opened external auditory pseudomeatus, the un-ossified nasal septum, the long contact between the lachrymal and the nasal bones. The development of the nuchal crest in *D. sumatrensis* is a little bit variable: in large males the nuchal crest overhangs the occipital condyles but in other specimens, such as NHMUK 1879-6-14-2, it is less posteriorly projected than the occipital condyles (Fig. 1). In dorsal view, several morphological differences can be detected among specimens of *D. sumatrensis*. The width of the nasals is evident and clearly different between sexes. The posterior border of the nuchal crest is normally slightly concave, but it can be also straight in some individuals and well-concave in some younger specimens.

The high morphological variability of *D. sumatrensis* in respect to the other extant rhinoceroses was also highlighted by Guérin (1980). In addition, as reported by Pocock (1946), the maximal width of the nasals in this species is reached when M3 starts to be worn. A similar pattern has been also recognised in the studied sample (Fig. 1). Further, specimens belonging to individuals grow up in optimal environmental conditions display relatively large size even if belonging to females (specimen NHMUK 1.1.22.1, type of *D. lasiotis*). These considerations could clearly affect the validity of some characters considered for species-specific attribution in fossil Pleistocene rhinoceroses. *Stephanorhinus lantianensis* has been claimed as a new species based on a cranium of an adult individual. The specimen is characterized by being smaller than *S. kirchbergensis* and by having sharply tapered nasal bones, and a long toothrow (P2-M3= 250 mm). The morphological characters of the teeth such as protoloph and metaloph parallel, and smooth ectoloph are probably due to the stage of wear of the teeth. The nasal bones in *S. lantianensis* strongly resembles those of the specimen IGF889 belonging to *S. etruscus*, and this character can be interpreted as sexually dimorphic, similarly to that observed in *D. sumatrensis*. At the present, *S. yunchuchenensis* is only recorded in one locality in Yushe Basin (Shanxi Province, Early Pleistocene), and, even if the exact location is uncertain, the age is estimated on regional geological information (Tong, 2012). Anyway, the morphology of the cranium and teeth referred to this species closely resembles *S. kirchbergensis* (as also noted by Chow, 1963). The expanded nasal bones are similar in shape and size to that observed in *S. kirchbergensis* skull SMNS 6617.2.12.67.3 and *S. hundsheimensis* skull MNHN PW 1958–764, and can be regarded as a sexual dimorphic trait. Taking into account the data on the extant Sumatran rhinoceros, the validity of some morphological traits normally used for species-specific attribution in Early Pleistocene fossil rhinoceroses should be revised. Sexual dimorphism and ontogenetic stage seem to drive the development of some important features in Eurasian rhinoceroses and a detailed comparison among crania could lead to new considerations on taxonomy, and, therefore, on palaeobiogeography and biochronology of the different species.

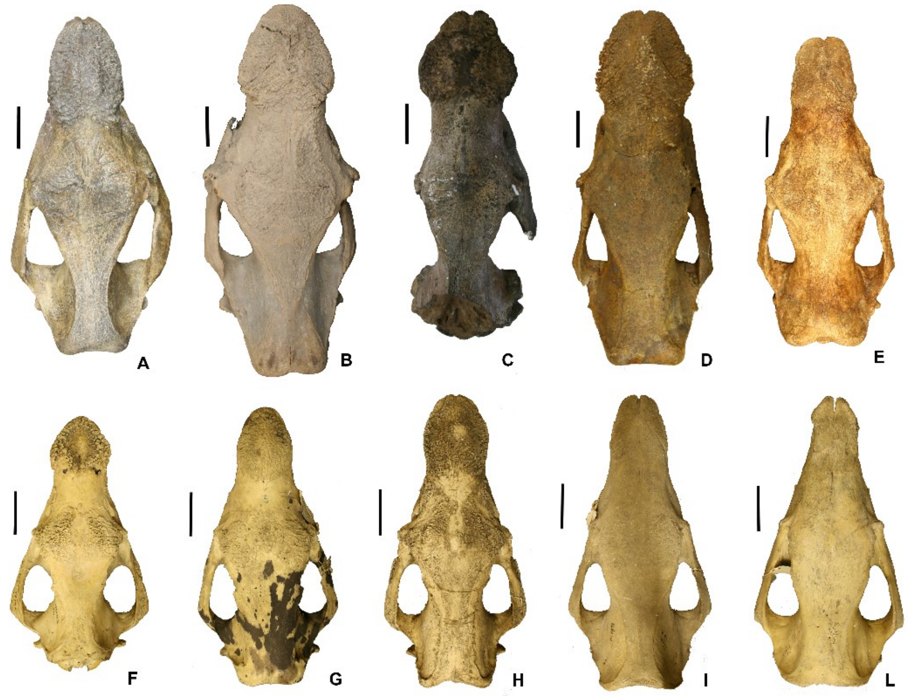


**Figure 1.** Morphological variability in the crania of selected Eurasian rhinoceroses in dorsal view. **A** *S. kirchbergensis*, SMNK PAL 4254, M3 fully erupted; **B** *S. kirchbergensis*, SMNS 6617.2.12.67.3, M3 fully erupted; **C** *S. yunchuchenensis*, IVPP V2879, M3 fully erupted?; **D** *S. hundsheimensis*, MNHN PW 1958 – 764, M3 fully erupted; **E** *S. hundsheimensis*, IGF 1931V, M3 fully erupted?; **F** *D. sumatrensis*, NHMUK 1879-6-14-2, unknown sex, M3 fully erupted; **G** *D. sumatrensis*, NHMUK 1921-2-8-4, female, M3 fully erupted; **H** *D. sumatrensis*, NHMUK 1894-9-24-1, male, M3 fully erupted; **I** *D. sumatrensis*, NHMUK 68-4-15-1, unknown sex, M3 fully erupted; **L** *D. sumatrensis*, NHMUK 1931-5-28-1, male, erupting M3.

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# RE-TREATMENT OF *CERVUS ELAPHUS* BONE MATERIAL IN GLIWICE RADIOCARBON LABORATORY USING ULTRAFILTRATION

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***Keywords***: *radiocarbon, AMS dating, bones, ultrafiltration*

Preparation of bones for radiocarbon dating is still quite a challenge for researchers. The methods are being tested and improved, to increase reliability of dating results and to verify the previous ones. In this work, a set of gelatine samples, extracted from *Cervus elaphus* and *Cervus canadensis* bones from various sites in Europe and a set of human bones from archaeological sites in Poland were subjected to re-treatment using ultrafiltration in Gliwice Radiocarbon Laboratory.

The tested samples represent a wide range of ages, from older than 40 000 $^{14}$C years BP to modern. The prepared material was subjected to the measurement of C/N atomic ratios and radiocarbon dating using the AMS technique. Also, the stable isotopes ($\delta^{13}$C and $\delta^{15}$N) values were determined. The results confirm usefulness of ultrafiltration to obtain material of better quality, even for gelatine stored for years in unfavourable conditions.

# SEQS-DATESTRA: UPDATES, PERSPECTIVES AND TARGETS FOR INQUA–ROME 2023

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***Keywords:*** *stratigraphy, correlations, Eurasia, database, Quaternary*

SEQS for the 2021-2023 Intercongress period aims to improve and complete the Database of Terrestrial European Stratigraphy (DATESTRA) designed for sites with stratigraphic importance across Europe. The need for an across-Europe Database is due to the different stratigraphical schemes derived by litho-, chrono-, and bio-stratigraphical criteria that made correlations in terrestrial Quaternary systems problematic because of the fragmentary nature of these records and to reliable dating techniques covering the full range of Quaternary time. DATESTRA (Figs. 1,2) should critically summarizes the sites with Terrestrial Quaternary deposits in Europe trying to bypass their fragmentary nature giving rapid access to the sections, techniques and methods used for their study. Regional names and subdivisions will be overpassed by DATESTRA by correlation with the main Quaternary stages as assessed by IGSC (Early-, Middle-, Late Pleistocene and Holocene). This approach should give a summary and overview of the main characters of the subseries/stages across Europe.

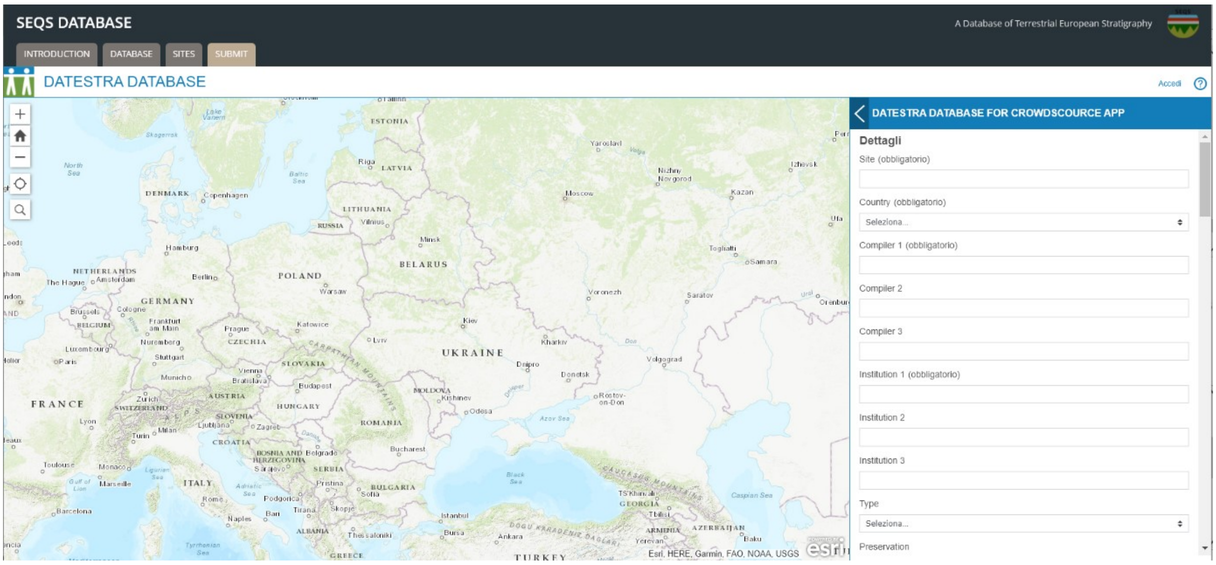


**Figure 1**. The new submission portal for DATESTRA.
Simply select from drop down menu the information related to the sites. This can be done from
https://unisiena.maps.arcgis.com/apps/MapSeries/index.html?appid=e87bdb952a854f0f8928ac8d0bc045a3
by clicking on the SUBMIT tab on top.

For this purpose, all the SEQS colleagues are invited to contribute submitting the most important sites from their Countries in order to collect a number of sites as abundant as possible to be offered in a public web-based output to the Quaternary scientific community.

In recent years, also due to the pandemic, the process of site submission decreased dramatically and DATESTRA experienced a sudden slowdown.

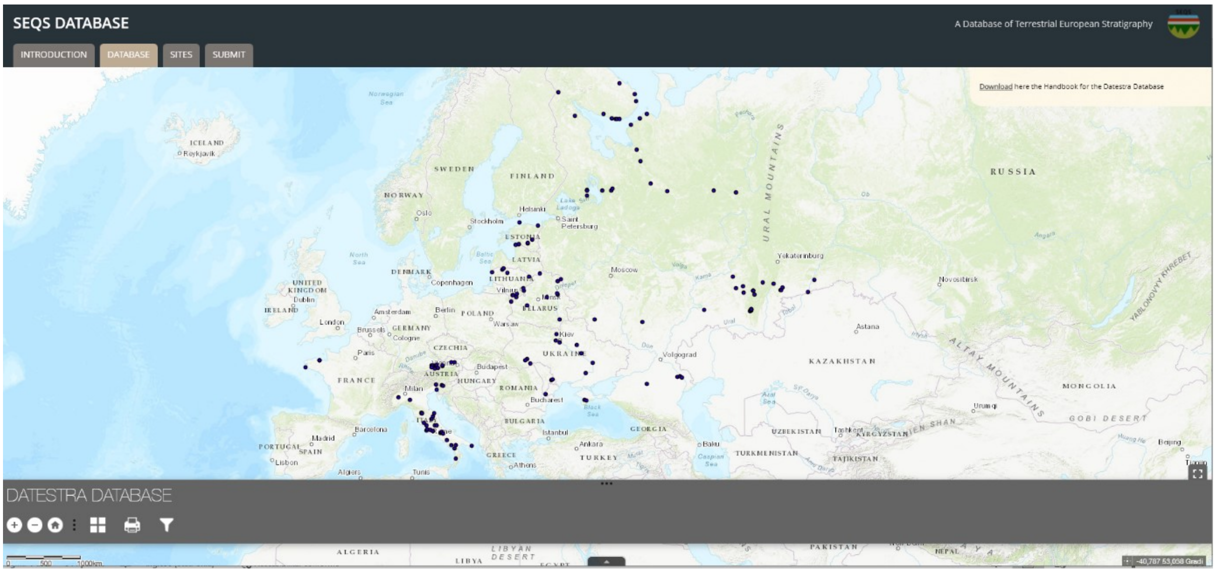


**Figure 2**. The web-app for DATESTRA visualization and query.
https://unisiena.maps.arcgis.com/apps/MapSeries/index.html?appid=e87bdb952a854f0f8928ac8d0bc045a3

However, SEQS made a great effort to reinvigorate DATESTRA also due to its important role as Working Group within INQUA-SACCOM Commission that is the only source of funding to provide the chance for ECRs' and DCRs' colleagues to attend the SEQS activities.

