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Preliminary paleoecological reconstruction of long-term relationship between human and environment in the northern part of Danube-along Plain, Hungary

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Abstract: The peat bog at Ócsa is located at the northern part of the Danube-Tisa Interfluves at the transitional zone of two landscapes with different morphological characters. At the boundary of the Danube-Tisa Interfluves and the Danube-along Plain a marshland sequence can be found from Hajós to Ócsa. We extended our research to the Ócsa peat bog to complete the environmental historical investigations in the examined area, as well.

The bog is located in a former pool formed by the Danube River in which aeolian sand and thick lake sediment deposited from the Late Pleistocene. The initial oligotrophic lake became mesotrophic, therefore thick carbonate sediment deposited. Afterwards, as a consequence of the Neolithic human occupations, the natural development of the lake changed drastically and the lake choked up. The pollen and quartermalacological analysis of the area support the mentioned geological processes.

Keywords: peat bog; Ócsa village; Hungary; anthropogenic impact; paleoenvironment; multi-proxy analyses

1 Introduction

The relationship between prehistoric human communities and their surrounding environment can be uncovered with various geoarcheological and paleoecological examinations. Out of these chronological, sedimentological, geochemical, palynological, macrobotanical and malacological analyses of sediments, which were accumulated in sediment-accumulation basins (*e.g.* lakes, peat-bogs), are remarkable. With these analyses environmental conditions and changes as well as anthropogenic environmental changes could be reconstructed. Such multi-proxy examinations were published from the southern part of the Ócsa-Őrjég-Hajós peat-bog system in the Danube alluvial plain [1], and this paper shows complex geoarcheological, paleoecological and archaeological results from the northern part of the peat-bog system mentioned above.

Relatively insufficient internationally accepted results are known of the paleoecological changes in the Pleistocene-Holocene transition from the Danube-along Plain [2]. Because of the wrong drilling method used by most of the researchers on sampling lakes, peat-bogs and mort-lakes, *i.e.* disturbed sediment cores were obtained. The other reason is that not a single radiocarbon date was available from these sections, that is why these results were negligible in international sphere [3].

Although several paleoecological examinations were fulfilled lately using undisturbed core drilling in the Great Hungarian Plain [1, 4–8], moreover radiocarbon dating were completed on undisturbed samples obtained previously. Thus a relatively significant paleoecological database was created in the Great Hungarian Plain using internationally accepted sampling and dating methods [9]. But because of the mosaic-like environmental conditions of the Carpathian Basin [10] these examinations must have expanded as many sites as possible to understand what happened with the environment and human communities during the global warming at the end of the Pleistocene [9]. Since some complex (radiocarbon, palynological, macrobotanical and malacological) analyses were made on lakes, peat-bogs and swamps in the Danube-Tisza Interfluves [2]. Therefore the northernmost part of the peat-bog system,

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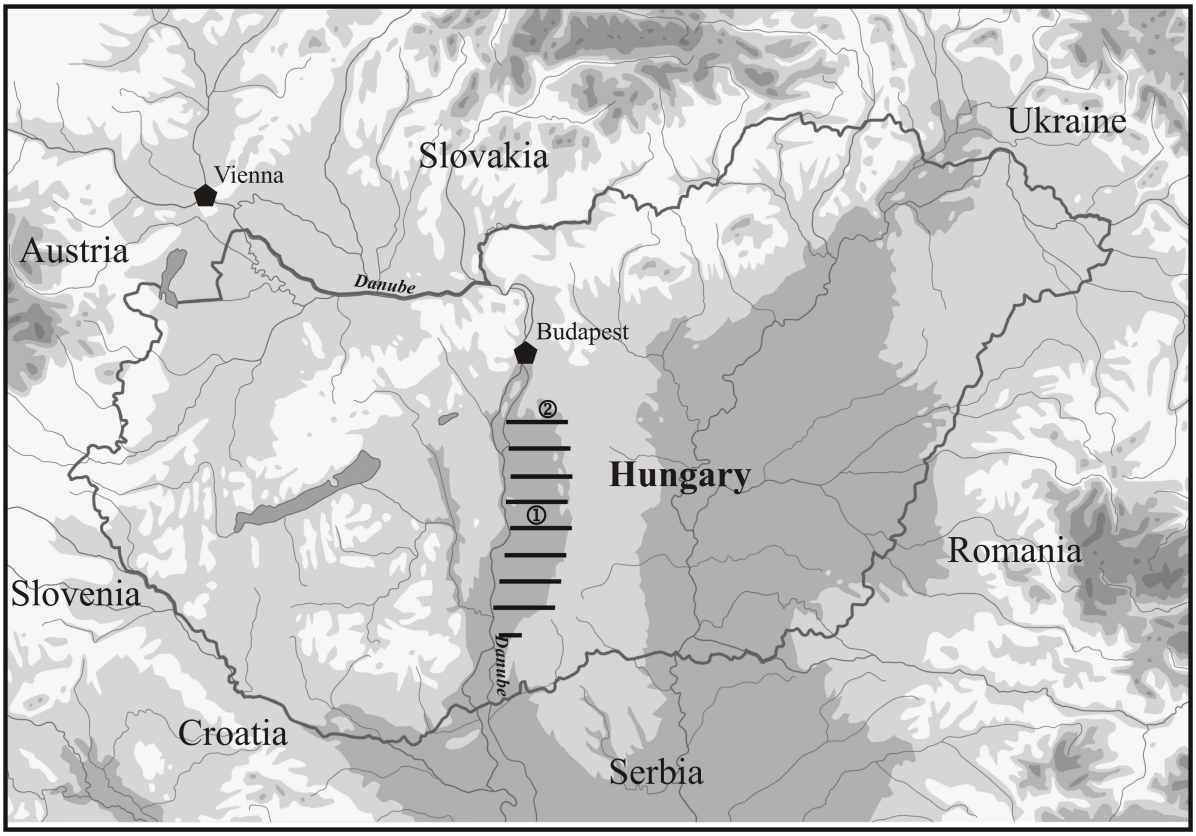

Figure 1: Location of the examined site of Ócsa *(1 = alluvium of Danube-along Plain; 2 = marshland site at Ócsa)*.

lying in the border area of the Danube-along Plain and the sand ridge (so-called *"turjános"*), near the town of Ócsa seemed a good examination site (Fig. 1). Paleoecological results were amplified with archaeological data from the Danube alluvial plain, south of the examination site [11], to reconstruct the long-term relationship between human and environment in the northern part of the Danube-along Plain (Pest Plain).

2 Geographical setting

The Ócsa peat-bog is situated in a remarkably complicated geomorphologic area (Fig. 2). It is bounded by aeolian converted sand-ridge and Pleistocene gravelly terrace of the Danube [12] from North and East. From South the area is bounded by the lower parts of the Danube alluvial plain. The geomorphologic dichotomy of the area is induced by the river Danube or one of its branches, when owing to tectonic and/or climatic causes it was progressively pressed to West and incised into its fan than eroded the fan's edge in hollow-like shape. Thus the examined site can be found in a lower-situated, choked-up Danube-branch in the foreground of the sand-ridge and the gravelly terrace (Fig. 2).

The peat-bog area was affected by human activity from the 20th century, for example irrigation of the lower parts, and expressive peat extraction in the *"Öreg Turján"* area. Nowadays the water-feeding of the area is solved from two main artificial channels, but by the reason of historic maps and geological examinations the original water-feed of the peat-bog was derived from the ground water, flowed from the higher-situated fan, and the accretion-waters from the Danube.

The Ócsa peat-bog – probably formed in a low situated, choked-up Danube-branch – can be already well investigated on the maps of the 1st Austrian Military Survey (Fig. 2). The branch itself had been partly buried by the latter sand-drift movements and segregated from the other branch-parts as it is visible in other abandoned branches in the Danube-Tisa Interfluves [7]. Periodically flooded gallery-forests and sudd spots could be found in the Ócsa peat-bog and grasslands, meadows and lawns represented the surrounding flora in the 18th century, ploughed fields were not distinctive. A significant environmental feature

