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BURIAL MOUNDS: DETECTING ANCIENT SURFACES THE METHOD OF (SEMI)QUANTITATIVE PHYTOLITH AND BIOMORPH ANALYSIS

1. Introduction

1.1 *The role of buried palaeosoils in palaeoecological research*

The burial mounds (kurgans) are keepers of a wide range of information. They are not only the memories of history and cultural heritage of the tribes that once populated the Carpathian Basin, but they are also the keepers of various landscape, archaeological, botanical, zoological and pedological information. Over the past decades, exclusively archaeological experts have dealt with the excavation of burial mounds. Only recently the need arose to involve other, primarily environmental and natural science disciplines in the excavations and surveys. During the evaluation of environmental aspects, it has been revealed that the so-called palaeosoil profiles, which are often found buried beneath the mounds and were blocked in their soil forming processes after the mound was built, can provide useful information for the reconstruction of the events of both the micro- and macro-environment, as well as for answering the questions on soil formation that are still debated today (Barczi, Sümegi, Joó 2004).

If we accept the famous statement of Dokuchajev, according to which the soil is the mirror of the landscape, and that through the examination of soil its micro-natural environment can be known, then we can also agree that the ancient soil profiles that were blocked in their process of development are the messengers of the former environment (Barczi, Joó 2004). The kurgans – also called burial mounds – constructed in the Metal Ages conceal underneath them undisturbed soil horizons that were isolated and blocked in their development. The acceptance of the above mentioned theory, and its connection to other interdisciplinary approaches, guarantes the complex evaluation of the mounds and the recognition of their value. For this reason, during the examination of the burial mounds of the Great Hungarian Plain the localization and exact definition of the horizons of the palaeosoil buried underneath the formation is an essential step.

The testing methods concerning the main questions of both classical and archaeological pedology are suitable for the clarification of some of the issues concerning soil development and the palaeoenvironment. The palaeobotanical reconstruction of the surfaces that were formed under dry, steppe conditions cannot always be carried out thoroughly by only analyzing organic micro

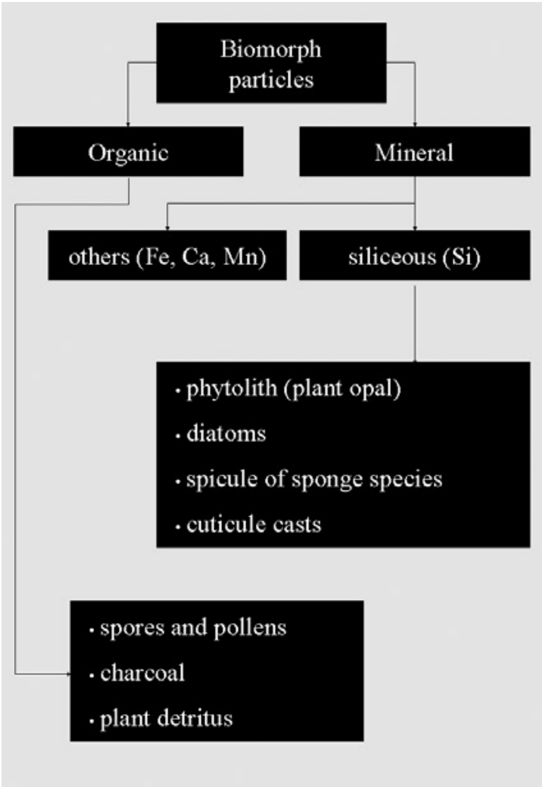

Fig. 1 – Classification of biomorph particles (modified after Golyeva 2001b).

and macroremains (e.g. pollen, charcoal), because their degree of conservation would be insufficient under the circumstances described. Acceptance of this may lead to the frequent application of the analysis of microscopic plant fossils, which are built of silicon-dioxide and which withstand the chemical and physical effect of weathering agents for a long time. Through the so-called "complex biomorph analysis", which deals with both organic and inorganic biogene particles and can be recovered from soil samples, we are able to paint a complex picture of the ancient environment.