Here we present the state-of-the-art and the news about the web-platform for the submission of data that should make easier the contribution by simplifying as much as possible the actions required by each contributor. In July 2023, the XXI INQUA Congress will be held in Rome and one of possible the main goal of the SEQS community is to present DATESTRA including a large number of sites all across Europe. This target is now quite far, due to the lack of any information from many countries mostly based in Central and Western Europe. Therefore, our hope is that the new settings and changes we introduced to DATESTRA will re-launch the project providing new lifeblood to the SEQS and the knowledge about European Quaternary Stratigraphy.

# EVALUATING THE AGE-DEPTH MODELS BASED ON COUPLED $^{14}C$ AND $^{210}Pb$ DATA

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***Keywords***: *radiocarbon, lead-210, age-depth models, accumulation rate, uncertainty*

$^{14}C$ and $^{210}Pb$ methods are regularly used to determine ages and accumulation rates of peat, fen and lake sediments. The overall aim is to estimate the age of discrete layers, which were analysed for environmental proxies. Ideally, the age-depth models should fit the investigated proxy in terms of resolution and give precise results. Nevertheless, the differences in the nature of dating methods and statistical treatment of data need to be considered.

Both $^{14}C$ and $^{210}Pb$ signals are integrated over a considerable period. Moreover, they originate from different sources. $^{210}Pb$ is bound to aerosols and trapped by peat while $^{14}C$ is bound from atmospheric $CO_2$ by photosynthesis. Hence, $^{210}Pb$ gives the time span during which the aerosol has been buried, whereas the $^{14}C$ date gives the time of death of a plant.

After the analysis, the results are usually combined into an age-depth model. This process involves statistical treatment of data during which specific assumptions and simplifications are made. Depending on the algorithm, they lead to alterations in modelled ages compared to unmodelled data. Principally it is a desired result–increasing the robustness and decreasing the uncertainty of the age-depth model. In worse cases models alter the modelled ages to an unacceptable extent, which may be overlooked if the results are treated automatically.

We test the performance of various age-depth modelling algorithms (OxCal P_Sequence, Bacon, clam, MOD-AGE) on a selected true dataset where $^{14}C$ and $^{210}Pb$ data overlap and are used simultaneously. Afterwards, a point estimate is selected and used for proxy analysis on a time scale and for calculation of the accumulation rates.

Together with the thickness of analysed samples, the age model provides an information about the time resolution of proxy analysis. While the age-depth curves, except outstanding circumstances, give relatively similar answers within 95% uncertainty ranges, the differences are observed in point estimates and accumulation rates, and they may be relevant for the palaeoenvironmental studies. With this exercise, we attempt to assess the uncertainty beyond simple age errors reported from the measurements and age-depth modelling.

# BILANOVE, A NEW LOCALITY OF THE PLEISTOCENE SMALL MAMMALS (POLTAVA REGION, UKRAINE)

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***Keywords:*** *Dnipro area, Late Middle Pleistocene, Late Pleistocene, small mammals, alluvium*

Here we report some results of several-year research of the Quaternary deposits exposed in quarries of Ferrexpo (Poltava Region, Ukraine). One of the sections studied, Belanovo, deserves a special look, yielding important biostratigraphic data.

The structure of the Quaternary cover exposed by the Bilanove quarry is quite uniform. The alluvial deposits of the Psel river and its small left tributary lay there on the Paleogene deposits; and, in the north-west wall of the quarry, on the layer of boulders (redeposited Dnipro moraine). Since the Dnipro glaciation was the only Pleistocene glaciation of this area, the Dnipro moraine is an important stratigraphic benchmark and, together with the presence of the hydromorphic Pryluky soil at the top of the alluvium, clearly defines the geological age of the alluvium as the Kaidaky stage.

To the south-west, the Priluky soil is replaced by the alluvial deposits. In such a way, the southern-west wall of the quarry represents two cycles of the alluvial deposition. It is two suits of light-grey fine-grained sands and silts that are separated by a more silty layer, with a total thickness of 6-7 m. The upper alluvial suite is of the Pryluky age and the lower one is Kaidaky. Fossils were found in the basal part of both units. Small mammal remains are well preserved (high percentage of jaws with teeth). Taxonomic composition of Bilanove-1 (upper cycle) and Bilanove-2 (lower cycle) are presented below, with all identifiable elements recorded.

Bilanove-1: *Crocidura* sp. (1); *Erinaceus* sp. (1); *Spermophilus superciliosus* (1); *Spermophilus suslicus* (12); *Scirtopoda* sp. (1); *Spalax* ex gr. *microphtalmus* (1); *Cricetus* sp. (1); *Cricetulus migratorius* (1); *Clethrionomys* sp. (1); *Lagurus lagurus* (23); *Eolagurus luteus* (7); *Arvicola terrestris* (8); *M. oeconomus* (5); *M. gregalis* (6); *M. arvalis (1); Microtus* sp. (16); *Microtinae* (16).

Bilanove-2: *Spalax* exgr. *microphtalmus* (1); *Clethrionomys* sp. (1); *Lagurus lagurus* (2); *Arvicola* cf. *mosbachensis* (6); *Microtus gregalis* (2); *Microtus* sp. (6).

**Bilanove-1.** The presence of *Arvicola* m1 (Fig. 1) is of the key importance. The quotient of enamel differentiation of *Arvicola* is the most reliable biostratigraphical indexes of arvicolids, and this index (we use it's BTQ modification (Tesakov, 2004)) shows *Arvicola* from Bilanove-1 to be obviously more advanced than *Arvicola* from Bilanove-2.

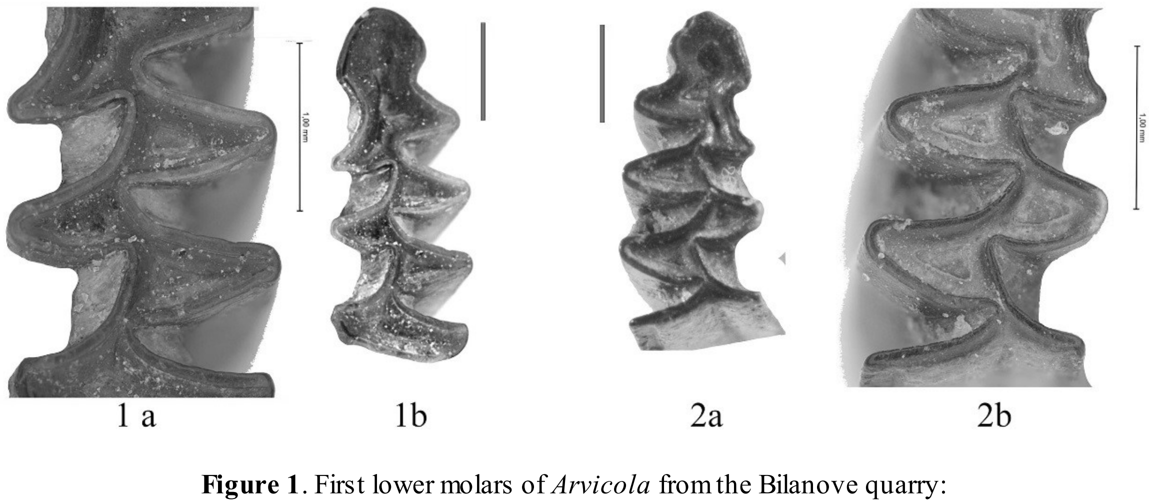


**Figure 1**. First lower molars of *Arvicola* from the Bilanove quarry:
1 - *A.* cf. *mosbachensis*, Bilanove-2; 2 - *A. terrestris*, Bilanove-1 (scale bars are 1 mm)

The water vole from Bilanove-1 is close to recent populations of *Arvicola terrestris* (not even to *Arvicola* with undifferentiated enamel, *A. chosaricus*, existed in the end of the Middle Pleistocene of Ukraine (Krokhmal' et al., 2021)). Unfortunately, there is no findings of the earliest *Arvicola terrestris* in the Dnipro area; but, in Central Europe, *Arvicola* with similar SDQ values becomes more or less common no earlier than MIS 5 (Socha, 2014). *Arvicola terrestris* in the Pryluky alluvium is an important rationale to place the Pryluky stage, which correlation with the West-European stratigraphic chart has contentious yet, in the Late Pleistocene, MIS 5.

Other fauna of Bilanove-1 corresponds to paleogeographic conditions of the Priluky stage. It is diverse steppe fauna, quite termophilous, with forest elements (*Clethrionomys, Erinaceus*). The presence of *Eolagurus* and a small jerboa may correspond to local takyr-like plots, at the same time, the area was well-watered, which is evidenced by the abundance of *Arvicola.*

**Bilanove-2.** *Arvicola* from Bilanove-2, in addition to the positive 'Mimomys' enamel differentiation, has the 'Mimomys'-fold, and the relatively short anteroconid (Table 1). This form looks more archaic than it could be expected given the geological structure of the section. Its enamel differentiation is similar to that of *A. mosbachensis* from Medzhybizh 1 (MIS 9), or, among the west-european faunas, to Weimar-Ehringsdorf (Maul et al., 1998) or even Schöningen-Reinsdorf (Kolfschoten, 2014), which correspond to MIS 7 and 9, respectively. Not excluded that the archaic features of *Arvicola* from Bilanove-2 has the same explanation as the Saalian-Eemian fluctuations of SDQ values in water voles of Western Europe, i.e., migration of a more archaic form from the south after climate warming (Koenigswald and Kolfschoten, 1996). However, the available material is obviously too scarce for a firm conclusion. For now, we use open nomenclature for *Arvicola* from Bilanove-2 to emphasis its similarity to *A. mosbachensis*, although Bilanove-2 (Kaidaky age) is out of the range of the stratigraphical distribution of this species.

**Table 1**. Morphometric characteristic of *Arvicola* from the Bilanove quarry

| | *Arvicola terrestris,* Bilanove-1 | *A.* cf. *mosbachensis* Bilanove-2 |
|---|---|---|
| L M3, mm | 2.42 | 2.57 |
| L m1, mm | 3.63 | 3.5 |
| A m1, mm | 1.69 | 1.5 |
| A/L, % | 46.49 | 42.84 |
| BTQ, % | 78.3 | 115.6 |

Authors thank the administration of FERREXPO Poltava Mining and FERREXPO Belanovo Mining for the access to the sections and the assistance during excavations. M. Stakhiv and M. Lyshenko take part in the excavations and authors are greatly indebted to them.

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# HOLOCENE SOIL EROSION ON AGRICULTURAL LOESS AREA WITH SAR OSL DATING, FALLOUT RADIONUCLIDES ($^{137}$CS AND $^{210}$PB$_{EX}$) AND SEDIMENTATION TRAPS – A MULTIPROXY CASE STUDY IN SOUTH POLAND

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***Keywords:*** *soil erosion, OSL dating, fallout radionuclides, loess areas*

Loess areas used for agriculture are susceptible to mechanical denudation associated with atmospheric precipitation. The soil erosion processes in Polish loess areas have already begun at the beginning of the Neolithic era and further intensified in the Middle Ages, drastically increasing in modern times. As a result of intensive denudation, at the foot of the slopes and in the bottoms of dry loess valleys, a series of redeposited loess-soil deposits have accumulated, reaching a thickness of up to several meters. The colluvial sequences are mainly composed of nonhomogeneous Holocene sediments of various ages and lithology (older soil material layers and noncarboniferous loess).

