Reconstruction of past environments based on pedological, micromorphological and phytolith analyses

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Abstract

Kurgans are significant cultural and ecological values of the Carpathian Basin and Hungary. These formations were primary built in order to serve sacral-burial purposes. By the erection of these mounds, the ancient soil surface has been covered and isolated. Due to the protection of law, kurgans in Hungary can only be examined by drillings. Due to a special and unconventional occasion the Lyukas-halom kurgan could have been excavated. The mound is situated on the Great Hungarian Plain in the Carpathian Basin. The surrounding landscape dominated by agricultural production. Together with archaeological experts transverse section of the kurgan has been prepared as a result of the excavation. It reveals the kurgan is 40 meters length and 8 meters height. Not only the stages of the erection of the mound were easily detectable, but the buried soil profile could be easily identified. According to the morphology (crumby structure, dun colour, typical lime and humus dynamics) and to the results of the laboratory analyses (TOC, loamy texture, balanced water regime) the 5500 B.P. aged soil (C^{14} calibration) can be classified as a Chernozem, which is interesting data in the light of former theories. Formerly, research on the vegetation development of the inner basin territories underlined the existence and dominance of forest cover on the Great Hungarian Plain. Additional soil analyses, such as micromorphological investigations and geochemical examinations support the same as no signs of Luvisol evolution processes, such as lessivage, clay migration nor forms of clay coatings were found. In addition, paleobotanical results (phytolith analysis) of the palaeo [A]-horizon refer to steppe-dominated vegetation mosaics.

Key Words

Palaeoecology, paleopedology, kurgan, soil micromorphology, phytolith analysis.

Introduction

The geomorphological, pedological and paleontological examination of ancient environment became more and more popular with the extension studies focusing on burial mounds and tells of the Eurasian steppe zone. As a pioneering forerunner of these tendencies, Sümegi *et al.* (1998) has undertaken the geoarcheological research of a Bronze Age tell, the so called Test-mound located near Szakáld. By implementing geological drillings, Sümegi's (2003) researches resulted in formative and new findings when he conflated data of soil resistance and magnetic anomaly measures from the Neolith Csősz-mound, the Bronze-aged Ásotthalom and Kenderföld tells, Kovács-mound and the Gara-mound. Similar geomorphological and stratigraphical investigations of the Büte-mound and other kurgans rising on the southern plain territories of Hortobágy National Park have been carried out by Tóth (1998). Füleky (2001) has reconstructed the original soil profile buried under a Bronze Age tell near Százhalombatta through pedological examinations. According to the morphological results the profile buried under a 1.5 meter thick cultural layer, turned out to be a Luvisol, with typical reddish, leached [B] horizon.

Our research team has started the pedological studies of kurgans and the paleoenvironmental reconstruction of their surroundings in 1999 (Barczi *et al.* 2003; 2004; Molnár *et al.* 2004). Our aim was to examine buried paleosoils underneath kurgans located at various territories of the Hungarian Great Plains and to detect geochemical processes. As all kurgans are protected by law in Hungary (*Law for the protection and conservation of nature, 1996. LIII.*) we could only undertake our researches by implementing drillings. The multidisciplinary excavation of the Lyukas-halom kurgan (Hajdúnánás, Hungary) was lead by the Department of Landscape Ecology from the Szent István University (Gödöllő, Hungary) in 2004. It was a special and unique occasion that we could collect all relevant permissions for the excavation. The cross-section wall of the – 5 meters high and approximately 42 meters in diameter wide – kurgan was prepared aiming detailed environmental and archaeological studies. The buried soil profiles under these 5000 to 6000 years old (B.C.) burial mounds are the messengers of ancient landscape forming factors and soil generation processes (Alexandrovskiy *et al.* 1999). There are contradictory theories on the Holocene landscape evolution of the Carpathian Basin. One of them describes the Holocene environment with closed forest vegetation, forest-steppe mosaics and claims the non-existence of sodic, alkaline soils in the early Holocene. In contrast to the first theory, the second one denies the dominance of closed, extended forest vegetation and the secondary, anthropogenic evolution of the sodic, alkaline soil area.

Main aims of preparing a cross-section wall were to clarify the circumstances of the kurgan's construction, to describe recent soil development, to study the buried soil profile and to reconstruct the one-time environment with the tools of paleoecology. The Lyukas-mound is situated in the Hajdúhát mesoregion of the Hungarian Great Plain, between Nyírség and Hortobágy mesoregions, near the town of Hajdúnánás (Figure 1a.). The area is a one-time silt-cone plain covered with loess and loessy silt. Its small relative relief is corrugated by 5-7 m high shifting sand accumulations and mounds covered by loessy sand. Climate of the microregion is moderately warm and dry, annual average precipitation is 550 mm. Its water regime is characterised by dryness, thin runoff and water shortage. Average depth of the groundwater is 2-4 m; its amount is not significant, with a calcium-magnesium-hidrocarbonate character. Potential vegetation of the area is oak-ash-elm grove forests, tartar maple steppe oak woods and loess steppes. The landscape is used by agriculture. The dominant soil type is Chernozem. Basic space of the designated kurgan is relatively great. Soil tillage is typical for the surroundings however; the kurgan itself has not been ploughed. Despite this fact, the body of the kurgan is not covered by natural vegetation, but by modern vegetation dominated by young locust woods. Thorough fox hollow system can be seen in the cross-section, ruining the upper layers of the kurgan. There is a dirt road on the northern and western sides of the kurgan, almost giving a kind of fence around these sides and compacting and cutting the original layers. Human influence could be detected in the upper (the highest) part in form of deep holes used for robbing in the body of the kurgan (Figure 1b.). The USLE soil erosion model was applied to show the erosion processes on the mound (Centeri *et al.* 2007).