According to Golyeva (1997a, 2001a), the soil components of biogenic origin play a prominent role in the evolution of the landscape and the evaluation of the soil development. The extractable biomorph particles are divided into organic and mineral sub-groups in Golyeva's division. According to the definition given earlier, the remains of spores, pollen, charcoal and the particles of detritus belong to the issue of "organic" biomorph analysis. From the previous list, the plant detritus particles play a particularly decisive role, as we can determine from their amount the quantitative characteristics of biomass productivity of the vegetation that developed and bred locally. The plant opal particles, or phytoliths, the shells of diatoms (*Bacillariophyaceae* spp.), the silica spicule of sponge species (*Porifera* spp.), as well as the silicified cuticule casts belong to the mineral, more specifically to the group of the silicified biomorph, particles (Fig. 1). Within this list the phytoliths are particularly important, as their quantitative and qualitative analysis helps to detect the surfaces that were once open and were covered with vegetation, and shows the differences in biomass productivity and vegetation changes.

1.2 *The theory and principles of quantitative phytolith and biomorph analysis*

According to Kamanina and Shoba (1997), quantitative analysis is the determination of the phytolith content of each fraction found in genetic soil horizons, as well as their vertical distribution along the soil profiles. During the phytolith and pedological analysis of the loess-ice complex of the Kolyma Lowland, the authors came to the conclusion that during soil development three main types could have formed in terms of the biolith (phytolith) distribution. Consequently, they defined an "accumulative" type that characterizes primarily the profiles, that have remained intact, untouched, but has a degraded second horizon of humus. The "accumulative-buried" type occurs in the case of the buried profiles, while the so-called "accumulative-sedimentative" denomination is valid for soils that have developed under the impact of strong sedimentation processes. In the case of the latter, the intensity of the sedimentation can be concluded from the vertical distribution of bioliths (phytolith). Kamanina (1997a, 1997b) introduced the concept of the "phytolith profile of a soil" (PhP) while examining the phytolith distribution of the soils of different landscapes. By definition, this is the total phytolith content, phytolith distribution as well as the phytolith morphotype spectrum of a given soil type.

With the help of this principle, Kamanina conducted the comparison of the vertical plant opal distribution of more than 10 soil types in Russia. Bobrova and Bobrov (1997) set the goal of demonstrating how the phytolith analysis can be applied for the reconstruction of pedogenesis. Their results shed light on the fact that the biogenic silica content of natural soils generally show a decreasing trend in the direction of the parent material. The authors pointed out that the redistribution (*redistributio*) of plant opal particles within the profile depends on the bioactivity of the soil, and they pointed out the fact that differences in sedimentation and soil formation (this can be apparent in the form of a second, or in multiple maximums of the vertical phytolith/biomorph distribution) probably indicate a past of disturbed soil development.

2. Methodology

2.1 *The methodological aspects of sampling*

This kind of analysis requires highly precise sampling. Because of the *ex lege status* of the mounds (regulated by the Hungarian act on the conservation of nature and cultural heritage), samples can be primarily obtained through drillings. Samples for this study were taken from the excavated profile of the Lyukas-mound kurgan (Hajdúnánás-Tedej, Hungary). It is worth mentioning that taking samples from an excavated cross-section wall or along soil profile is always easier and can be accomplished more precisely and in adequate concentration from the surface of the assumed palaeosoil.

2.2 *The methodology of the preparation of the soil samples*

Samples were collected from the upper 1-2 cm thick layer of the individual soil horizons and were treated in a multi-stage procedure (Piperno 1988; Golyeva 1997b, 2001b) in order to analyze the biomorph content. The preparation of soil samples in the laboratory can be divided into the following main steps:

– destroying organic material content with hydrogen-peroxide (H_2O_2 cc. 33%);
– separation of clay fraction with the method of gravity sedimentation according to Stoke's law;
– separation of sand fraction with sieving;
– centrifugation with a heavy liquid of a specific gravity 2.3-2.4 g/cm^3, which ensures the separation of phytoliths.