This work presents the results of the study of Holocene soil erosion and sediment accumulation in agricultural loess areas near the village Ujazd (Proboszczowicki Plateau, South Poland). For the determination of modern soil erosion, methods based on fallout radionuclides were used for the last century ($^{137}$Cs, $^{210}$Pb$_{ex}$). The study area is located in the region where a higher concentration of $^{137}$Cs in the soil may be expected due to the Chernobyl accident. The concentration of Chernobyl $^{137}$Cs could vary widely even within one field. For this reason, the fallout model of $^{137}$Cs fallout was constructed apart from the measurement reference value of $^{137}$Cs fallout for the study area. The age of the sediments was determined using the OSL method. To study soil erosion, about 24 soil cores were collected from the selected field. For six soil cores along the cross-section of the slope, a detailed physicochemical analysis of soil and sediment properties, including pH, C, N-tot, $Fe_{dith,}$ $Fe_{ox}$, grain size, was performed. Besides this, soil cores from undisturbed areas were collected as a reference.

In addition, sediment samples were also collected in the sediment traps arranged along the slope. For those sediment samples, OSL dating, as well as isotope studies and chemical properties studies, were conducted. The results obtained have shown that Holocene colluvial sediments containing grains of quartz can be approximately dated using OSL. The obtained results are important for the study of Holocene soil erosion and accumulation of colluvial sediments not only on a local scale but also in a wider range, e.g. for the loess uplands of central Europe. Although $^{210}$Pb is widely used to study lake sediment accumulation, its application to the study of soil erosion is rather limited. Based on the fallout radionuclides data and OSL dating results, it was possible to reconstruct the history of soil erosion and sediment accumulation for the study area during the Holocene period. The soil erosion for the study area has already started in the middle age and increased drastically in the last century. The detailed study of sediment with additional monitoring of sedimentation traps shows the behaviour of bleaching of OSL signal of quartz grains during the redeposition.

# LONG TERM PANNONIAN FLUVIAL MAGNETIC SUSCEPTIBILITY RECORDS DOCUMENTING ALPINE PERMAFROST DEVELOPMENT IN COLD EVENTS OF THE EUROPEAN QUATERNARY

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***Keywords:*** *fluvial deposits, mountain permafrost, magnetic susceptibility, reference section*

In 2015 (at Strati2015, Graz, Austria) the magnetic susceptibility (MS) was invoked as a possible correlation tool in Quaternary alluvial stratigraphy. The reason of this idea was that, according to the mineralogical investigations, the high MS values observed regularly in the 440–480 m thick fluvial sediment sequence of the Körös Basin (East Hungary) are determined by the climatic control on delivery and preservation of magnetic minerals, mainly of magnetite (Püspöki et al. 2016 figure 6). The possible explanation was that under cold-and-dry climate these minerals were released owing to frost shattering in the adjacent hinterlands and were transported to alluvial plains in the early postglacial periods thanks to the increasing discharge of rivers. However, with further warming the weathering-sensitive magnetic minerals soon disappeared from the soils of the catchment area and thus from the fluvial load (figure 11 *ibid*).

Between 2016 and 2019 further studies on 350–650 m thick Quaternary fluvial successions in the adjacent sub-basins (Jászság Basin, Makó Trough) were performed to extend the initial observations. The cross-basin correlations were based on the laboratory measurements of MS values (0.5–1 m sample steps) in fully cored boreholes, and on complementary palaeontological (molluscan) data. The resulted age models were confirmed by multi-proxy time series analyses revealing fundamental Milankovitch frequencies (~100 and ~41 ka) in the correlated sections. These investigations indicated that (1) the climate-dependent fluvial MS signal can be traced far into the basin in both channel and floodplain environments and (2) can occur related to various sources of magnetite in the catchment areas. The early postglacial escape and spreading of the magnetite fraction can greatly support (1) the mapping of the unconformable Quaternary base, (2) the cross-basin correlations between different sub-basins (Püspöki et al. 2020 figure 4) and (3) the cross-facies correlation in the heterogeneous alluvial sequences (supplementary figure 1 at the same place), in short, (4) high-resolution Quaternary stratigraphic correlations and reservoir modelling in the Pannonain freshwater aquifer system. With the Alps in the catchment area, it was also recognised that in the case of significant altitudes in the associated catchment area, orographic aspects can also occur in the climatically controlled fluvial MS record, as the gradually retreating permafrost zone causes upwards decreasing trends in the MS records (Püspöki et al. 2021a, figure 11).

Based on these preliminaries, in 2021 the high-resolution regional Quaternary stratigraphy of the Great Hungarian Plain was established by correlating the fluvial MS records of 13 fully cored boreholes eight of which represent complete or almost complete Quaternary (2500 ka) sections (Püspöki et al. 2021b, figures 4 and 5). Additionally, supported by the evaluated palaeomagnetic reversals and instability events in the most representative Dévaványa and Vésztő borehole sections, the regionally correlated MS peaks were correlated to the cold stages of the marine isotope stage records (MIS) (Lisiecki and Raymo 2005). The regionally relevant MS peaks represent MIS 104, 100, 98, 82, 60, 52, 34(-36) and 26 of increased heavy oxygen isotope value, constituting the significant Early Pleistocene glaciations, and MIS 18, 16, 12, 8, 6 and 2 (figure 6 *ibid*) mostly representing the substantial Middle and Upper Pleistocene European glaciation events (Ehlers and Gibbard 2004). Thus, the interpretation of early postglacial fluvial MS maxima was confirmed by the correlation of MS peaks to the changes of the global ice volume. As a result, fluvial MS records can be considered as a proxy on mountain permafrost development in the catchment areas.

The correlation to the sea-floor stratigraphy confirmed that the main Pannonian Quaternary sub-basins are sites of almost continuous fluvial/alluvial records of the past 2500 or even 2600 ka. Thus, the Pannonian Quaternary fluvial succession is sufficiently complete to provide satisfactory records of mountain permafrost development of the Alp-Carpathian region the latter being a globally relevant European representative of the mid-latitude mountain regions.

The similarity of the Pannonian fluvial MS records as a potential permafrost proxy, for example to the marine ice-rafted detritus (IRD) records (Mangerud et al. 1996, Jansen et al. 2000) and MS data of Chinese loess/palaeosol sequences (Ding et al. 2005, Sun et al. 2006), promises further comparative investigations and joint interpretations of the globally relevant proxy records and the mid-latitude mountain permafrost development (Püspöki et al. 2021b, figure 9). To support these comparisons, the palaeomagnetically documented Dévaványa borehole section can be proposed as a potential reference section of the European intra-terrestrial Quaternary fluvial deposits.

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# NONLINEARITY, THRESHOLD EFFECT AND EMERGENCE PROPERTY IN EVOLUTION OF THE CENTRAL EUROPEAN REGIONAL MAMMAL ASSEMBLAGE IN MIS7–MIS1 (~200 CAL KA)

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***Keywords:*** *mammal assemblage, the Pleistocene, evolution, complex system*

The evolution of species composition in the Central European Northern regional mammal assemblage has been studied in the time interval from the end of the Middle Pleistocene to the Middle Holocene (~200 cal ka). The region includes, mainly, the territories of the Czech Republic, Poland, Belarus, Lithuania, Estonia, west of Ukraine. The study is based on species lists of 353 palaeontological sites (657 localities). 63 intervals of time scale characterized by unique distributions of different species localities were used as elements of the evolutionary models. The multivariate descriptive models were obtained for full mammal assemblages (138 species including bats) and separate mammalian groups ("guilds"): carnivorous (25 species), large and medium sized herbivorous (22 species), small herbivorous (52 species) (Fig. 1) and insectivorous (16 species). Within the general framework of non-linear system concept, one may interpret stationary states highlighted in the Fig 1A (grey polygons) as fluctuations of a system around some "attractor" in phase space of the descriptive model. In general, a self-organisation of the system in an evolutionary time may be described as a motion from one attractor to the other. In the beginning the system abruptly loses stability (threshold effect) (Groffman et al., 2006), and then it shifts, relatively quickly, to a new area of phase space and forms a new adaptive attractor (Bohórquez Arévalo and Espinosa, 2015). The hypotheses of species collectively (holistic) responses (Lyons et al., 2010) and species-specific ("individualistic") responses (Grayson, 2007) on global climate variations was tested at a guilds level. The descriptive models of separate guilds are differing significantly from each other and from the model of full assemblage. This fact that descriptive evolutionary models cannot be reduced to each other (uniqueness property) expresses the property of the complex systems, namely "emergence" (Ladyman et al., 2013; Palombo, 2018). An emergence means that it is impossible to provide adequate description of the system's dynamics only at a particular hierarchal level of its organisation, without taking into account how it behaves at "neighbouring" hierarchal levels. We believe that both "holistic" and "individualistic" responses exist, but they reflect different aspects of evolutionary dynamics of a complex system. These phenomena are not reduced to each other. The emergence property does not allow for a mechanistic extrapolation of the study results between different hierarchal levels or parts of such complex systems as species assemblages.

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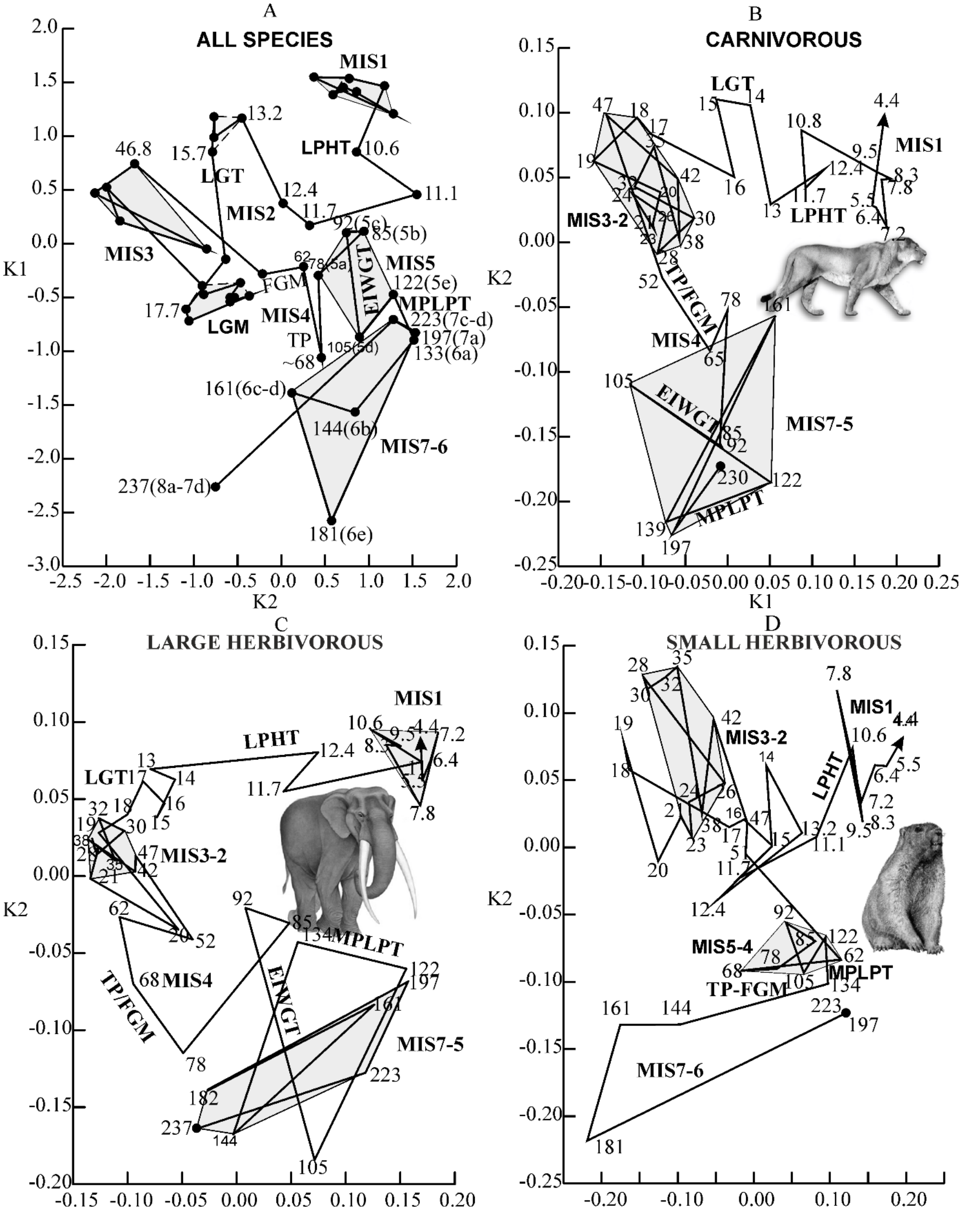


**Figure 1**. Descriptive models of evolution of full mammal assemblage (A), carnivorous (B) large herbivorous (C) and small herbivorous (D) in the Central European Northern bioregion between MIS7 and MIS1 stages. The abbreviations: TP, FGM – Transitional Phase and First Glacial Maximum of MIS4, respectively; LGM – the Last Glacial Maximum, LGT – Last Glacial Termination, MPLPT – the Middle– Late Pleistocene Transition, LPHT – the Late Pleistocene–Holocene Transition, EIWGT – the transition between the Eem Interglacial and the Weichselian/Valdai Glaciation. The numbers on the graph represent the age in cal ka BP.

