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

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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,[2] 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

[1] WEST 1988.
[2] ZAGWIJN 1961; 1974.
[3] SHACKLETON 1977; SHACKLETON–OPDYKE 1973; SHACKLETON et al. 1983; 1984; IMBRIE et al. 1984; RUDIMANN et al. 1986.
[4] SÜMEGI–HERTELENDI 1998.
[5] RUDNER–SÜMEGI 2001.
[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 Rudner[9] have been recovered from the Palaeolithic sites themselves (Bodrogkeresztúr–Henye-tető: 26,318 ± 365 BP; Megyaszó, Szeles-tető: 27,070 ± 680 BP; Püspökhatvan–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 Basin[10] 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-Sümegi[12] 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 Körös – 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 geographers[14] 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

[9] WILLIS et al. 2000; RUDNER–SÜMEGI 2001.
[10] GÁBORINÉ-CSÁNK 1980; T. DOBOSI 2000.
[11] SÜMEGI 1996; SÜMEGI et al. 1999.
[12] STIEBER 1967; RUDNER–SÜMEGI 2001.
[13] SÜMEGI 1995; 1996.
[14] FÁBIÁN et al. 2004; KOVÁCS et al. 2007.

Carpathian Basin during the Upper Palaeolithic, based on archaeological results.[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)[16] as well as environmental historical (pollen and macrocharcoal) sites: Lago Grande di Monticchio,[17] Les Echets,[18] Lac du Bouchet,[19] Grands Pile,[20] Monte Cavallo,[21] Korrestobel,[22] Barenhöhle,[23] Baumkrichen,[24] Tischofer-Höhle.[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 *Picea* and those of *Pinus cembra, Larix-Picea, Pinus sylvestris, Juniperus, Abies, 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 (*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 elements 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[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 *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 (*Pinus cembra*).

This picture is clearly congruent with the one reconstructed for the southern foothills of the Northern Carpathians and the Northern Mid-mountains 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.[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.[28] This site yielded numerous vertebrate bones assigned into the Istállóskő fauna phase,[29] studied by Miklós Kertzoi and István Vörös.[30] The bones recovered from a surface of 258 m^2 by Viola T. Dobosi and that of 165 m^2 sampled by László Vértes were dominantly those of wild horses, moose, mammoths and

15 GÁBORINÉ CSÁNK 1980, 217.
16 DAMBLON 1997.
17 WATTS et al. 1996.
18 BEAULIEU–REILLE 1984.
19 LALLIER-VERGÈS, 1991.
20 GUIOT et al. 1989.
21 FUCS 1969.
22 GROSS 1958; 1959.
23 KNEUSSL 1972.
24 BORTENSCHLAGER–BORTENSCHLAGER 1978.
25 KNEUSSL 1973.
26 MASON et al. 1994; RYBIČKOVÁ–RYBNÍČEK 1991.
27 NIKOLOV–HELMISAARI 1991.
28 VÉRTES 1966; T. DOBOSI 2000.
29 KRETZOI 1953; JÁNOSSY 1979.
30 VÖRÖS 2000.

buffaloes, both in terms of specimen numbers and the amounts of meat yields.[31]

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[32] and macrocharcoal analysis[33] 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.)[34] 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. This may be attributed to the low number of excavated areas in those regions at the first sight. Nevertheless, it is also quite interesting that no Palaeolithic artifacts have been recovered from the thoroughly investigated palaeosol horizons of the numerous artificial outcrops in Southern Transdanubia or the area of the Alföld, dated into the Denekamp interstadial. On the other hand, as the environmental historical data available for the area imply, a different ecological unit characterized by the dominance of Norway pine and birch forest steppes must have evolved in these latter areas.[35] According to the former anthracological studies[36] 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 Pleniglacial, 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.[37] 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*[38] in Hungary have also come to light from this horizon.[39]

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.
[32] SÜMEGI 1996; SÜMEGI–HERTELENDI 1998.
[33] RUDNER–SÜMEGI 2001.
[34] T. DOBOSI 1994.
[35] SÜMEGI 1996.
[36] STIEBER, 1967.
[37] SÜMEGI–HERTELENDI 1998; SÜMEGI–KROLOPP, 2002.
[38] LOŽEK 1954.
[39] SÜMEGI 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.[40] 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.[41] However, the southern slopes, thanks to the favourable morphological conditions must have been characterized by mean July palaeotemperatures around 14 °C. Thanks to the special location of the Carpathian Basin[42] 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.[43]

This assumption is corroborated by the findings of Stieber[44] 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, Artemeisia, 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).[45] 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.[46] 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,[47] 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[48] *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 (*Micortus gregalis* as the dominant form, plus *Lagurus*, *Citellus citelloides*, *Allactaga*, *Sicista*).[49] These data, being completely congruent with each other, clearly indicate the appearance of the characteristic forms of the Eastern European and

[40] KROLOPP et al. 1995.
[41] SÜMEGI 1996.
[42] SÜMEGI 1995; 1996.
[43] BOND et al. 1992; 1993.
[44] STIEBER 1968.
[45] WILLIS et al. 2000; DELI–SÜMEGI 1999.
[46] KRETZOI 1969; JÁNOSSY 1979.
[47] PAZONYI 2004.
[48] MENG 1995.
[49] KORDOS–RINGER 1991.

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] anthracological,[52] and palynological investigations of the Upper Würmian loess profiles in the Carpathian Basin[53] 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 eurytpic, 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 palynological[58] and malacological analyses of radiocarbon-dated profiles from the northern and

[50] PÉCSI 1975; 1977; 1993.

[51] SÜMEGI 1989; 1995; 1996; SÜMEGI–KROLOPP 1995, 2002.

[52] RUDNER–SÜMEGI 2001, 2002.

[53] SÜMEGI et al. 1999; MAGYARI 2002; MAGYARI et al. 1999.

[54] WEST 1988.

[55] SÜMEGI 1989.

[56] MAGYARI 2002; MAGYARI et al. 2000; 2002.

[57] BOND et al. 1992; 1993.

[58] SÜMEGI et al. 1999; MAGYARI et al. 2000.

southern areas of the basin,[59] 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,[60] and malacological results.[61] 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[62] 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.[63] 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 basin 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.*),[64] 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,[65] 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, Macrogastra 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.[66] 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, Pupilla sterri, Vallonia tenuilabris*) experienced either a steady

[59] SÜMEGI 1989; 1995; 1996; SÜMEGI–KROLOPP 2002.

