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HUMAN INFLUENCE ON ENVIRONMENTAL CHANGE - RESEARCH ON AN INTERDUNE AREA IN THE SOUTH NYÍRSÉG

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Introduction

The aim of the recent study is to present the characteristics of the landscape development of the South Nyírség, southeast of Debrecen in the late Holocene, to determinate how the human influence affected the processes of natural landscape development, and to specify its way and degree in the different historical periods.

In the neighbourhood of the research area no palynological research have been carried out formerly, and the closest pollen data are from the Ér-mellék (*Félegyházi E. 1997, 1998; Sümegi P. 1992*), from the Kokad swamp (*Csinádi G. 1960)* and from the Bátorliget swamp (*Csinádi G. 1954, Willis K.J. et al 1995*), therefore, they are not suitable for supplying pollen data for our research area. Therefore, we have carried out a pollenanalytical research on the selected site to determine the relative age of the sediments in the interdune hollow and to find out what kind of human influence (if there was any) was characteristic at time of deposition. The discussion of the results do not follow the traditional way, but at first we present the results of the pollen analysis and than those of the sedimentological study.

Research area

During the *Pliocene* and *Pleistocene* epochs in the foreground of the Eastern Carpathians the Tisza and its tributaries built up an extensive alluvial fan, which expanded toward south, south-east. At the beginning of the *Upper Pleniglacial* period (22,000-22,000 B.P.) the Tisza abandoned the alluvial fan and turned to northwest towards the Bodrogköz (*Borsy Z. 1990*), therefore, huge inundation-free areas evolved in the region. At the end of the Pleistocene under the cold and arid climatic conditions the fluvial deposits on the surface were covered by scanty vegetation, which could not provide protection against strong winds, thus, in the unprotected areas blown sand movement took place and the evolution of various sand formations could begin. The most intensive aeolian activity occurred at the first cold maximum of the Upper Pleniglacial period, 27,000-22,000 ys ago (*Borsy Z. 1985*). On the southern part the sand movement took longer, until the Bölling Interstadial, therefore, no loess blanket could form on the surface. In the Bölling Interstadial the climate turned milder and more humid, so the dunes were gradually overgrown by steppe vegetation, thus, the blown sand movement decreased considerably. During the Dryas periods course of sand movements took place, but in much smaller areas than in the Upper Pleniglacial, thus, the forms of the present-day surface were developed in the Younger Dryas (11,300-12,900 B.P.) period (*Borsy Z. 1994*).

At the beginning of the *Holocene* the sand surfaces on the alluvial fan became more and more overgrown by vegetation, so that sand movement practically ceased. Intensive sand movement has occurred mostly since the 18th century as a result of deforestation or overgrazing (*Borsy Z. 1960*). This human influence resulted in the dissection of dunes, though, unambiguous evidence have not been found yet; and even Borsy Z. (*1982*) refers to this as "a sand movement with scarcely distinguishable morphological effect".

The selected site must fulfill some basic criteria: first of all it has to be enclosed by dunes, therefore, the eroded material would entirely accumulate in a basin. The surrounding sand dunes must be tall enough to show intensive erosion due to a possible human impact. Finally, the interdune area must be swampy or at least the groundwater level must be high, since it is the basic criterium for palynological sampling, because pollens are preserved only under anaerobic conditions.

The most adequate site was found SE of Debrecen, west of Újléta in the territory of Bánk Forest (*Fig.1*). This interdune area is bordered by edge dune on the N, W and S sides, while on E a smaller dune can be found. The greatest difference in altitude is 8,0 m between the hollow and the NW sand dune, the other dunes are higher than the interdune area only by 3-4 m. The deepest parts are occupied by swampy vegetation, the higher but still wet parts are characterised by reeds, on the margins willow bushes can be found, while the dunes are covered with pine and locust plantations. The hollow was swampy until 1964, when it was drained. Nowadays only the vegetation refers to the former hidrography.

Methods

Starting from the NW dune 10 drillings were made along a NW-SE section, besides, a trench was made, as well. Samples were taken with a Földvári type hand-drill from every 5 cm. The total depth of drillings reached 180-300 cm. Due to the high level of ground water, the trench could be deepened only on the slope of the dune. Here, samples were taken from the stratigraphic boundaries.