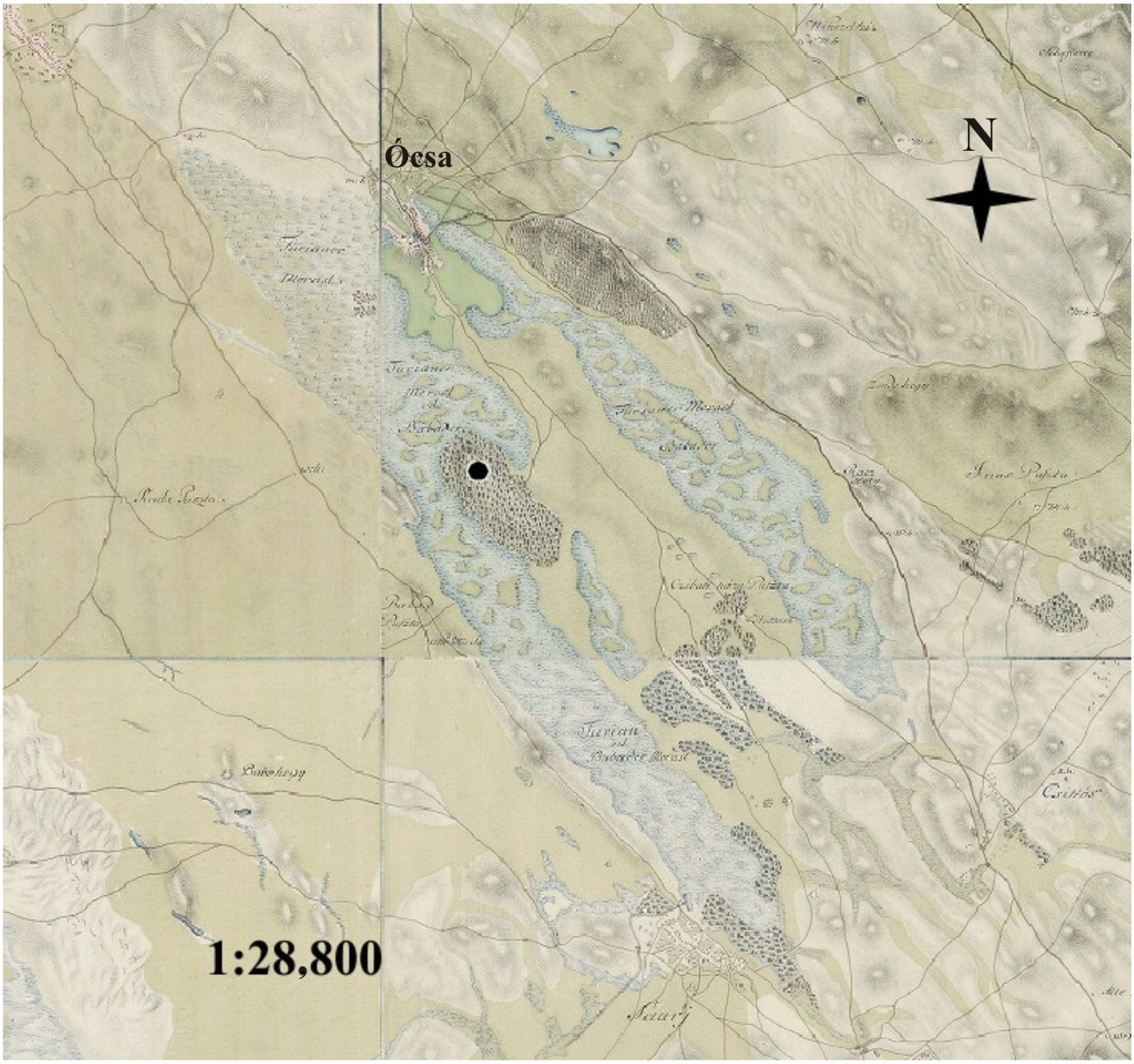

Figure 2: The marshland and bore-hole point at Ócsa on the first Austrian Military map (1782) *(black dot = undisturbed coring point; dark green hatched areas = marshland areas; pale yellow areas = aeolian sand ridges)*.

of the area is the forest in the Selyemrét area which was present in the 18th century as well.

Originally the area was covered by spots of gallery-forests and sedge communities, and clump-peat formation was typical on the surface of the bog. Unfortunately owing to the irrigating and channelling, started in 1928, the main part of the bog was transformed, and clump-sedge lands were replaced by marsh-fields. The peat extraction lasted about 70 years, and finished in the 1970s. Fortunately the examined Selyemrét area was not affected by the peat extraction very much, but drainage canals were built thus the permanent flooded area become periodically flooded. This is why significant sediment compaction was investigated in the layers. At the present time marsh-fields with rush and purple moor grass, sporadically sedge communities in the *"Öreg Turján"* area and forests – narrow-leafed ash (*Fraxinus angustifolia*) and alder (*Alnus*) bogs, oak (*Quercus*), elm (*Ulmus*), ash (*Fraxinus*) mixed forests – were survived in the Ócsa peat-bog. During the malacological examinations two important but pretty rare species came to light, the *Pomatias elegans* and the *Vertigo pusilla* [13–16]. Both species are common in mid-mountain region and in this case they mark the connection between the examined area and the Pleistocene forest refugees [17].

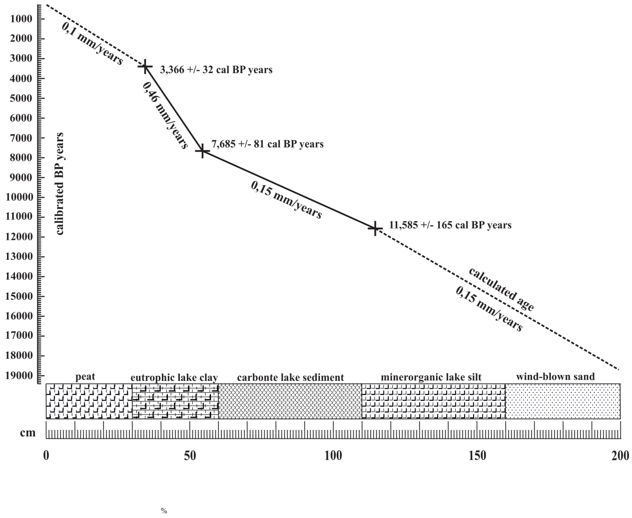

Figure 3: Sedimentation rate changes in the core geological sequence at Ócsa based on radiocarbon data.

3 Material and methods

The sampling of the 2 m deep, undisturbed sedimentary sequences from the swamp at Ócsa (Fig. 3) was carried out using a special Russian core-head drill, with which 40 cm long, undisturbed cores were obtained. The main lithostratigraphic features of the sedimentary sequence were determined and analyzed. For the description of the cores the internationally accepted system and symbols of Troels-Smith developed for unconsolidated sediments was adopted [18]. During the sedimentological examinations Casagrande's hydrometric grain-size analysis [19] was used. For LOI examinations sub-samples were taken in every 4 cm, so the examination was carried out on 48 sub-samples, and the method was Dean's loss on ignition which is commonly used for analyze organic matter and carbonate content on calcareous sediments [20].

For radiocarbon analyses two *Pisidium* shells (from different parts of the sequence) and a piece of charcoal were used. Previously the shells were wet-screened and cleaned with hydrogen-peroxide (H_2O_2) to remove the inactive carbonate from the shells' surface [21]. The samples were analyzed using the AMS technique at the Pozńan Radiocarbon Lab, Poland. The raw dates were calibrated using the Oxcal v.3.9 software package [22], using the athmospheric data of Stuiver *et al.* [23]. The obtained raw dates (^{14}C) are indicated as uncal BP, while the calibrated dates are indicated as cal BC or cal BP by using the CALIB 4.0 [23] and the CalPal software pack [24, 25]. Besides the ^{14}C analysis, age-marker sediment facies were [26] investigated for the chronological fixation.

Samples were prepared for elemental composition analyses using the sequential extraction method of Dániel [28]. Concentrations of selected major and trace elements were determined via flame and graphite furnace atomic absorption spectroscopy.

From the upper part (130–160 cm) sub-samples were taken in every 16 cm, and from 130 cm to the top every 8 cm. The pollen concentration was determined by the method of *Lycopodium* spore-tablet [29]. A volumetric sampler was used to obtain 1 cm^3 samples, which were then processed for pollen [30]. A known quantity of exotic pollen was added to each sample in order to determine the concentration of identified pollen grains [29]. A minimum count of 300 grains per sample (excluding exotics) was made in order to ensure a statistically significant sample size [31]. Charcoal abundances were determined using the point count method [32]. Tablets with a known *Lycopodium* spore content (supplied by Lund University, Sweden) were added to each sample to enable calculation of pollen concentrations and accumulation rates. The pollen types were identified and modified according to Moore *et al.* [33], Beug [34] and Punt *et al.* [35], Kozáková and Pokorny [36], supplemented by examination of photographs in Reille [37–39] and of reference material held in the Hungarian Geological Institute, Budapest.

The full result of pollen analysis is not suitable to publish in this paper because the 8 and 16 cm sub-sample distances average a few hundred years in pollen concentration. Thus the results were only used to examine the pollen concentration of each archaeological level and to show the anthropologic pollens in the samples. The 2 cm sample distance analysis is now in progress. Modelling and empirical studies [40, 41] indicate that for a lake such as Selyemrét at Ócsa (150–200 m diameter), the correlation between pollen abundances and vegetation composition is not improved by considering vegetation more than 400–600 m from the lake. The regionally "uniform" background pollen component representing vegetation between 600 m and tens of kilometres from the lake, accounts for c. 45% of the total pollen [41]. The Selyemrét pollen data thus provide an integrated palaeovegetation record for the landscape around the lake and the surrounding region, with pollen from extra-local and regional sources [42] predominating. The biomization procedure translates pollen and plant macrofossil spectra into biome assignments. The biomization method [43–45] is an objective method based on assigning taxa to one or more plant functional types (PFTs). The concept and the different steps of this method were fully described in Prentice *et al.* [44] and Prentice-Webb [45].

The basis of reconstructing the paleovegetation was the pollen analytical works of Sugita [40], Soepboer *et al.* [41], Jacobson and Bradshaw [42], Prentice [46] and Magyari *et al.* [27]. Each vegetation type and indicator elements in addition the elements of weed-vegetation were defined using the works of Allen *et al.* [47], Behre [48, 49], Elenga *et al.* [50], Magyari *et al.* [6], Prentice *et al.* [44], Prentice and Webb [45] and Tarasov *et al.* [51, 52]. By using these works 6 environmental indicator elements were defined: warm steppe, cool steppe, cool-mixed wood steppe, cool mixed forest, temperate deciduous wooded steppe and temperate deciduous forest.

Percentages of terrestrial pollen taxa, excluding Cyperaceae, were calculated using the sum of all those taxa. Percentages of Cyperaceae, aquatics and pteridophyte spores were calculated relative to the main sum plus the relevant sum for each taxon or taxon group. Calculations, numerical analyses and graphing of pollen diagrams were performed using the software package Psimpoll 4.26 [53]. Local pollen assemblage zones (LPAZs) were defined using optimal splitting of information content [54], zonation being performed using the 20 terrestrial pollen taxa that reached at least 5% in at least one sample.

