13th International Meeting on Phytolith Research

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Abstracts

Oral presentations

Bringing plant Si and phytoliths into ecological theory, and links to archaeology

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Despite recent developments in the field of plant Si and phytolith research and its increasing appearance within the scientific community, the field still struggles to make its way into scientific mainstream. One manner of overcoming this challenge is bringing the field into existing theoretical frameworks, which serve as gateways into theory and discourse. In the case of ecology, for example, recent evidence suggests that plant Si and phytolith content qualify as a plant functional trait within the trait-based ecology framework. Evidence now shows that including this trait in the plant functional traits suite improves models that explain plant community composition and ecosystem functioning. Likewise, this trait can be framed as a progenitor of many ecosystem services that benefit humankind, and thus its importance can be better communicated to the public and decision-makers. The latter possibility is especially intriguing if one considers that archaeology – as human ecology – has been studying ecosystem services supply and utilization long before the term was even introduced. Hence, the field of plant Si and phytoliths cannot only benefit from such theoretical frameworks, but also serve as an important link among disciplines.

Location and speciation of carbon occluded in phytoliths using synchrotron scanning transmission x-ray microscopy

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Phytolith occluded carbon (PhyOC) has raised intriguing research questions and controversy regarding the impact of carbon on phytolith structure and the potential for long-term carbon sequestration within phytoliths. This work investigated the location and chemical speciation of PhyOC by developing an innovative sample preparation followed by synchrotron X-ray imaging. We used a focused ion beam with scanning electron microscopy (FIB-SEM) as a low-invasive method to obtain thin (<500 nm) phytolith lamella directly from the epidermis of sugarcane stalks. These lamellae are transparent to X-

rays, enabling the use of Scanning Transmission X-ray Microscopy (STXM) to map silicon and carbon with a pixel size of 20 nm. Furthermore, spectral analysis at the Si and C K-edges allows chemical speciation of these elements in the phytoliths. While the Si spectrum was everywhere consistent with amorphous silica, the C spectra presented multiple spectral and spatial signatures, including evidence of carbon occlusion within the phytoliths. This study demonstrates a novel method to dig into the origins, quantities, locations, and types of PhyOC, opening new avenues in phytolith research.

Palm-leave manuscripts and palm leave-phytoliths: how does the leaf preparation process influence the phytoliths assemblages and why can it be important for the study of the palm manuscripts?

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Arecaceae is a plant family known for its ability to form specific phytoliths, sometimes genera specific ones. The morphological identification and classification of palm phytoliths are still ambiguous as there is not much specific research performed on the Arecaceae family. However, the developing of detailed morphological classification of palm phytoliths could potentially be helpful for the palaeoecological and archaeological studies in tropics and subtropics, where the palms are common but their macro- and microremains could be scarce and, therefore, contribution of the Arecaceae family into the past vegetations or to the past cultures could be underestimated or misinterpreted. Palm phytolith studies could also be relevant to the palm manuscript research. This contribution summarizes our pilot investigations of the palm phytolith morphology in two most common palm species used as a writing support (i.e. *Barassus flabellifer* – palmyra, or tal palm and *Corypha umbraculifera* – talipot palm) with regard of the changes in phytolith assemblages, e.g. in their forms, deformations, relative abundancies of the morphotypes, and their diversity at every stage of the palm leaf manuscript preparation. In total, 150 samples of each species were studied, at least 20 for every leaf preparation stage. The stage-specific changes demonstrated robust trends for the both studied species. Should these findings appear to be the region- or the preparation recipe-specific, they potentially could help to identify the origin of the old palm-leaf manuscripts that offer no explicit geographical information. The limitation of method is discussed in terms of invasive and non-invasive palm manuscript sampling.

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Plant use and processing with stone tools by Early Holocene societies in Central Brazil: phytoliths of Lapa do Santo Rock Shelter

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Lapa do Santo site is in a karstic archaeological region in Central Brazil (Lagoa Santa, Minas Gerais). Since the Early Holocene, the people occupying the rock shelter consumed starchy plants and small to medium-sized animals. The site contains more than 30 human burials showing complex funerary practices and most of the sedimentary sequence of the shelter is composed of ashes deriving from the combustion of firewood. The lithic artifacts are flakes and cores made from crystals of hyaline quartz, which are of small dimensions and rarely retouched. Technological and experimental studies suggest that they were used to cut and scrape plants but also soft materials. This research analysed plant micro-remains from 20 lithics and 6 sediment samples. The extractions highlighted the presence of both phytoliths and starch grains in the tools' residues while phytoliths were present in all sediment samples. Identified phytoliths originated from grasses (Panicoideae, Aristidoideae, Bambusoideae, Chloridoideae), herbs (Cyperaceae, including *Cyperus/Kyllinga* sp.), palms (Arecaceae), and Eudicots. The plants identified could be remains from: the used firewood, stone tools use, their consumption as food, and other activities carried out in the site.

