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THESES OF Ph.D. DISSERTATION

The importance of phytoliths in geoarchaeological studies

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INTRODUCTION

There has been an increased need for the results of the archaeological, geological and historical environmental researches in the past decades. The reason for this, on the one hand, is the greater interest on the part of archaeology that has the relationship between humans and their former environment in the centre.

On the other hand, the experience essential for modelling the present and future effects of climate change are related with the climate changes which already took place in the past.

Manifold examinations are needed to do a research in the environmental events of the past (such as climate changes, environmental effects, the human activities changing the environment etc.) which, owing to their many aspects, make sure that the results of the research are more precise and nuanced.

Besides the generally accepted – and almost routinely used- custom in the national archaeological, geological and historical environmental researches, there are less known Hungarian sample fields used in the researches. Such field is the research of phytoliths the microscopic-sized little grains of opal developed in the epidermal tissue, despite the fact that the results of this method are useful additional to other researches concerning former vegetation, such as pollen analysis, macro botanical examinations, definition of charcoal.

RESEARCH OBJECTIVES

The aims of the researches based on phytolith analysis described in the doctoral dissertation are the followings:

1. The examination of the efficiency of the phytolith analysis in case of the geological and archaeological samples originated primarily from the sites of the Carpathian-Basin.
2. The patterns and types of the samples should possibly cover the widest spectrum possible of those sample types that might get into the focus of the future archaeological, geological and environmental historical examinations.
3. Testing the exploring methods described in the special literature on national samples and in particular cases changing them, as well as drawing up methods to explore phytolith more suitable for the national needs.
4. Answering factual archaeological, geological or environmental historical questions in connection with the examined samples based on the phytolith analysis.
5. To define those sample groups that might be regarded as promising with respect to the phytolith examination based on the experiences and results gained in the course of the research.
6. The examination of the combination and the comparison of the results of the phytolith analysis with that of the archaeological, geological and environmental historical researches applied so far.

LITERATURE ANTECEDENTS

Despite the fact that the phytolith analysis is acknowledged in the international researches (Piperno 2006), the number of the national publications is not many (8 sites) and in most cases they have been carried out by foreign researchers (Engel-di Mauro 1995, Gyulai 1996, Barczi et al. 2007, Madella 2007, Windland 2007, Persaits et al. 2008, Pető 2009).

The Hungarian samples examined so far are originated from kurgan, leftovers, archaeological objects, lake drillings as well as from loess and paleosoil series.

APPROACH AND METHODS

The sampling was done, on the one hand, on my own, on the other hand, by archaeologists. In the course of the sampling exploration, after removing the organic matter and the carbonates and having divided the surplus of the small particles (wet sifting, Atterberg sedimentation), phytoliths were gained with the help of flotation with heavy liquid (Sodium- poliwolframát).

This was followed by a photo documentation and identification under a light microscope magnified five hundred times.

The identification was carried out with the help of the referential collection of the University of Szeged Geology and Palaeontology Department as well as with the help of professional publications. When it was possible, the rest of the remaining paleobotanical results originating from the same place were used in the course of the interpretation and evaluation of the results of the phitolithe analysis.

EXAMINED SITES AND OBJECTS

The researches described in the dissertation were carried out in 8 Hungarian and one Dutch site in their broadest sense. Based on the archaeological, chronological ranging of the samples, they are dated from Palaeolithic, Mesolithic, Neolithic, Copper Age, Bronze Age, Iron Age, Imperial Period, Age of the Migration Period, Arpadian Age as well as from the period of the Middle Ages. The examined samples are originated from loess wall, shallow lake sediments, buried soil, filling-ups and different archaeological objects and samples (vascular cast, hole, well, charcoal and mud-flake layers, grave, pit, granary, ditch, post-hole, house, kiln, mill and grinding stones, pork tooth and coprolite as well as system of canalization). Altogether 449 samples were explored and defined.

The loess profile in the bricklayer of Katymár: an 11-meter-excavation on the loess plateau, which is originated between 32-13 thousand years (CAL BC). The profile was examined in 8-centimetre-resolution and was shown on 119 samples.