The malacological examinations were carried out from every 8 cm of the section, each sub-sample were about 0.5 kg. The samples were wet-screened in a screen with 0.5 mm mesh. After drying and sorting each shell were identified and clustered into paleoecological groups by using the works of Ložek [55], Evans [56], Krolopp [57] and Sümegi [58]. After that computerized processing was carried out using Bennett's Psimpoll software package [59].

4 Results

4.1 Chronology and Lithology

The age of the upper 115 cm of the section was dated between 11,700 and 11,500 cal. BP years, usingthe radiocarbon data. By the latest chronological standards it can be completely clustered into the Holocene. It is supported by some methods which show annual cycles: German pine-chronological data [60], Japanese [61, 62] and Venezuelan [63] lake laminae and counting off coral-banks [64, 65]; than a 5-year-period calendar was created, using all of these methods, ^{14}C and GRIP data, from the Late Pleistocene to the Early Holocene [66–68].

Thus the lower part of the section, below 115 cm, was deposited during the Pleistocene. The low-carbonated and low-organic-matter containing sand in the substratum is the oldest part of the section, deposited probably during the Upper-Weichselian/Würmian [26] (Fig. 3).

Above the sandy substratum a mid-calcareous farther low organic matter containing, coarse and fine silty, minerorganic lake sediment was deposited between 160 and 110 cm. Based on ^{14}C data and stratigraphic comparisons [7, 69] the accumulation period of this sediment was between 17,000–18,000 and 11,600 cal. BP years (Fig. 3). This minerorganic limnic sediment-type usually deposited in Late-Pleistocene cold, low weathered lakes. This is why the low clay content, but high mineral and wind transported silt content in the sediment. By several results [7, 69] this sediment-type was deposited up to 22,000 cal BP years in the Carpathian Basin.

From 110 cm the quality of the sediment is changed, the rate of (aeolian origin) coarse silt fraction decreased than the carbonate content gradually the clay content drastically increased. This means a deposition of a fossiliferous caustic sludge (clayey silt) between 100 and 60 cm (11,600–11,500 and 7,700–7,600 cal BP years) as regards to the Bátorliget [4, 58] or Kardoskút [69] sections.

Above 60 cm (7,700–7,600 cal BP years) the sediment-quality changes again, the carbonate content decreased from 30% to 5% and the organic-matter content increased from 1–2% to above 60% (Fig. 3). This horizon (60–30 cm) is constituted by eutrophic, peaty, silty-clayey lake sediment. This condition probably remained until the channelling works in the 19th century but owing to the irrigating in the area from 1928 the upper part of this peaty sediment was run dry and pedogenetic processes become determinant.

The thickness of the peaty horizon probably was much larger but owing to the drying processes the layer could be compacted (from about 100 cm to 30 cm). The eutrophic swampy lake condition could be make parallel with the Culture of Linear Pattern Poetry in the 5,600s BC.

As a consequence of these processes, the former Late-Pleistocene oligotrophic lake was choked up and became a calcareous eutrophic system [70–72]. The increased organic matter content owing to the in-washed organic matter and soil and the transformation of the lake-system could be well demonstrated by the carbonate and organic matter content charts in Fig. 3. In the uppermost 30 cm part of the section the carbonate content increases and the organic matter content decreases again because of the last 150–160 years' irrigation works in the area.

4.2 Geochemical analysis

The content of water-soluble Na and K shows small fluctuations along the section, the highest values can be linked to the high organic-matter containing parts of the section. Both elements are linked to the organic matter content, *i.e.* significant organic-matter content can be linked to high rainfall and mild climate, when rich vegetation can develop. The increased content of Na and K marks intensive weathering processes [76, 77]. The water and littoral plants (*e.g.* Na accumulating reed species) could help fixing the Na and K ions [78, 79].

Minor maximum values of the water-soluble Ca content can be shown in the slightly carbonated oligotrophic layers, but the highest concentration values are from the caustic sludgy layers. The Mg content was quite similar to the Ca-trends but with lower concentration values. Geochemical data suggest that the originally oligotrophic lake system became mesotrophic in the early Holocene [80]. In the near-surface, high organic-matter containing layers, maximum concentration of Na and K can be measured. The Na-content links to the organic-matter content, but the K-content could be linked to flying ashes or in-washed burnt wood components [76, 77].

4.3 Palynological analysis

The results of palynological investigations show that the sandy base of the section was devoid of pollens. From the second horizon (160–110 cm), so-called minero-organic horizon, good quantity and quality of pollen came into light. The dominance of woody species can be observed: from Pinaceae the *Picea*, *Pinus cembra*, and *Betula*. Besides them with about 5% dominance pollens of thermo-mesophilous woody species (*Quercus*, *Ulmus*, *Tilia*, *Corylus*) also appear. The pollen-composition can be compared to the pollen data of Bátorliget, Hungary [4] where a Late-Pleistocene boreal-type mixed coniferous forest refuge (or a nearby refuge) was reconstructed. It is not certain in the case of Selyemrét, because of the short time horizon what the section contains so it cannot be proved that the thermo-mesophilous species could survive the Last Glacial Maximum (LGM) or not.

The second horizon contains some *Salix*, *Alnus* and *Betula* pollen. Thesespecies can be found in forests with moist underwood, designating a higher humidity and ground water-level [81]. From herbs the Poaceae were dominant, but *Artemisia*, Chenopodiaceae and *Centaurea* species were found. This horizon shows the cool-mixed forest (CLMX), cool-mixed wooded steppe (CMWS) and marshland (sedge) vegetation mosaics around the oligotrophic lake.

The next pollen horizon can be characterized by the high volume of *Carpinus* pollen. This high dominance can be detected from 60 cm (8,000 cal BP years) with the higher dominance of *Fagus* pollen. This change is also characteristic in the northern part of Transdanubia [94, 95], but in the Nyírjes bog at the Mátra mountains in Hungary this change can be observed as well [96]. In this period *Quercus-Carpinus-Fagus* mixed washland forests developed in the examined area. After this pollen composition change, some cultivated plants (*Triticum*, *Hordeum*) appear in the section with segetal weeds (*Plantago major/media*, *Plantago lanceolata*). The appearance and diffusion of Neolithic farming caused the first anthropogenic impacts which can be observed at 7,400–7,600 cal BP years (5,400–5,600 cal BC years) in the Selyemrét section. Nevertheless there are not any significant changes in the composition of the aquatic vegetation, but the increased dominance of bulrush and sedge what could be mark increased choking up processes (Fig. 7).

4.4 Malacological analysis

For malacological analysis only a meter high part of the section was suitable. From this part of the section 34 mollusc taxa (22 terrestrial and 12 freshwater) with more than 1,000 specimens were found. The section can be divided into 5 horizons by the ecological demands of the mollusc species and these horizons can be paralleled with palaeoecological changes [55, 57, 58]. The 1st horizon between 114 and 82 cm, the 2nd between 82 and 66 cm, the 3rd between 66 and 34 cm, the 4th between 34 and 18 cm and the 5th is between 18 and 10 cm.

The 1st horizon is dominated by the hygrophilous coastal *Succinea oblonga* and the carbonated water bearer *Anisus spirorbis*; the accompanying fauna contains of shallow, partly searing, carbonated water bearing or dry lake basin living species (*Vallonia pulchella*). By the constitution of the fauna, the early Holocene lake could be quite shallow, and probably periodically dry. One significant result is that the shells of *Pomatias elegans* were found in this horizon, because this species is known as a Tertiary warm, humid forester [105], thus the early Holocene appearance of this species (Fig. 8) implies a refuge area, an oasis [106].

The 2nd horizon shows appearance of the higher-organic-matter-content bearing *Valvata cristata*, but only low dominance compared to the dominance of *Succinea oblonga* and *Vallonia pulchella* and other few hy-