[60] MAGYARI et al. 2001.

[61] SÜMEGI 1989; 1995; 1996; SÜMEGI–KROLOPP, 2002.

[62] WILLIS et al. 2000.

[63] SÜMEGI 2001.

[64] LACZKÓ 1929; BANNER 1936; GÁBORI 1954; 1969; GÁBORI M.–GÁBORI V. 1957; GÁBORINÉ-CSÁNK 1970; 1978; 1984; T. DOBOSI 1967; 1975; 1989; 1993; 1994; T. DOBOSI–KÖVECSES-VARGA 1991; CSONGRÁDI-BALOGH–T. DOBOSI 1995; DOBOSI et al. 1983; 1988; SIMÁN 1989; VÉRTES 1964-1965.

[65] KROLOPP–SÜMEGI 2002.

[66] SÜMEGI 1996; KROLOPP et al. 1995; HUM 1998, 1999; FARKAS 2000.

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 belts[69] (*Carpathicum, Illyricum, Noricum*[70]). 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 areas[74] 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 Hahn[76] 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 (h_1).[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 stage[80] 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

[67] SÜMEGI–KROLOPP 2000; 2001.
[68] SÜMEGI–KROLOPP 2000.
[69] WILLIS et al. 1995; 1997; 2000; SÜMEGI 1996.
[70] SOÓS 1943.
[71] SÜMEGI 1996; DELI–SÜMEGI 1999.
[72] SÜMEGI et al. 1998.
[73] SÜMEGI 1996.
[74] VARGA 1981.
[75] SÜMEGI et al. 1992.
[76] STIEBER 1967; PÉCSI 1975; 1993; HAHN 1977.
[77] PAYETTE 1992.
[78] HAHN 1977; PÉCSI 1975; 1993.
[79] HAHN 1977; PÉCSI 1975; 1993.
[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,[86] because according to the latest findings of the analysis of vertebrate remains[87] 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.[88]

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,[89] also Atlanto-Mediterranean,[90] *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.[91]

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.[92] 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.[93]

According to the palynological findings for the Bátorliget, Kelemér, Hortobágy, 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

[86] STURDY 1975.
[87] VÖRÖS 1982.
[88] VÖRÖS 1982.
[89] KERNEY et al. 1983.
[90] BÁBA 1982; 1983a; 1983b; 1986.
[91] SÜMEGI 1996.
[92] SÜMEGI 1996; SÜMEGI et al. 1999; SÜMEGI–KROLOPP 2000, 2001.
[93] SÜMEGI–KROLOPP 1995; 2000; 2001.

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.*[94] 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 quarternary malacological results.[95] This climatic period seems to be well correlated with the emergence of the so-called Heinrich event (H1 level) of the North Atlantic regions[96] and the oldest Dryas horizon established on the basis of palynological results.[97] 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,[98] with a predicted value of 16 °C in the southern areas.[99]

It was this horizon referred to as the *Pupilla sterri zonula*[100] that marked the last large-scale appearances of cold-resistant, xerophilous, presently xeromontane mollusc species in the central parts of the Carpathian Basin.[101] 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.[102]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 venerabilis*, *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.[103] According to the available Hungarian palynological data,[104] 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.[105] However, in contrast to the earlier assumptions,[106] this was the time of last occurrence of mammoth in the basin as well.[107] 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.[108] 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.

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94 SÜMEGI et al. 2008a.
95 SÜMEGI 1989; 1996; 2003a, b; 2007; SÜMEGI et al. 1992; 1999; KROLOPP–SÜMEGI 1992, KROLOPP et al. 1995.
96 BOND et al. 1992; 1993.
97 JARAI–KOMLODI 1969; MANGERUD et al. 1974.
98 SÜMEGI 1995.
99 HUM 2000.
100 SÜMEGI 1989; SÜMEGI et al. 1992.
101 SÜMEGI–KROLOPP 1995; SÜMEGI et al. 1998.
102 BORSY et al. 1982; 1985; SÜMEGI et al. 1998; PECSI 1975, 1993.
103 SÜMEGI 1996; SÜMEGI et al. 1998; SÜMEGI–KROLOPP 2002.
104 MAGYARI 2002; SÜMEGI 2004.
105 KROLOPP et al. 1995.
106 VÖRÖS 1987.
107 KROLOPP et al. 1995.
108 KORDOS–RINGER 1991; SÜMEGI 1989; 1996.

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.[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).[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[111] while the foothill areas were covered by closed mixed woodlands with elements deriving from the Illyric, Carpathian and Transsylvanian woodland refugia.[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,[113] palynological,[114] vertebrate[115] and anthracological analyses.[116] Several faunal (*Cepaea vindobonensis*: Sümegi, 1989, 1996) and floral elements (*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.[117]

[109] BELL–WALKER 1992; JARMAN et al. 1982.
[110] SÜMEGI et al. 2005; 2006; SÜMEGI–SZILÁGYI 2010.
[111] SÜMEGI 2003 a, b; JAKAB et al. 2004,
[112] SÜMEGI 2004.
[113] SÜMEGI 1989.
[114] WILLIS et al. 1995; 1997.
[115] VÖRÖS 2000; JÁNOSSY–KORDOS 1976.
[116] BORSY et al. 1982; STIEBER 1968.
[117] GÁBORI 1956; 1968; KERTÉSZ et al. 1997.

References

BÁBA, K.

1982 Eine neue zoogeographische Gruppierung der Ungarische Landmollusken und die Wertung des Faunabildes. *Malacologica* 22, 441-454.

1983a Magyarország szárazföldi csigáinak állatföldrajzi besorolásához felhasznált faj-area térképek. *Folia Musei Historico-naturalis Musei Matraensis* 8, 129-132.

1983b A Szatmár-Beregi sík szárazföldi csigái és a környezetükre levonható következtetések. *Acta Academiae Paedagogienis, Szeged, Series Biologica-Geographica* 12, 27-41.

1986 Magyarország szárazföldi csigáinak állatföldrajzi besorolásához felhasznált faj-area térképek. II. *Folia Musei Historico-naturalis Musei Matraensis* 11, 49-69.

BANNER, J.

1936 Az első alföldi paleolit lelet. *Dolgozatok a Magyar Király Ferencz József Tudományegyetem Régiségtudományi Intézetéből* 12, 1-13.

DE BEAULIEU, J. L.–REILLE, M.