In all, 285 samples were collected from the studied area in order to perform sedimentological examinations. The granular composition of samples was determined with Köhn-pipette, and dry sieving. The pH values were measured from H_2O solution. The calcium-content was determined with a Scheibler type calcimeter. Results were represented for each drillings in diagrams, and in a summed cross-section.

On the cores of a part of the samples (102 pieces) palynological analyses were performed. For the extraction the Zólyomi-Erdtman type, zinc-chloride method was applied. Sporomorphs were determined under a 400-600 X magnification on the level of species, genus, and familia. From the results two types of summed pollen diagrams –absolute value, percentage –, were drawn by Tilia and Tilia Graph softwares. Beside determining pollens, fungi spores and algae were counted, too. Later ones were determined on a species and genus level. A sample was considered sterile, if 20 g of the processed material contained less than 100 pollens. The pollen-content of samples became comparable by applying a pollen/cm^2 unit for characterising their pollen distribution.

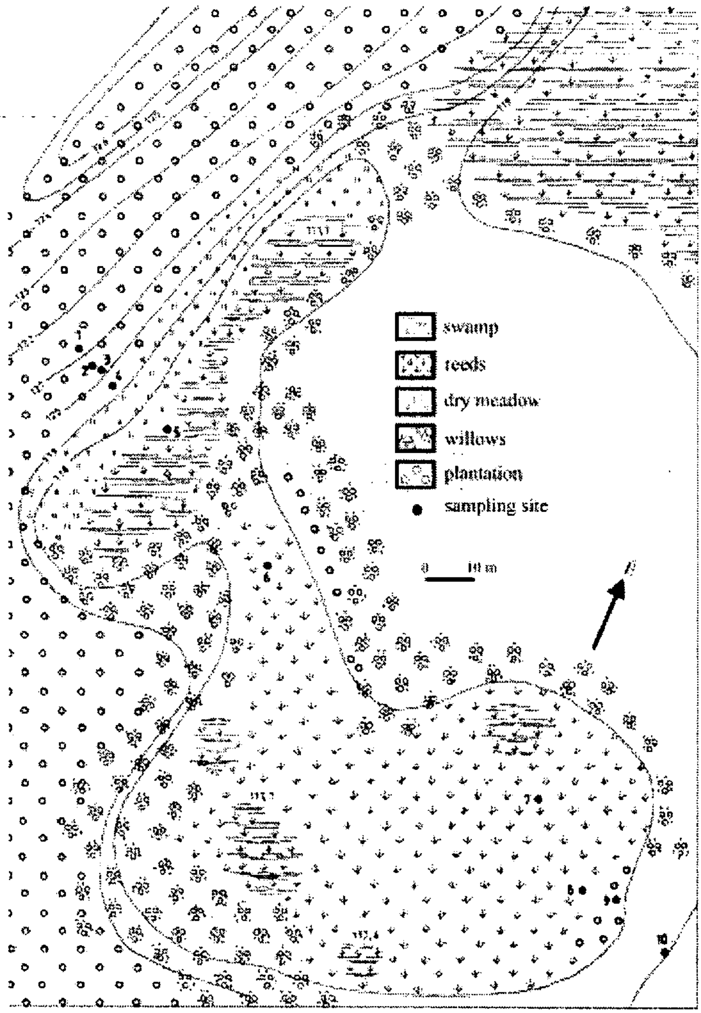


Figure 1 The study area and the drillings

Examinations were complemented with radiocarbon measurements, which were carried out by the Environment Analytic Laboratory of the ATOMKI, Debrecen. Since, during sampling no charcoal remainings were found, analyses were performed on humus. While dating, we applied the generally accepted dating of Andersen-de Vries-Zagwijn (*1960*) that is confirmed with radiocarbon data.

Results

When presenting the results, not the normal way of analysis will be applied but first the palynological then sedimentological the results are going to be set forth. The reason for this is that with the help of pollen analytical data the relative age of sediments, and the possible human impact on the environment are well detectable. However, the characteristics and the pace of landscape development can be deduced from sedimentological results.

For a detailed presentation, the palynological and sedimentological data of the Erd.5-6. drillings were chosen, because these well represent the results of the other drillings of the section. Of course, there are some minor and major differences, but these will be detailed when analysing the stratigraphic profile of the basin.