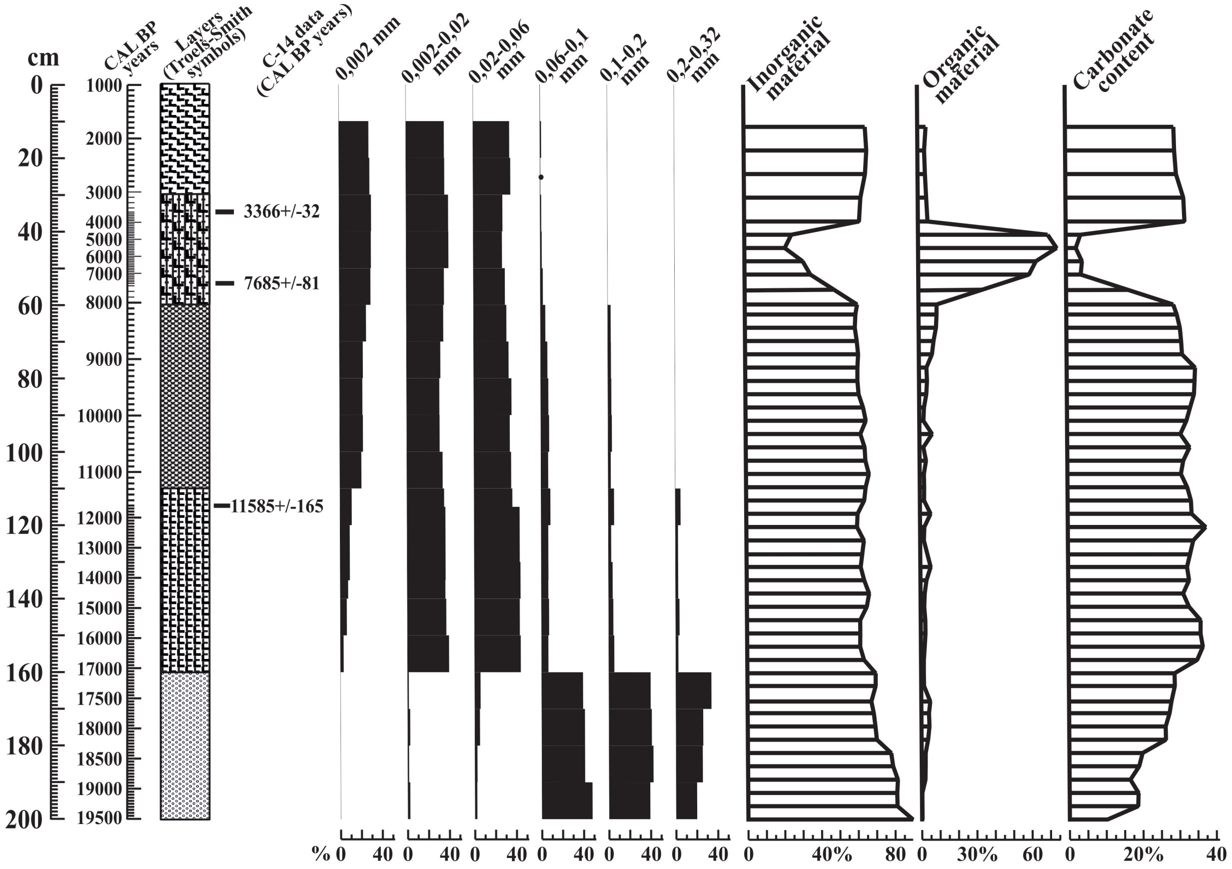

Figure 4: Results of sedimentological analysis of the geological core sequence at Ócsa. The grain sizes and organic matter, carbonate, inorganic matter percentage plotted against depth.

grophilous and sub-hygrophilous terrestrial species. Probably a coastal and water planted zone was developed in the edge area of the reservoir and owing to the found *Pomatias elegans* shells deciduous tree and shrub containing parkland developed in the surroundings.

In the 3rd horizon organic-matter-rich water species dominated (*Valvata cristata*), and sedge-reed zone-dweller species (*Succinea putris*, *Carychium minimum* and *Vertigo antivertigo*) appeared. The composition of the fauna shows parity with the sedge and reed pieces found in the sediment of this horizon. It is not impossible that a part of the sediment-accumulation basin transformed into a shallow vegetated, periodically swampy lake (Fig. 8).

The 4th horizon contains high dominance of eutrophic lake dwelling *Valvata cristata* and *Bythinia tentaculata* and terrestrial species *Pomatias elegans* and some typical forest dweller species *Vertigo pusilla* and *Cochlodina laminata*. The increased dominance of freshwater taxa and the remarkable number of terrestrial, forester species shows robust soil erosion and fast choking up processes [56].

In the 5th zone coastal, humid pasture-land species (*Vertigo angustior*) and the *Lymnaea truncatula* a swampy-clumpy environment can be reconstructed. This is why the appearance of rheophilous, moving water environment dweller *Valvata piscinalis* is so surprising: this species is incongruous in this environment. These specimens could have been transported by sticking to the legs of waterfowls [107].

5 Discussion

By using the various results of the paleoecological and geoarchaeological examinations, the development history of Ócsa peat bog can be reconstructed. The results of geochemical analysis reinforce the sedimentological results (Fig. 4). The water-soluble iron content shows two maximum concentration peaks. The first maximum marks the oligotrophic lake conditions during the Late Pleistocene when, owing to the high dominance of cold-loving coniferous trees, acidic podsol soils formed [73]. In podsol soils, because of the acidic pH, the iron (and manganese) content dissolve and link to clay minerals [74]

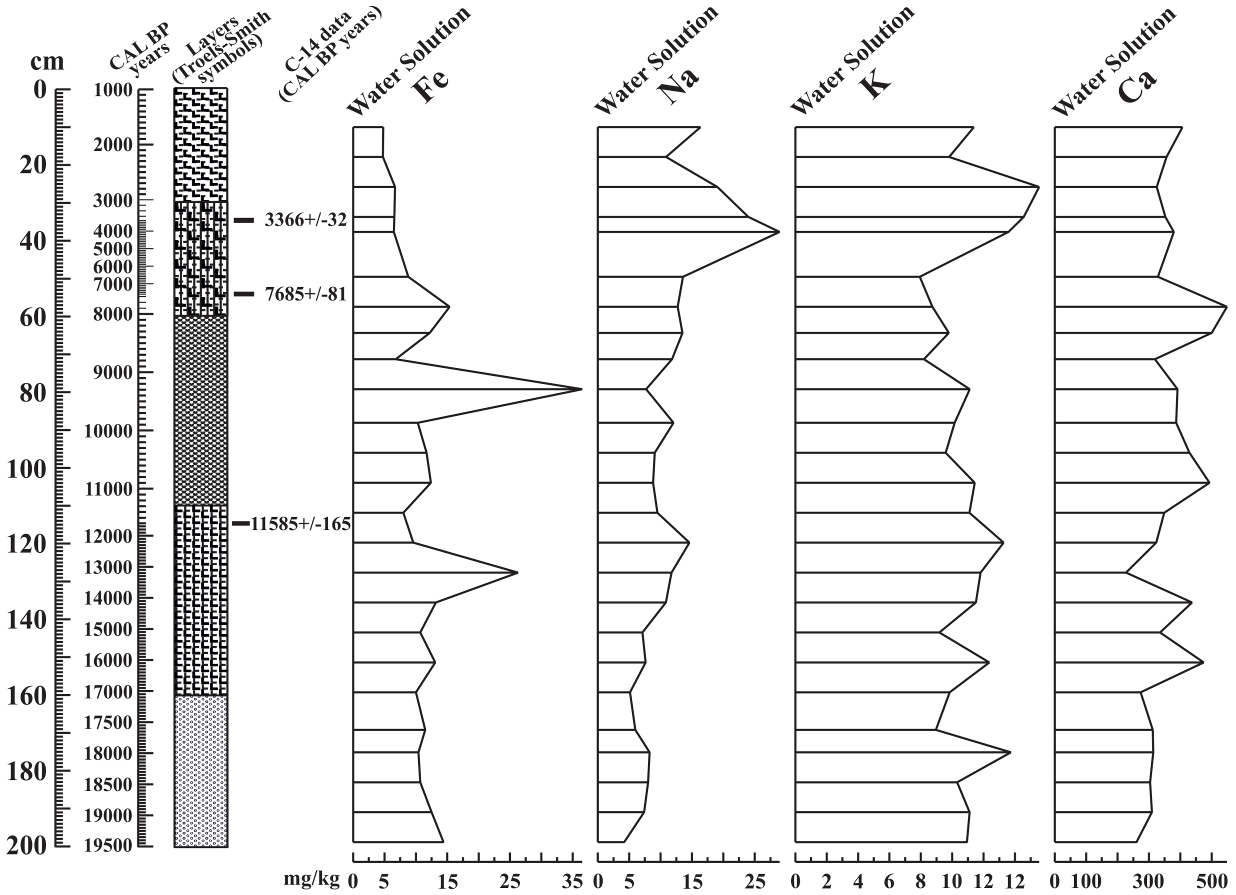

Figure 5: Results of geochemical analysis of the geological core sequence at Ócsa. Water soluble Fe, Na, K and Ca content plotted against depth.

showing higher peaks during geochemical analysis [75]. The other maximum peak of iron concentration marks the mesotrophic lake conditions which could be linked to the regulated ground water level, and because of this, abundant siderophilous bacteria at the border of oxidative/reductive horizons (Fig. 4).

The archaeological adaptation of palynological results revealed the anthropogenic history of Selyemrét site. According to the pollen composition, a mixed coniferous forest ruled in the area in the Late Pleistocene with some moist, swampy spots around the lakes, perhaps some cool steppe mosaics. During the Late Pleistocene the area progressively afforested since in the beginning pollen dominance of arboreal taxa was under 70% (around 50–60% only) later than, about 13,500 cal BP years the dominance was over 75% [6, 44, 47]. It is possible that cool mixed forest steppe dominance was appeared during the Upper Palaeolithic and cool mixed forest dominance was formed in the Epipalaeolithic. The radiocarbon ages cannot show the change of these horizons but it is possible that the process passed off during 13,000 cal BP (11,000 cal BC) years similarly to other data [82, 83]. The change of vegetation composition resulted in faunal changes, among them the large herbivorous animals which were so important for the Upper Palaeolithic human communities [84–87]. Thus the Late Palaeolithic environmental (floral and faunal) changes indicated a techno-cultural transformation of the human communities in the Carpathian Basin.