1984 A long upper Pleistocene pollen record from Les Echets, near Lyon, France. *Boreas* 13, 111 –132.

BELL, M.–WALKER, M. J. C.

1992 *Late Quaternary Environment Change*. Longman Press.

BOND, G.–HEINRICH, H.–BROECKER, W.–MCMANUS, J.–LABEYRIE, L.–ANDREWS, J.

1992 Evidence for massive discharges of icebergs into the North Atlantic ocean during the last glacial period. *Nature* 360, 245-249.

BOND, G.–BROECKER, W.–JOHANSEN, S.–LABEYRIE, L.–MCMANUS, J.–JOUZEL, J.–BONANI, G.

1993 Correlation between climate records from North Atlantic sediments and Greenland ice. *Nature* 365, 245-249.

BORSY, Z.–CSONGOR, É.–LÓKI, J.–SÁRKÁNY, S.–SZABÓ, I.

1982 A futóhomok mozgásainak periódusai az Alföld ÉK részében. *Acta Geographica, Geologica et Meteorologica* 20, 5-16.

1985 Recent results in the radiocarbon dating of wind-blown sand movements in the Tisza-Bodrog Interfluve. *Acta Geographica, Geologica et Meteorologica Debrecina* 24, 35-50.

BORTENSCHAGER, I.–BORTENSCHAGER, S.

1978 Pollenanalytische Untersuchungen am Bänderton von Baumkirchen (Inntal, Tirol). *Zeitschrift für Gletscherkunde und Glazialgeologie* 14, 95-103.

CSONGRÁDI-BALOGH, É.–T. DOBOSI, V.

1995 Paleolithic settlement traces near Püspökhatvan. *Folia Archaeologica* 44, 37-59.

DAMBLON, F.

1997 Paleobotanic study of representative Upper Palaeolithic sites in the Central European Plain: a contributibn to the SC-004 projet. *Préhistorie Europénne* 11, 140-149.

DELI T.–SÜMEGI P.

1999 Biogeographical characterisation of Szatmár-Bereg plain based on the mollusc fauna. In: HAMAR, J.–SÁRKÁNY–KISS, A. ed.: *The Upper Tisa Valley*. Tiscia Monograph Series, Szeged. 471-477.

T. DOBOSI V.

1967 Új felső-paleolit telep az Alföldön. *Archeologiai Értesítő* 94, 184-193.
1975 Magyarország ős- és középső kőkori lelőhely katasztere. Register of Palaeolithic and Mesolithic Sites in Hungary. *Archeológiai Értesítő* 102, 64-76.
1989 Madaras-Téglavető felsőpaleolit telep. Régészeti feldolgozás. *Cumania* 11, 45-58.
1993 Jászfelsőszentgyörgy-Szúnyogos, felső-paleolit telep. *Tisicum* 8, 54-60.
1994 Contribution to the Upper Palaeolithic topography. *Acta Archeologica Hungarica* 46, 3-20.
2000 Archaeological investigations at Bodrogkeresztúr-Henye. In: T. DOBOSI V. ed.: *Bodrogkeresztúr-Henye (NE-Hungary), Upper Palaeolithic site*. Magyar Nemzeti Múzeum Kiadványa, Budapest, 5-111.

T. DOBOSI, V.–KÖVECSES-VARGA, E.

1991 Upper Palaeolithic site at Esztergom-Gyurgyalag. *Acta Archaeologica Hungarica* 43, 233-255.

T. DOBOSI, V.–VÖRÖS, I.–KROLOPP, E.–SZABÓ, J.–RINGER, Á.–SCHWEITZER, F.

1983 Upper Palaeolithic Settlement in Pilismarót-Pálrét. *Acta Archaeologica Hungarica* 35, 288-311.

T. DOBOSI, V.–JUNGBERTH, B.–RINGER, Á.–VÖRÖS, I.

1988 Palaeolithic settlement at Nadap. *Folia Archaeologica* 39, 13-39.

FÁBIÁN, SZ. Á.–KOVÁCS, J.–NAGYVÁRADI, L.–VARGA, G.

2004 Was There Desert Climate in the Carpathian Basin, or Not? *Studia Geomorphologica Carpatho Balcanica* 38, 49-58.

FARKAS, SZ.

2000 A bátaszéki téglagyár pleisztocén képződményei. *Malakológiai Tájékoztató* 18, 21-27.

FUCS, F.

1969 Eine erste 14C datierung für das Paudor Interstadial am Alpensündrand. *Eiszeltalter und Gegenwart* 20, 68-71.

GÁBORI, M.

1954 A piliszántói kőfülke magdaléniai kultúrája és eredete. *Archaeológiai Értesítő* 81, 3-9.
1956 Mezolitikus leletek Sződligetről. Mesolithische Funde von Sződliget. *Archeológiai Értesítő* 83, 177-182.
1968 Mesolithischer Zeltgrundriss in Sződliget. *Acta Archeologica Hungarica* 20, 33-36.
1969 Paläolitische Schnecken depots von Szob. *Acta Archaeologica Hungarica* 29, 3-11.

GÁBORI, M.–GÁBORI, V.

1957 Les station de loess paléolithiques de Hongrie. *Acta Archaeologica Hungarica* 8, 3-117.

GÁBORINÉ CSÁNK V.

1970 C-14 dates of the Hungarian Palaeolithic. *Acta Archaeologica Hungarica* 22, 3-11.
1978 Une oscillation climatique a la fin du Würm en Hongrie. *Acta Archaeologica Hungarica* 30, 3-11.
1980 *Az ősember Magyarországon*. Gondolat Kiadó, Budapest.
1984 A felső paleolitikum nyoma Budapesten. *Budapest Régiségei* 25, 7-14.

GROSS H.

1958 Die bisherbingen Ergebnisse von 14C Messungen un Palaeolitischen Unterschubgen für die Gliederung nd Chronolie des Jungpleistozän in Mitteleuropa und den Nachbargebieten. *Eiszeltalter und Gegenwart 9*, 155-187.
1959 Noch einmal: Riss order Würm. *Eiszeltalter und Gegenwart 10*, 65-76.

GUIOT, J.–POAS, A.–DE BEÍULIEN, J.L.–REILLE, M.

1989 A 140.000-year continental climate reconstruction from two European pollen record. Nature 338, 309-313.

HAHN, GY.

1977 A magyarországi löszök litológiája, genetikája, geomorfológiai és kronológiai tagolása. *Földrajzi Értesítő* 26. 1. 1-28.