# QUATERNARY REMAINS OF BOVIDAE GRAY, 1821 FROM CAVE EMINE BAIR KHOSAR (CRIMEA)

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***Keywords:*** *quaternary remains, Bovidae, Emine Bair Khosar, Cave*

The Emine-Bair-Khosar is a mega-trap cave containing sediments with rich assemblages of Late Pleistocene fauna. It is located on the Chatyrdag Plateau in the Crimean Peninsula. For the first time, the cave was explored in 1908 by Alexander Kruber, but paleontological research began only in 1999. The assemblage comprised in total almost 50 species of vertebrates. The main bone accumulation (section Ba2-Bc) was deposited during the Eemian (Kaydaky, Mikulino, MIS 5e) interglacial and Middle Planiglacial (Middle Valdai, Vytachiv, MIS 3) interstadial, to the end of the Pleistocene and the Holocene, including gaps during stadials. The studied material includes the family Bovidae Gray, 1821, the most important faunal representative of the *Mammuthus-Coelodonta* complex.

Three members of this family were recorded: *Bison priscus* and *Saiga tatarica*, with the rare presence of *Bos primigenius*. Most bones belonged to juveniles. The remains of the steppe bison were similar in size to those of the Upper Pleistocene from Poland. Saiga antelope remains were similar to specimens from other sites of the Crimea like Surien 1, and from the Czech Republic and France. However, they were more distinctly longer and more massive than representatives of modern saiga from the Thuringian Plain.

# MARTYNIVKA: A NEW CAVE SITE WITH LATE PLEISTOCENE SMALL MAMMALS' FAUNA IN THE MIDDLE DNIESTER AREA (UKRAINE)

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***Keywords:*** *cave, gypsum karst, rodents, Novgorod-Siverskyi fauna, Late Pleistocene*

Although the karst cavities, especially the numerous huge maze-caves, are widespread in the Middle Dniester area's sulphate deposits, the caves containing Pleistocene faunal remains in the area are rare (Ridush, 2009, 2014). Therefore, discovering a new cave site with the Pleistocene fauna is essential for reconstructing local landscapes in the Pleistocene.

Martynivka Cave is a karst cave, developed in the Miocene gypsum strata, in the Middle Dniester area (48° 32′ 22.52″N, 25° 58′ 0.54″E). The two cave entrances with the height of human growth are in the gypsum cliff, 30 m above the valley bottom, on the right bank of the Chornyi Potik River, a right tributary of the Dniester River. The 10 m thick gypsum strata in this area is represented with white and light-grey microcrystalline nodular gypsum. According to the morphology of the cave it is of the hypogenic origin but also is strongly modified by the weathering processes. The total length of all cave galleries is 80 m, but the main gallery is just 25 m long, 2-5 m wide, and 2-3 m high (Ridush and Kuprich, 2003). The gallery ends with a large rock blocks collapse.

**Stratigraphy**. From 1960$^{th}$ the archaeological layers of the 7-8$^{th}$, 13$^{th}$, and 17$^{th}$ centuries are known (Ridush B, 2000). The up to 1,0 m thick cultural layer of the 17$^{th}$ century overlaps the rock-fall. During human inhabiting of the cave in the 13$^{th}$ century, all the natural sediments in the entrance part of the cave were removed, and the cultural layer of that period was bedded immediately on the rock floor. In the 17$^{th}$ century, most of the 13$^{th}$-century cultural layer was also removed. The undisturbed sediments were preserved only below the large blocks in the inner part of the gallery. The excavation of the gypsum blocks gave numerous faunal remains of small mammals deposited in loose sediments between blocks and the cave wall and between the blocks. The bone-bearing sediments are represented by 0.3-0.6 m thick alevritic loess-like yellow, sometimes light brown, sediment and fine gypsum cryogenic debris, with inclusions of coarse debris.

There are three orders represented: Insectivora, Chiroptera and Rodentia. Pikas (*Ochotona pusilla*) and hamsters (*Cricetus cricetus*) dominate; fewer water voles (*Arvicola amphibius*) and voles (*Alexandromys oeconomus = Microtus oeconomus*). Forest forms are sporadic: dormice (*Glis glis*), squirrels (*Sciurus vulgaris*), and red forest voles (*Clethrionomys glareolus*). Very few voles (*Microtus arvalis*). The presence of lemmings (*Dicrostonyx henseli*), steppe lemming (*Lagurus lagurus*) and narrow-headed vole (*Lasiopodomys gregalis*) is unique. The species assemblage indicates the ecologically mixed nature of the fauna with the dominance of the species of mesophilic habitats and the predominance of steppe species over cold-loving species (lemmings and narrow-headed voles).

It can be considered that this is the extreme southern area of periglacial fauna in Eastern Europe (including the northern part of Moldova where lemmings were also known (Lozan, 1971)) in the late Pleistocene, probably its final stages (MIS 2). A typical periglacial fauna of Eastern Europe is the fauna of Novgorod Siverskyi in northern Ukraine: a unique combination of tundra and steppe biocenoses with minimal mesophilic biocenoses (Krokhmal' et al., 2021). The Martynivka biocenosis is dominated by mesophiles, which is typical of the more western regions of Europe. This fauna can also characterize the transition between the steppe faunas of southern and eastern Europe and more western, even more mesophilic faunas. On the one hand, it is an extreme version of the periglacial, and on the other – it characterizes the transition to western fauna, which have many forest forms, and which are not (practically) in Novgorod Siverskyi and Martynivka. Ecologically, the fauna of Martynivka is specific. Taxonomically, picas (steppe) and hamsters (mesophiles, but also more inclined to moist steppe stations) predominate. Steppe lemming (*L. lagurus*) are also well represented in the west, but in Martynivka, it may be a feature of taphonomy that they are so few.

**Taphonomy**. Nowadays, the site is situated in the semi-aphotic part of the cave. Considering the regular slope regression that is characteristic for the area, 20-30 kys BP, the site was further from the entrances, in the aphotic zone. The bone accumulation could be connected to the activity of troglophilic small carnivores like foxes or mustelids, which are inhabiting the cave or visiting it. Such animals as picas and dormice are also troglophilic species and could die during winter hibernation. The nesting of the birds of prey in this place is very unlikely because of low ceiling of the gallery.

**Acknowledgements**. The authors are grateful for the assistance in excavations given by cavers of the Chernivtsi speleological club "Troglodite".

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# SMALL MAMMALS FROM IVITSA SITE (RUSSIA, TVER REGION)

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***Keywords:*** *Late Pleistocene, small mammals, lemming fauna*

In 2018, on the Ivitsa River (right tributary of the Medveditsa River, Volga basin, Tver Region, see Fig. 1), a local resident discovered a fragment of a mammoth skull with teeth. In 2019, excavation work was carried out at the site by a joint expedition of the Borissiak Paleontological Institute of the Russian Academy of Sciences and the Institute of Geography of the Russian Academy of Sciences. The bone bed lies 80 cm above the river's edge and at a depth of about 2.5 m from the surface in thin-bedded sands, the roof of which is disturbed by cryoturbation (Voskresenskaya et al., 2019).

The alluvial deposits overlying the mammoth skeleton were washed on sieves to obtain the bones of small vertebrates. Interest in the fossil find is due to the incomplete information about the mammoth range in the Late Pleistocene and the small number of localities with the fauna of small mammals in the northwestern part of the Russian Plain for the border of the last glaciation. The localities Cheremoshnik, Levinka, Mikhailovka and Bolshoi Shezhim are known from the Russian Plain (Agadjanyan, 1972; Agadjanyan and Erbaeva, 1983; Agadjanyan, Motuzko, 1972). Typical lemming faunas of small mammals have been described for them.


**Figure 1**. The geographical position of the Ivitsa site

The material of small mammals was obtained from Ivitsa site. These are isolated teeth and skeletal fragments of small mammals. The color of the material is light brown, the preservation is medium. The species composition is not random and contains species typical of the lemming faunas.

There are collared lemming *Dicrostonyx* cf. *torquatus*, east european lemming *Lemmus* cf. *sibiricus,* narrow-skulled vole *Lasiopodomys (Stenocranius) gregalis.*

The distribution of lemming faunas in the Late Pleistocene has been well studied in Europe (Hinton, 1926; Nehring, 1890 etc.), in the Urals, in Western and Eastern Siberia (Sher, 1984; Zazhigin, 2003 etc.) and North America (Repenning et al., 1964; Guilday, 1968 etc.). The composition of lemming faunas in different points of the range is heterogeneous. In Western Europe in lemming fauna, along with lemmings, there are red-backed vole *Clethrionomys*, water vole *Arvicola*, tundra vole *Microtus oeconomus*. In Eastern Europe, forest forms are replaced by steppe ones: narrow-skulled vole, steppe lemmings Laguridae. A characteristic feature of the lemming faunas of Europe is the predominance of the collared lemming over the east european one. In Siberia, the collared lemming is less; it is replaced by the east European one. The faunas of Siberia are characterized by a combination of lemmings, narrow-skulled vole and long-tailed ground squirrel *Spermophilus undulatus*. The areal of the lemming fauna probably formed by the Late Pleistocene throughout the Holarctic realm. At this time, tundra-steppe biotopes were widespread and began to decline in the Holocene. According to the morphological study of the teeth of rodents from Ivitsa, the fauna of this locality has a Late Valdai age (Würm, MIS2). Which is consistent with the Ivitsa radiocarbon analysis data. The radiocarbon dates obtained from the mammoth skull show a scatter of calibrated dates. There are 16100 ± 390 calBP (No LU-9362) and 11520 ± 470 calBP (No LU-9363). The composition of the fauna of Ivitsa is typical for the lemming faunas of Europe, the composition of which is dominated by the collared lemming over the east European one. Probably, during the Late Valdai time, there was a distribution of treeless arid tundras in this area.

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# MULTIPHASE CRYOGENESIS IN NORTH-WESTERN SIBERIA DURING MIS2: COMPARISON WITH THE EUROPEAN PERIGLACIAL ZONE

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The scenario of MIS2 (the Sartanian time in the Siberian scale) environment free of glacial ice in the north of West Siberia is widely accepted by researchers at present. In the absence of the Sartanian till and ice-dammed lake deposits supposed earlier for this area and usually used as an informative indicator to reconstruct former events, the question arises about a representative geological object which could be considered as a regional reference unit for this period and used for the correlations on the continental scale. Earlier the present authors define the North-West Siberian palecryopedogenic horizon as a specific product of the surface geological processes in the north of West Siberia during the Last (Sartanian) Cryochron. Further research has demonstrated however that this horizon had multiphase development witnessed by two groups of evidences.

The first group is related to the complex structure of the large ice wedge pseudomorphs at the high old terraces MIS3 and older. These pseudomorphs can reach 5-6 m in height and 3-4 m in breadth. Incised smaller wedges-pseudomorphs separated by the rusty rims were observed within the larger wedge structures. Radiocarbon dates from the humus-rich sedimentary blocks (morphons) of the ice wedge pseudomorphs infillings show a variety of ages which mostly fit into 3 main clusters: 1) around 16-17 ka BP – beginning of the Post-Sartanian warming; 2) around 13-14 ka BP – the Greenland Interstadial I (Bølling–Allerød); 3) around 11-10 ka BP – onset of the Holocene. More detailed section was found at the lower terrace where the sedimentation proceeded throughout MIS2.

