

Phytoliths in archaeology: recent advances

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In the last two decades, the number of phytolith studies has been growing exponentially (Hart 2016), and phytolith analysis has developed into an established methodological tool for answering numerous archaeological and palaeoenvironmental questions. In archaeology, phytoliths can give information about origin and dispersal of domesticated plants (Ball et al. 2016), diet, agricultural practices, plant processing, the use of domestic space and non-dietary plant exploitation, to name but a few.

This special volume of VHA illustrates the rapidly increasing importance of phytoliths in archaeology. It is one of the outcomes of the 9th International Meeting for Phytolith Research (IMPR), which was held at the Royal Belgian Institute of Natural Sciences, in Brussels, 10th–12th September 2012. The 9th IMPR gathered 69 participants from 19 different countries over six continents (Argentina, Brazil and Chile; Canada and USA; Australia and New Zealand; China and South Korea; Belgium, Finland, France, Germany, Hungary, Italy, Russia, Spain, United Kingdom; South Africa).

The main theme of the conference was “Towards integrative phytolith research”. The aim was to highlight the interpretative potential when using several lines of

evidence, a modern standard in archaeology. The studies assembled in this volume combine phytoliths with plant macro-remains, pollen, starch, non-pollen palynomorphs (NPPs), organic residues, micro-charcoal, geochemistry, ancient DNA (aDNA) and micromorphology. Phytoliths are a valuable source of proxy evidence when other botanical remains, such as seeds or charcoal, are absent, but their full potential becomes evident when they are used as a complementary tool in a multiproxy approach with the help of multivariate statistics, for example Pető et al. (2015).

In most archaeological and palaeoenvironmental sites, Poaceae phytoliths make up the majority of the silicified plant remains, and it is therefore not surprising that grass phytoliths are the main topic in nine of the ten papers presented here. Grass phytoliths are very diverse and show a high degree of multiplicity, thus numerous different morphotypes can exist in different parts of the same plant specimen (Rovner 1971). Poaceae culms, leaves and inflorescences produce distinct phytolith morphotypes which open up a wealth of new applications in the reconstruction of human activities connected to cereal cultivation, harvest, storage and processing, as well as secondary and tertiary use of by-products, such as straw, chaff and dung.

Three papers (Dal Corso et al., Bates et al., Garcia-Granero et al.) deal with archaeological phytolith evidence for crop processing. The study of Dal Corso et al. on a Bronze Age site in Italy highlights the explanatory potential of phytoliths for studying archaeological contexts outside of domestic structures. Samples from a shallow ditch filled with settlement waste and from a near-site fen included wheat and barley chaff phytoliths that indicated the processing of cereals at the site and the possible use of chopped straw as fodder. Silica skeletons from the inflorescences of panicoid grasses, although not identifiable to

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species yet, probably originated from *Panicum* or *Setaria* and indicated that small hulled millets were processed at the site. Many culm and inflorescence silica skeletons had peculiar sharp cut borders, pointing to the use of a threshing sledge (*tribulum*).

The paper by Bates et al. presents a combination of macro-remains and phytolith analysis from sites of the Indus civilization. The authors refine Hillman's (1984) and Jones' (1984) classical models for cereal processing by introducing phytoliths as additional evidence, thus exploiting the differing preservation potential of the two proxies. The macrobotanical remains allow for species-level analysis, while the early stages of processing are represented by the less highly resolved but better preserved phytolith remains. Different patterns for the macro- and micro-remains of winter and summer crops indicate that wheat and barley were less commonly used and less regularly processed than small hulled millets which are cultivated in summer. The authors conclude that seasonality of cropping drove decisions relating to labour organisation at these settlements, which is contrary to many of the models of crop processing that have been developed for the Indus civilisation.

The paper by Garcia-Granero et al. shows the potential of phytoliths for reconstructing plant use at sites where macro-remains are absent or poorly preserved. In their study of phytoliths and starch remains on grinding stones from archaeological sites in northern India, the authors highlight the importance of control samples and the application of multivariate statistics. Phytolith and starch assemblages from grinding stones should only safely be attributed to the actual former use of the stones as tools when post-depositional contamination can be excluded.

As with other proxies, taphonomy is a central issue in the study of phytoliths from archaeological sites, and is reflected in several papers of this volume. Patterns of preservation, deposition, post-depositional disturbance and contamination have to be considered in the interpretation of archaeological phytolith samples. Experimental studies reveal the taphonomic processes eventually resulting in particular phytolith assemblages. Portillo et al. describe the experimental processing of hulled barley, including dehusking, cleaning/winnowing and grinding with traditional tools in Menorca, Spain. They show that the size of multicelled silica skeletons from cereal inflorescences can considerably decrease due to breakage during mechanical processing. This has to be considered when the size of silica skeletons is used for the reconstruction of irrigated vs. dry-farming of cereals (Rosen and Weiner 1994).