The Late Pleistocene pollen compositions transformed rapidly from 11,500 BP years. The dominance of Pinaceae and later the *Betula* drastically decreased and concurrently the dominance of *Corylus* and thermomesophilous trees (*Tilia*, *Quercus*, *Ulmus*, *Fraxinus*) are increased remarkably. Owing to the change of woody vegetation typical washland forests, lime-plane mixed oak-ash-elm hardwood and willow-common elder softwood gallery forests developed in the vicinity of Selyemrét in the Early Holocene, so the cold loving mixed taiga forest transformed into a temperate deciduous forest during the Pleistocene-Holocene transition. Parallel with this transformation, the pollen rate of *Phragmites*, *Typha*, *T. latifolia*, *Artemisia* species increased, thus it is possible that the

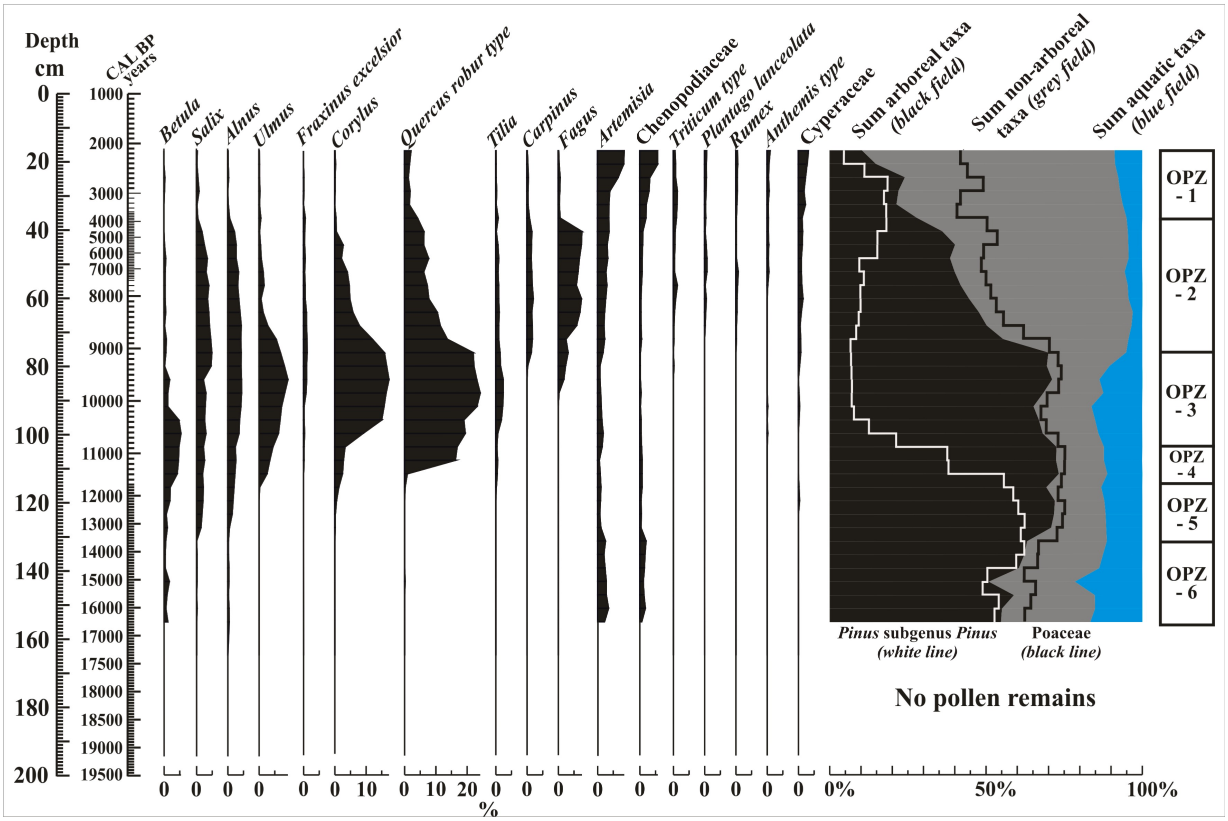

Figure 6: Diagram of arboreal, non-arboreal and aquatic pollen percentage plotted against depth in the geological core sequence at Ócsa.

water level rose and a bulrush-reed zone developed between the coastal sedge zone and the open water. A temperate hydro-series was formed in the area (lacustrine, coastal, washland forest and dune). It is likely that a type of a wooded steppe vegetation developed on the top of the dunes and the pollen of steppe species could derived from there [88].

On the basis of radiocarbon data and the derived deposition rate it is possible that this coastal, swampy (sedge) area with small mosaics of temperate wooded steppe and temperate deciduous woodland was developed during the Mesolithic. The Early and Late part of Mesolithic can be well separated using the vegetation data: the Early Mesolithic can be characterized with high dominance of *Betula* species. Various sections from the Carpathian Basin [58, 82, 89–91] show similar results, the Early Mesolithic can be separated from the Late Mesolithic from environmental view. This change indicates that during the Late Mesolithic, a techno-cultural revolution occurred in the human communities in the Carpathian Basin. Although Hungarian archaeological data for the Mesolithic are sporadic and chronologically problematic [92], these few data also show the technological development to a unifying geometric microlith shape in the second half of the Mesolithic [93].

The appearance and diffusion of Neolithic farming caused the first anthropogenic impacts, which can be observed at 7,400–7,600 cal BP years (5,400–5,600 cal BC years). Tilling agriculture pursuing communities appeared on the northern parts of Transdanubia and the Danube-valley and also in the northern parts of the Great Hungarian Plain. The appearance of a tilling lifestyle and the other impacts of anthropogenic activity (farming, rearing, settling and road development) caused a decrease in the arboreal areas than owing to these processes soil and other humic horizons were in-washed into the lower areas such as the peat-bog of Ócsa.

The paleoecological results, the settled lifestyle and the plant disturbance can be well compared with other excavations from the Carpathian Basin [11, 97–100]. The results of the dating show that the earliest Neolithic communities were settled in the Carpathian Basin in the end of the 7th millennia BC.

The most intensive anthropogenic impact can be reconstructed from the late Bronze Age (Fig. 7). During this term impacts of the settled human lifestyle (settlements,

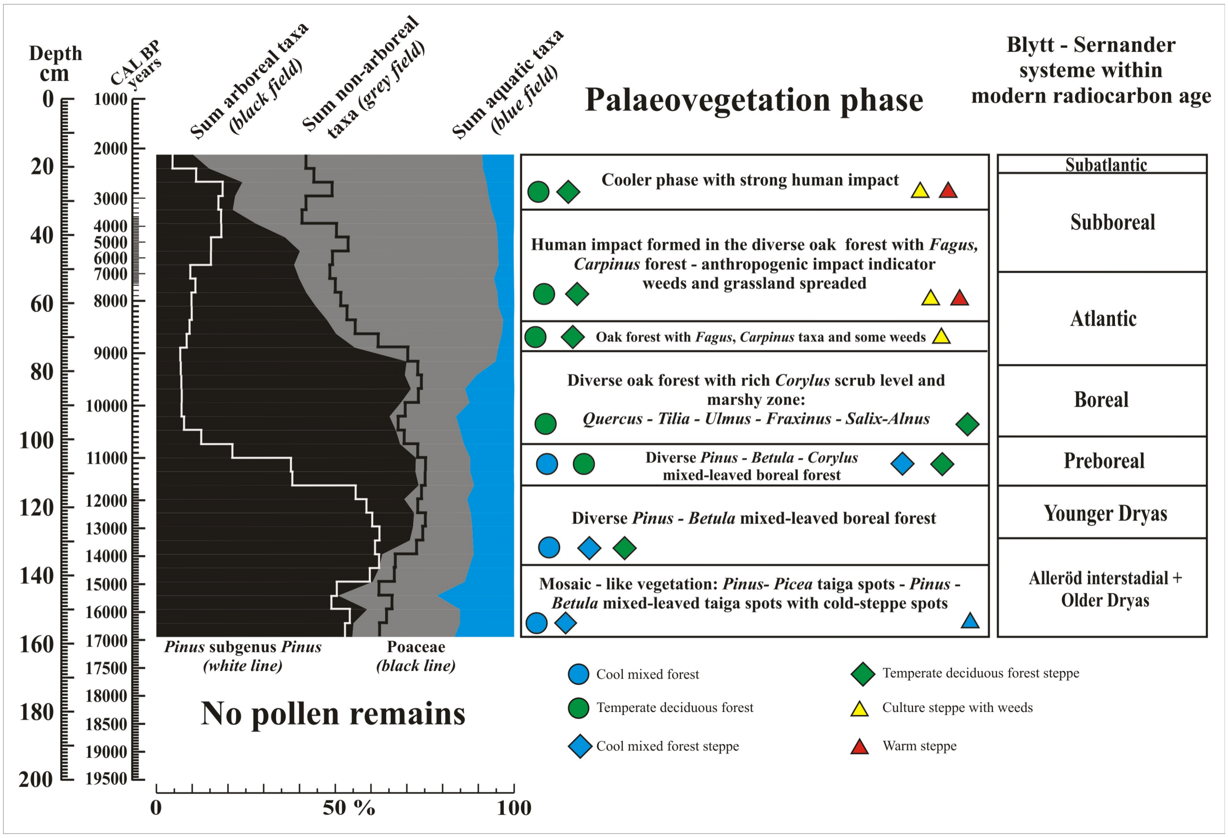

Figure 7: Summary of arboreal and non-arboreal pollen taxa plotted against depth in the geological core sequence at Ócsa, sorted by palaeovegetation phase and correlated with the Blytt-Sernander sequence.