We found a paleosol with the radiocarbon date of about 15 ka BP, buried under alluvial sandy deposit partly reworked by the eolian processes. This deposit was dissected by thin but deep cryogenic cracks associated with the horizon of involutions with the $^{14}$C dates of 9-10 ka BP, overlain by the Holocene peat (Fig. 1, 2). These cryogenic features are supposed to be formed during the Younger Dryas.

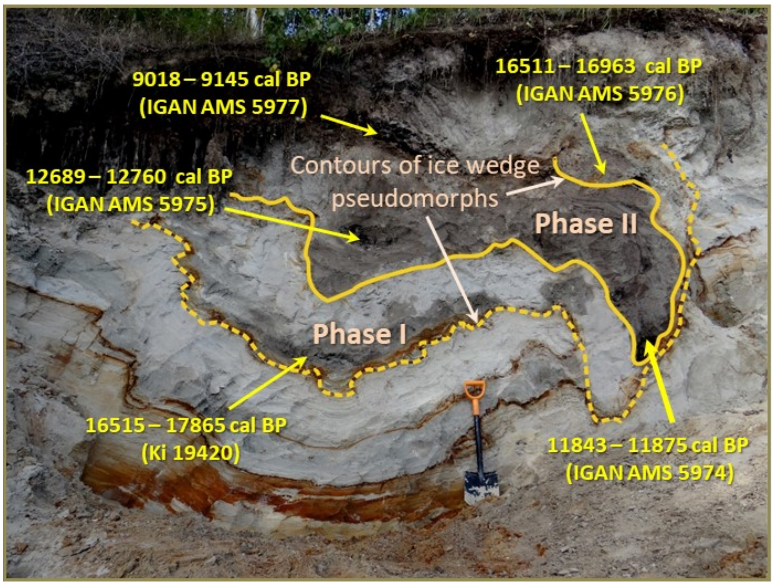


**Figure 1**. Complicated ice wedge pseudomorph with structures of different generations embedded one after the other in the body of a Sartanian terrace in the Lower Nadym River basin. Photo from the archive of V.S. Sheinkman.

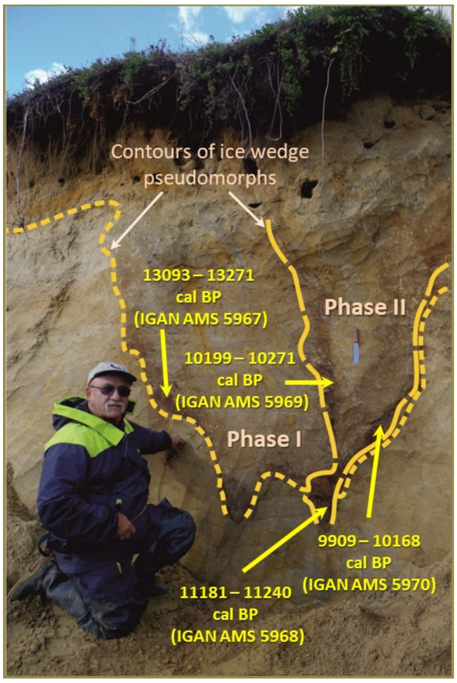


**Figure 2**. Complicated ice wedge pseudomorph with structures of different generations embedded one after the other in the body of a Sartanian terrace in the Taz Nadym River basin. Photo from the archive of V. S. Sheinkman.

All the observations show that several cryogenic phases were alternating with the intervals of milder climate promoting pedogenesis during the second half of MIS2, most probably they were controlled by the global climatic changes. What is important, the revealed Sartanian North-Western Siberian paleocryopedogenic horizon representing a result of environmental development under properly permafrost conditions, could be correlated with the European MIS2 cryogenic horizons and paleosols identified in Poland, Ukraine and East Russia as a result of periglacial conditions. A detailed correlation reveals specific cryogenic units corresponding to the Younger Dryas observed throughout the Northern Europe with the features very similar to those detected in the North-Western Siberia.

# IS THE TRACE ELEMENTS GEOCHEMISTRY USEFUL FOR THE STRATIGRAPHIC PURPOSES IN PERIGLACIAL LOESS? CASE OF POLISH LATE PLEISTOCENE LOESS-PALAEOSOL SEQUENCES

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The loess-palaeosol sequences (LPS) composed of the alternation of loess and palaeosol horizons, are considered as key-archives for reconstructions of palaeoclimates, palaeoenvironments, and palaeolandscapes (e.g. Lehmkuhl et al., 2021, and the references therein). Because of palaeoenvironmental changes, the LPS differs in chemical composition even from one stratigraphic unit to another, thus it can be potentially used as a criterion to verify the stratigraphic subdivisions (e.g. Skurzyński et al., 2019, and the references therein). The above-mentioned assumption is particularly useful for analyses of long LPS such as in China or Serbia. For example, at least 44 major shifts from glacial to interglacial conditions can be found in the Chinese loess record (Kukla and An, 1989). In Poland, such long proxy-dataset cannot be found – typically, only the last glacial-interglacial cycle can be investigated due to e.g. limited exposure of the research profiles. In addition, Polish loess represent a different, much more dynamic environment of deposition. It is related to the Pleistocene glaciations, and developed in general as a result of short distance aeolian transport, after the long-term glacial and fluvial reworking of "fresh" and "older" cover sediments delivered originally both from northern Europe (by the British and Fennoscandian ice sheets), and also from the local sources (e.g., Rousseau et al., 2014; Skurzyński et al., 2020; Baykal et al., 2021).

It is shown in the Fig. 1 (on the example of loess in the Złota profile; e.g. Skurzyński et al., 2020) that only some of major elements are clearly highlighting the variability of the main pedo-lithostratigraphic units. The distributions of trace elements (including REE) are not particularly dependent on the pedo-lithostratigraphy (Fig. 1). Similar trends were found also for other Polish LPS (Biały Kościół and Tyszowce). It may mean that despite its enormous importance for palaeoenvironmental analyses, high-resolution multi-elemental chemical investigation is not really useful for stratigraphic interpretations of the Polish periglacial Late Pleistocene LPS.

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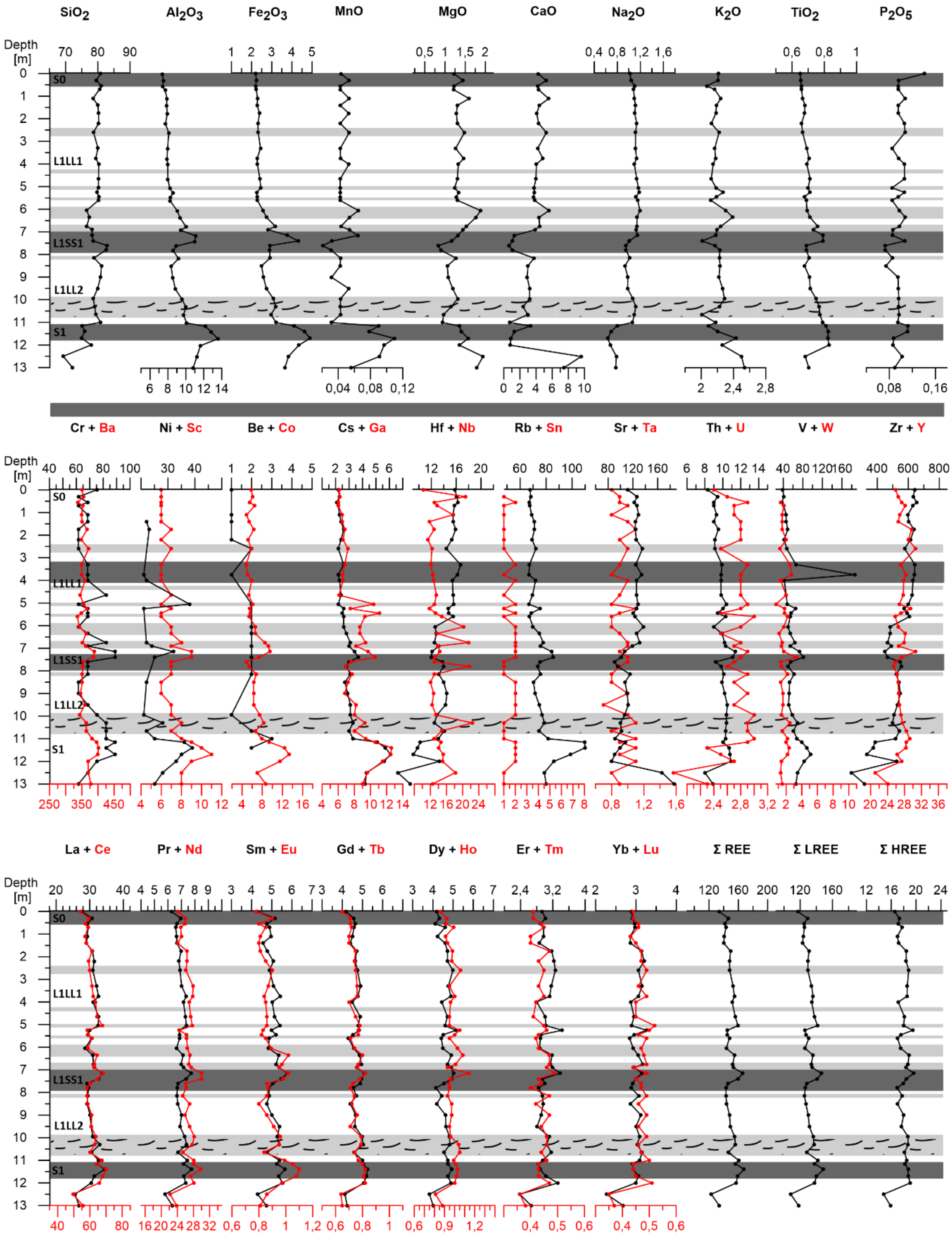


**Figure 1.** Distribution of major (wt%) and trace (including REE; ppm) elements contents of the Złota profile (after Skurzyński et al., 2020). The pale grey rectangles are horizons with signs of the gley processes. Main pedo-lithostratigraphic units are shown. For methodological and technical description of analyses, please refer to Skurzyński et al. (2020).

# CHRONOLOGY AND PALAEOCLIMATE CONDITIONS OF THE MID PLEISTOCENE BŁĄDZIKOWO FORMATION, OSŁONINO CLIFF SECTION, NORTHERN POLAND

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***Keywords:*** *periglacial structures, Marine Isotope Stage 7, Meandering fluvial system, palynological analysis*

The Błądzikowo formation was firstly described and established by Skompski (1997) and related to the fluvial deposition in the Eemian Interglacial. One of the several outcrops, where its sediments are available to studies is the Osłonino Cliff. The outcrop is located at the western coast of the Gulf of Gdańsk, southern sector of the Baltic Sea. Along of 400 m coastline cliff and up to 20 m high the Pleistocene series are exposed. Three main sedimentary units have been distinguished there: the till from the last glaciation (U3 unit), glaciolacustrine sediments (the Rzucewo clays, U2 unit) and sandy sediments (the Błądzikowo Formation, U1 unit). U1 unit was the subject of interdisciplinary studies, including sedimentary, palynological and optically stimulated luminesce (OSL) age analyses.

The main aim of the studies is to: (i) reconstruct sedimentary processes; (ii) establish chronology of the processes; (iii) reconstruct palaeoenvironmental conditions and their impact on sedimentation. In total, three profiles were studied in detail to obtain aims mentioned above. Fluvial series was subdivided into two main subunits: lower, U1a and upper, U1b. The lower subunit consists of coarse- to fine-grained sands deposited in sand-bed braided to meandering river system. This subunit is correlated to fluvial series described from the nearby located, the Mrzezino and Reda sites (Sokołowski et al., 2019, 2021). However, OSL dating results are in a wide range, the younger results (223 +/- 12 ka, 184.2 +/- 9.7 ka) are comparable to the results from the Mrzezino and Reda sites (Sokołowski et al., 2019, 2021). In this case, we assume that deposition took place in the Marine Isotope Stage 7 (MIS 7). The quartz grains and heavy minerals analyses suggest that it was redeposited sediment of glacial origin with short transport and without influence of aeolian processes.