Pollenanalytical examinations

With the help of pollenanalytical methods we intended to determine the stratigraphical layer's *relative age, the predominant climatic situation during sedimentation, and changes of the surrounding vegetation.* On the basis of the characteristics of climate, we can come to certain conclusions in connection with the course of landscape development, which was also influenced by the changes of the area's vegetation, that provides further information for deciding whether landscape changes were due to natural or artificial factors.

As a reference diagram for pollenanalytical examinations two neighbouring diagrams (Erd.5-6.) were applied (*Fig. 2*). In case of drilling Erd.5. the upper half's, in case of drilling Erd.6. the lower half's pollen content was higher. Therefore, when reconstructing the history of the pollen trap, lower strata were analysed on the basis of Erd.6., while upper strata on the basis of Erd.5. drilling, nevertheless, both were complemented with the additional data gained from the other.

Concerning this interdune basin under discussion, the studied strata's *age* can only be determined uncertainly by pollen analytical methods, since the area from the beginnings might be under human influence (pollens of plants indicating disturbance are dominant, and many of the pollens are shattered or burnt). Therefore, during relative dating a special attention was paid to the presence of phase marking pollens.

The pollen profiles can be divided into two levels, the boundary between them is represented by a sterile stratum (Erd.5. 95-70 cm; Erd.6. 115-55 cm)

In the *lower level* (Erd.6. 290-115 cm) the ratio of pinaceae (Coniferopsida) is high (80-100 %) everywhere. This could refer to a very cold climate, but on the other hand in drilling Erd.6. We have found oak (Quercus) and in drilling Erd.5. holly (Ilex) pollens. The later one is an Atlantic-Mediterranean floral element, it needs an even marine climate and a great humidity (*Gencsy, L. 1997*), and it was a characteristic plant of the Atlantic Phase (*Járainé 1966*). The presence of alder (Alnus) and peat-moss (Sphagnum) also reinforce the assumption that there was an abundant precipitation, moreover, according to the pollens of reeds and sedge, there could be an increased groundwater level in the interdune hollow, as well.

In the *upper level* (Erd.5. 75-0 cm) the proportion of Pinaceae is still high, though for a smaller degree (35-90 %). Regarding deciduous trees, birch (Salix), linden (Tilia), oak (Quercus), popular (Poplus), and also beech (Fagus) are present in a greater proportion. Since, the pollen of beech was found only in one sample, the occurrence of the Subboreal Phase in the pollen spectrum cannot be proved without doubt, however, the proportion of hydrophilous plants, preferring fresh habitats is also high in this stratum, which is not in accordance with the drying at the end of Holocene.

According to radiocarbon data, the age of the upper level's sterile lower part (Erd.5. 80-85 cm) is 3720±65 years BP. Therefore, these results reinforce the assumption that this sterile stratum divides the Subboreal and Atlantic Phases. *Thus, the lower level formed during the Atlantic, while the upper one during the Subatlantic Phases.*