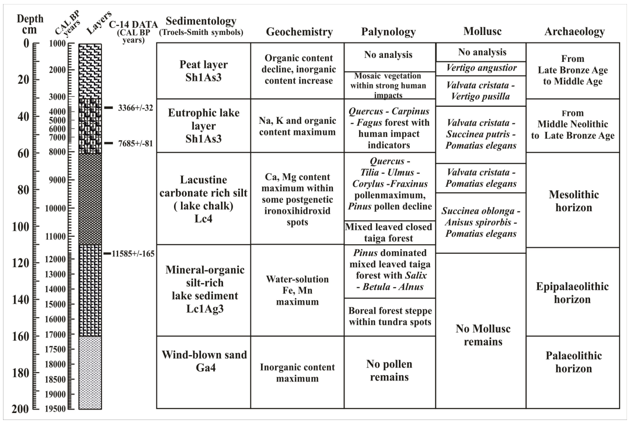

Figure 8: Description of geochemical, mollusc and pollen zones within sedimentary sequence at Ócsa.

roads, arable land, pasture land) *i.e.* the rate of human indicator weeds [49**?**] is the highest in the section. This data is well correspond with results of excavation of Harta village, south from Ócsa, where settlements and objects from middle and late Bronze Age came to light [11]. Based on the examination of Harta objects the Bronze Age communities were well and deliberately utilized the floodplain areas among others the washland forests [11]. Based on the geoarchaeological and paleoecological examinations in the late Bronze Age the environment was completely transformed owing to the human impact in both sites. Because of human impacts the Late Pleistocene lake system choked up at Ócsa and from the late Bronze Age it become a peat bog, and even these changes can be examined in other sites [101–104]. From the second part of the Bronze Age another technological change and/or overpopulation can be traceable because of the formation of peaty areas. This change may caused by the increased anthropogenic erosion and the choking up of the lake basin at Ócsa during the second half of the Bronze Age. Poorly the near-surface part of the borehole section was dried out and decayed owing to the 19th–20th irrigation processes thus the upper part from the Iron Age was awkward for palynological analyses (Fig. 8).

The composition of the malacofauna indicates a progressively choking up lake environment where the faunal changes followed the sedimentologic changes, but in every horizon a mosaic-like territory should be supposed.

Prominent elements of malacofauna are the *Pomatias elegans*, the *Vertigo pusilla* and the *Cochlodina laminata*. Recent living specimens can be found only of the first two species, *Cochlodina laminata* can only found as a fossil in the Ócsa peat-bog (Fig. 8).

6 Conclusions

The Ócsa, Selyemrét site is a sediment-accumulation basin formed on wind-blown sand surface, where choking up process would started from the late Pleistocene. During the late glacial a mixed leaved taiga surrounded oligotrophic clear watered lake developed where silty, carbonated, low organic matter containing lake sediment deposited. The late Pleistocene lake would be 1–5 metres deep, according to the plant fossils. The area then transformed, during the end period of the upper Palaeolithic cool wooded steppe, then during the Epipalaeolithic cool mixed forest developed (Fig. 8).

In the transition period of the Pleistocene and the Holocene a specific sediment change happened: the carbonate and the organic matter content suddenly raised and a temperate mesotrophic lake system formed. Even the mixed leaved taiga transformed, deciduous forest and rich coastal vegetation surrounded the early Holocene lake. The soundings decreased and a periodically searing hydrological system developed. The pollen content results show *Betula* and *Pinus* pollens in the early Mesolithic and temperate wood elements in the upper Mesolithic. The carbonated lake system remained as far as the early Neolithic (6th millennia BC) and after that owing to the increasing organic matter content it became a eutrophic lake system (Fig. 8).

This middle Holocene eutrophic lake was divided with swampy islands and floating mats and it was surrounded by big-ranged bulrush-reed littoral zone. Anthropogenic impacts can only traceable from the middle Neolithic. Than the progressive vegetation and sediment-content changes can probably bind to robust human activities, and in the late Bronze Age a short term environment reshaping human impact can be reconstructed (Fig. 8).

Rare snail species (*Pomatias elegans*, *Vertigo pusilla*, *Cochlodina laminata*) which make the Ócsa peat bog unique in the plain environment have already been appeared in the Neolithic. The late Bronze Age deforestation and the found *Pomatias elegans* specimens in the inwashed soil presumes disturbed coastal vegetation what might refer the ceased filter capability. After the Bronze Age a swamp-marshland stage remained until the 19th century when channelling works were made (Fig. 8).

After the channelling works the swamp soil progressively went dry, transformed, the organic matter content decayed and became a hydromorph soil. By the results of this paper it can be said that the anthropogenic activities had already affected the environment before the channelling. However, after the channelling, much significant transformation happened, and because of it the former environmental conditions could only remain in a few small spots in the area.

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References

[1] Knipl I., Sümegi P., Life at the interface of two distinct landscapes – relationship of humans and environment in the periphery of the Danube–Tisza Interfluve between Hajós and Császártöltés. Central European Journal of Geosciences, 2012, 4, 439–447

[2] 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, 2004, 47, 373–409

[3] Berglund B.E., Birks H.J.B., Ralska–Jasiewiczowa M., Wright H.E., Palaeoecological Events During the Last 15000 Years: Regional Syntheses of Palaeoecological Studies of Lakes and Mires Europe. J. Wiley&Sons Ltd., Chichester, 1996

[4] Willis K.J., Sümegi P., Braun M., Tóth A., The Late Quaternary environmental history of Bátorliget, N. E. Hungary. Paleogeography, Paleoclimatology, Paleoecology, 1995, 118, 25–47

[5] Willis K.J., Impact of the early Neolithic Körös culture on the landscape: evidence from palaeoecological investigations of Kiri-tó. In: Whittle A. (ed.), The Early Neolithic on the Great Hungarian Plain: investigations of the Körös culture site of Ecsegfalva 23, Co. Békés. Varia Archaeologica Hungarica XXI. MTA Régészeti Intézet, Budapest, 83–99, 2007

[6] Magyari E., Chapman J.C., Passmore D.G., Allen J.R.M., Huntley J.P., Huntley B., Holocene persistence of wooded steppe in the Great Hungarian Plain. J Biogeography, 2010, 37, 915–935

[7] Sümegi P., Molnár M., Jakab G., Persaits G., Majkut P., Páll D.G., Gulyás S., Jull A.J.T., Törőcsik T., 2011. Radiocarbon–dated paleoenvironmental changes on a lake and peat sediment sequence from the central part of the Great Hungarian Plains (Central Europe) during the last 25,000 years. Radiocarbon, 2011, 52, 85–97

[8] Sümegi P., Persaits G., Gulyás S., Woodland-Grassland Ecotonal Shifts in Environmental Mosaics: Lessons Learnt from the Environmental History of the Carpathian Basin (Central Europe) During the Holocene and the Last Ice Age Based on Investigation of

Paleobotanical and Mollusk Remains. In: Myster R.W. (ed.), Ecotones Between Forest and Grassland. Springer Press, New York, 17–57, 2012

[9] Sümegi P., Magyarország negyedidőszak végi környezettörténete. DSc thesis, Budapest–Szeged, 2007 (in Hungarian)

[10] Sümegi P., Az utolsó 15000 év környezeti változásai és hatásuk az emberi kultúrákra Magyarországon. In: Ilon G. (ed.), A régésztechnikusok kézikönyve. Savaria Kiadó, Szombathely, 1998 (in Hungarian)

[11] Kustár R., Sümegi P., Őskörnyezeti változások rekonstrukciója Harta környékén a 2002–2003. évi ásatások tükrében. In: Kreiter A., Pető Á., Tugya B. (eds.), Környezet–Ember–Kultúra: Az alkalmazott természettudományok és a régészet párbeszéde. Magyar Nemzeti Múzeum Nemzeti Örökségvédelmi Központ 2010. október 6–8–án megrendezett konferenciájának tanulmánykötete. Budapest, 107–114, 2012 (in Hungarian)

[12] Burján B., A Pesti–síkság fiatal–harmadidőszaki és negyedidőszaki kavics–képződményeinek összehasonlító vizsgálata, PhD thesis, Szegedi Tudományegyetem Természeti Földrajzi Tanszék, 2002 (in Hungarian)

[13] Bába K., Szárazföldi puhatestű közösségek successiója magyarkőrises égerlápokban. Szegedi Tanárképző Főiskola Tudományos Közleményei, Szeged, 1973, 18: 43–50 (in Hungarian)

[14] Bába K., Wassermollusken–Zönosen in den Moorwälden Anion glutinosae (Macnit) der Ungarischen Tiefebene. Malacologia, 1973, 14, 349–354 (in German)

[15] Bába K., Különböző állapotú csévharaszti tölgyesek puhatestűinek mennyiségi viszonyai. Abstracta Botanica, 1974, 2, 71–76 (in Hungarian)

[16] Rakonczay Z., Természeti értékek: Ócsai láperdő, Dabasi turjános, Csévharaszti borókás, Pusztavacsi országközpont, Pest megye helyi jelentőségű természeti értékei. In: Rakonczay Z. (ed.), Csévharaszttól Bátorligetig. Az Észak–Alföld természeti értékei. Mezőgazdasági Könyvkiadó, Budapest, 107–148, 1988 (in Hungarian)

[17] Sümegi P., A Vertigo pusilla (O.F. Müller, 1774) Mollusca faj a magyarországi Nagyalföldön. Malakológiai Tájékoztató, 1988, 9, 15–18 (in Hungarian)

[18] Troels–Smith J., Karakterisering af lose jordater. Danmarks geologiske Undersogelse. 1955, IV. 3. (10). (in Dansk)

[19] Vendel A., A kőzethatározás módszertana. Akadémiai Kiadó, Budapest, 1959 (in Hungarian)

[20] Dean W.E., Determination of carbonate and organic matter in calcareous sediments and sedimentary rocks by loss on ignition: Comparison with other methods. J. Sedimentary Petrology, 1974, 44, 242–248

[21] Hertelendi E., Sümegi P., Szöőr Gy., Geochronologic and Paleoclimatic characterization of Quaternary sediments in the Great Hungarian Plain. 1992, Radiocarbon, 34, 833–839

[22] Bronk Ramsey C., Development of the Radiocarbon calibration program OxCal. Radiocarbon, 2001, 43, 355–363

[23] Stuvier M., Reimer P.J., Bard E., Beck J.W., Burr G.S., Hughen K.A., Kromer B., McCormac G., van der Plicht J., Spurk M., INTCAL98 Radiocarbon age calibration, 24,000–0 cal BP, Radiocarbon, 1998, 40, 1041–1083