HUM, L.

1998 Geochemical investigations of the Dunaszekcső loess-paleosol sequence, SE Transdanubia, Hungary. *Acta Minerologica et Petrographica Szegediensis* 39, 139-150.
1999 Mohácstól délre fekvő fiatal lösz-szelvények paleoökológiai vizsgálatai. *Malakológiai Tájékoztató* 17, 37-52.
2000 A Szekszárd, volt Budai úti téglagyári lösz-paleotalaj sorozat paleoökológia vizsgálatai. *Malakológiai Tájékoztató* 18, 29-50.

IMBRIE, J.–HAYS, J. D.–MARTINSON, D. G. –MCINTYRE, A. –MIX, A. C. –MORLEY, J. J–PISIAS, N. G–PRELL, W. L. –SHACKLETON, N. J.

1984 The orbital theory of Pleistocene climate: supportfrom a revised chronology of the marine delta 18 O record. In: BERGER, A. L. et al. ed.: *Milankovich and climate*. Part 1. Boston, 169-305.

JAKAB, G.–SÜMEGI, P.–MAGYARI, E.

2004 New Quantative Method for the Paleobotanical Description of Late Quaternary Organic Sediments (Mire-Development Pathway and Paleoclimatic Records from Southern Hungary). *Acta Geologica Hungarica* 47, 373-409.

JÁNOSSY, D.

1979 *A magyarországi pleisztocén tagolása gerinces faunák alapján*. Budapest.

JÁNOSSY, D.–KORDOS L.

1976 Pleistocene-Holocene mollusc and vertebrate fauna of two caves in Hungary. *Annales Historico-Naturales Musei Naturalis Hungarici* 68, 5-29.

JÁRAI-KOMLÓDI, M.

1969 Adatok az Alföld negyedkori klíma és vegetációtörténetéhez II. Botanikai Közlemények 56, 43-55.

JARMAN, M. R.–BAILEY, G.N.–JARMAN, H.N. ed.

1982 *Early European agriculture*. Cambridge.

JUHÁSZ, I. E.

2002 *A Délnyugat Dunántúl negyedkori vegetációtörténetének palinológiai rekonstrukciója*. (Reconstitution palynologique de la végétation depuis le Tardiglaciaire dans la région de Zala, sud-ouest de la Hongrie). Unpublished PhD thesis, Pécs-Marseille

KERNEY, M. P.–CAMERON, R. A. D.–JUNGBLUTH, J. H.

1983 *Die Landschnecken Nord- und Mitteleuropas*. Hamburg-Berlin.

KERTÉSZ R.–SÜMEGI P.–KOZÁK M.–BRAUN M.–FÉLEGYHÁZI E.–HERTELENDI E.

1997 Ásatások Jászberény I. lelőhelyen. Előzetes jelentés az első azonosított alföldi mezolit telepen végzett kutatásokról. *Archeológiai Értesítő*, 3-26.

KNEUSSL, W.

1972 Vorbeicht über eine Grabung in der Bärenhöhle am Pendling bei Kufstein (Nordtirol). *Zeitschrift für Gletscherkunde und Glazialgeologie* 8, 329-330.

1973 Höhlenbarenknochen au der Tischofen-Höhle (Kaisebtal bei Kufstein Nordtirol) mit 14C Methode altebrbestimmt. *Zeitschrift für Gletscherkunde und Glazialgeologie* 9, 237-238.

KORDOS L.–RINGER Á.

1991 A magyarországi felső-pleisztocén Arvicolidae-sztratigráfiájának klimato- és archeosztratigráfiai korrelációja. *MÁFI Évi Jelentése 1989 évről*, 523-533.

KRETZOI M.

1953 A negyedkor taglalása gerinces faunák alapján. *MTA Műszaki Tudományos Osztályának Alföldi Kongresszusa* 89-99.

1969 A magyarországi quarter és pliocén szárazföldi sztratigráfiájának vázlata. *Földrajzi Közlemények* 93, 197–204.

KROLOPP E.–SÜMEGI P.

1992 A magyarországi löszök képződésének paleoökológiai rekonstrukciója Mollusca-fauna alapján. pp. 247-263. In: SZÖŐR, GY. ed. *Fáciesanalitikai, paleobiogeokémiai és paleoökológiai kutatások.* MTA Debreceni Bizottsága, Debrecen, 263.

2002 A ságvári lösz-rétegsor csigafaunája. *Malakológiai Tájékoztató* 20, 7-14.

KROLOPP E.–SÜMEGI P.–HERTELENDI E.–KUTI L.–KORDOS L.

1995 Szeged-Öthalom környéki löszképződmények keletkezésének paleoökológiai rekonstrukciója. *Földtani Közlöny* 125, 309-361.

LALLIER-VERGÈS, E.–SIFEDDINE, A.–BEAULIEU, J. L. DE-REILLE, M.–TRIBOVILLARD, N.–BERTRAND, P.–MONGENOT, T.–THOUVENY, N.–DISNAR, J. R.–GUILLET, B.

1991 Sensibilité de la sédimentation organique aux variations climatiques du Tardi-Würm et de l'Holocène-le Lac du Bouchet (Haute Loire, France), *Bulletin of the Society Geologie France,* 164, 661-673

LACZKÓ D.

1929 Őstörténeti adatok a Balaton környékéről. *A Szent István Akadémia mennyiségtan, természettudományi osztályának felolvasásai.* Budapest.

LOŽEK, V.

1954 Neue Mollusken aus dem Tschechoslowakischen Pleistozän: Vertigo pseudosubstriata sp. n., Pupilla muscorum densegyrata spp. n., und Pupilla loessica sp. n. *Antropozoikum* 3, 327-343.

MAGYARI, E.

2001 A bükk (Fagus sylvaticus) és a gyertyán (Carpinus betulus) terjedésének problematikája a Kárpát-medence holocén vegetációfejlődésében. *4. Magyar Őslénytani Vándorgyűlés kiadványa, Tihany,* 26-27.

2002 *Climatic versus human modification of the Late Quaternary vegetation in Eastern Hungary*. Unpublished PhD Thesis, Debrecen.

MAGYARI, E.–JAKAB, G.–RUDNER, E.–SÜMEGI, P.

1999 Palynological and plant macrofossil data on Late Pleistocen short term climatic osscilations in North-east Hungary. *Acta Palaeobotanica* 2, 491–502.