The recovered material was submerged in glycerin for examination with a light microscope. A magnification of 350-700x should be applied during both the quantitative and qualitative analysis.

2.3 *The theoretical method of the quantitative analysis*

The biological fraction content of the individual soil samples can be measured, if the proper measurements are made during the preparation procedure, and the data are recorded. Surface characteristics of ancient soil horizons can be adjudged on the basis of the quantification of the biological fraction. In this way, the individual soil horizons become comparable. For the calculations, the following data should be collected:

Denomination	Layer codes*	Depth	$m/m\%_{bio/centr}$	biomorph content
modern A-horizon	Ly9	0-10 cm	5,8441%	
third cultural layer (K3)	Ly6	227-225 cm	3,5087%	
second cultural layer (K2)	Ly5	242-240 cm	11,9205%	
first cultural layer (K1)	Ly4	322-320 cm	6,2068%	
palaeo [A]-horizon	Ly3	425-423 cm	13,7254%	
palaeo [B]-horizon	Ly2	462-460 cm	6,4516%	
parent material of the palaeosoil	Ly1	512-510 cm	6,5693%	

Tab. 1 – Location of strata and results of laboratory analysis (* see Fig. 2 for stratigraphy).

1. mass of the raw soil sample (m_0);
2. mass of the dishes used for the first drying (m_1);
3. mass measured together with the dried sample (m_2);
4. mass of the samples measured in the centrifuge tube (m_3);
5. mass of the vessels used for the second drying (m_4);
6. mass measured together with the dried sample (dried sample + m_4 = m_5);
7. mass of the sample measured in the test tube (m_6).

The following, simple calculations can be carried out using the above listed data:

a) $m/m\%_{bio/silt} = [(m_5-m_4) / (m_2-m_1)] \times 100$ = biomorph content of the silt fraction;
b) $m/m\%_{bio/centr} = [(m_5-m_4) / m_3] \times 100$ = biomorph content in the material used for centrifugation;
c) $m_{silt} = m_2-m_1$ = the mass of the total silt fraction;
d) $m/m\%_{silt\%} = (m_2-m_1) / m_0 \times 100$ = the silt fraction of raw soil sample in percentages;
e) $m_{residue} = m_0-(m_2-m_1)$ = the total mass of the removed organic material, sand and clay fraction.

3. Results and conclusions based on a case study

In terms of the relevant study, the quantity and the distribution of the biomorph content in the material used for centrifugation ($m/m\%_{bio/centr}$) is the most informative. The individual values give an answer to whether a given layer or horizon once formed a surface in the past. This examination is related to the fact that the results of the biomass production of the former surfaces are concentrated in the uppermost soil layer or horizon, so there is a higher biomorph-concentration unless other erosive effects impact the surface.

To illustrate this method, the case study of the Lyukas-mound kurgan, which is situated near the town of Hajdúnánás, was used as a pilot study. The kurgan was excavated by an interdisciplinary working group led by the

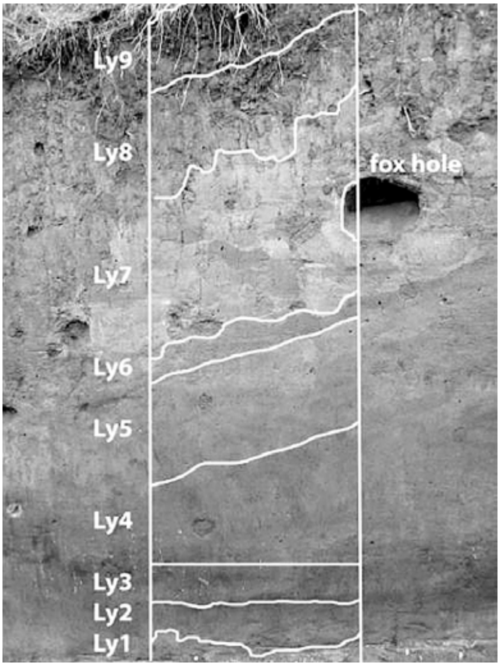

Fig. 2 – The (archaeo)stratigraphy of the excavated profile of the Lyukas-mound kurgan (photo A. Barczi).

