MODELING THE RELATIONSHIP OF THE UPPER PALAEOLITHIC COMMUNITIES AND THE ENVIRONMENT OF THE CARPATHIAN BASIN DURING THE UPPER WÜRMIAN

Keywords: Palaeolithic, radiocarbon dating, sedimentology, Quaternary malacology, palaeoenvironment

Introduction

According to malacological data from 36 radiocarbon dated Upper Würmian loess profiles the first chronological unit determined from the inferred palaeoclimatic changes embeds a period between 32,000 – 25,000 BP years. This unit was correlated by the Denekamp interstadial \(^1\) located at the boundary of the Middle and Upper Pleniglacial in Western Europe?, and between the SPECMAP 2 and 3 isotopic stages.\(^3\) The palaeosol horizons dated into this period can be correlated with the Stillfried B palaeosol. According to the available malacological data, this period can be divided into two parts. The older phase between 32-27,000 BP years was characterized by milder and more humid conditions. While the younger phase representing the period between 27-25,000 BP years was characterized by lower temperatures and drier conditions.

For this time period we could infer mean July palaeotemperatures ranging around 19-20 °C in the southern parts of the Carpathian Basin, 18 °C in the central parts of the Great Hungarian Plains, and 17 °C in the Northern Mid-mountains and the southern foothills of the Northern Carpathians, respectively. This N-S trend observable in the distribution of the temperature values is congruent with the differences observable between the individual parts of the country even today; i.e. a 2-3 °C difference between the northern and southern parts. Furthermore, we had only minimal deviations from the modern temperature values here being in the range of 2-3 °C implying the presence of very mild conditions between 32,000-27,000 BP years.

There were large-scale differences in the climatic conditions observable at the micro-scale, in accordance with the topography, as it could have been clearly justified by the analysis of the mollusc fauna of the palaeosol horizon of the Nagy Hill profile at Tokaj, corresponding to this period\(^4\) as well as the embedded charcoal remains.\(^5\) Thanks to the versatile topographic conditions mean July palaeotemperatures ranging between 14-17 °C could have been reconstructed for the different slopes characterized by different exposition. It’s worth mentioning that from the bedrock of the Nagy Mohos peat-bog of Kelemér\(^6\) managed to infer a similar strong warming in the climate via the advent of thermomesophilous deciduous arboreal elements during this time as well. From the palynological results\(^7\) we could have inferred mean July palaeotemperatures of 16-17 °C in the Kelemér valley\(^8\) during this time, which is congruent with

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\(^1\) WEST 1988.
\(^2\) ZAGWJN 1961; 1974.
\(^6\) JUHÁSZ 2002, 46.
\(^7\) JUHÁSZ 2002; MAGYARI 2001.
\(^8\) JUHÁSZ 2002, 46; SÜMEGI et al. 2008.
the values of the mid-mountains reconstructed via the application of the malaco-thermometer method.

According to our palaeobotanical data, a mixed taiga dominated by spruce must have emerged in the area of the Northern Mid-mountains and its foothills during this time (Fig. 1.). It might be important to know in reconstruction of the surrounding environment of the Palaeolithic hunters, that several *Picea* charcoal remains studied by Edina Rudner⁹ have been recovered from the Palaeolithic sites themselves (Bodrogkereszttűr–Henye-tető: 26,318 ± 365 BP; Megyaszó, Szelestető: 27,070 ± 680 BP; Püspökhátván–Diós, Öregszőlő: 27,700 ± 300 BP; Hont–Parassa III/Orgonás: 27,350 ± 610 BP).

**Results**

All these data seem to underlie that the earliest Gravettian hunting groups appearing during an interstadial at the end of the Middle Würmian in the Carpathian Basin¹⁰ must have populated spruce woodlands containing thermomesophilous arboreal elements (*Carpinus* – hornbeam, *Salix* – willow, *Alnus* – alder, *Betula* – birch, *Pinus sylvestris* – Scotch pine and possibly *Corylus* – hazelnut, *Tilia* – elm, *Quercus* – oak) as well. Sporadic changes in the dominance of shade-loving mollusc species, as well as the scatteredness of the charcoal remains forming major spots refer to the presence of variegated mixed taiga woodland containing steppe elements (forest steppe). The differences in exposure between the slopes might have contributed to the emergence of minor spots, characterized by warmer conditions harbouring thermomesophilous arboreal elements within the spruce woodland. A modern analogy of this spruce woodland can be found in the Altai Mts. where a mixed spruce woodland of loose stands can be found at lower elevations containing such elements as Norway pine, alder, willow and oak (*Quercus mongoliensis*).¹¹ According to the data of Stieber and Rudner-Sümegi¹² this spruce woodland can be traced within the Carpathian Basin as far as the Transdanubian Mid-mountains, turning gradually into forest steppes dominated by Norway pine and birch in the southern parts of Transdanubia and the Danube-Tisza Interfluve. While the area of the Hajdúság in the Tiszántúl harboured thermomesophilous steppes at the same time. Finally the areas of the Hortobágy, Nagykunság, and Kőröös – Maros Interfluve were characterized by floodplain areas studded by alkaline steppes. These open vegetation areas were studded by gallery forests running along the watercourses, and were characterized by hydromorphic, black earth and alkaline soils (Fig. 2.), parallel with the podzolic soils of the Northern Mid-mountains. The area of the Danube-Tisza Interfluve was characterized by wind-blown sand deposition and movement as well as the development of soils under a highly special forest steppe vegetation composed of dominantly Norway pines and birches. The southern parts of Transdanubia were covered by evenly distributed woodlands, and clear signs referring for the closure of the arboreal vegetation could have been found in the former fauna and flora there. To my mind,¹³ a major environmental boundary must have emerged in the center of the Carpathian Basin (Fig. 2.) dividing it into two parts characterized by different evolutionary histories of the vegetation. These regional differences follow the same trends as observable today, only the composition of the vegetation was different from the modern one. These differences between this former vegetation characterized by a dominance of pines at 32,000 – 27,000 BP years, and the modern vegetation characterized by a dominance of deciduous trees must be attributed to the shorter growth periods and the cooler winter temperatures during the interstadial. Nevertheless, it’s rather surprising that the Gravettian sites of this period are restricted to the spruce woodlands of the Northern Mid-mountains.