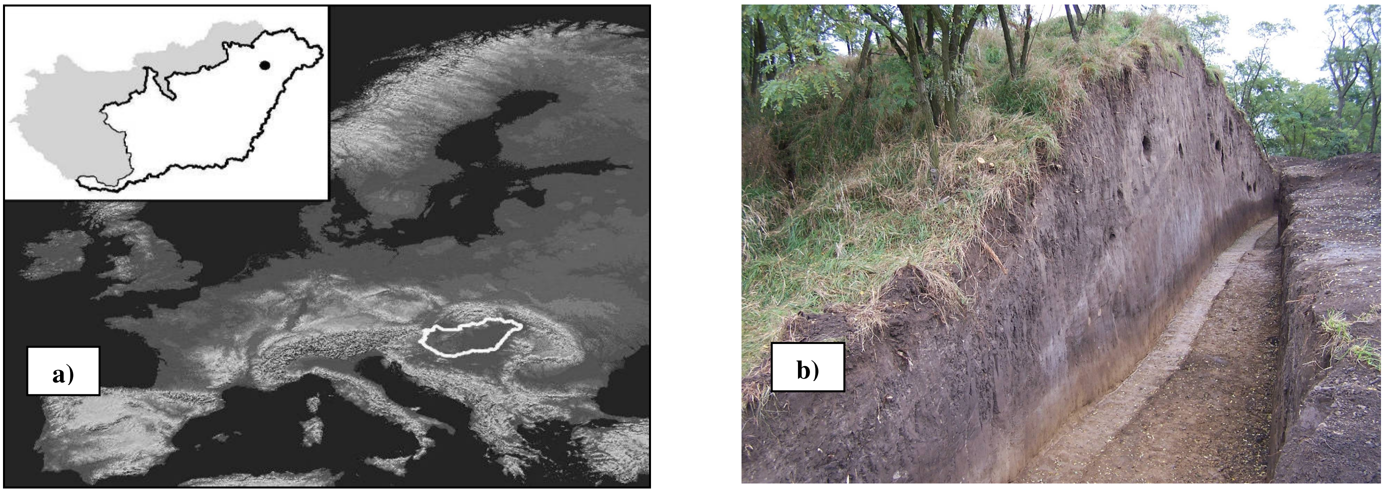

Figure 1. Location (a) and the prepared cross-section (b) of the Lyukas-mound, Hajdúnánás, Hungary.

Methods

Differences between colour, structure, lime content, moisture content and compactness were observed in the cross-section wall. Situation of visible concretions and morphological parameters (root systems in the soil, animal tubes, iron, lime and silica concretions, bones etc.) were recorded. The prepared soil column of the kurgan was separated into layers based on their morphological features (Figure 2.) (Stefanovits 1963). Layers were separated according to our observations and were sampled to conduct pedological, micromorphological and biomorphic laboratory analysis. Samples for pedological survey were taken from each layer and basic laboratory analysis was done: pH (KCl), $CaCO_3$ % (Scheibler method), organic matter % (Total Organic Carbon), humus % (Tyurin's method), total salt %, mechanical analysis %, total phosphorus (mg/kg) (Buzás 1988). Samples for phytolith analysis were taken from the upper 1-2 centimeters of each soil horizon buried under the kurgan. The preparation of soil samples for the biomorphic analysis was done in several discrete steps according to Piperno (1988) Golyeva (1997), Golyeva (2001a) and Golyeva & Khokhlova (2003). After the separation method was completed, a drop (0.5 mL) of each specimen mixed with the same amount of additional glycerin was examined under optical microscope. A magnification ranging from 350x to 700x was applied. Classification system used in the analysis was developed by Golyeva (2001b). It includes identification classes for plant residues indicating typical association types of a given biome and of significant climatic conditions. For micromorphological analysis, oriented samples were collected with modified Kubiena tins (Kubiena 1938). The preparation method was done in two discrete steps. After air drying at the temperature of 30°C the blocks were impregnated with Oldopal P80-21, cut and polished to 6.0 x 9.0 cm slices, with a thickness of 10 µm after the procedure of Beckmann (1997). Diamond emery- and cutting-wheel was used to prepare the samples. The micromorphological description was carried out according to Stoops (2003).