Department of Nature Conservation and Landscape Ecology in 2004 (Barczi *et al.* 2006a). Table 1 shows the laboratory results of 7 samples taken from the cross-section wall, including the biomorph content values ($m/m\%_{bio/centr}$) in percentage.

The measurement of the biomorph content in the palaeo [A]-horizon (layer code: Ly3) located in a depth of 423 cms (measured from the central highest point of the mound) resulted the highest value in the vertical section. All signs and test results show that the kurgan was built in several steps, with significant differences in time. This is underlined by the measurements in the second cultural layer (layer code: Ly5). The amount of biomorph content did not reach the amount measured in the palaeo [A]-horizon, though it shows only small differences.

In order to present the tendencies outlined above, we demonstrate graphically the relation between the depth and the vertical biomorph distribution of the cross-section wall (Fig. 3). The graph shows the two layers with their peak values: the palaeo [A]-horizon and the surface of the second cultural layer, which was used to erect the mound. Practically the emerging

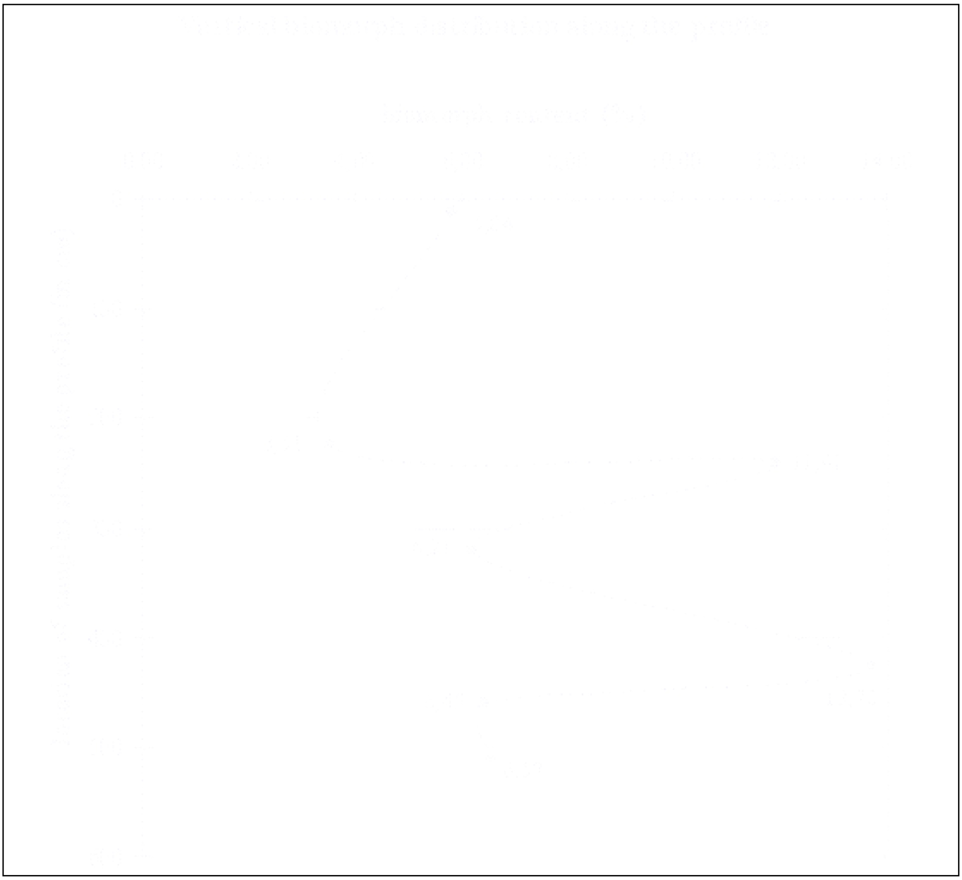

Fig. 3 – Vertical biomorph profile of the kurgan (modified after Pető 2007).

points that symbolize the outstanding values can be identified as the former surfaces. Looking only at the quantitative analysis and the curve illustrated on the graph, two former surfaces emerge reducing the possibility of the existence of more.