MAGYARI E.–JAKAB G.–SÜMEGI P.–RUDNER E.–MOLNÁR M.

2000 Paleobotanikai vizsgálatok a keleméri Mohos-tavakon. In: SZURDOKI, E. szerk.: *Tőzegmohás élőhelyek Magyarországon: kutatás, kezelés, védelem*. CEEWEB Munkacsoport, Miskolc, 101-131.

MAGYARI, E.–SÜMEGI, P.–BRAUN, M.–JAKAB, G.

2002 Retarded hydrosere: anthropogenic and climatic signals in a Holocene raised bog profile from the NE Carpathian Basin. *Journal of Ecology* 89, 1019-1032.

MANGERUD, J.–ANDERSEN, S. T.,–BERGLUND, B. E.–DONNER, J.J.

1974 Quaternary stratigraphy of Norden, a proposal for terminology and classification. *Boreas* 3, 109-127

MASON, S. L. R.–HATHER, J. G.–HILLMAN, G. C.

1994 Preliminary investigation of the plant macro-remains from Dolni Vestonice II, and its implications for the role of plant foods in Palaeolithic and Mesolithic Europe. *Antiquity* 68, 48-57.

MENG, S.

1995 Die Mollusken der Weichsel-Kaltzeit von Erfurt (Thüringen). *Veröffentlichungen des Naturkundemuseums Erfurt* 14. 150-167.

NIKOLOV, N.–HELMISAARI, H.

1991 Silvics of the circumpolar boreal forest tree species. In: SHUGART, H. H.–LEEMANS, R.–BONAN, G. B. ed.: *A Systems Analysis of the Global Boreal Forest*. Cambridge.

PAYETTE, S.

1992 Fire as a controlling process in the North American boreal forest. In: SHUGART, H–LEEMANNS, R. –BONAN G. B.: *A systems analysis of the global boreal forest*. Cambridge, 144-169.

PAZONYI, P.

2004 Mammalian ecosystem dynamics in the Carpathian Basin during the last 27,000 years. *Palaeogeography, Palaeoclimatology, Palaeoecology* 212, 295-314.

PÉCSI, M.

1975 Lithostratigraphical subdivision of the loess sequences in Hungary. *Földrajzi Közlemények* 23, 228-239.

1977 A hazai és az európai löszképződmények paleogeográfiai kutatása és összehasonlítása. *Geonómia és Bányászat. MTA X. Osztályának Tudományos Közleményei* 10, 183-221.

1993 *Negyedkor és löszkutatás*. Budapest.

RUDNER, E.–SÜMEGI, P.

2001 Recurring taiga forest steppe habitats in the Carpathian Basin in the Upper Weichselian. *Quaternary International* 76/77, 177-189.

2002 Charcoal as a remain of natural and human-set fires of Palaeolithic Times – case study from Hungary. *British Archaeological Report* 1089, 11-18.

RYBNÍČKOVÁ E.–RYBNÍČEK K.

1994 The environment of the Pavlovian – palaeoecological results from Bulhary, South Moravia. 73-79. In: KOVAR-EDER, J. ed. *Palaeovegetational development in Europe andbregions relevant to its palaeofloristic evolution*. Museum of Natural History, Vienna.

SHACKLETON, N. J.

1977 The oxygen *isotope* stratigraphic record of the late Pleistocene. Philosophical *Transactions of the Royal Society of London* Series B280, 169-179.

SHACKLETON, N. J.–IMBRIE, J.–HALL, M. A.

1983 Oxygen and carbon isotope record of East Pacific core VI9-30: implications for the formation of deep water in the late Pleistocene North Atlantic. *Earth Planet. Science Letter* 65: 233-244.

SHACKLETON, N. J.–OPDYKE, N. D.

1973 Oxygene isotope and paleomagnetic stratigraphy of equatorial Pacific core V28-238: oxygene isotope temperatures and ice volumes on a 10^5 year and 10^6 year scale. *Quaternary Research* 3, 39-55.

SHACKLETON, N. J.–HALL M. A.–BOERSMA, A.

1984 Oxygen and carbon isotope data from Leg 74 foraminifers. pp. 599-612. In: MOORE, T. C.–RABINOWITZ, J.R. et al.: *Deep Sea Drilling Project Initial reports*, Volume 74. Washington.

SIMÁN, K.

1989 Hidasnémeti - Upper Palaeolithic Site in the Hernád valley (Northeast Hungary). *Acta Archaeologica Carpathica* 28, 5-24.

SOÓS, L.

1943 *A Kárpát-medence Mollusca-faunája*. Budapest

STIEBER, J.

1967 A magyarországi felső-pleisztocén vegetációtörténete az anthrakotómiai eredmények (1957-ig) tükrében. *Földtani Közlöny* 97, 308-316.

1968 *Anthrakotómia, kvarter kronológia és a hazai pleisztocén vegetáció*. MTA Doktori cím elnyeréséért benyújtott disszertáció, ELTE Növénytani és Szövetfejlődéstani Tanszék, Budapest.

STURDY, D. A.

1975 Some Reindeer economies in Prehistoric Europe. pp. 55-98. In: HIGGS, E. S. ed.: *Palaeoeconomy*. Cambridge.

SÜMEGI, P.

1989 *Hajdúság felső-pleisztocén fejlődéstörténete finomrétegtani (üledékföldtani, őslénytani, geokémiai) vizsgálatok alapján.* Unpublished dissertation, Debrecen.

1995 Az utolsó 30.000 év változásainak rekonstrukciója őslénytani adatok alapján a Kárpát-medence centrális részén. *"Berényi Dénes professzor születésének 95. évfordulója" tiszteletére rendezett tudományos emlékülés előadásai. MTA Debreceni Területi Bizottsága, Meteorológiai Munkabizottság és KLTE Meteorológiai Tanszék Kiadvány*, 244-258.

1996 *Az ÉK-magyarországi löszterületek összehasonlító őskörnyezeti rekonstrukciója és rétegtani értékelése*. Unpublished dissertation, Debrecen.

2001 *A negyedidőszak földtanának és őskörnyezettanának alapjai*. Szeged.

2003a *Régészeti geológia - tudományos interdiszciplinák találkozása.* Habilitációs dolgozat. Szeged.

2003b *Régészeti geológia és történeti ökológia alapjai*. Szeged.