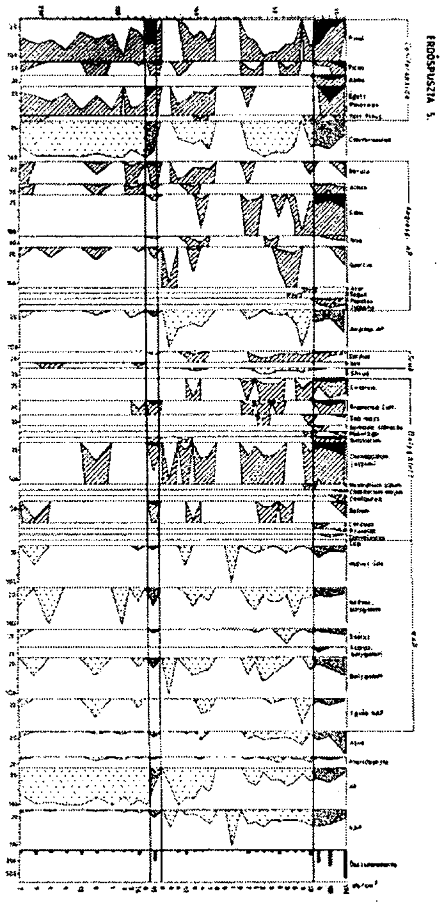


Figure 2a Pollen diagrams of Erd.5. drillings

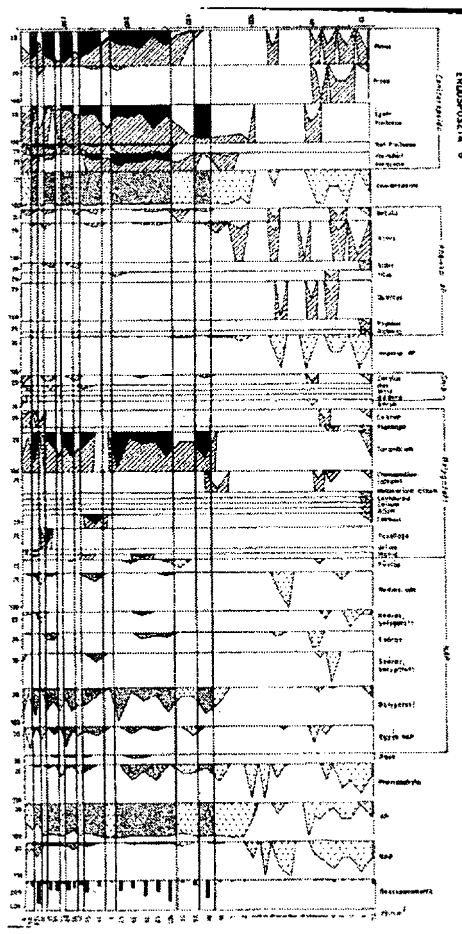


Figure 2b Pollen diagrams of Erd.6. drillings

The most precious and abundant information provided by the pollen spectrum have been those of referring to ***human activity***.

In the *lower level* (Erd.6. 290-115 cm) the number of burnt and corroded pollens is very high. This cannot be explained only with natural causes, since, in this phase we cannot assume such a significant aridity that could reason the occurrence of forest-fires. The pollens of herbs also refer to human disturbance: horse-thistle (Cirsium), lion's tooth (Taraxacum), horse-foot (Tussilago), thistle (Carduus), and nettle (Urtica). All these mean that *the forest was burnt time to time.* The burning-revival rhythm is represented well in drilling Erd.6. Directly after burning the proportion of small- grained sand (0.2-0.1 mm) increased in the sequence of the interdune basin, what refers to inwash or maybe aeolian transportation of the bare dune's material into the basin. The increased erosion occurred repeatedly according to the alternation of pollen-rich and pollen-poor strata, since the redeposited material is usually poor in pollen (*Faegri, K. - Iversen, J. 1989*). Right after the burning the resettlement of vegetation was begun, in the first place by the above mentioned herbs, that indicate disturbance, and pine-trees (Pinus). Pollen-rich strata of this type have a finer granular composition, and corroded pine-tree pollens also occur in a larger number in them. This fact, and the increase of humus-content refer to the beginning of soil formation.

In the *upper level* (Erd.5. 75-0 cm) the pollens imply a change in the type of human activity. Still, pine-trees are dominant on the surrounding territory, but burnt pollens can be detected more rarely and in a lower number. Concerning deciduous trees, the pollens of willow, that has an invaluable wood, are present for all along. The presence of species of hard wood is sporadic in the pollen spectrum. Since, the climate does not reason such disappearance and appearance of trees, we suppose that the forest was cut down regularly. Besides, the pollens of a planted species, walnut (Juglans regia), that occurred in the Carpathian Basin before the Hungarian conquest (*Gencsi, L. 1997*), also appear.

On the basis of NAP pollens, the upper level can be divided further, into two sublevels:

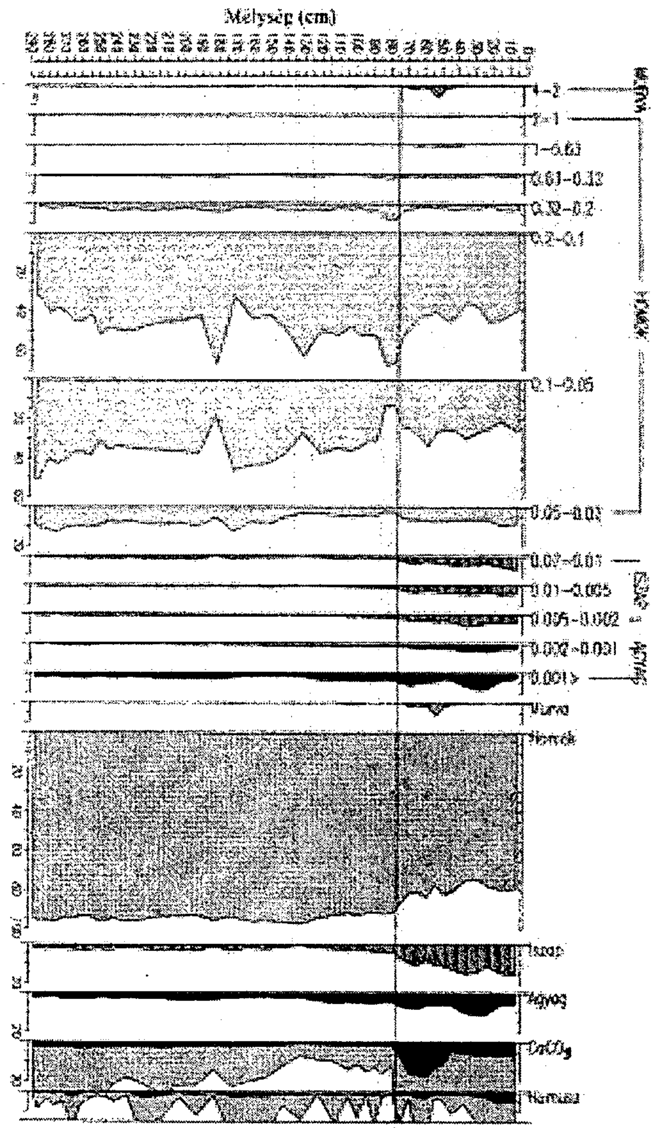
75-25 cm: The increased amount of thistle refers to pasturing on the territory, what is also reinforced by other plants that indicate a strong treading. These are plantain (Plantago), and lion's tooth (Taraxacum).

25-0 cm: In the upper most stratum the pollens of grown plants were found: crops (cultur Graminea), spinach (Spinacia oleacea), maize (Zea mays); and species of weed associations: bindweed (Convolvulus), ragged robin (Melandrium), and goose-foot (Chenopodium). Therefore, beside animal breeding, plant growing also had an important role, and there might be plough-lands and gardens in the vicinity.

Sedimentological examinations

On the basis of pollenanalytical results, we concluded the time and type of the different human activities that affected the area, nevertheless, the question how these activities affected landscape evolution cannot be answered just with palynological analyses. To solve this problem we used the results of sedimentological analyses.

Drilling Erd.6. can be divided into two parts (*Fig. 3*). The boundary is represented by sample 70-75 cm.



Figures 3 Sediment strata of the Erd.6. drilling

In the *lower part of the drilling* (290-75 cm) the proportion of sand fraction is high (≥90 %), though, the amount of small-grained sand (0.2-0.1 mm) exceeds that of fine-grained (0.1-0.05 mm) only to a small degree. The amount of small-grained sand exceeds 70 % only once (125-135 cm), and twice (175-185 cm and 80-85 cm) falls between 60-70 % (both times 67 %). This suggests that once surely but maybe three times the aeolian sand of the dune got into the basin (sediment trap). The humus-content is also very diverse in this zone but remains usually under 1 %, however, in an upward direction with an increasing frequency (in eight occasions) its amount grows significantly (1.2-2.7 %). This could happen only in case these strata were on the surface undisturbed for a longer time, and soil formation could begin on them. In those three cases when the sand of the dune got into the basin (aeolian or fluvial process), the material covered the strata of higher humus-content. The organic matter content of the thickest humus-rich stratum (145-175 cm) is 1.7-2.3 %, which implies a longer period of soil formation.

In the *upper part of the drilling* the proportion of silt and clay fractions increases. Oolitic marsh ore concretions appear in this zone (45-60 cm), too. Their presence can be concluded from the increased ratio of rubble (≥1 mm) fraction. Above this stratum the proportion of calcium grew to an unusual level (16-17 %) compared to that of the calcium-poor sands of the Nyírség. This can be both of organic and inorganic origin, and previous pollen analytic investigations (*Csinády, G. 1954, 1960, Willis, K. J. et al.*) always dated it to the Atlantic Phase. Toward the surface the amount of humus gradually increases, and the upper most 40-50 cm is represented by a dark coloured swampy stratum.

An outline of the stratigraphic sequence of the studied area

In order to compare drillings we set the diagrams of their granular composition. As a result of comparisons we drew the stratigraphic cross-section of the basin, during which we considered the following principles:

Little differences in the quality of strata are important, too.