The quantitative part of the biomorph analysis is able to provide graphical results, and with its help we can obtain data about the existence of the former surfaces. In the case of the pilot study and on the basis of the method of biomorph analysis – besides numerous other information, which result from the qualitative analysis – we may conclude that the "layer" previously described as palaeo [A]-horizon really functioned as a surface. From the phytoliths discovered the vegetational picture of the former environment and the area surrounding the mound can be reconstructed. Taking into account the opinion of the archaeologists and accepting their hypothesis that the mound was constructed in multiple steps, our results may give answers and clues on how much time passed between the building of the mounds, and subsequently the burial compared to each other.

In the case of Lyukas-mound, on the top of the second surface of the mound outstandingly high values were measured, which suggests that the surface of this mound, compared to the others, provided ideal circumstances for a long period of time for a vegetation process. From the results, the surface location of this sample seems evident. This is underlined by the large amount of organic and inorganic biomorph particle found during the examination of the sample. The numerous epidermal longcell phytoliths, as well as the plant detritus also suggest a vegetation cover of high productivity, just like in the case of the palaeo [A]-horizon.

Several ideas have been formulated with regard to the origin of the so-called third cultural layer (layer code: Ly6), according to which this layer is either a geochemical border or a young soil formation. The pedological examination confirms the latter hypothesis (Barczi *et al.* 2006a), suggesting that the pedogenetical processes played a key role in the evolution of this layer, whilst the geochemical analysis could trace a geochemical boundary in this depth (Barczi *et al.* 2006b). It is interesting to note that during the phytolith countings, phytolith and biomorph particles hardly appeared. This result is also shown in the low percentage value of the biomorph content (Fig. 3).

It is possible that the development of this level can be brought into connection with the abundant vegetation of the second, 220 cm high mound that existed beneath it, and had high biomass productivity. Considering the known data, we cannot reject the theory, according to which, beneath the steppe vegetation that bred on the second mound over many centuries, an almost 20 cm thick humic layer developed – which had started the journey of soil development and was showing the first phases of it – and was then blocked in its development due to the appearance of some external (presumably anthropogenic) effect.

The quantitative data of the samples from the second cultural layer also refer to this. Based both on the biomorph and pedological survey, a strong development of humus may have started under the steppe vegetation of the second mound. Presumably this thin layer is also the result of this process. However, we have to be aware of the fact that a long period of time has to pass for the accumulation of the phytoliths, so the small amount of phytolith that appears in the layer could determine its age. Of course, to prove this idea once and for all or to reject the hypothesis, further pedological, geochemical and palaeecological examinations are needed apart from the additional phytolith analyses – that may provide answers both on the circumstances of its formation, as well as the reasons for the lack of biomorph content measured in this layer.

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Ákos Pető
Institute of Environmental and Landscape Management
Szent István University – Gödöllő
National Centre for Cultural Heritage
Hungarian National Museum

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ABSTRACT

The detection of ancient palaeo-surfaces and horizons is feasible with various pedological methods. The aim of the biomorph analysis is to provide data on the properties of ancient surfaces by locating the palaeo-horizons and describing their vegetational patterns. While conducting the kurgan research, we have often faced the problem of the precise description and localisation of palaeo-horizons within the stratigraphy of the formations.

The biomorph analysis provides data in palaeoecological research through the examination of "phyto" and "zoo" microremains. The so-called "multiple biomorph analysis" works both with organic (spores, pollen, charcoal, detritus) and mineral (inorganic) (phytoliths, spicules of sponges, diatoms) biogenic microparticles that can be recovered from soil/sediment samples. One aim of the quantitative analysis of these particles is the identification of the biomorph content in the relevant fractions of the cultural layers and genetic soil horizons and the graphical display throughout the examined cross-section. The present paper is aimed at introducing the utilisation of the quantitative biomorph analysis in palaeoecology and environmental archaeology.