2004 The results of paleoenvironmental reconstruction and comparative geoarcheological analysis for the examined area. In: SÜMEGI, P.–GULYÁS, S. ed. *The geohistory of Bátorliget Marshland*. Budapest. 301-348.

2007 *Magyarország negyedidőszak végi környezettörténete*. Unpublished dissertation, Budapest–Szeged.

SÜMEGI, P.–HERTELENDI, E.

1998 Reconstruction of microenvironmental changes in Kopasz Hill loess area at Tokaj (Hungary) between 15.000-70.000 BP years. *Radiocarbon* 40, 855-863.

SÜMEGI, P.–KROLOPP, E.

1995 A magyarországi würm korú löszök képződésének paleoökológiai rekonstrukciója. *Földtani Közlöny* 124, 125-148.

2000 Palaeoecological reconstruction of the Ságvár-Lascaux interstadial. In: MESTER, ZS.–RINGER, Á. eds.: *A la recherche de l'Homme Préhistorique*, ERAUL 95, Liège. 103-112.

2001 Új adatok a holocén rétegtani és őskörnyezeti vitás kérdéseihez. *4. Magyar Őslénytani vándorgyűlés előadáskivonatai*, Pécsvárad, 33.

2002 Quartermalacological analyses for modeling of the Upper Weichselian palaeoenvironmental changes in the Carpathian Basin. *Quaternary International* 91, 53-63.

SÜMEGI, P.–SZILÁGYI, G.

2010 A Hortobágy új felszínfejlődési modellje és a szikesedés eredete. *Acta Biologica Debrecina* 22, 27-36.

SÜMEGI, P.–BODOR, E.–TÖRŐCSIK, T.

2005 The origins of sodification in the Hortobágy region in the light of the palaeoenvironmental studies at Zám–Halasfenék. In: GÁL, E.–JUHÁSZ, I.–SÜMEGI, P. ed.: 2005. *Environmental Archaeology in North-Eastern Hungary*. Varia Archaeologica Hungarica 19. 115-126.

2006 A hortobágyi szikesedés eredete. In: KISS, A.–MEZŐSI, G.–SÜMEGHY, Z. ed:. *Táj, környezet és társadalom*. Ünnepi tanulmányok Keveiné Bárány Ilona professzor asszony tiszteletére. Szeged, 633-641.

SÜMEGI, P.–KROLOPP E.–HERTELENDI E.

1998 A Ságvár-Lascaux interstadiális őskörnyezeti rekonstrukciója. *Acta Geographica, Geologica et Meteorologica Debrecina*, 34. 165-180.

SÜMEGI, P.–JUHÁSZ, I.–MAGYARI, E.–JAKAB, G.–RUDNER, E.–SZÁNTÓ ZS.–MOLNÁR, M.

2008 A keleméri Mohos-tavak fejlődéstörténete paleobotanikai adatok alapján. In: Boldogh S.–G. Farkas, T. ed.: *A keleméri Mohos tavak kutatás, kezelés, védelem*. Aggtelek, 35-58.

SÜMEGI, P.–GULYÁS, S.–JAKAB, G.

2008a Holocene paleoclimatic and paleohydrological changes in Lake Balaton as inferred from a complex quantitative environmental historical study of a lacustrine sequence of the Szigliget embayment. *Documenta Praehistorica* 35. 33-43.

SÜMEGI, P.–MAGYARI, E.–DANIEL, P.–HERTELENDI, E.–RUDNER, E.

1999 A kardoskuti Fehér-tó negyedidőszaki fejlődéstörténetének rekonstrukciója. *Földtani Közlöny* 129. 479-519.

SÜMEGI P.–LÓKI J.–HERTELENDI E.–SZÖŐR GY.

1992 A tiszaalpári magaspart rétegsorának szedimentológiai és sztratigráfiai elemzése. *Alföldi Tanulmányok* 14, 75-87.

VARGA Z.

1981 Az elterjedési területek recens és történeti dinamikája a Palaearktikus Lepidoptera-fauna állatföldrajzi elemzése. Biológia Tudományok Doktora értekezés tézisei, Debrecen, 1-23.

VÉRTES, L.

1964-65 Das Jungpalaelithikum von Arka in Nord–Ungarn. *Quartär* 15/16, 79-132.

1966 The Upper Palaeolithic site on Mt. Henye at Bodrogkeresztúr. *Acta Archaeologica Hungarica* 18. 3-14.

VÖRÖS, I.

1982 Faunal remains from the Gravettian reindeer Hunters' campsite at Ságvár. *Folia Archeologica* 33. 43-69.

1987 Large mammalian faunal changes during the Late Upper Pleistocene and Early Holocene times in the Carpathian Basin. In: PÉCSI, M ed. *Pleistocene environment in Hungary*. Budapest, 81-101.

2000 Hunted mammals from the Gravettian campsite Bodrogkeresztúr-Henye. In: T. DOBOSI, V. ed.: *Bodrogkeresztúr-Henye (NE Hungary) Upper Palaeolithic Site*. Magyar Nemzeti Múzeum, Budapest, 113-186.

WATTS, W. A.–ALLEN, J. R. M.–HUNTLEY, B.

1996 Vegetation history and palaeoclimate of the last glacial period at Lago Grande di Monticchio, southern Italy. *Quaternary Science Review* 15. 133–153.

WEST, R. G.

1988 The record of the cold stages. *Philosophycal Transaction of the Royal Society of London B. series* 318. 505-522.

WILLIS, K. J.–BRAUM, M.–SÜMEGI, P.–TÓTH A.

1997 Does soil change cause vegetation change or vice-versa? A temporal perpective from Hungary. *Ecology* 78. 740-750.

WILLIS, K. J.–SÜMEGI, P.–BRAUN, M.–TÓTH, A.

1995 The Late Quaternary environmental history of Bátorliget, N. E. Hungary. *Palaeogeography, Palaeoclimatology, Palaeoecology* 118. 25-47.

WILLIS, K. J.–RUDNER, E.–SÜMEGI, P.

2000 The full-glacial forests of central and southeastern Europe: Evidence from Hungarian palaeoecological records. *Quaternary Research* 53. 203-213.

ZAGWIJN, W.H.

1961 Vegetation, climate and radiocarbon datings in the Late Pleistocene of the Netherlands. Part I: Eemian and Early Weichselian. *Mededelingen Geologische Sticht* 14. 15-45.