The U1b subunit consists of fine-grained sands and silts with lithofacial succession of point-bar and floodplain features. This allows to interpret the U1b subunit as deposited in sand-bed meandering river with well-preserved floodplain. In specific lithofacies numerous syn-depositional periglacial structures were observed. The presence of continuous peat layers give an opportunity to reconstruct plant cover. Palynological analysis suggest that steppe-tundra predominated in severe, periglacial climate. This interpretation is confirmed by quartz grains and heavy minerals analyses. Their results reveal multiple redeposition of the sediment and strong influence of aeolian processes.

OSL dating results from subunit U1b are as well in a wide range. Younger part of the dates (194 +/- 12 ka, 157 +/- 9.7 ka) suggest MIS 6, presumably prior to the Late Saalian (Wartanian) glaciation.

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# PLENIGLACIAL AND LATE GLACIAL EVOLUTION OF THE EXTRAGLACIAL PROSNA RIVER FLUVIAL SYSTEM, CENTRAL POLAND

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***Keywords:*** *lithofacial analysis, periglacial structures, braided fluvial system, OSL dating*

Extraglacial river systems functioned in the Pleistocene in front of ice-sheets with hydrological system independent of direct influence of glacial melt-waters. Evolution of such river systems is well documented in western and central Europe (Bridgland, Maddy, 2004; Starkel et al., 2007; Vandenberghe, 2008). However, most of extraglacial fluvial systems did not feel the influence of the ice-sheet margin. One of the river, which joined to ice-marginal valley, is the Prosna river, central Poland. Today, this river flows from the south to the Warta River as its left-bank tributary. During the Last Glacial Maximum, the Prosna river flowed into the so-called Warsaw-Berlin ice-marginal valley system (Rotnikcki, 1987). In the Pleniglacial and the Late Glacial a system of fluvial terraces formed as a response to climate and base-level changes (Rotnicki, Latałowa, 1986; Rotnicki, Młynarczyk, 1998). Therefore, we studied in detail several outcrops with fluvial series in the Prosna river valley to establish sedimentary environments, chronology and climate conditions during depositional processes.

In order to achieve the set goal of the research, detailed studies were carried out at 6 sites: Ciemierów, Zawady, Tursko, Turowy, Piła and Kwileń. They are located in the lower and middle course of today's Prosna river within its terraces. The present-day Prosna valley has a well-developed terrace system with large meanders from the end of the Pleistocene. On the other hand, the higher terrace (or terraces) have a strongly reshaped relief due to aeolian processes.

Conducted studies let to identify gravel-sand glaciofluvial series, presumably of Late Saalian (Wartanian) age below fluvial series. Fluvial units above are separated from glaciofluvial series below by an erosional surface of regional significance emphasized by an erosional boulder lag. Fluvial units represent several incision-aggradation cycles. The top of fluvial units are overlain by fluvio-aeolian and aeolian complexes, as well as floodplain deposits of the Holocene age. To establish the type of fluvial deposition lithofacial analysis was used. To reconstruct climate conditions periglacial structures analysis as well as textural analyses of fluvial deposits were used. Optically stimulated luminescence (OSL) method was used to perform time framework of fluvial processes.

The thickness of the fluvial units range from 7-8 m to 11-12 m. Fluvial deposits were formed mainly in the channel facies, which accounts for 80-90% of all sediments. The channel facies consist of sands with an admixture of gravel with through- and tabular cross-bedding in medium and large scale. The measured directions of transport indicate the N-NW direction for the fluvial series and S-SE for the fluvioglacial series. The overbank facies are mainly formed in the form of horizontally laminated sands and silts with a thickness of up to 1.3 m. At the Zawady, Piła Jaźwiny and Kwileń sites several generations of syngenetic frost wedges and involution complexes were identified. The length of wedges in the Zawady site exceeds 5 m. The dimension of involutions in the Kwileń site is up to 1 m thick and are developed within the overbank sediments.

The results of OSL dating suggest that fluvial units were deposited in the middle and late part of the Pleniglacial. The first phase of fluvial aggradation took place 28-25 ka in the lower part of the Prosna river valley. This unit was deposited in high-energy sandy-gravelly braided river system. The fluvial processes were accompanied by the aggradation of permafrost. Exposed surface of mid-channel bars and abandoned channels were exposed at aeolian processes. The role of aeolian redeposition is revealed in the middle part of the Prosna river valley, where fluvio-aeolian cover was simultaneously deposited (30.0±2.1 ka – 27.5±1.9 ka). The first phase of aggradation was interrupted by amelioration of climate conditions. In this relatively short period (between 25 and 24 ka) permafrost experienced melting and deposition of fine material on floodplain prevailed. The next phase of fluvial aggradation is situated between 24.9±2.0 ka and 17.3±1.0 ka. Deposition in channel sub-environment prevailed. We interpret predominance of through cross-bedding as a result of deposition in sand-bed braided river. Fluvial deposits were reworked by aeolian processes and fluvio-aeolian cover aggraded on floodplain and abandoned channels. Numerous syn-genetic ice-wedge casts document cold climate conditions, widely reported from the Late Pleniglacial (Kozarski, 1993; Zieliński et al., 2014). The last phase of fluvial activity is noted from big meander system. Previous results suggest that its deposition developed in the Younger Dryas (Rotnicki, Latałowa, 1986). Our studies suggest slightly earlier time, presumably in the Bølling-Allerød interstadial.

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# PEDOGENIC CARBONATE NODULES AS SEASONAL PALEOCLIMATE ARCHIVE

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***Keywords:*** *pedogenic carbonates, nodules, thermodynamic model*

Pedogenic carbonates can form in wide range of climates. They precipitate from supersaturated soil solutions during dry periods when evapotranspiration exceeds rainfall. These solutions are impacted by the chemistry of rainwater that equilibrates with soil $CO_2$, which is released by root and microbial respiration as well as by organic matter decay. Consequently, isotopic signature of pedogenic carbonates is highly influenced by climatic conditions present during their formation, and its study in carbonate nodules of paleosoils can be used to unravel changes in climate conditions during the geological record. The $\delta^{18}O$ values of pedogenic carbonates are mostly related to the isotopic signal of meteoric water, while the $\delta^{13}C$ signal reveals information about dominant vegetation cover at the time of their formation (Zamanian et al., 2016).

However, the isotope signals represent only the conditions at the time of carbonate precipitation. So, it is key to understand any possible seasonal bias in the rate of pedogenic carbonate formation to prevent any misinterpretation of the data as paleoclimate indicators. We studied a 0.6 m deep Red Mediterranean Soil profile in Dalmatia (Croatia) having a calcic horizon at the bottom. Over the period of 3 months, soil temperature, soil water content, soil bulk electrical conductivity and soil air $CO_2$ were measured at the location. Based on the data collected, a thermodynamic model was developed for dissolution and precipitation of calcite in the soil. According to the results, two phases can be distinguished. From mid-April to mid-July a stage dominated by calcite dissolution is present. In this period soil water content was still high and progressive rise in temperature caused $CO_2$ to build up in the soil, eventually resulting in dissolution of calcite, including some of the previous pedogenic carbonates. From mid-July until the end of our record high temperatures caused a negative soil water balance and eventually leaded to supersaturation of the soil solution and precipitation of pedogenic calcite. In both stages temperature controlled indirectly the chemistry of the solution. During the first stage, rise in temperature enhanced the microbial activity and/or other processes that increased the concentration of soil $CO_2$ and caused the dissolution of calcite. During the second stage, however, temperature resulted in a negative effect on soil water balance by enhancing evapotranspiration, which controlled the chemistry of the solution causing precipitation of pedogenic carbonates.

This research proves that at our studied site dissolution and precipitation events of pedogenic carbonates are related to specific stages within the year. Although a full year was not modelled, preliminary monitoring results suggest that not one, but two cycles of precipitation (summer and winter) and dissolution (spring and autumn) can be identified in a year at the studied site. Our results highlight the importance of understanding site specific soil dynamics for interpreting isotope records from pedogenic carbonates. Thus, pedogenic carbonates might be useful archives of seasonality rather than average climate and environmental conditions of the past. Continuous monitoring and modeling studies at the studied site, together with isotope analyses on carbonate nodules, will allow us to identify the potential of isotope studies to characterize seasonality over full annual cycles.

*This work is part of the research project "Inter-comparison of karst denudation measurement methods" (KADEME, IP-2018-01-7080) and "Young Researchers' Career Development Project – Training New Doctoral Students" (DOK-2021-02) financed by Croatian Science Foundation.*

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# ESTIMATION OF RECHARGE FROM KARST SOIL BY RESERVOIR CASCADE SCHEME MODEL

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***Keywords:*** *reservoir cascade scheme, recharge, preferential flows, karst soil*

Recharge from soil to karst was estimated in a 0.6 m deep soil profile developed on dolomite marbles with a small cave system, at a location in central Spain [1]. Soil water content (SWC) was simulated for six layers in soil by reservoir cascade scheme (RCS) approach. In RCS approach, soil is considered as a unit made of imaginary layers, i.e., reservoirs. Each reservoir gains and loses water by major hydrological processes which include precipitation, runoff, plant interception, evaporation, transpiration, infiltration, redistribution, and drainage or deep percolation [2, 3]. Soil field capacity (FC) is considered a key parameter in RCS approach since it represents a threshold that controls process of drainage in a way that whenever SWC exceeds FC of a certain layer, drainage occurs [4]. Besides when FC of soil is exceeded, drainage as well occurs in the form of preferential flows. Drainage from the deepest soil layer enters as recharge from soil to the vadose zone of karst. Therefore, three different configurations of the model are assumed. Configuration 1 considers only basic RCS module, while configurations 2 and 3 include preferential flows. Configuration 2 considers RCS module together with a continuous preferential flow module, where 1 to 5% of available SWC from each layer is drained every day along preferential pathways, while Configuration 3 contains discontinuous preferential flow module in addition to all previous modules. The discontinuous preferential flow is only activated during rainfall events occurring after long dry periods. Therefore, model provides three different estimations of recharge. The simulation shows that preferential flows significantly impact the amount of soil-karst recharge. When only RCS module is considered (Configuration 1), recharge occurs only during winter-spring period, while during summer months, no recharge occurs. When preferential flows are considered, recharge occurs during summer months as well. Furthermore, cave hydrology depends on recharge amount from the surface, impacting speleothems formation. Therefore in order to accurately interpret paleoclimate proxies from speleothems it is important to understand water dynamics in soil and at soil-rock interface.

*This work is part of the research project “Inter-comparison of karst denudation measurement methods” (KADEME, IP-2018-01-7080) and “Young Researchers’ Career Development Project – Training New Doctoral Students” (DOK-2018-09-5748) financed by Croatian Science Foundation.*

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# LATE EARLY AND EARLY MIDDLE PLEISTOCENE BIOSTRATIGRAPHY OF THE EASTERN SEA OF AZOV REGION

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***Keywords:*** *Middle Pleistocene, Eastern Europe, biostratigraphy, faunal communities, paleoecology*

Several key sections exposed in coastal outcrops and sand pits in the Sea of Azov and Lower Don River Region allow to consider a relatively detailed sequence of early Middle Pleistocene deposits. Different types of fluvial and lagoonal deposits, and paleosols are characterized by the remains of large and small mammals, fishes, molluscs, palynology, and other fossils. It makes it possible to document the forming and transformation of Tiraspolian Faunal complex (=Cromerian), and reconstruct the paleoecological conditions in the region during the studied period.