[24] Behre K.E., Van der Plicht J., Towards an absolute chronology for the last glacial period in Europe: radiocarbon dates from Oerel, northern Germany. Vegetation History and Archaeobotany, 1992, 1, 111–117

[25] Jöris O., Weninger B., Towards an Absolute Chronology of the Last Glacial. Journal of Quaternary Science, Rapid communication, 2000

[26] Borsy Z., Blown sand territories in Hungary. Zeischrift für Geomorpholie N.F. Supplemen, 1991, 90, 1–14

[27] Magyari E., Sümegi P., Braun M., Jakab G., Molnár M., Retarded wetland succession: anthropogenic and climatic signals in a Holocene peat bog profile from NE Hungary. Journal of Ecology, 2001, 89, 1019–1032

[28] Dániel P., Results of the geochemical analysis of the samples from Bátoliget II profile. In: Sümegi P., Gulyás S. (eds.), The geohistory of Bátorliget Marshland. Archaeolingua Press, Budapest, 95–128, 2004

[29] Stockmarr J., Tables with spores used in absolute pollen analysis. Pollen Spores, 1971, 13, 615–621

[30] Berglund B.E., Ralska–Jasiewiczowa M., Pollen analysis and pollen diagrams. In: Berglund B.E. (ed.), Handbook of Holocene Palaeoecology and Palaeohydrology. J. Wiley&Sons Ltd., Chichester–Toronto, 455–484, 1986

[31] Maher L.J. Jr., Nomograms for computing 0.95 confidence limits of pollen data. Review of Palaeobotany and Palynology, 1972, 13, 85–93

[32] Clark R.L., Point count estimation of charcoal in pollen preparations and thin sections in sediments. Pollen et Spores, 1982, 24, 523–535

[33] Moore P.D., Webb J.A., Collinson M.E., Pollen Analysis. Blackwell Scientific Publications, Oxford, 1991

[34] Beug H.J., Leitfaden der Pollenbestimmung für Mitteleuropa und angrenzende Gebiete. (Textbook of pollen identification for Central Europe and adjacent regions). Pfeil, München, 2004 (in German)

[35] Punt W., Hoen P.P., Backmore S., Nilsson S., Le Thomas A., Glossary of pollen and spore terminology. Review of Palaeobotany and Palynology, 2007, 143, 1–81

[36] Kozáková R., Pokorný P., Dynamics of the biotopes at the edge of a medieval town: pollen analysis of Vltava river sediments in Prague, Czech Republic. Preslia, 2007, 79, 259–281

[37] Reille M., Pollen et Spores d'Europe et d'Afrique du Nord. Laboratoirede Botanique Historique et Palynologie, Marseille, 1992 (in French)

[38] Reille M., Pollen et Spores d'Europe et d'Afrique du Nord. Supplement 1. Laboratoirede Botanique Historique et Palynologie, Marseille, 1995 (in French)

[39] Reille M., Pollen et Spores d'Europe et d'Afrique du Nord. Supplement 2. Laboratoirede Botanique Historique et Palynologie, Marseille, 1998 (in French)

[40] Sugita S., Pollen representation of vegetation in Quaternary sediments: theory and method in patchy vegetation. Journal of Ecology, 1994, 82, 881–897

[41] Soepboer W., Sugita S., Lotter A.F., van Leeuwen J.F.N., van der Knaap W.O., Pollen productivity estimates for quantitative reconstruction of vegetation cover on the Swiss Plateau. The Holocene, 2007, 17, 65–77

[42] Jacobson G.L., Bradshaw R.H.W., The selection of sites for palaeovegetational studies. Quaternary Research, 1981, 16, 80–96

[43] Prentice I.C., Cramer W., Harrison S.P., Leemans R., Monserud R.A., Solomon A.M., A global biome model based on plant physiology and dominance, soil properties and climate. Journal of

Biogeography, 1992, 19, 117–134
[44] Prentice I.C., Guiot J., Huntley B., Jolly D., Cheddadi R., Reconstructing biomes from palaeoecological data: a general method and its application to European pollen data at 0 and 6 ka. Climate Dynamics, 1996, 12, 185–194
[45] Prentice I.C., T. Webb III., BIOME 6000: global paleovegetation maps and testing global biome models. Journal of Biogeography, 1998, 25, 997–1005
[46] Prentice I.C., Pollen representation, source area, and basin size: toward an unified theory of pollen analysis. Quaternary Research, 1985, 23, 76–86
[47] Allen J.R.M., Watts W.A., Huntley B., Weichselian palynostratigraphy, palaeovegetation and palaeoenvironment: the record from Lago Grande di Monticchio, southernItaly. Quaternary International, 2000, 73–74, 91–110
[48] Behre K.E., The interpretation of anthropogenic indicators in pollen diagrams. Pollen et Spores 1981, 23, 225–245
[49] Behre K.E. (ed.), Anthropogenic Indicators in Pollen Diagrams. Balkema Press, Rotterdam – Boston, 1986
[50] Elenga H., Peyron O., Bonnefille R., Jolly D., Cheddadi R., Guiot J., Andrieu V., Bottema S., Buchet G., de Beaulieu J.L., Hamilton A.C., Maley J., Marchant R., Perez–Obiol R., Reille M., Riollet G., Scott L., Straka H., Taylor D., Van Campo E., Vincens A., Laarif F., Jonson H., Pollen–based biome reconstruction for southern Europe and Africa 18,000 yr BP. Journal of Biogeography, 2000, 27, 621–634
[51] Tarasov P.E., T. Webb III., Andreev A.A., Afanas'eva N.B., Berezina N.A., Bezusko L.G., Blyakharchuk T.A., Bolikhovskaya N.S., Cheddadi R., Chernavskaya M.M., Chernova G.M., Dorofeyuk N.I., Dirksen V.G., Elina G.A., Filimonova L.V., Glebov F.Z., Guiot J., Gunova V.S., Harrison S.P.. Jolly D., Khomutova V.I., Kvavadze E.V., Osipova I.M., Panova N.K., Prentice I.C., Saarse L., Sevastyanov D.V., Volkova V.S., Zernitskaya V.P., Present–day and mid–Holocene biomes reconstructed from pollen and plant macrofossil data from the former Soviet Union and Mongolia. Journal of Biogeography, 1998, 25, 1029–1053
[52] Tarasov P.E., Volkova V.S., T. Webb III., Guiot J., Andreev A.A., Bezusko L.G., Bezusko T.V., Bykova G.V., Dorofeyuk N.I., Kvavadze E.V., Osipova I.M., Panova N.K., Sevastyanov D.V., Last glacial maximum biomes reconstructed from pollen and plant macrofossil data from northern Eurasia. Journal of Biogeography, 2000, 27, 609–620
[53] Bennett K.D., Psimpoll manual. Available at: http:/www.kv.geo.uu.se/psimpoll.html (accessed 12 February 2008)
[54] Birks H.J.B., Gordon A.D., Numerical methods in Quaternary pollen analysis. Academic Press, London, 1985
[55] Ložek V., Quartermollusken der Tschechoslowakei. Rozpravy Ústavu ústavu geologichkého, 1964, 31
[56] Evans J.G., Land Snails in Archeology. Seminar Press, London, 1972
[57] Krolopp E., A magyarországi pleisztocén képződmények malakológiai tagolása. Candidate dissertation, Budapest, 1983 (in Hungarian)
[58] Sümegi P., The results of paleoenvironmental reconstruction and comparative geoarcheological analysis for the examined area. In: Sümegi P., Gulyás S. (eds.), The geohistory of Bátorliget Marshland. Archaeolingua Press, Budapest, 301–348, 2004
[59] Bennett K.D., PSIMPOLL – A quickBasic program that generates PostScript page description of pollen diagrams. INQUA Commission for the study of the Holocene: working group on data handling methods. Newsletter, 1992, 8, 11–12
[60] Spurk M., Friedrich M., Hofmann J., Remmele S., Frenzel B., Leuschner H–H., Kromer B., Revisions and extension of the Hohenheim oak and pine chronologies: New evidence about the timing of the Younger Dryas/Preboreal transition. Radiocarbon 1998, 40, 1107–1116
[61] Kitagawa H., Fukuzawa, I., Nakamura T., Okamura M., Takemura S., Hayashida A., Yasuda Y., AMS 14C dating of varved sediments from Lake Suigetsu, central Japan and atmospheric 14c change during the late Pleistocene, Radiocarbon, 1993, 37, 371–378
[62] Nakagawa T., Kitagawa H., Yasuda Y., Tarasov P.E., Gotanda K., Sawai Y., Pollen/event stratigraphy of the varved sediment of Lake Suigetsu, central Japan from 15,701 to 10,217 SG vyr BP (Suigetsu varve years before present): Description, interpretation, and correlation with other regions. Quaternary Science Reviews, 2005, 24, 1691–1701
[63] Hughen K.A., Overpeck J.T., Lehman S.J.. Kashgarian M., Southon J.R., Peterson L.C., A new 14C calibration data set for the last deglaciation based on marine varves. Radiocarbon, 1998, 40, 483–494
[64] Edwards R.L., Beck J.W., Burr G.S., Donahue D.J., Chapell J.M.A., Bloom A.L., Druffel E.R.M., Taylor F.W., 1993 A large drop in atmospheric 14C/12C and reduced melting in the Younger Dryas, documented with 230Th ages on corals. Science, 1993, 260, 962–968
[65] Bard E., Arnold M., Hamelin B., Tisnerat–Laborde N., Cabioch G., Radiocarbon calibration by means of mass spectrometry 230Th–234U and 14C ages of corals: an updated database including samples from Barbados, Mururoa and Tahiti. Radiocarbon, 1998, 40, 1085–1092
[66] Hughen K.A., Southon J.R., Lehmna S.J., Overpeck J.T., Synchronous Radiocarbon and Climate Shifts During the Last Deglaciation. Science, 2000, 290, 1951–1954
[67] Hughen K.A., Lehman S., Southon J., Overpeck J., Marchal O., Herring C., Turnbull J., 14C activity and global carbon cycle changes over the past 50,000 years. 2004, Science, 303, 202–207
[68] Hughen K.A., Southon J.R., Bertrand C.J.H., Frantz B., Zermeno P., Cariaco basin calibration update: Revisions to calendar and C–14 chronologies for core PL07–58PC. Radiocarbon, 2004, 46, 1161–1187
[69] Sümegi P., Magyari E., Dániel P., Hertelendi E., Rudner E., A kardoskúti Fehér–tó negyedidőszaki fejlődéstörténetének rekonstrukciója. Földtani Közlöny, 1999, 129, 479–519 (in Hungarian)
[70] Dean W.E., The carbon cycle and biogeochemical dynamics in lake sediments. J. Palaeolimnology, 1999, 21, 375–393
[71] Thompson R., Batterbee R.W., O'Sullivan P.E., Oldfield F., Magnetic susceptibility of lakes sediments. Limnology and Oceanography, 1975, 20, 687–698
[72] Oldfield F., Richardson N., Lake Sediment Magnetism and Atmospheric Deposition. Philosophical Transactions of the Royal Society London B, 1999, 327, 325–330
[73] Willis K.J., Braun M., Sümegi P., Tóth A., Does soil change cause vegetation change or vice – versa? A temporal perpective from Hungary. Ecology, 1997, 78, 740–750
[74] Sümegi P., Dániel P., Kovács–Pálffy P., The results of abiotic components analysis. In: Sümegi P., Gulyás S. (eds.), The geohistory of Bátorliget Marshland. Archaeolingua Press, Budapest, 150–154, 2004