1974 Vegetation, climate and radiocarbon datings in the Late Pleistocene of the Netherlands. Part II: Middle Weichselian. *Mededelingen Rijks Geologische Dienst*, 25. 101-111.

A FELSŐ PALEOLIT KÖZÖSSÉGEK ÉS KÖRNYEZETÜK MODELLEZÉSE A KÁRPÁT-MEDENCÉBEN A FELSŐ WÜRM IDEJÉN

SÜMEGI PÁL

Kulcsszavak: *őskőkor, radiokarbon kormeghatározás, szedimentológia, negyedidőszaki malakológia, paleo-környezettan*

Az északkelet magyarországi löszös területek mellett az elmúlt 15 évben számos felső Würm időszaki és késő glaciális lösz profilt vizsgáltunk a Dunántúlon és az Alföld déli és középső részén, vagy újraértelmeztük 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.

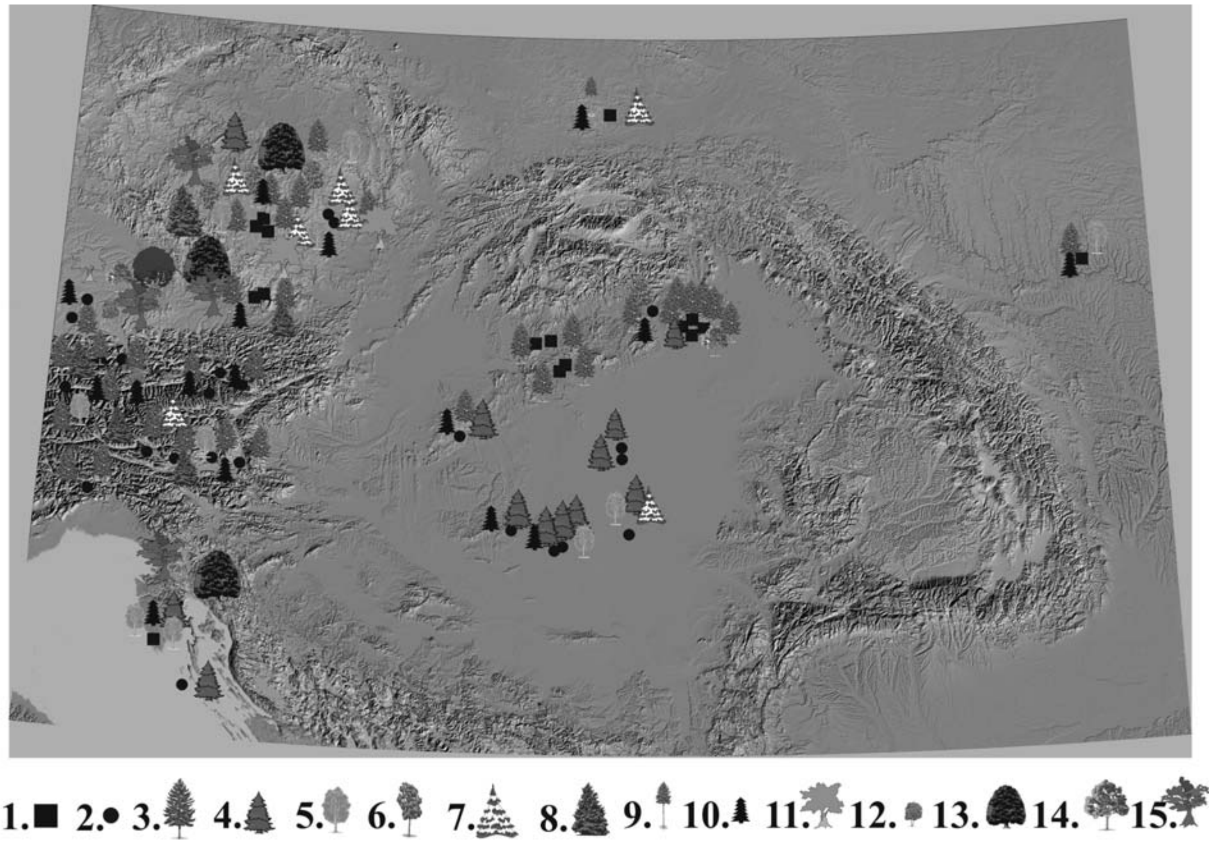

Figure 1.: Upper Paleolithic sites and palaeovegetation of the interstadial phase between 32,000 – 25,000 BP years

1. Upper Palaeolithic sites, 2. Palaeoecological sites, 3. *Picea* (spruce) remains, 4. *Pinus sylvestris* (Scotch pine) remains, 5. *Betula, Salix, Alnus* (birch, willow, alder) remains, 6. *Pinus cembra* (cembra fir) remains, 7. *Abies* (fir) remains, 8. Juniperus (juniper tree) remains, 9. Larix (larch tree) remains, 10. Pinus (needle leaved tree) remains, 11. Quercus (oak) remains, 12. Corylus (hazel) remains, 13. Ulmus (elm) remains, 14. Carpinus (hornbeam) remains, 15. Fagus (beech) remains

1. ábra: Felső paleolit lelőhelyek és paleovegetáció az interstadiálisban, 32,000 – 25,000 BP évek között