Results and Conclusion

With regard to the pedological survey the parent material of the examined paleosoil underneath the Lyukas-mound is bright, loessy sediment with high lime content. Its organic matter content is low, shows typical values for parent materials (Table 1.).

Table 1. Basic laboratory data of the paleosoil horizons.

Code*	pH (KCl)	humus %	TOC %	$CaCO_3$ %	P_{total} ppm	Total salt %	Mechanical analysis % clay	silt	sand
Ly3	7.69	1.54	4.43	0.37	1198	0.16	9	49	42
Ly2	7.91	0.61	5.84	6.05	1325	0.13	15	49	36
Ly1	7.96	0.51	3.83	10.52	1105	0.07	17	45	38

see Figure 2.

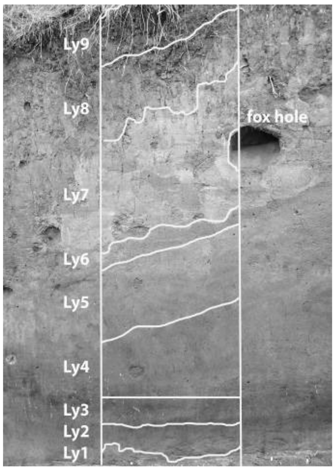

Figure 2. Layers and soil horizons of the Lyukas-mound.

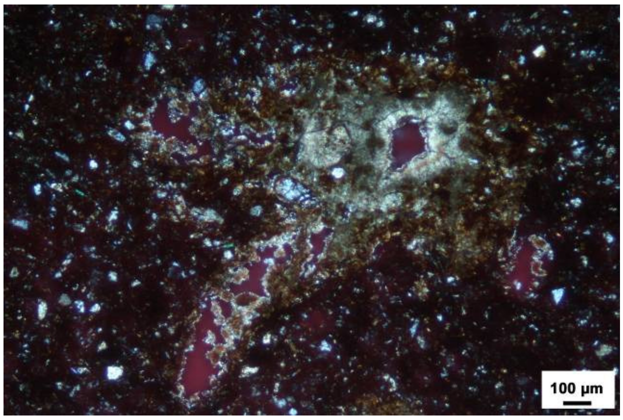

Figure 3. Carbonate precipitations in a kurgan.

During the biomorphic analysis of sample Ly1/2 - deriving from the interface of the parent material and the paleo [B]-horizon we found indicator forms (diatoms and sponge spicules) typical for water-effected surfaces. So water could have played a significant role in the evolution of the parent material. There are possible theories to support this idea. Either the sedimentation of airborne dust on a water-effected surface, or the effect of regular flowing water may have resulted in the generation of this parent material. The existence of the needle-formed carbonate precipitations (Figure 3.) that are visible in the thin section prepared from this layer confirms this theory, as the generation process of these is forms done through a relative fast down evaporation of calcium- and magnesium-ions dominated solutions. These results let us conclude, that the evolution of the parent material was predonimated by water to a certain extent. The occurrence of strongly corroded coniferous phytolith forms are an effect of hydrochor dispersion. These give us a broader view and additional information on the mound’s wider paleoenvironment. The micromorphological analysis proved the existence of *Mollusc* species. Further malacological analysis is preferable to extend our knowledge in terms of the paleoenvironmental factors and the ancient flora and fauna that inhabited the surroundings.

The biomorphic analysis of sample Ly2/3 deriving from the interface of paleo [B]- and [A]-horizons shows indicate grass biomass production to a greater extent and the closeness of a once-existed surface. Corroded phytoliths mark their ancient matter and reflect the first stages of soil development.
The paleo [A]-horizon still preserves its well-developed crumby structure. Its micromorphology is characterised by definite microaggregation and a higher organic matter content. Lime content is typical for Chernozem [A]-horizons. The high amount of phytoliths proves that this has been a surface once and collates with the pedological and macromorphological observations according to that of the location of the paleosoil. Among the biomorphs single particles of sponge spicules appear as a heritage of the parent material. The

amount of arboreal detritus correlated to the total biomorph content refers to an one-time grove, a grassland vegetation with discrete tree species. The macro- and micromorphological and biomorphic analysis together with chemical and physical soil qualities clearly show a Chernozem-type soil development. The texture is loamy and the mechanical analysis refers to water effects. All undertaken analyses prove the complex, water-effected evolution of the parent material. According to the results of the total phosphorus content, we did not find any traces of significant human impact, such as ploughing nor any form of human-related erosion. We did not find the micro- nor macromorphological traces of clay lesivage, clay formation nor intensive weathering and leaching processes. The extent of leaching, the dispersion of the carbonate is characteristic of Chernozem soils. This statement is also supported by the vertical distribution patterns of the humus and the animal soil activity, which played a significant role in its structure development. The biomorphic analysis of the pale [A]-horizon proves that this has been a surface in ancient times and describes the vegetational patterns of the surrounding environment. According to the results we assume that the primary vegetation was predominated by steppe flora in addition with discrete tree species forming a grove type habitat. Mosaic-like habitat patches of wetter, muddy areas may have occurred within this predominantly dry environment.

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