Several researchers, primarily geographers¹⁴ have questioned the reliability of our temperature reconstruction considering them too high. They have also debated our data referring to the presence of thermomesophilous arboreal elements in the vegetation, especially that of *Carpinus* (hornbeam) along with the presence of two biogeographic units, despite the fact that several archaeologists have noted the presence of two climatic-economic units within this relatively closed system of the

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¹¹ SÜMEGI 1996; SÜMEGI et al. 1999.
¹³ SÜMEGI 1995; 1996.
¹⁴ FÁBIÁN et al. 2004; KOVÁCS et al. 2007.
Carpathian Basin during the Upper Palaeolithic, based on archaeological results.\textsuperscript{15}

In order to put an end on these debates, we have attempted to compare our vegetation and palaeoenvironmental data with those of the neighbouring areas to disprove the hypothesis according to which the Carpathian Basin was nothing else but an alternation of cold and warm desert conditions during the stadials and interstadials of the Würmian. We have tried to gather all the available information from coeval archaeological (Willendorf, Dolní Věstonice, Pavlov)\textsuperscript{16} as well as environmental historical (pollen and macrocharcoal) sites: Lago Grande di Monticchio,\textsuperscript{17} Les Echets,\textsuperscript{18} Lac du Bouchet,\textsuperscript{19} Grands Pile,\textsuperscript{20} Monte Cavallo,\textsuperscript{21} Korrestobel,\textsuperscript{22} Barenhöhle,\textsuperscript{23} Baumkrichen,\textsuperscript{24} Tischofer-Höhle.\textsuperscript{25}

According to the gained information from the literature, our findings can not be treated as unique to the Carpathian Basin by any means. Since numerous charcoal remains of \textit{Picea} and those of \textit{Pinus cembra}, \textit{Larix-Picea}, \textit{Pinus sylvestris}, \textit{Juniperus}, \textit{Abies}, \textit{Taxus baccata} have been recovered from various sites in the layers dated between 25,000-32,000 BP years in Moravia, the Alps and the Vienna Basin (Fig. 1.). Besides the coniferous elements, remains of several deciduous elements have also been retrieved (\textit{Betula, Salix, Tilia cordata, Ulmus betulus, Populus, Fagus silvaticus, Quercus robur, Corylus avellana}) implying the development of favourable microclimatic conditions and a warming of the climate. The pollen charts containing information from this studied interstadial interval all indicated the appearance and expansion of thermomesophilous forms along with a strong advent of the coniferous forms during this period. The complex, systematic comparative archaeological and environmental historical investigations implemented at the sites of Pavlov and Dolní Věstonice\textsuperscript{26} have univocally justified the development of gallery forests dominated by pines but containing several thermomesophilous elements as well at the end of Denekamp interstadial, beginning of the Upper Pleniglacial in the valley of the Dyje creek. While the loessy hills elevated over the creek’s alluvium and giving the settlement site of the Gravettian hunters was harbouring forest steppes with loose stands of dominantly \textit{Picea} pines. Several thermomesophilous arboreal elements also populated these pine woodlands. The higher areas were covered by steppes containing stands of spruce and alpine pine (\textit{Pinus cembra}).

This picture is clearly congruent with the one reconstructed for the southern foothills of the Northern Carpathians and the Northern Midmountains in the Carpathian Basin via the investigation of charcoal, pollen, and mollusc remains, marking the presence of mixed spruce woodlands composed of loose stands of pines and various thermomesophilous deciduous arboreal elements in the mid-mountain zone of the Northern Carpathians and probably the northern parts of the Alps as well. The soils of the spruce woodlands must have been affected by intensive podzolization during this climatic stage.\textsuperscript{27} Consequently, the distribution of the oldest Gravettian sites seems to be closely linked to that of the spruce woodlands (Fig. 2.).

This may refer to the development of a close-knit relationship between the fauna and ecological conditions of these pine woodlands and the life strategies of the oldest Gravettian hunting groups. In order to elucidate something about this special relationship, we were trying to find connections between the prey animals and the former vegetation using information from the literature. The oldest Hungarian Gravettian site is that of Bodrogkeresztúr Henye-tető.\textsuperscript{28} This site yielded numerous vertebrate bones assigned into the Istállóskő fauna phase,\textsuperscript{29} studied by Miklós Kertzoi and István Vörös.\textsuperscript{30} The bones recovered from a surface of 258 m\textsuperscript{2} by Viola T. Dobosi and that of 165 m\textsuperscript{2} sampled by László Vértés were dominantly those of wild horses, moose, mammoths and