Lancelotti et al. present an ethnographic study of fuel use in northern India and its reflection in the phytolith record, also with a strong focus on taphonomy. In arid environments with low availability of woody plants,

alternative fuels used are often dung and crop-processing by-products, such as chaff and straw. The combination of phytolith analysis with geochemistry on samples from domestic contexts suggests that the surroundings of a fireplace can give important information about fuel use. Cooking and the periodic cleaning of the hearth result in a constant dispersal of ash in the surroundings of the fireplace. As these are repetitive activities, they continuously deposit microremains on the floor, and this accumulation leaves a clear signature in the phytolith and geochemical record.

The paper of Alonso-Eguiluz et al. is another example for the potential of phytoliths in archaeological sites where macroremains are not preserved. The authors analysed the *fumier* (ancient burnt dung) deposits from a Neolithic cave site in northern Spain, with a combination of phytoliths, faecal spherulites and ash pseudomorphs. They could show that the stratified cave sediments consisted mainly of dung from sheep and goats, and the phytoliths give evidence that the animals were feeding on the grassy vegetation in the surroundings of the cave. The use of the cave in spring and summer is indicated by the numerous inflorescence phytoliths which are produced by grass plants at the time of flowering.

Redundancy, the occurrence of similar phytolith morphotypes in different plant species, is a constant challenge for phytolith researchers. Application of finer shape and ornamentation descriptors sometimes enables separation within a taxonomic group, for example Bowdery (2015). Morphometric analysis has proven to be an effective tool for distinguishing between phytolith assemblages produced by closely related plant taxa. Ball et al. used morphometry to study the wave patterns of articulated dendritic phytoliths which occur in the inflorescence bracts of Triticeae. They found that shape morphometries are more reliable and require a smaller sample size for statistical confidence than size morphometries. They also observed significant variance in dendritic wave lobes among different accessions of a species, among the different types of inflorescence bracts in one species and among each bract type's location on the inflorescence. Despite this considerable variance, there is considerable potential for discrimination of species, as could be demonstrated for samples of cereal inflorescence phytoliths from archaeological sites in Brussels.

In her study on rice and millet farming in Neolithic and Bronze Age central China, Weisskopf presents a refreshing alternative to the long-lasting discussion on phytoliths as indicators of early rice and millet domestication there. Weisskopf's study is based on morphotypes from other grasses and weedy taxa that can be used to reconstruct the ecological conditions of different cultivation regimes and to differentiate between wet and dry farming. By

distinguishing morphotypes from cells that are genetically predisposed to be silicified (fixed) from those that only form silica bodies when there is sufficient water uptake (sensitive), Weisskopf could separate several ecological variations of the rice cultivation regimes. The use of macroremains of potential weedy taxa for reconstructing farming practices is well established in the Near East and Europe and especially important as evidence for pre-domestication cultivation (Kreuz et al. 2005; Willcox 2012). Adopting this approach for phytoliths opens up new perspectives for the Neolithic in China, which probably had a long pre-domestication cultivation phase.

Musaubach and Beron analysed several microremains from charred residues in cooking pots from hunter-gatherer sites in Argentina. Maize starch was present in some of the residues, but no maize phytoliths were found. The grass phytoliths probably came from wild plants which had been used for other purposes than food, for instance for cleaning or thermal insulation during roasting or cooking. Starch grains of maize and *Prosopis* show the contemporary use of wild plants and maize by mobile pre-Hispanic hunter-gatherers in the western Pampas and their contacts with semi-sedentary populations of the Andes.

Last but not least a non-grass phytolith jewel. Pető et al. discussed phytoliths of *Lagenaria siceraria* (bottle gourd) from a pericarp fragment preserved in a pot. The waterlogged site of the 14th–15th century AD in southeast Hungary provided excellent preservation conditions, allowing observation of the phytoliths in anatomical context, as well as aDNA analysis. The authors discuss the anatomical features of the pericarp that separate *L. siceraria* from *Cucurbita pepo* and they describe two different morphotypes in the endocarp and mesocarp of the bottle gourd rind. aDNA analysis proves the Asian origin of the crop, but it is not clear if it had been locally grown or introduced. Macroremains of 25 other plants from the pot infill, most of them arboreal taxa, were also studied in detail. The paper is

a brilliant example of the potential of phytolith analysis as part of a multi-proxy approach, from macro- to microscale and further down to the molecular level.

These studies illustrate the new perspectives by which phytoliths can contribute to archaeology, making their study a valuable research tool especially when used in conjunction with other proxies.

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