The naming fraction(s) of the stratum is not necessarily the one that is of the greatest proportion but the one whose amount increased significantly within the stratum.

I paid special attention to the ratio of small-grained sand (0.2-0.1 mm). According to Borsy, Z. (*1960*): "small-grained is the dominant in the blown sand of the Nyírség". He also published the mechanic composition of some exposures, and the proportion of small-grained sand reached 76-86 % in these. Our own experiences also support the fact that on the studied area the proportion of 0.2-0.1 mm sand fraction always exceeds 60 % in the sand of dunes. Therefore, when we found a stratum where the proportion of small-grained sand was higher than 60 %, then we regarded it as the redeposited material of the dune, and if this stratum stretched along the whole basin, then we concluded that it was of aeolian origin. However, if this layer wedged out near the dune, then we handled it as a redeposited_material, since, according to previous measurements, the material of the dune cannot be transported far by the erosion induced by precipitation (*Kiss, T. 1997*).

In the enclosed basin the material of the drillings, similarly to that of the valley, can be divided into three levels (in Erd.6. only the lower two occurred):

the lower most level is rather sandy, the proportion of fine-grained and small-grained sand is high (these two fractions give approximately the 80 % of the sediment);

the middle level is a more silty, more clayey stratum, that wedges out in the base and in the side of the dune. It was the thickest (0.8 m) at drilling Erd.7.;

the upper most level, the material of the dune was exposed on the western edge by drillings Erd.1-4., on the eastern edge by drillings Erd.9-10.

In the *lower most level* the strata stretch along the whole length of the basin (*Fig. 4*), strata that wedge out or in can be found only at the base of the dune. Those three strata that contain sand of aeolian origin and appeared in drilling Erd.6. are present in all the other drillings, too. Thus, these refer to erosion activities caused either by wind or precipitation – that affected the whole territory of the basin, and the neighbouring dunes.

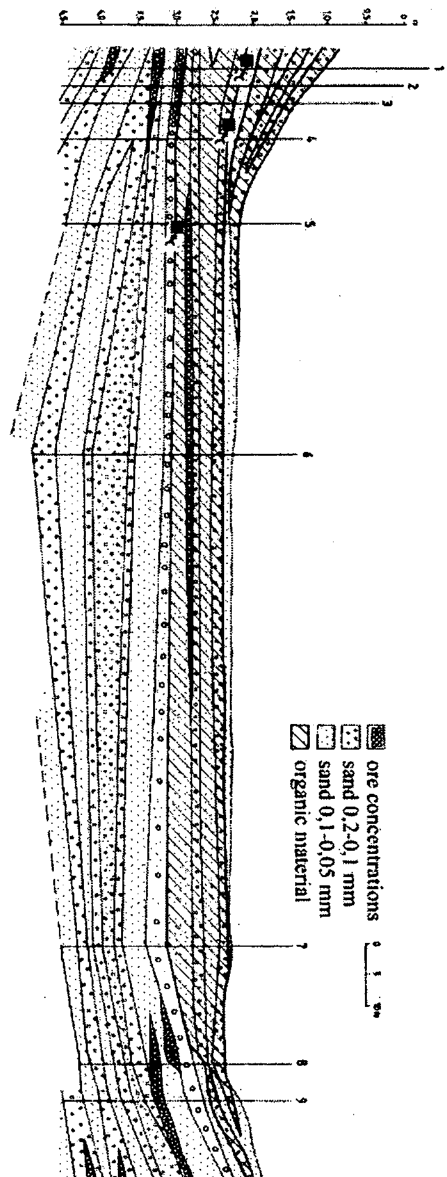


Figure 4 Stratigraphical sequence of the studied interdune area

The *middle level* is the one that appears on the surface of the basin, and that is buried in the western edge, while it wedges out at the base of the eastern dune. A general characteristic of it is that the proportion of grains smaller than 0.05 mm (in average 20-25 %) increases in it. In the bottom of the zone a stratum, consisting of mainly fine-grained sand, can be found, from above which in drillings Erd.5-6. marsh ore concretions turned up. These are covered in the middle of the basin by the calcareous accumulation that was detected in drillings Erd.6-7. The maximum calcium content (19.5 %) was found in drilling Erd.7. at 40-50 cm. The $CaCO_3$ accumulation is generally covered by a stratum with an increased proportion of fine-grained sand. On the surface its amount gets higher again, and parallel with it the humus-content increases, too, and reaches up to 4-5%.