\begin{footnotesize}
\begin{enumerate}
\item \textsuperscript{15} GÁBORINÉ CSÁNK 1980, 217.
\item \textsuperscript{16} DAMBLON 1997.
\item \textsuperscript{17} WATTS et al. 1996.
\item \textsuperscript{18} BEAULIEU–REILLE 1984.
\item \textsuperscript{19} LALLIER-VERGÈS, 1991.
\item \textsuperscript{20} GUCS et al. 1989.
\item \textsuperscript{21} FUCS 1969.
\item \textsuperscript{22} GROSS 1958; 1959.
\item \textsuperscript{23} KNEUSSL 1972.
\item \textsuperscript{24} BORTENSCHLAGER–BORTENSCHLAGER 1978.
\item \textsuperscript{25} KNEUSSL 1973.
\item \textsuperscript{26} MASON et al. 1994; RYBIČKOVÁ–RYBNIČEK 1991.
\item \textsuperscript{27} NIKOLOV–HELMISAARI 1991.
\item \textsuperscript{28} VÉRTES 1966; T. DOBOSI 2000.
\item \textsuperscript{29} KRETZOI 1953; JÁNOSSY 1979.
\item \textsuperscript{30} VÖRÖS 2000.
\end{enumerate}
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buffaloes, both in terms of specimen numbers and the amounts of meat yields.  

When we have a look at the habitat preference of the individual vertebrate species (Table 1.), we can clearly see that the highly complex, mosaic-like patterning in the environment inferred from the results of malacological studies and macrocharcoal analysis is also corroborated by the findings on the vertebrate fauna. However, the extraordinary proportions of steppe elements, especially those of the wild horses calls for further explanation. The camp site of the Gravettian hunters at Henye tető was located in a spruce woodland on the hill. Several drinking sites must have been present on the underlying floodplain along a river, which must have occupied the site of the present-day Bodrog river, at a distance of only 1.0-1.5 km, where the herds of animals dwelling in different habitats must have gathered increasing the chance of a successful hunt for the humans. It is rather interesting that the local environment of the oldest Gravettian sites was characterized by similar natural endowments at each and every Hungarian site (Püspökhatvan Diós, Püspökhatvan-Öregszőlő, Verseg, Hont Parassa I.-II.-III.) with a creek valley harbouring mixed taiga woodlands surrounded by loess-covered hills of steppes and spruce forests, the latter giving the camp sites of the hunters, similarly to the coeval sites along the Morava at Dolní Věstonice and Pavlov. It’s also worth noting that not a single artifact belonging to the Gravettian culture has come to light from the areas located south of the mid-mountains and the belt of spruce woodlands within this chronological period. Nevertheless, it is also quite interesting that no Palaeolithic artifacts have been recovered from the thoroughly investigated palaeosol horizons in Southern Transdanubia or the area of the Alföld, dated into the Denekamp interstadial, and the beginning of the Upper Pleni-glacial, characterized by a retreat but by no means complete disappearance of the thermophilous and woodland elements. These must have survived in the protected refugia of the region. This transformation in the mollusc fauna may refer to a global cooling of the climate as the cold-loving elements gave a significant part of the mollusc faunas of the Carpathian Basin during this time with the presence of such forms as the Boreo-Alpine Columella columella, Vertigo modesta, V. parcedentata and the Northern Asian, xeromontane Vallonia tenuilabris. Representatives of the newly identified Pupilla cf. loessica in Hungary have also come to light from this horizon.

According to the former anthracological studies there was a gradual increase in the arboreal vegetation cover towards the southern parts of Transdanubia characterized by the presence of such arboreal elements as Corylus, Fagus, Quercus, Ulmus, Fraxinus besides Pinus sylvestris and Betula. A very similar pattern is observable in the distribution of the individual mollusc species with the presence of xerothermophilous elements like Pupilla triplicata, Chondrula tridens along the foothills of the Northern Mid-mountains, complemented by such thermophilous forms as Granaria frumentum, Vallonia enniensis, Helicopsis striata in the southern parts of the Great Hungarian Plains. While in the southern parts of Transdanubia the deciduous woodland and forest steppe dweller Cepaea vindobonensis and the woodland dweller Aegopinella ressmanni also turn up in this chronological horizon.

There was a complete turnover in the mollusc fauna at the end of the Denekamp interstadial, and the beginning of the Upper Pleni-glacial, characterized by a retreat but by no means complete disappearance of the thermophilous and woodland elements. These must have survived in the protected refugia of the region. This transformation in the mollusc fauna may refer to a global cooling of the climate as the cold-loving elements gave a significant part of the mollusc faunas of the Carpathian Basin during this time with the presence of such forms as the Boreo-Alpine Columella columella, Vertigo modesta, V. parcedentata and the Northern Asian, xeromontane Vallonia tenuilabris. Representatives of the newly identified Pupilla cf. loessica in Hungary have also come to light from this horizon.

Even though these cold-loving, open area dwellers composed the major part of the mollusc fauna, significant differences can be observed in their dominance values moving from the north to the south in the basin ( NE: >80 %, center 40-50 %, S < 20 %). Parallel with this spatial decrease in the proportions of the cold-loving elements, a concomitant increase in the ratio of the mesophilous and cold-resistant forms is observable in the fauna.