The stratigraphic level of the terminal Early Pleistocene correlated to the paleomagnetic subchron between Jaramillo and top of the Matuyama Chron, is known in the section Margaritovo 2 (southern coast of the Taganrog Gulf) and in the section Gorkaya Balka in the middle reaches of the Kuban River in the North Caucasus. Both mammal bearing levels are represented by fluvial deposits underlying subaerial loess-like deposits that include Matuyama-Brunhes boundary. Biochronologically this time corresponds to the terminal Tamanian faunal unit, the regional zone MQR7a, and traditional Petropavlovka faunal phase of Eastern Europe (Vangengeim et al., 2001). Mammalian fauna is characterised by first *Microtus (Stenocranius) hintoni* and *Prolagurus pannonicus transylvanicus*. No faunas in the immediate stratigraphic vicinity of Matuyama-Brunhes reversal have been found in our studies so far. Large mammal remains from these sites are not very rich (*Marmota* sp., *Trogontherium* cf. *cuvieri*, *Ursus* sp., *Archidiskodon* sp., *Equus* sp., *Bison* sp.), but can characterize the general pattern of communities. The next younger documented level is the early Middle Pleistocene interval proper, correlated with the Cromerian period. The early Middle Pleistocene time is represented in the region of the study by thick deltaic-fluvial formation of the ancient Don River, the so called Paludina sands or Semibalki fluvial formation. These deposits are paleomagnetically normally polarized and represent the lower Brunhes Chron. Numerous sites along north and south coasts of the Taganrog Gulf expose this formation. The most important are Semibalki 2 (two), Zelenyi, Platovo, Taganrog, Gerasimovka, and others. This faunal level is well correlated with the classical Cromerian of East Anglia. In regional biochronology it corresponds to Tiraspol faunal unit and zone range of MQR4 to 6. From the same layers, an association of rodents originates, including the primitive *Lagurus transiens*, *Stenocranius gregaloides*, and *Microtus nivaloides*. These abundant forms are indicators of steppe landscapes. Other forms of open biotopes include *Eolagurus argyropuloi*, *Spermophilus* sp., the earliest *Marmota*, and the *Pygeretmus jerboas*. Rarer mesophilic elements of the rodent fauna include the vole *Clethrionomys*, *Microtus oeconomus*, and *M. savini (=intermedius)* (Tesakov et al., 2007). Large mammals are represented by remains of *Mammuthus trogontherii* (i.e., three almost complete skeletons), and the genera *Trogontherium, Crocuta, Equus*, *Praemegaceros*, and *Bison*.

The fish assemblage from the cross-bedded quartz sands indicates to a large fluvial, mostly freshwater body of water with different ecological conditions. The remains of the tench *Tinca tinca* and a group of limnophilic mollusks indicate the presence of calm areas with a silty bottom and thickets of aquatic and near-water vegetation. Rheophilic conditions with a faster current and rocky or sandy bottom are reconstructed based on the presence of fish remains of *Gobio* sp., cf. *Chondrostoma* sp., *Leuciscus* sp., as well as shells of mollusks of the genera *Unio* and *Crassunio*. The characteristics of coastal biotopes are evidenced by the finds of an amphibiotic species of the mollusk *Lymnea* (*Peregriana*) *peregra*, which usually settles in temporary water bodies, and also occurs along swampy river banks. The presence of terrestrial mollusks of the genus *Vallonia* indicates the presence of humid biotopes along the banks, where they occupy a niche among grass, moss and under the bark of fallen trees. They are found both in mixed forests and in shrubs in meadows and steppe areas (Frolov, Kurshakov, 2015). This correlates with palynological data from the Platovo locality, indicating the growth of mixed forests along the banks, as well as the presence of steppe areas on the watershed (Cross-section of the newest sediments ..., 1976).

Additional data comes from a paleosol, correlated with the studied period. It was found in several sections of the Sea of Azov Region (Semibalki-Ip, Shabelskoe, Port-Katon-2p, Melekino). This is the horizon of the Vorona paleosol complex correlated with the main optimum of the Muchkap interglacial, MIS 15. The paleosol properties indicate that it belongs to the group of subtropical savannah soils. Such ecosystems existed in climatic conditions where January temperatures were close to + 12 ... + 14 ° C, July temperatures were + 24 ... + 25 ° C, annual precipitation was about 550–650 mm (Velichko et al., 2012). The small mammal fauna obtained from the rodent burrows (krotovinas) of this horizon includes *Ochotona* sp., *Spermophilus* sp., *Pygeretmus* sp., *Spalax* sp., *Ellobius* (*Ellobius*) sp., *Lagurus transiens* sp., *Microtus* cf. *arvalidens*, *M. gregaloides*, *M*. ex gr. *arvalis* (Velichko et al., 2009). This association indicates a wide distribution of steppe areas.

The herpetofauna of the Tiraspolian faunal complex includes *Hyla* sp., *Bufotes viridis* s.l., Lacertidae indet., Colubrinae indet. Ratnikov (2002) listed the following forms from the early Middle Pleistocene of the Don drainage basin: *Salamandrella keyserlingii*, *Triturus* cf. *cristatus, T. vulgaris, Bombina bombina, B. variegata, Pelobates fuscus, Pliobatrachus cf. langhae, Bufo bufo, B. verrucosissimus, B. viridis, Rana ridibunda, R. temporaria, R. arvalis, Anguis fragilis, Lacerta agilis, Elaphe dione, Natrix natrix, N. tessellata, Vipera berus, Vipera ursinii,* and other forms.

The youngest Cromerian fauna in the region is Port-Katon 4 (southern coast of the Taganrog Gulf) found in fluvial clays. The fauna corresponds to the transition between Tiraspol and Khazar s.l. faunal units and zone MQR3. The fauna includes *Trogontherium cuvieri, Microtus arvalidens*, advanced *Lagurus transiens*, earliest *Arvicola mosbachensis (=cantianus*). The clayey sands of this fossiliferous horizon contain shells of modern boreal species of stagnophilic freshwater molluscs (*Lymnaea*, *Planorbarius*). The malacofauna is characterized by the absence of any thermophilic elements. An interesting find of the extinct gastropod mollusc *Parafossorulus* cf. *crassitesta* is one of the youngest records in Eastern Europe.

Recently the foregoing mammalian biochronology was tested by methods of aminostratigraphy (Tesakov et al., 2020). Aminoacids were extracted from operculi of fresh-water molluscs (Bithyniidae) co-occurring in the reference localities with mammals. This method successfully confirmed the general faunal sequence previously based entirely on stage of evolution and superposition approaches. It also illustrated large scale of redeposition of fossils in major fluviatile formations.

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# MORPHOTYPICAL AND DIMENSIONAL CHARACTERS OF CRASEOMYS RUFOCANUS MOLARS FROM THE LATE PLEISTOCENE-HOLOCENE CAVE DEPOSITS FROM THE RUSSIAN FAR EAST

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***Keywords:*** *morphological characters, Holocene, Late Pleistocene, Sikhote-Alin*

Small mammal remains are found mainly in cave deposits in the South and Middle parts of the Russian Far East. The abundant remains were discovered in the Holocene and Late Pleistocene deposits. Presence of a large number of red-backed vole's remains, in particular *Craseomys rufocanus,* in Tetyukhinskaya cave (the Middle Sikhote-Alin) and Medvezhyi Klyk cave (the Southern Sikhote-Alin) as well as presence in a modern fauna of this region served as a basis of the study. In both localities *C. rufocanus* was the dominant species in comparison with others throughout the entire depth of the cave deposits.

The present study focuses on the morphotypical and dimensional characters of the first lower molars (m1) of *Craseomys rufocanus* from the Late Pleistocene and Holocene cave deposits. 5162 molars from the Tetyukhinskaya cave (n=2667 m1) and Medvezhyi Klyk cave (n=2495 m1) were studied. As a result of the analysis, no differences in the length and width of the crown of molars from the Tetyukhinskaya cave were found. The tendency to increase the linear dimensions of *C. rufocanus* molars with an increase of depth of the Medvezhyi Klyk cave deposits until the Late Pleistocene ($F = 0.08\text{-}8.15$; $p < 0.05$) was revealed. Molars from the Tetyukhinskaya cave are comparable to m1 from the Holocene of the Medvezhyi Klyk cave in length, but less in width ($F = 6.62$; $p < 0.05$).

In the study of morphotypical characteristics (according to the approach - Markova, 2014) it was revealed that the m1 from the Tetyukhinskaya cave characterized by simple morphotypes than m1 from the Holocene and Late Pleistocene deposits of the Medvezhyi Klyk cave ($F = 3.175$; $p < 0.05$).

The obtained results can be explained by different conditions during the Holocene. They also support a variety of data about a complex intraspecific structure of the *C. rufocanus* in the south of the Far East (Ognev, 1950; Abramson et al., 2012).

*This study was performed within the framework of state contract with the Institute of Plant and Animal Ecology, Ural Branch of the Russian Academy of Science.*

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# SPACE-TEMPORAL MORPHOLOGICAL VARIATION IN THE SAMPLES OF FIRST LOWER MOLARS OF REED VOLE *ALEXANDROMYS FORTIS* (BÜCHNER, 1889) FROM PRIMORSKY KRAI (SOUTH OF THE RUSSIAN FAR EAST)

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***Keywords***: *anteroconid, morphotypes, islands, fossils, Primorye, Alexandromys fortis*

The morphotypic variability of the anteroconid form of the first lower molar of fossil and modern (continental and island populations) reed voles *(Alexandromys fortis*) from the territory of Primorye (south of the Far East) was analyzed. We examined 165 lower molars from 2 localities of the continental part of the south of Primorsky Territory, 341 teeth from samples from the islands of the Peter the Great Bay and 125 fossil teeth from the Late Pleistocene and Holocene deposits of the Medvezhy Klyk Cave (43 ° 01'43`N, 133 ° 01'23 `E). Material from the Medvezhy Klyk Cave sediments is divided into 4 samples. Late Pleistocene sample 1 - material from 12 and 11 layers, the age of the deposits is about 40–35 thousand years (Panasenko and Tiunov, 2010; Omelko et al., 2020). Late Pleistocene sample 2 - material from inclined layers 6–9, about 14–11 thousand years old. Middle Holocene sample - material from layer 5, about 6 thousand years old. Late Holocene sample - material from layers 3 and 4, about 3-4 thousand years old.

The morphotypic variability was taken into account on the basis of the study of variations in the structure of the labial and lingual sides of the anterior unpaired loop and the structural features of the lingual inward angle 4. Using the constructed combinational lattice, 36 morphotypes of the structure of the unpaired anteroconid loop of the anteroconid m1 were revealed. In Alexandromys fortis, like in most voles (Maleeva, 1976), a small group of morphotypes (from 2 to 4) predominates in all samples. A temporary complication of the prevailing type of m1 masticatory surface of the reed vole in the Holocene was noted. At present, on the continent, the highest occurrence is noted for the morphotype, which prevailed in the Late Pleistocene. Changes in the frequency of occurrence of morphotypes that took place in the Holocene may be associated with the resumed distribution, merging of scattered populations, and the restoration of the reed vole population (Alekseeva and Golenishchev, 1986) after a decrease in its number during the period of maximum cooling of the climate. The peculiarities of the m1 morphotypic composition of isolated populations of the reed vole on the islands of Durnovo, De Livrona, and Vera are determined by the genotypes of the founders of the island populations and the originality of new habitat conditions that initiated a high rate of evolution, the release of hidden diversity, and an increase in the number of rare morphotypes.

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# THE LATE PLEISTOCENE SUMMARY SECTION OF THE KULOI PLATEAU (EUROPEAN NORTHEAST)

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***Keywords**: Late Pleistocene, glaciations, marine transgression, glacio-marine environment, chronology, White Sea*

The Kuloi plateau is located in the far European Northeast, forming the large peninsula of the East European Plain pushing out into the White Sea. Tectonically this is a stable northeastern part of the Russian Plate and is bounded (from west to east) with Dvina Bay, Gorlo Strait and Mezen Bay. The coasts have their geographical names (from west to east) - Zimny (Winter) and Abramovskiy. To study the Late Pleistocene sediments in this area, field work was carried out in 2020-21, and the new data were obtained on the chronostratigraphy and palaeogeography of the Kuloi plateau, as a result.

Reconstructions of the Late Pleistocene history of the Kuloi plateau are still based on conflicting concepts concerning the chronology and eventfulness of glaciations. So far it has been reliably established that an extensive Boreal transgression took place here at the beginning of the Late Pleistocene, synchronous with MIS 5e and the Eemian (Mikulino) interglacial (Deviatova, 1982), covering the coastal area of the Kuloi plateau and entering far upstream the rivers Severnaya Dvina, Kuloi and Mezen. According the reconstructions of QUEEN project, in the first half of Weischselian (Early Valdai, MIS5d - MIS4) several glaciations may have developed in this area with the center in the Barents-Kara Sea region: 90 ka (Svendsen et al., 2004, Astakhov et al., 2016), 75-70 ka and 70-65 ka (Larsen et al., 2006). In addition, at the turn of MIS 4 and MIS 3 (60 ka), both glaciation (Svendsen et al., 2004) and marine transgression (the so called Mezen transgression) (Jensen et al., 2006) are reconstructed, and another glaciation occurred again 50-45 ka ago (Larsen et al., 2006). Various research groups achieve some uniformity of opinion only regarding the last glaciation during MIS 2, which completely covered the study area, but its eastern border and the deglaciation boundaries have not yet been established (Zaretskaya et al., 2021). Therefore, the main goal of our research is to obtain sufficiently reliable geochronological and lithostratigraphic data for the reconstruction of the Late Pleistocene sedimentary succession of the region. The studies on the Kuloi plateau coastal area (Zimniy and Abramovskiy coasts of the White Sea) included the lithostratigraphic description of the sections, sampling for OSL and $^{230}$Th/U dating and diatom analysis, as well as the binding of layers and samples to the absolute elevation scale. For a series of sections, the first OSL dates have already been obtained, thus we present some preliminary chronostratigraphic results.