Sunk undisturbed core recovery drilling in the Szigligeti-öböl (Szigliget bay): The sunk drilling on the shore of the biggest lake in Central Europe the layers of which can be regarded complete and it embraces 17000 years. The analysis of the phitolithe was carried out in 8-centimetre resolution on 63 samples.

Sunk undisturbed core recovery drilling in the Tóköz: The sunk drillings (4) on the Csornai-sík (Csomai plains) excavate the Arpadian Aged system of canalization (Takács 2001) with its triple structured ditch out of which 80 samples have been processed in 2-centimetre-resolution.

Samples originated from archaeological sites of the bypass of the M43 highway to Makó: There has been an analysis of the samples of the Arpadian-Aged objects (vascular cast, charcoal and mud-flake layers, hole, well, grave, pit) which were found in the course of the excavations on the trace of the highway, and from a drilling in a former mortlake as well as from samples from a geological profile. Their numbers are 40 altogether.

Analysis of the samples from the objects excavated in Tételhegy in Solt: 62 samples of phitolithe have been analysed, each originated from the ancient, from the Arpadian Aged and from the Middle Aged objects (ditch, post-hole , pit, house, granary, kiln, grave), in the course of the excavations carried out on the erosive remnant hill rising above the neotectonic valley of the Danube on the Solt-plateau.

The examination of the Sarmatian kiln: The aim was to define the former combustible of a very typical object based on (10 samples) the examination of the whole cross-section of the Sarmatian kiln excavated in the first surface of the Hetény part of Apostag on the Solt-plateau, too.

The examinations of the samples originated from the sites of the southern sector of the highway M0 (Ecser, Vecsés): 25 samples, all of which originated from the Copper Age, Imperial Period and from the period of the Middle Ages, have been analysed from the sites found on alluvial cone plateau of Pest. Typically, they were found in ditches, kilns, pits and wells.

Examination of the mill and grinding stones in the site of Kemenspálfa-Zsombékos: The samples of Kemenesalja are from the late Iron-Age (5) and the early Middle-Ages (5). During the examination, the only aim was to define the plants ground by the former, examined tools.

The examination of the Neolithic Aged samples of the Dutch Swifterbant: The samples originated from the Flevolnad territory of the Dutch Kingdom are from the sites of the Oostelijk Flevolnad polder. In the course of the examination, we were looking for proofs for crop growing from soil monolith as well as structures referring to human culture (digging stick imprint). We carried out a phytolith analysis on a Neolithic aged pork tooth and pork coprolithes. Altogether 40 samples were excavated and analysed.

SUMMARY OF THE RESULTS

A thesis-like summary of the examinations introduced in the doctoral thesis:

1. With the alteration of the generally used methods to excavate the phytoliths, a much better excavation method was developed which went matched with the characteristics of the samples examined and also in the case of soil samples, lake sediments, loess samples and the samples of the mill and grinding stones explored with ultrasound. At the same time in the case of the loess samples and the shallow lake sediments the internationally accepted 5 grams weight of the samples to be examined should be increased to a minimum of 10-15 grams.

2. Seven phytolith zones could be separated based on phytolith analysis of the samples taken from the loess wall of the bricklayer of Katymár. The bases of the separation of the phitolithes were in the first place their abundance as the quantity of the excavated phytoliths were few and had only a few shapes. The most significant phytolith content within the loess profile was contained by the typical loess layer developed between 680-400 cm. The phytolith zones can be made parallel with the changes which can be observed in the sedimentological characteristics as well as with the changes marked by the cooling down (Heinrich event) and the warming up cycles (Dansgaard-Oesheger cycle) of the malachofauna At the same time, the borders of the phytolith zones follow the beginning of these cycles late.

3. Following the analysis of the sunk drilling in the Szigligeti-öböl (Szigliget bay), 11 zones could be defined which almost corresponded to the macrobotanical zones of the same drilling. The rising level of the water surface in the examined site is marked by the decrease of the abundance of the phytoliths, while the decrease of the water level is marked by the increase in the abundance of the phytoliths.

4. Based on the triple structured Arpadian Aged system of canalization drillings in the Tóköz, 6-7 cycles could be defined, out of which in 2-3 cases it could be observed that the basal area of the canals became more intense which meant that the conservation of the canal was not carried out.