We have managed to come across specimens of Pupilla cf. loessica everywhere in the northern

31 VÖRÖS 2000.  
35 SÚMEGI 1996.
sites, while this taxon was substituted by *Pupilla sterri* in the southern parts of the basin during this period. Thus a mean July palaeotemperature of 14 °C could have been inferred for the southern, southwestern parts of the basin (Fig. 3), while this value could have gone up as high as 15-16 °C in the southern slopes of the hills, sand dunes and the more protected microhabitats. Conversely, the reconstructed mean July palaeotemperature values for the NE parts were much lower around 12 °C. Moreover, even colder temperatures could have developed in the colder, less protected valleys and crests with a tundra-like vegetation during the referred period. However, the southern slopes, crests with a tundra-like vegetation during the referred period must have been characterized by mean July palaeotemperatures around 14 °C. Thanks to the special location of the Carpathian Basin at the interface of several climatic influences, several minor protected warm spots and habitats could have survived even during this strongest global cooling between 25-22,000 BP, offering a safe haven to the cold-resistant and mesophilous elements. This referred cold stage could have been correlated with the Heinrich 3 event.

This assumption is corroborated by the findings of Stieber who managed to identify charcoal remains of *Pinus sylvestris, Picea, Pinus cembra, Larix, Salix, Betula* within this chronological horizon. There is only a single radiocarbon-dated profile known to intersect this period in Hungary located in the areas of the Hortobágy, as the ages of the other profiles formerly classified into the Upper Pleniglacial was highly questioned by the newly gained radiocarbon results. According to the observable characteristics in the radiocarbon-dated Hortobágy profile, the cold continental steppes of the period must have been characterized by an advent of such elements as *Poaceae, Artemisia, Chenopodiaceae*, with a coeval survival of the alkaline species as well. However, among the APs the presences of *Pinus, Picea, Juniperus, Betula, Salix* and *Larix* could have been justified, indicating the presence of a steppe-dominated forest steppe vegetation in the Carpathian Basin under colder climatic conditions. However, the deciduous elements could have survived despite the a strong global warming in the areas where the milder microclimatic conditions, attributable to the favourable orography were combined by higher humidity values thanks to a higher ground water table (sand dunes, the interface of the natural levees and alluvial plains). Unfortunately not a single Palaeolithic site have been identified from this period hampering the elucidation of the interrelations between the Upper Palaeolithic hunters and their surrounding environment during the first stage of loess formation in the Upper Würmian (25,000-22,000 BP years).

Conversely, the characteristic advent of the Arctic elements in the vertebrate fauna marks the development of a newer environmental historical phase, the so-called Pilisszántó fauna stage. The macrovertebrate fauna was dominated by caribou (*Rangifer tarandus*), snow grouse (*Lagopus mutus*) and ptarmigan (*Lagopus lagopus*). The microvertebrates were dominated by *Dicrostonyx, Ochonata* along with such sporadic elements as arctic fox (*Vulpes lagopus*), wolverine (*Gulo*), arctic vole (*Microtus nivalis*). Despite the efforts of Pazonyi, this fauna zone could not have been divided into further subzones thanks to the lack of sufficient radiocarbon dates.

On the other hand, as the example of the Tokaj-Csorgókút profile have clearly demonstrated, there is a good chance for preparing such subdivisions in the zonation of the Upper Würmian vertebrate fauna, by the introduction of new finer sampling methods, the screen washing of more deposits and the implementation of several radiocarbon analysis on the samples, finally leading to a complete reevaluation of the former results. According to the findings of investigations implemented in this former profile of the Tokaj area, parallel with the dominance of the Northern Asian, xeromontane *Vallonia tenuilabris* in the mollusc fauna, several microvertebrates characteristic of the Northern Asian and Southern Siberian cold continental steppes could have been recorded in this horizon (*Micoturs gregalis* as the dominant form, plus *Lagurus, Citellus citelloides, Allactaga, Sicista*). These data, being completely congruent with each other, clearly indicate the appearance of the characteristic forms of the Eastern European and

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40 KROLOPP et al. 1995.
41 SÜMEGI 1996.
42 SÜMEGI 1995; 1996.
44 STIEBER 1968.
47 PAZONYI 2004.
48 MENG 1995.
Central Asian loess plateaux in the NE parts of the Carpathian Basin during the times of the strongest coolings, in proportions of no match in other parts of the basin. This picture brings up the possibility of the evolution of an ecological corridor between the two areas during the strongest stadials, microinterstadials, when the Carpathian Basin must have formed the western margin of the Central Eurasian- Eastern European Pleniglacial loess belt, with a fauna poor in species but characterized by high specimen numbers.

On the other hand, according to the findings of the sedimentological,50 malacological,51 anthropological,52 and palynological investigations of the Upper Würmian loess profiles in the Carpathian Basin53 the loess formation was not continuous in this area during the Upper Würmian or the Upper Pleniglacial as in Western Europe.54 But this strong cooling phase was interrupted by several alternating short warmings and coolings, lasting for some hundred or some thousand years (microinterstadial) which slowed down loess accumulation in the area. The first microinterstadial was recorded at 21,000 BP years, and was characterized by an increase in different APs (Sambucus, Pinus, Larix, Picea, Betula, Alnus), but the preservation of the original duality of the palaeoenvironmental conditions in the basin. The northern parts were inhabited by mixed taiga woodlands harbouring such elements as Picea, Pinus cembra, Pinus mugo, Salix, Larix. While the southern mixed taiga woodlands were dominated by such taxa as Pinus sylvestris, Salix, Betula. These latter elements were also present on the floodplains in the company of some thermophilous arboreal taxa (Quercus, Acer, Corylus). The proportions of APs exceeded 70-80 % in the river valleys of the Great Hungarian Plains, and the lower-lying valleys of the mid-mountains. Conversely, alkaline meadows must also have emerged due to edaphic reasons in the extensive floodplain areas located behind the gallery forest-covered river banks (Hortobágy). The southern areas witnessed an expansion of the thermophilous elements of the mollusc fauna during this time (Granaria frumentum), while the waterbank areas were populated by euryptic, hygrophilous forms requiring larger vegetation cover and inhabiting the modern boreal woodlands as well (Clausilia dubia, Perofratella bidentata, Arianta arbustorum, Discus ruderatus). Conversely, the closed woodland elements have undergone an increase in the southwestern parts of the basin (Orcula dolium, Vitrea crystallina). These palaeoenvironmental data imply the survival of the formerly existing mosaic-patterning in the environment and the flora during this time, leading to the emergence of mixed, extinct floral and faunal associations. However, a characteristic increase in the dominance of the mesophilous, forest steppe dweller Vallonia costata is clearly observable in the majority of the profiles for this time (Vallonia costata zonula).55