The summary section of the Late Pleistocene of the Kuloi plateau is as follows. The lower part of the section is represented by deposits of the Mikulino (Eemian) interglacial. They were previously described in the borehole within the Gorlo strait close to Zimniy coast (Zaretskaya et al., 2021). These are sands covered with till of the last glaciation and dated to 161-111 ka BP. In the underlying blue-gray clays, a foraminiferal assemblage was revealed, represented mainly by Boreal species (Sobolev, 2008). On the Dvina Bay coast of the Kuloi plateau, the Mikulino horizon was identified in the lowest part of the section. It is represented by a pinkish-brown stratum of fine-grained sand with ripple marks, unevenly interbedded with silt. An OSL date of 104 ka was obtained from the sand. We assume that the stratum was formed in the deltaic conditions of the tidal sea.

The next stratum is represented by dark gray to black silty clay, occasionally with rock clasts of varying degrees of roundness, shell detritus or whole shells. These deposits are found in the lower parts of the sections practically along the entire Zimny coast. The bottom of the stratum is not exposed. We suppose the marine or glacio-marine origin of these sediments. Apparently, it accumulated in the setting of an ice-covered sea under conditions of cover glaciation, when the boundary of the glacier advancing from the Barents Sea may have been located in the Mezen Bay or the Voronka of the White Sea. The possible age of this sequence corresponds to MIS 5d or MIS 5b.

The layer overlying the dark silts with erosional boundary is represented by massive brown clays, alternating up the section by variously bedded sands with shell detritus and whole shells. This layer is traced in all sections of the Zimniy and Abramovskiy coasts. For this stratum, OSL dates were obtained in the age range of 62-52 ka. It can be correlated with the deposits of the Mezen transgression, reconstructed for the Cheshskaya and Mezen Bays, the age of which is estimated at 60 ka (Jensen et al., 2006) and for which a large series of dates was obtained in the range of 77-52 ka (Jensen et al., 2006; Larsen et al., 2006; Zaretskaya et al., 2021).

The next layer in the stratigraphic sequence of the Kuloi plateau was identified in the eastern part the of Dvina Bay coast. It is represented by interbedded silt and sand with gravel, pebbles and boulders. For this sequence, OSL dates were obtained in the range 39-34 ka. The origin of this layer is still questionable, as well as the origin of geological bodies that we discovered on the southeastern coast of the Gorlo Strait. These are lens-shaped bodies up to 500 m long and up to 25 m thick, composed of interbedded fine-grained sand and silt or clayey silt, and ripple marks can be traced. These bodies lie stratigraphically above the deposits of the Mezen transgression, sometimes replacing them along the strike, and their age and origin are still in question.

The LGM glacial deposits lay at the top of the Late Pleistocene stratigraphic sequence of the Kuloi plateau. Presumably, we traced the till of the last glaciation along the entire length of the Zimniy and Abramovskiy coasts, and the deglaciation deposits were noted on the western coast of the Kuloi plateau. An OSL date of 15 ka was obtained from glaciofluvial deposits. The thickness of glaciofluvial and glacial deposits varies from 18-20 meters in the western part of the study area to 1-2 m in the eastern. The glaciofluvial sand was earlier OSL-dated back at 21 ka in the section at Cape Abramovskiy (Larsen et al., 2006).

Thus, we can preliminarily assume that during almost the entire Late Pleistocene, except for MIS 2, marine sedimentation environments dominated at the edge of the Kuloi plateau. The multiplicity of glaciations in the Early Valdai time is still doubtful and contradicts the obtained lithological and geochronological data. It should be noted that the most complete Late Quaternary sections are exposed in the sections of the Zimniy coast, greatly reducing on the Abramovskiy coast, where deposits of the maximum stage of the last glaciation lie on the clays and sands of the Mezen transgression, probably due to tectonic subsidence of this flank of Kuloi plateau.

*This work was financially supported by the Russian Foundation for Basic Research (project No. 20-05-00613).*

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# ENVIRONMENTAL AND ARCHAEOLOGICAL CONTEXTS OF THE LUSATIAN CULTURE JATWIEŹ DUŻA SITE (NE POLAND) – KEY STUDY

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***Keywords:*** *Jatwieź Duża site, human-environment relations, Bronze Age, Lusatian culture, NE Poland*

The main aim of this paper is to present results of geoarchaeological investigations of a network of 27 sites of the Lusatian ash fields culture assemblage and human-environment relationships from NE Poland (Podlasie voivodeship). As an example of a model site identified in the context of palaeogeographic and archaeological research, the site of Jatwież Duża will be presented (Fig. 1).

The network of these Prehistoric, Late Bronze Age and Early Iron Age, structures has relatively uniform location and structure. They are mainly located in the basins of the two main rivers of the region - Biebrza and Narew. In terms of their construction they have a circular arrangement with two areas - a protective area consisting of a system of ditches and embankments and a central area consisting of a flat central square (Fig 1) (Żurek et al. 2020).

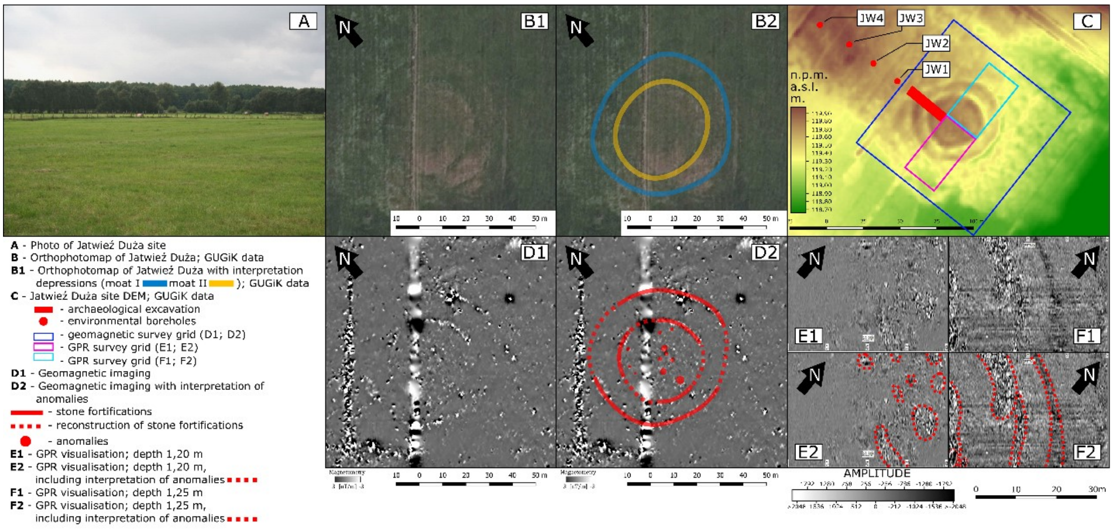


**Figure 1**. Jatwież Duża site; compiled by K. Żurek; A - photo, A. Wawrusiewicz; B - orthophotomap, GUGiK data; C - DEM, GUGiK data; D - geomagnetic data, interpretation by K. Żurek after study by J. Niebieszczański; E and F - GPR data after Żurek et al. 2021

This region dominated for ages by groups of communities with a hunter-gatherer economy only at the turn of the Subboreal and Subatlantic becomes an oecumene of Lusatian culture (Żurek et al. 2020). It seems that this community is the first to establish a coherent network of sites, which can be associated with a stable settlement network and intensive agricultural use of the environment.

This is confirmed by data from the Archaeological Map of Poland, e.g. from the microregion of the Jatwież Duża site (radius 5 km from the site). The site recorded 64 points of community activity from the Bronze Age but only 1 from the Mesolithic, 4 from the Neolithic, 9 from the Iron Age and 1 from the Medieval period.

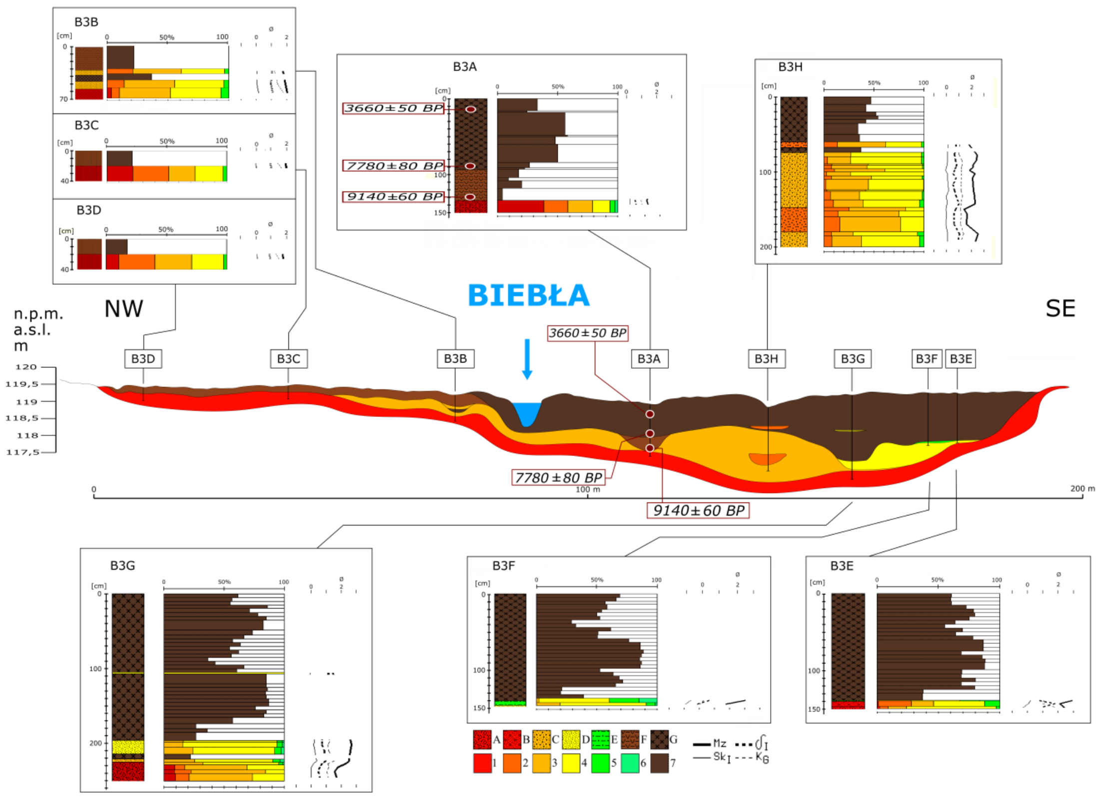


**Figure 2**. Schematic geological cross-section of the Biebła valley. Lithology: A - sand with gravels, B - sands with single gravels, C - medium-grained sands, D - fine-grained sands, E - silts and clays, F – peaty silt, G – peats; Fractions: 1 – gravel (under -1ϕ), 2 - coarse sand (-1 to 1ϕ), 3 – medium sand (1-2ϕ), 4 – fine sand (2-4ϕ), 5 – silt and clay (4-8 and above ϕ), 6 – clay (above 8ϕ), 7 – organic mattery; Folk-Ward's distribution parameters: Mz - mean diameter, $\delta_1$ - standard deviation (sorting), $Sk_I$ - skewness, $K_G$ - kurtosis

This settlement has led to a precipitation of the natural environment from entropy and its transformation. The use of natural resources for the needs of this community can be observed in the drainage basins of the Brzozówka river and its left-bank tributary Biebła river (Fig. 2). Intensive deforestation of the area caused a decrease of organic matter content in peats, which have been growing in both valley floors since the Preboreal period (9770-9180 BP). This change took place after 3660±50 BP (Biebła) and after 1870±60 BP (Brzozówka) (Żurek et al., 2021; Żurek et al., 2022).

Determining the function of the objects in this network is extremely difficult. There are many indications that we are dealing here rather with a kind of stable socio-administrative-religious centre concentrating dispersed in the microregion population of the Lusatian ash fields culture.

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**ISBN:** 978-83-942304-2-5