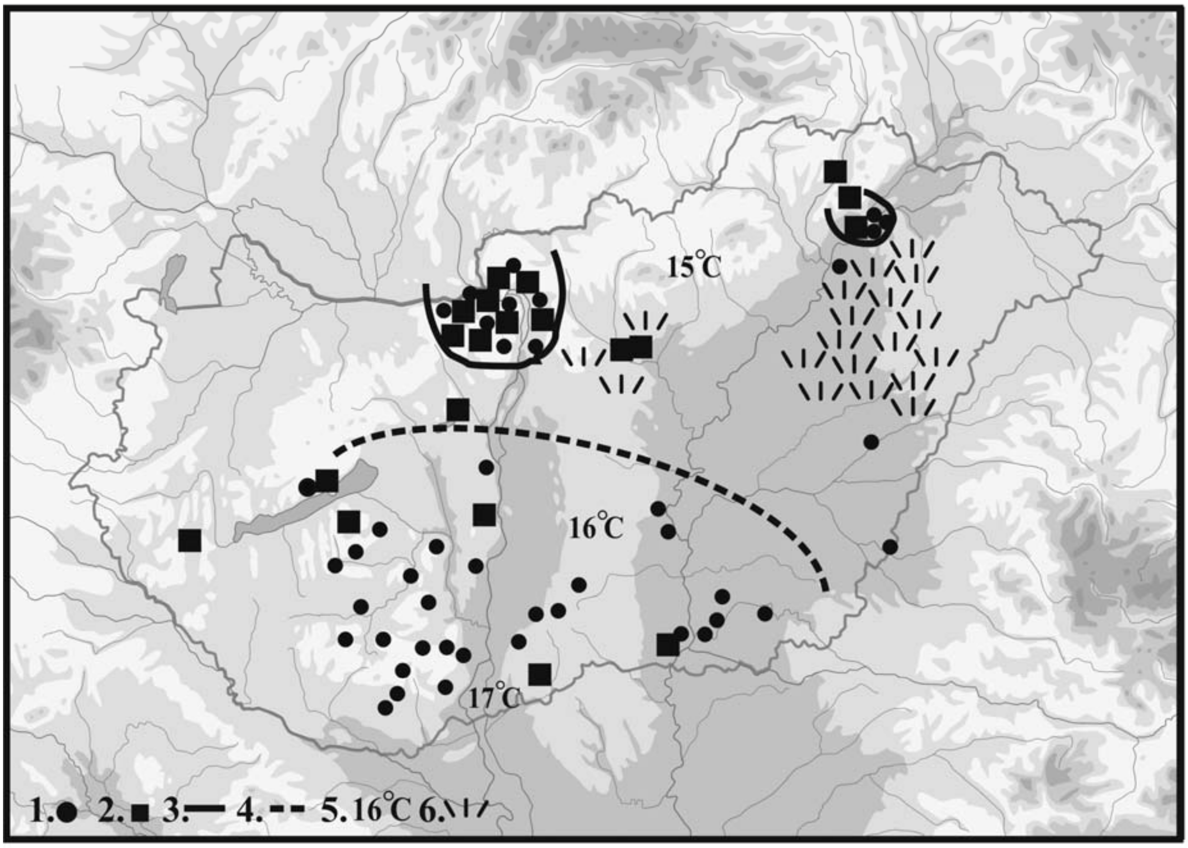

Figure 2.: The Upper Palaeolithic sites, vegetation, July palaeoclimate, shade-loving Mollusc sites and environmental transition line position in the Carpathian Basin between 18.000 – 16.000 BP years

1. Ecotone and shade-loving Mollusc site, 2. Upper Palaeolithic site, 3. Closed taiga forest, 4. Northern borderline of Palaeoillyrian type mixed taiga forest, 5. July palaeotemperature, 6. Grassland

2. ábra: Felső paleolit lelőhelyek, vegetáció, júliusi középhőmérséklet, árnyék-kedvelő molluszka fajok lelőhelyei a Kárpát-medencében 18.000 – 16.000 BP évek között

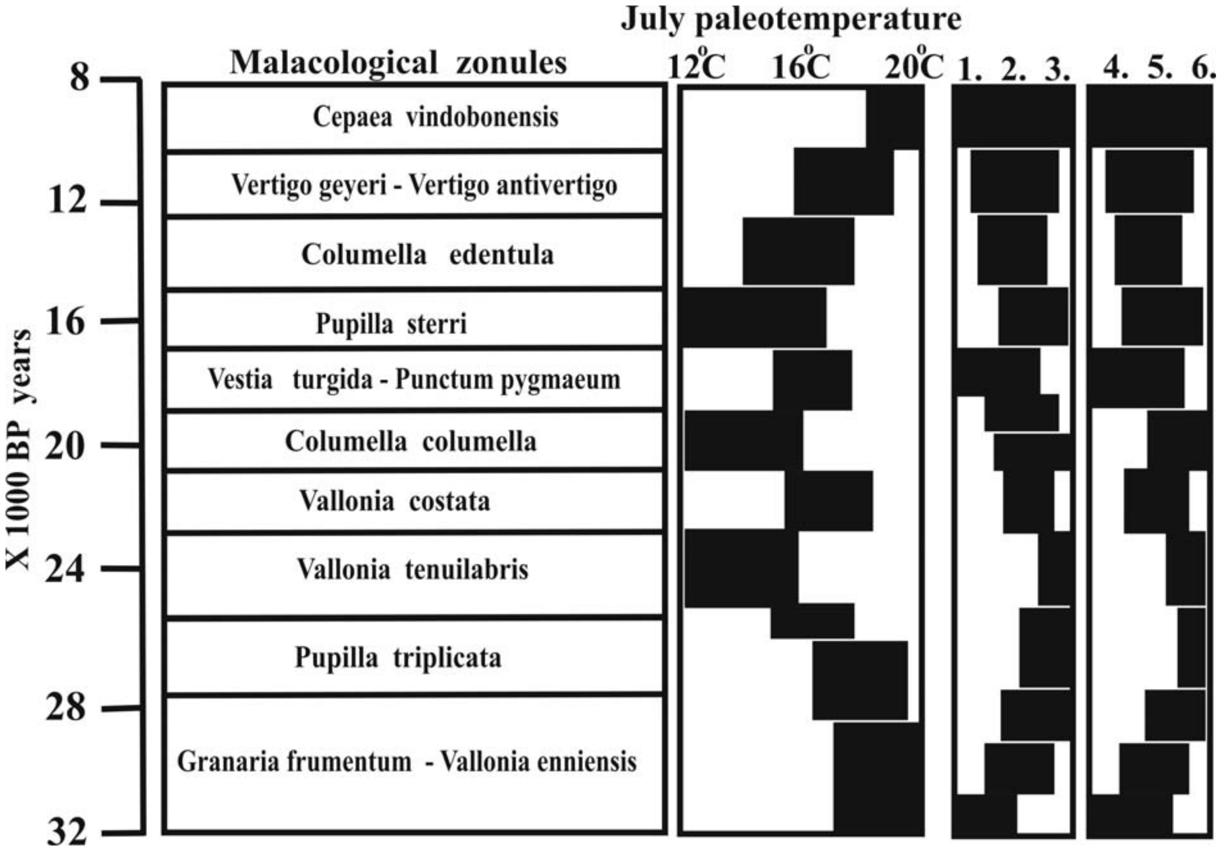

Figure 3.: Malacostratigraphic units and palaeoenvrionmental factors between 30, 000 and 8,000 BP years in Hungary

1. Wet climate, 2. Transition climate, 3. Dry climate, 4. Woodland, 5. Forest steppe 6. Open vegetation (steppe or/and tundra like vegetation)

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