After this microinterstadial, another strong transformation is observable in the flora and the fauna of the Carpathian Basin characterized by the advent of the cold, continental steppe-tundra vegetation in the area of the Northern Mid-mountains, dominated by Chenopodiaceae, Artemisia, Poaceae and such Arcto-Alpine vegetation elements as Sanguisorba officinalis, Thalictrum, Epilobium, Polygonum bistorta, Pleurospermum austriacum, Saxifraga oppositifolia, S. granulata type, Ephedra fragilis for example.56 Conversely, APs of trees and bushes like Betula pubescens, Larix, Pinus, Juniperus have also been recovered during this stage of the Upper Pleniglacial from the zone of the mid-mountains. The disappearance of the thermophilous molluscs, concomitant with the transformations in the vegetation as well as a retreat of the mesophilous mollusc elements, plus the recurrent advent of the cold-loving, cold-resistant, Boreo-Alpine, Northern Asian steppe and tundra-like habitat preferring molluscs (Columella columella, Vertigo geyeri, V. genesii, V. parcedentata, V. substriata, P. sterri, P. cf. loessica, C. nitens, Vallonia tenuilabris) as well as their peak dominance implies the development of a strong cooling in the climate, corresponding to the so-called Heinrich 2 event,57 the Last Glacial Maximum during this time in the Carpathian Basin.

Conversely, according to the findings of the palynological58 and malacological analyses of radiocarbon-dated profiles from the northern and

54 WEST 1988.
southern areas of the basin, there were significant differences in the palaeotemperatures of the individual regions not only at a regional but a local scale as well. The reconstructed mean July palaeotemperatures in the southern areas of the basin were around 14 °C, while those of the northern parts ranged around 12 °C, as it could have been inferred from palynological, and malacological results. On the other hand, there were several micro areas which were either cold spots with palaeotemperatures below 10 °C and a tundra vegetation or acted as warm spots with highly deviating temperatures of 16 °C at a local scale in the northern parts of the basin. These data further corroborates the presence of a mosaic-like patterning in the environment both at the regional and at a local scale as well. Accordingly the northern parts of the basin and the areas of the mid-mountains must have harboured a mosaic vegetation characteristic of the tundra/taiga boundary today. While the southern parts must have hosted a mix of boreal forest steppes and continental cold steppes with such scattered arboreal elements as Pinus cembra, Larix, Pinus sylvestris, Betula pubescens, Salix. The local cold-spots must have harboured Arcto-Alpine vegetation elements, while the local warm spots or oasis must have hosted thermomesophilous trees and bushes.

This picture reconstructed by us for the Upper Würmian might be surprising for those who previously assumed a relatively homogenous environment for the area of the Carpathian Basin forming a part of the Eurasian loess belt. However, as our findings clearly demonstrated the source and erosion, transportation and accumulation areas of the material required for loess formation should be by all means separated from one another. In the light of our results, we must account for not only NS but EW trends in the palaeoenvironmental conditions of this belt as well. In our opinion, the observed differences in the vegetation of the Carpathian Basin must be attributed to the fact, that the central parts of the basis must have formed the interface of the sporadic and discontinuous permafrost belts during the Upper Würmian interstadials. And this must be attributed to a similar overlap of several climatic zones or influences during this period to the one observable in the basin today.

**Discussion**

Nevertheless, one of the fundamental goals of our work was to clarify how these environmental mosaics might have affected the hunting Upper Palaeolithic Gravettian cultures in the basin. Even though we could not gain radiocarbon dates for each and every one of the numerous excavated Upper Palaeolithic sites dating to the Upper Würmian (Fig. 2), the presently available information points to the recurring appearance of these cultural groups in the basin during both the interstadials and stadials of the mentioned period. Conversely, the majority of the radiocarbon-dated Upper Palaeolithic sites seems to be restricted either to the transitional periods between the cold and warm waves, or to the period dated between 18,000 – 16,000 BP years at the end of the Upper Würmian.