At the same time, 2-4 cycles can be shown referring to the cleaned stage in the course of which the canal could have been conserved. The conservations might have meant burning in the winter as dark coloured traces containing combusting residues were found and because of the significant fluctuation of the temperature (owing to the burning in the winter), uncommon cleft have developed in the phytolith structure of the reed (*Phragmites australis*).

5. Examining the drilling samples of the bypass of the M43 highway to Makó, five phytolith zones were defined in the former mortlake, in which one can follow the transformation of the cold lake into mesotrophic. The change that happened at the turning of the Holocene is clearly outlined in the course of which we can see an increase in the biomass owing to which the abundance and the diversity of the phytoliths also increase.

6. The geological profile of the bypass of the M43 highway to Makó, just as the geological objects, contains only a few phytoliths. The reason for this can be the dissolving again due to alkaline pH.

7. The reconstruction of the vegetation close to the former objects, based on the phytolith analysis of the geological objects of the bypass of the M43 highway to Makó and the geological objects of Tételhegy of Solt, was successful. Owing to the keeping of livestock the traces of treading and manuring can be seen in most cases. All examined sites can be reconstructed as an open grassy area with steppe elements in the examined geological ages. Out of the objects of these sites, the kilns, pits and charcoal layers are the most suitable for phytolith examinations.

8. The ancient samples can be well separated from the samples of the Arpadian Age and the Middle Age based on the similarity examination of the main phytolith types, which was carried out in the case of the statistically appreciable samples of Tételhegy of Solt. In case of the similar types of objects, (e.g.: pit) the samples of different ages show different phytolith compounds.

9. It can be proved with the phytolith analysis of the profile fillings of the Sarmatian kiln originating from the borders of Apostag, that the combustible was mainly wood contrary to the dried manure occasionally used as combustible. The climatic changes, drawn up with the help of climatic indicator phytoliths of the samples taken from the former soil layers which were found in the cross section of the kiln, can be well

compared to the findings of the pollen analysis originated from neighbourhood of the site (Császártöltés). The settlement of the Sarmatians (the building of the kiln) was preceded by a period characterised by the push of the ligneous then the slowing of this process followed by its decline and later on their ousting which can be characterised by the changes of the rates of the indicators signing first the cool and wet then the warm and dry climate in the samples of the phytoliths.

10. The most significant result of the phytolith analysis originated from the southern sector of the highway M0, is that it proved the applicability of the phytolith morphology system of Golyeva (Golyeva 2001) in case of the Hungarian sites and geological objects. The effect of former keeping of livestock can be demonstrated by the relation of the size, the quantity and the form of the Elongate phytoliths.

11. The former ground plants were demonstrated from the examination of the mill and grinding stones in the site of Kemenspálfa-Zsombékos. On the stones of the late Iron Age (Celtic) on the examined site, the phytoliths of the einkorn (*Triticim monococcum*) and in smaller amount the emmer (*Triticum dicoccum*) were determinant while in the samples of the phytoliths of the 9^{th}-11^{th} century, the common wheat (*Triticum aestivum*) is determinant, however, the phytoliths of the emmer are still present on the surface of the samples.

12. The phytoliths of grains could successfully be demonstrated (*Triticum monococcum*, *Triticum dicoccum, Horeum vulgare*) in the examined soil monolithe of the Neolithic Aged sites of Swifterbant, thus proving the crop growing. These data support the phytoliths of the grains detected from pork coprolithes.

13. It was proved by the phytolith analysis of the examined soil monolithe of the structures of Swifterbant, that it is not a (digging stick imprint) under

the former surface of the soil but a naturally formed cast load with a flame structure evolved after a sudden flooding of the sea.

14. The forming of the samples of the pork coprolithes of Swifterbant are dated in the autumn period based on their crop phytoliths and reed phytoliths contents. This was also the time when pigs ate the harvested crop and the rhizome of the reed.

15. More typical indicator forms could successfully be demonstrated (warm-humid, cool-humid climatic indicators) in all the examined samples (soil samples, pork coprolithes and tooth), which proves the mosaic vegetation character of the former site.

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