This levell has the characteristics of the sediments of interdune areas: iron concretions and calcareous precipitations refer to a strong influence of water; as a result of the beginning of soil formation the amount of silt and clay is high. Due to redeposition, this zone can also be found at the NW end of the cross-section, under the dune, but similarly to the SE end it wedges out quickly.

The upper most level was separated in the western edge and in the eastern edge on the basis of drillings Erd.1-4. , and Erd.9-10., respectively. The summed proportion of silt and clay at this level does not exceed 4-5 %. Small-grained sand is dominant (>70 %), the humus content is low. This level must be regarded as the material of the surrounding dunes. The fact that the thickness of this stratum continuously decreases, while eventually in drilling Erd.6. it disappears, means that the sand was washed in the basin gradually, and covered its muddy sediments.

Conclusion

Based on the palynological and sedimentological analyses of the drillings of the interdune basin, and with the help of archaeological findings and written documents that originate from the area, it is possible to reconstruct the natural and artificial impacts that affected the sampled territory and its surroundings.

We can reconstruct the evolution of the landscape from the **Atlantic Phase** (7500-5000 BP.), since this was the lowest stratum that the drillings reached. The warm, wet climate would have been favourable for the development of mixed oak forests. But on the contrary, oaks grew in the area just occasionally, because their habitat was occupied by pine-trees, that could regenerate faster after forest-fires. Natural fires under prevailing climatic conditions did not or just rarely could occur, thus, it is probable that such frequent forest-fires can only be explained by human influence. Consequently, the people of the Neolithic Age had been doing shifting agriculture that required regular forest burning. The cracked and eroded pollens that we found, and the fact that the material of the dunes got into the sediment trap from time to time refer to an intensive soil erosion. Hence, from this stage the lowering of dunes probably started, their slopes became gentler, and in the basin on the redeposited material soil formation began at least eight times – on the basis of sedimentological analyses.

The place of the early stage of the **Subboreal Phase** is uncertain in the profile, but according to ^{14}C measurements, it might be at the bottom of the sterile stratum (70-100 cm).

Supposedly, Pinus species and different deciduous trees grew on the dunes at this period. Under the cold, wet climate of the phase the level of ground water in the interdune basin increased continuously, and there might be even an open water surface.

The NAP pollens imply that the territory was used for pasturing. The wet, swampy basin was ideal for animal breeding, since even in the hottest summer the wet hollow could provide some grass for the stocks, then in the winter the heat of the rotting material of the swamp might melt the snow, and animals could find feed again.

The relatively rich archaeological findings of the area refer to Copper and Bronze Age settlements. According to Mesterházy, K. (*1984*): "we can count on a quite dense population", and the appearing of the Nyírség culture is also dated to this era. Maybe, due to the increasing importance of agriculture and the decreasing role of animal breeding – especially in the Copper Age, but in the Bronze Age, as well (*Kovács, T. 1977*) – we did not find evidence of significant erosion in the sequence of this phase. This might be explained by the assumption that in case of agricultural landuse the degree of erosion is smaller.

In the **Subatlantic Phase** the composition of the surrounding sparse forests (proportion of tree pollens is low) could be very mixed. The hollow, that remained wet, was framed by reeds and sedge. A more widespread agriculture characterised the territory at this phase. Mainly crops and maize were grown. Deforestation could also be significant – numerous burnt pollens were found –, however, pollens of non-native species (locust, walnut) that refer to tree plantation, appear too.

The human activity became more and more significant, and caused the transformation of the environment: erosion started on the bare dune, and the swamp of the interdune basin was partly covered by its eroded material. On the basis of radiocarbon datings (1060±65 B.P. and 825±65 BP.) this might happen in the 10^{th}-13^{th} centuries. On the basis of contemporary remainings and written documents, at this time Bánk, a settlement near the studied area, was a populated village with a church – it disappeared only in the middle of the 16^{th} century *(Zoltai, L. 1932, Györffy, Gy. 1966*), consequently, there could be agricultural activity during the ages of the Árpáds. Nevertheless, this does not mean that all of the fields around the village were cultivated: according to contemporary documents, there were huge forests in the vicinity of the settlement in the 14^{th}-15^{th} centuries (*Zoltai, L. 1932, Jakó, Zs. 1940*).

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