According to our findings, the species requiring larger vegetation cover underwent an expansion between 16,000-18,000 BP in the areas of the Danube bend, the foothills of the Northern Mid-mountains, as well as the southern parts of Transdanubia, the Tiszántúl and the Danube-Tisza Interfluve (Mastus venerabilis, Discus ruderatus, Punctum pygmaeum, Clausilia dubia, Vestia turgida, Macragrastra ventricosa, Aegopinella ressmanni, Semilimax semilimax, S. kotulai, Vitrea crystallina, Vitrina pellucida, Bradybaena fruticum, Arianta arbustorum) becoming dominant elements of the fauna in the studied profiles. Parallel with the expansion of the woodlands elements, and those dwelling at the border zone of the open and closed vegetation areas, the cold-loving and open area dwellers (Columella columella, Papilla sterri, Vallonia tenuilabris) experienced either a steady

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60 MAGYARI et al. 2001.
decrease, or completely disappeared from the studied faunas.67

The inferred mean July palaeotemperatures also rose to the values ranging between 14-16 °C, compared to the 12-14 °C values of the Last Glacial Maximum, with an average value of 15.6 °C. It’s worth noting that the average mean July temperature values inferred for the NE parts of Hungary were around 15.2 °C, while those of the sites of southern Transdanubia and Great Hungarian Plains were 15.8 °C and 16.2 °C, respectively. These differences and trends in the regional temperature values are congruent with the ones observable today.68

On the basis of an observable increase in the dominance of the woodland dweller, hygrophilous mollusc species, a relative warming of the climate could have been inferred, embedding about 2000 years and characterized by a 2-3 °C rise in the mean July palaeotemperatures, as well as a considerable rise in the amount of the precipitation. This was congruent with an expansion of the arboreal elements inhabiting the woodland refugia located in the transition zones of the Carpathian Basin (Pannonicum) and the surrounding mountain belts69 (Carpathicum, Illyricum, Noricum70). These marginal woodland refugia belonging to the areas of the Precarpathicum,71 Preillyricum,72 and Prenoricum, experienced fluctuations in space and time in accordance with the global and regional climatic changes, characterized by iterative expansions and retractions (e.g. the woodland refugium of the Kereszt Hill site).73 These peripheric fluctuating areas74 extended into the margins of the Pannonicum between 16,000-18,000 BP years. However, they also could have infiltrated into the central parts of the Pannonicum via the ecological corridors of the river valleys (e.g. Tiszaalpár profile).75

The vegetation cover inferred from the analysis of malacological data indicating the spreading of woodlands has been justified by the findings of Stieber (1967), who could infer the presence of

taiga vegetation in the Carpathian Basin between 16,000-18,000 BP years via the analysis of charcoal from deposits of the same age. Burnt charcoal zones observed by Stieber, Pécsi and Hahn76 also indicate the presence of an extensive taiga, as the development of forest fires tends to follow a cyclic pattern as well in the present-day taiga vegetation zone especially in its southern margin characterized by mixed forests.77 As a result of the increasing forest cover due to a milder and wetter climate intensive humidification initiated in the area leading to the formation of a less- developed top soil of the Dunaújváros-Tápiósüly Loess Complex (h1).78

According to the detailed investigations on the Tápiósüly profile, this soil horizon can be dated between 16,000-17,000 BP, corresponding to the development of the Punctum pygmaeum - Vestia turgida zonula.79

Only scant information is available for the vertebrate fauna of the Ságvár-Lascaux interstadial, representing the Bajothian fauna stage80 with a few exceptions known from the archaeological layers and archaeology of the Upper Palaeolithic Gravettian sites.81 However, the large quantities of caribou bones retrieved from several sites are quite remarkable.82 The presence of these caribou bones, serving as potential prey animals at the sites further underlie the palaeoecological picture reconstructed for the Carpathian Basin on the basis of the mollusc fauna for the period between 16,000-18,000 BP (17,100-19,500 CAL BC), as hunting must have taken place at the time of herd formation and migration of the caribous.83 The migration of the caribou is related to the alternation of the seasons as they tend to dwell in the tundra during the summertime and retract into the taiga belt during the winter.84 Their migration between the two belts or zones appears during the spring and fall. Palaeolithic hunters specialized for the hunting of these animals, which served as a basis of their subsistence tended and tend to pursue the herds throughout their migration.85 Caribous must have

70 SOÓS 1943.
72 SÜMEGI et al. 1998.
73 SÜMEGI 1996.
74 VARGA 1981.
75 SÜMEGI et al. 1992.
80 VÖRÖS 1987; 2000.
81 VÖRÖS 1982.
82 VÖRÖS, 1982.
83 STURDY 1975.
84 JARMAN et al. 1982.
85 STURDY 1975; JARMAN et al. 1982.
migrated between the taiga areas of the Carpathian basin and the tundra regions surrounding the basin from the north and the west between 16.000-18.000 BP years as well, because according to the latest findings of the analysis of vertebrate remains the caribous were hunted down during the winter in the Carpathian Basin. In other words during the period when the caribous were dwelling in the taiga zone. The migration of the caribous to the winter taiga zone is an annual process triggered by the lack of food resources and unfavourable conditions of the tundra in wintertime and the presence of lichens as food source in relation to the coniferous vegetation in the taiga. Thus it is not surprising that the southern margin of the taiga zone coincides with the southern limit of migration of the caribous. Consequently, during the Late Würmian it was the area of Transdanubia, or at a broader scale the southern margins of the Carpathian Basin that formed a southern boundary of the distribution of caribous.

The emergence of this interstadial also witnessed the expansion of floral and faunal elements characteristic of the taiga and mixed taiga zones from the forest refugia and relict spots surviving in the marginal areas of the embracing mountains and the area of the Pannonicum. As a result of this process, the marginal areas of Pannonicum became covered with woodlands with the emergence of a vegetation zone observable in the southern margins of the present-day taiga. Nevertheless, the floral and faunal assemblages surviving among different environmental conditions (Carpathicum, Illyricum) expanded differentially at the northern and southern margins of the Carpathian basin. For example it was the forest dweller Carpathian spindle snail (Vestia turgida) that populated the northern and eastern parts of the basin, while the smooth spindle snail (Cochlodina laminata) was restricted to the southern areas. The distributions of the Carpathian-Alpian Semilimax kotulai and the Western-Central European, also Atlanto-Mediterranean Semilimax semilimax were influenced by the actual positions of the colder but wetter Carpathian montane climate center and the milder, more temperate and also wetter oceanic climatic center. These differences tend to indicate the emergence of an environmental barrier zone in the central parts of the Carpathian basin during the closure of the Pleistocene.