[75] Braun M., Sümegi P., Tóth A., Willis K.J., Szalóki I., Margitai, Z., Somogyi A., Reconstruciton of long–term environmental changes at Kelemér, in Hungary. In: Gál E., Juhász I., Sümegi P. (eds.), Environmental Archaeology in North–Eastern Hungary. Varia Archaeologica Hungarica series XIX., MTA Régészeti Intézet, Budapest, 25–38, 2005

[76] MacKereth F.J.H., Chemical investigations of lake sediments and their intepretation. Proceedings of the Royal Society of London, Series B, Biological Sciences, 1965, 161, 295–309

[77] MacKereth F.J.H., Some chemical observation on post–glacial lake sediments. Phylosophical Transaction of the Royal Society of London, Biological Sciences, 1966, 250, 165–213

[78] Braun M., Sümegi P., Szűcs L., Szöőr Gy., A kállósemjéni Nagy–Mohos láp fejlődéstörténete (Lápképződés emberi hatásra és az ősláp hipotézis). Jósa András Múzeum Évkönyve, 1993, 33–35, 335–366 (in Hungarian)

[79] Beeton A.M., Eutrophication of the St. Lawrence Great Lakes. Limnology and Oceanography, 1965, 10, 240–254

[80] Dean W.E., Gorham E., Major components of Minnesota lake sediments. Limnology and Oceanography, 1976, 21, 259–284

[81] Majer A., Erdő– és termőhely típusok útmutató növényei. Országos Erdészeti Főigazgatóság, Budapest, 1963 (in Hungarian)

[82] Sümegi P., Paleohistory of the Northern Mountains at the end of Quaternary. Connection between Man and environment in the Subcarpathian – Upland – region. In: Guba Sz., Tankó K. (eds.), „Régről kell kezdenünk”... Studia Archaeologica in honoreum Pauli Patay. Szécsényi Múzeum Kiadványa, Szécsény, 295–326, 2010

[83] Vértes L., Az őskőkor és az átmeneti kőkor emberei Magyarországon. Akadémiai Kiadó, Budapest, 1965 (in Hungarian)

[84] Kretzoi M., Ecological conditions of the "loess period" in Hungary as revealed by vertebrate fauna. Földrajzi Közlemények, 1977, 25, 75–89

[85] Vörös I., 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. Geographical Research Institute, Hungarian Academy of Sciences, Budapest, 81–101, 1987

[86] Jánossy D., A magyarországi pleisztocén tagolása gerinces faunák alapján. Akadémiai Kiadó, Budapest, 1979 (in Hungarian)

[87] Kordos L., Climatostratigraphy of Upper Pleistocene Vertebrates and the condition of loess formation in Hungary. GeoJournal, 1987, 15, 163–166

[88] Küster H., Herkunft und Ausbreitungsgeschichte einiger Secalietea–Arten. Tuexenia, Mitteilungen der Floristisch–sociologische Arbeitsgemeinschaft, 1985, 589–597 (in German)

[89] Stieber J., Badania węglików drzewnych z późnopaleolitycznej warstwy kulturowej w Szekszard–Palank. Światowit, 1962, 24, 227–230 (in Polish)

[90] Stieber J., A magyarországi felső–pleisztocén vegetációtörténete az anthrakotómiai eredmények (1957–ig) tükrében. Földtani Közlöny 1967, 97, 308–317 (in Hungarian)

[91] Sümegi P., The environmental history of the Jászság. In: Gál E., Juhász I., Sümegi P. (eds.), Environmental Archaeology in North–Eastern Hungary. Varia Archaeologica Hungarica series XIX., MTA Régészeti Intézet, Budapest, 103–110, 2005

[92] Kozlowski J.K., Remarks on the Mesolithic int he Northern part of the Carpathian Basin. In: Gál E., Juhász I., Sümegi P. (eds.), Environmental Archaeology in North–Eastern Hungary. Varia Archaeologica Hungarica series XIX., MTA Régészeti Intézet, Budapest, 174–186, 2005

[93] Kertész R., Sümegi P., Kozák M., Braun M., Félegyházi E., Hertelendi E., Mesolithikum in nördlichen Teil der Grossen Ungarischen Tiefebene. Jósa A. Múzeum Kiadványa, 1994, 36, 15–61 (in German)

[94] Magyari E., The Holocene expansion of beech (Fagus sylvatica L.) and hornbeam (Carpinus betulus L.) in the eastern Carpathian basin. Folia Historico–Naturalia Musei Matraensis, 2001, 26, 15–35

[95] Juhász I.E., Reconstitution palynologique de la végétation depuis le Tardiglaciaire dans la région de Zala, sud–ouest de la Hongrie. PhD thesis, Pécs–Marseille, 2002 (in French)

[96] Gardner A.R., Neolithic to Copper Age woodland impacts in northeast Hungary? Evidence from pollen and sediment chemistry records. The Holocene, 2002, 12, 541–553

[97] Bánffy E., Eastern, Central and Western Hungary – variations of neolithisation models. Documenta Praehistorica, 2006, 33, 125–142

[98] Bánffy E., The boundary in Western Transdanubia: variations of migration and adaptation. In: Bailey D., Whittle A., Hofmann D. (eds.), Living well together? Materiality in the Neolithic of South–East and Central Europe. Oxbow, Oxford, 151–163, 2008

[99] Bánffy E., Oross K., The „earliest” and the „earlier” phase of the LBK in Transdanubia. In: Gronenborn D., Petrasch J. (eds.), The spread of Neolithic to Central Europe. RGZM Tagungen, Bd. 2, Mainz, 255–272, 2010

[100] Bánffy E., Marton T., Osztás A., Early neolithic settlement and burials at Alsónyék–Bátaszék. First report. In: Kozlowski J.K., Raczky P. (eds.), Neolithisation of the Carpathian Basin: Northernmost distribution of the Starcevo/Körös culture. Kraków–Budaspest, 37–51, 2010

[101] Sümegi P., Bodor E., Sedimentological, pollen and geoarcheological analysis of core sequence at Tököl. In: Poroszlai I., Vicze M. (eds.), SAX: Százhalombatta archaeological expedition : annual report 1–field season 1998. Matrica Múzeum, Százhalombatta, 83–96, 2000

[102] Sümegi P., Bodor E., Geoarcheological and archaeobotanical investigations in the valley of the Benta (Békás) creek. In: Poroszlai I., Vicze M. (eds.), SAX: Százhalombatta archaeological expedition: report 2 – field season 2000–2003. Matrica Múzeum Kiadványa, Százhalombatta, 209–236, 2005

[103] Sümegi P., Juhász I., Bodor E., Gulyás S., Bronze Age Agricultural impacts in the central part of the Carpathian Basin. British Archaeological Report, 2004, 1271, 171–177

[104] Sümegi P., Törőcsik T., Jakab G., Gulyás S., Pomázi P., Majkut P., Páll D.G., Persaits G., Bodor E., The environmental history of Fenékpuszta with a special attention to the climate and precipitation of the last 2000 years. Journal of Environmental Geography, 2008, 2, 5–14

[105] Krolopp E., Varga A., A Pomatis elegans (O. F: Müller, 1774) újra felfedezett lelőhelye (Mollusca: Pomatiasidae). Folia Historico Naturalia Musei Matraensis, 1991, 16, 95–103 (in Hungarian)

[106] Willis K.J., Rudner E., Sümegi P., The full–glacial forests of central and southeastern Europe: Evidence from Hungarian palaeoecological records. Quaternary Research, 2000, 53, 203–213

[107] Krolopp E., Vörös I., Macro-Mammalia és Mollusca maradványok a Mezőlak-Szélesmező pusztai tőzegtelepről. Folia Mu-

sei Historico–Naturalis Bakonyiensis, 1982, 1, 39–64 (in Hungarian)