Most likely taiga forests with a dominance of Picea (spruce) must have emerged in the north while similar type of woodlands with a dominance of Pinus sylvestris (forest pine) must have developed in the southern areas (Sümegi 1996). Nevertheless, on the basis of the malacological findings the intermittence of open, steppe-like regions must have broken down the uniform taiga forests into mosaic-like smaller patches. Present-day analogies of this Late Würmian taiga, mixed taiga vegetation with intermittent patches of steppe areas can be found today in the northern rim of the Altai mountains, at the Kulunda-, Baraba-steppes, The Upper-Ob floodplains and the Vasjugan mountains, as well as the opening of the Surgut Plains. Here, at the interface of the taiga and the tundra the classical “Dokuchaevan” Eurasian floral and pedological zones form environmental mosaics corresponding to the local topography and hydrography.

This former landscape of the Carpathian Basin characterized by dominantly taiga forests, yet displaying a mosaic-like patterning regarding vegetation cover and soils, was one of the major destinations of the migration of Upper Würmian caribou herds and the Upper Palaeolithic hunters pursuing them. According to our findings, the hunting communities of the Gravettian culture were practising a hunting following the seasonal migration of caribou herds between the taiga, steppe-taiga or taiga steppe areas of the inner margins of the Carpathian basin and the tundra developed in the northern and western outer margins of the Carpathians around 16,000-18,000 BP years during the Ságvár-Lascaux interstadial.

According to the palynological findings for the Bátorliget, Kelemér, Hortóbágy, Balatonederics and Baláta profiles, the rate of arboraceous pollens displayed a significant drop following the Ságvár-Lascaux interstadial (between 16,000-18,000 BP or 17,100-19,500 CAL BC), accompanied by an increase and dominance of plant pollens characteristic of the steppes and open vegetation areas (Gramineae, Cyperaceae) as well as a rise in

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86 STURDY 1975.
87 VÖRÖS 1982.
88 VÖRÖS 1982.
89 KERNEY et al. 1983.
91 SÜMEGI 1996.
the ash concentrations recording cyclic forest
burnings.

Moreover, several character forms of the tundra
vegetation was recovered from the section of the
Balatonederics profile dated to 14,240 BP, such as
*Dryas octopetala, Betula nana.* According to the
pollen composition, a colder and drier climatic
cycle emerged during this phase. This can be placed
between 13,500-16,000 BP (14,200-17,100 CAL
BC) years on the basis of radiocarbon dated pollen
analytical and quaternary malacological results. This
climatic period seems to be well correlated
with the emergence of the so-called Heinrich event
(H1 level) of the North Atlantic regions and the
oldest Dryas horizon established on the basis of
palynological results. According to the results of the
malaco-thermometric method, the prevailing
mean July temperatures were around 12-14 °C in
the northern and eastern parts of the Carpathian
Basin, with a predicted value of 16 °C in the
southern areas.

It was this horizon referred to as the *Pupilla
sterri zonula* that marked the last large-scale
appearances of cold-resistant, xerophilous,
presently xeromontane mollusc species in the
central parts of the Carpathian Basin. The Upper
Würmian wind-blown sands of the Nyírség and the
Danube-Tisza Interfluve, as well as the closing
member of the Hungarian loess series, the so-called
“top loess layers” emerged parallel with the
development of this colder and drier climatic
period. This period also corresponds to the last
significant appearance of cold-loving elements in
the mollusc fauna; i.e. the typical loess steppe
dweller elements in the Carpathian Basin. The
major part of the basin was covered by cold
continental steppes studded by tundra vegetation
during this time. Besides some areas characterized
by favourable edaphic microclimatic conditions
must have harboured spots of mixed taiga
woodlands, hosting thermomesophilous arboreal
elements as well.

Surprisingly several forest dweller species have
come to light from the loessy layers of Southern
Transdanubia and the Southern Great Hungarian
Plains from the same period (e.g.: *Mastus
tuberculatus, Discus perspectivus, Aegopinella
ressmanni*), indicating that the development of the
flora, fauna as well as the climatic conditions must
have taken a different path in the southern parts of
the Carpathian basin from that of the northern and
eastern areas, similarly to the times of preceding
coolings and warmings as well. According to the
available Hungarian palynological data, a mean
July palaeotemperature of 13.4 – 14.2 °C could
have been inferred for this period. These data are in
good correlation with the ones gained for the mean
July palaeotemperatures of the northern areas of the
Carpathian Basin via the application of the malaco-
thermometer method.

As it can be seen from the available
radiocarbon data, this period marks the last
appearance of Upper Palaeolithic hunters related to
the Gravettian culture in the Carpathian Basin. However, in contrast to the earlier assumptions, this
was the time of last occurrence of mammoth in
the basin as well. Most likely the steppe
vegetation favourable for the mammoth populations
was still present in a part of the basin during this
period for the last time, and was totally expelled
from the basin after 13,500 BP with its
accompanying faunal associations as a result of
initiating environmental changes connected to a
global warming. The number of Northern Asian and
Central Asian vertebrate and Mollusc elements is
surprisingly high in the loess areas of the NE Great
Hungarian Plains (Hajdúság) and the northern
foothills for this period. The malacofauna, poor in
species, seems to be in close affinity with those of
the Russian and Ukrainian loess areas. This
period also corresponds to the last appearance of the Arcto-Alpine and Northern Eurasian elements
of the vertebrate fauna in the Carpathian Basin
(*Elephas primigaenius, Rangifer tarandus, Ovibos*);
i.e. the closing phase of the Bajothian fauna.

94 SÜMEGI et al. 2008a.
98 SÜMEGI 1995.
105 KROLOPP et al. 1995.
107 KROLOPP et al. 1995.
All these findings along with the palaeoenvironmental results from Bátorliget, Balatonederics, Kelemér, Baláta and Kardoskút seem to indicate the possible presence of a floral and faunal migration pathway or green corridor for the continental elements between the Eastern European Lowland and the Great Hungarian Plains during this time in the northern parts. Most likely it was this corridor that offered a path for a NE retreat of the seasonally migrating big games and the pursuing Palaeolithic hunters following the initiation of a Late Glacial warming.\textsuperscript{109} Meanwhile, the southern and southwestern parts of the basin were characterized by an expansion of woodlands. According to the results of the detailed malacological and palynological analysis of the Bátorliget, Kelemér, Baláta and Balatonederics profiles, an expansion of the taiga woodlands must have occurred at 13,000 BP thanks to a warming during the Late Glacial, which must have resulted in the closure of the above mentioned continental corridor. Nevertheless, as it was inferred from the profiles of the Hajdúság and the Hortobágy such as a continuous “ecological island” of extensive continental steppes, floodplain meadows and alkaline steppes have managed to survive in the central parts of the Great Hungarian Plains (Hajdúság, Hortobágy).\textsuperscript{110} Furthermore, the elevated loess plateaux (Mezőföld, Bácska) were characterized by the presence of local extensive forest steppes containing open arboreal spots of Norway pine and birch, thanks to the favourable hydrologic and orographic conditions\textsuperscript{111} while the foothill areas were covered by closed mixed woodlands with elements deriving from the Illyric, Carpathian and Transsylvanian woodland refugia.\textsuperscript{112} By this time elements characteristic of closed mixed taiga woodlands dominated the flora and the fauna everywhere in the basin, as it was shown by the results of malacological,\textsuperscript{113} palynological,\textsuperscript{114} vertebrate\textsuperscript{115} and anthracological analyses.\textsuperscript{116} Several faunal (\textit{Cepaea vindobonensis}: Sümegi, 1989, 1996) and floral elements (\textit{Corylus avellana}: Sárkány in Borsy et al. 1982; Willis et al. 1995; Juhász 2002), which underwent an expansion during the beginning of the Holocene appear here, marking the complete disappearance of the background environmental conditions required for the life of the Upper Palaeolithic hunting groups in the basin. The presently available archaeological data also indicates the appearance of Epipalaeolithic, Mesolithic groups in the basin during this time, taking over the place of the Upper Palaeolithic hunters.\textsuperscript{117}

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\bibitem{110} SÜMEGI et al. 2005; 2006; SÜMEGI–SZILÁGYI 2010.
\bibitem{111} SÜMEGI 2003 a, b; JAKAB et al. 2004,
\bibitem{112} SÜMEGI 2004.
\bibitem{113} SÜMEGI 2003 b.
\bibitem{114} WILLIS et al. 1995; 1997.
\bibitem{115} VÖRÖS 2000; JÁNOSSY–KORDOS 1976.
\bibitem{116} BORSY et al. 1982; STIEBER 1968.
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MODELLEZÉSE A KÁRPÁT-MEDENCÉBEN A FELSŐ WÜRM
IDEJÉN

SÜMEGI PÁL

Kulcsszavak: Őskőkor, radiokarbon kormeghatározás, szedimentológia, negyedidőszi malakológia, paleo-környezettan

Az északkelet magyarországi löszös területek mellett az elmúlt 15 évben számos felső Würm időszi és késő glaciális lösz profilt vizsgáltunk a Dunántúlon és az Alföld déli és középső részén, vagy újraértelmezük őket az új radiokarbon koradatok birtokában. Annak ellenére, hogy a felmelegedések és lehűlések ritmusa a felső Würm során egységes, számos jelentős különbséget tudtunk megállapítani a vizsgált területek molluszka-faunájának összetételében.
Figure 1.: Upper Paleolithic sites and palaeovegetation of the interstadial phase between 32,000 – 25,000 BP years


1. ábra: Felső paleolit lelőhelyek és paleovegetáció az interstadiálisban, 32,000 – 25,000 BP évek között
Figure 2: The Upper Palaeolithic sites, vegetation, July palaeoclimate, shade-loving Mollusc sites and environmental transition line position in the Carpathian Basin between 18.000 – 16.000 BP years


2. ábra: Felső paleolit lelőhelyek, vegetáció, júliusjáteményes környék, árnyék kedvelő molluszka fajok lelőhelyei a Kárpát-medencében 18.000 – 16.000 BP évek között
Figure 3.: Malacostratigraphic units and palaeoenvironmental factors between 30,000 and 8,000 BP years in Hungary


3. ábra: Malakosztratográfiai egységek és paleo-környezeti tényezők 30,000 és 8,000 BP évek között Magyarország területén