Bulk samples and thin sections. Integrating two different techniques to the phytolith analysis, the case study of DIVA (Antwerp, Belgium).

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Traditionally, phytolith analyses of soils and sediments are carried out by extraction from bulk samples. This technique provides information relating not only to their taxonomical attribution (morphological

identification) but also to their concentrations (quantitative analyses). Nonetheless, extraction results in the loss of part of the phytolith's context.

Over the last 20 years, the study of phytoliths in soil and sediment thin sections has revealed to be a reliable method for phytolith analysis since it provides information about, among others, their (post)depositional histories, as there is no removal of the sedimentary matrix, nor artificial concentration of the phytoliths.

Here, we present preliminary results of the study of urban Dark Earths from the DIVA site (Antwerp, Belgium). The Dark Earth deposits are dated between the end of the Galo Roman empire and the 11th century. This research constitutes a novel methodological development in phytolith analysis by combining qualitative and quantitative analysis of phytoliths extracted from bulk samples with the analysis of phytoliths in soil thin sections.

Some issues of stratigraphy of the bolgar fortified ancient town

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Our study presents of the comprehensive scientific research conducted at the ancient town of Bolghar (Tatarstan republic, Russia). Bolgar was intermittently the capital of Volga Bulgaria from the 10th to the 13th centuries. The UNESCO World Heritage Committee inscribed Bolgar Historical and Archaeological Complex to the World Heritage List in 2014

Our study is shown that the development and functioning of the town had not stable character: the periods of habitation turns by short stages of neglet.

We also discusses the genesis of the so-called "sand" layer, a characteristic feature of the occupational layer in the central part of Bolgar. In previous researchers, this layer was associated with the consequences of the Bolgar defeat by the Mongol army in 1236, since a coal (fire) streak had always been found under it. Based on a complex of physicochemical and microbiomorphic methods our study shows that in all cases this layer is distinguished from the rest in terms of the content of gross phosphorus and phytoliths. The "sand" proper constitute only a small proportion of it, moreover, traces of thermal effects were not observed. Therefore, the genesis of this layer is not mineral, but mainly biogenic in nature. The authors propose several hypotheses about the origin of this layer as accumulations of manure of herbivores or remains of adobe structures transformed by natural processes.

Thanks to their research, it was possible not only to reconstruct the natural environment during the existence of the city in the 10–14th centuries.

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Resilience and adaptation to drylands: phytoliths, experimental cultivation and ethnographic modelling to reconstruct past plant water availability

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Phytoliths can be an extremely powerful tool to reconstruct plants growing conditions in the past. In this talk I will showcase the results of experimental cultivation, ethnoarchaeological and ethnographic modelling research conducted in the framework of the RAINDROPS project. The project focuses on dryland cultivations, namely sorghum, pearl millet and finger millets. These crops are often underrepresented in macrobotanical assemblages, and consequently, in mainstream narratives of domestication, agricultural strategies and, ultimately, human occupation of drylands.

First, I will describe how we identified a way of mapping potential areas of growth of the three dryland crops under study in historical/modern settings and in past scenarios. This was achieved through the combination of environmental, climatic, and socio-cultural data. Then, I will explain how, by comparison with data of phytolith extracted from experimentally grown crops, we were able to define models applicable to archaeological contexts. Finally, applying these models to phytolith assemblages from archaeological sites of different locations and periods, we were able to suggest possible interpretations on how these cereals were grown in the past.

This is a method that can be potentially used for any crop in any region.

Predicting water availability from phytolith assemblages of finger millet, pearl millet and sorghum

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The interpretation of water management practices and consequently the use of irrigation for agricultural intensification has been central to the archaeological debate. Until now no direct method has been presented for the discrimination of water availability for assemblages of C4 cultivated crops, which represent the main components of the agricultural package in drylands. In this study, phytoliths and their silicon isotopic content have been suggested as possible proxies to overcome the methodological issue.

Two experimental cultivations of traditional landraces of C4 species, specifically sorghum, pearl millet and finger millet, have been conducted, simulating irrigated and rainfed fields in drylands. Morphotypes concentration and ratios in relation to water availability have been investigated from the experimental plants and a prediction model was built on the basis of the results obtained. Finally, a pilot study has been carried out on sensitive morphotypes of sorghum, analysed for their silicon isotope composition.

Phytolith assemblages show variability according to the water regimes, which can be better predicted by the application of a logistic regression model rather than with the use of ratios. Predictive morphotypes do not always increase in percentage in well-irrigated conditions while some morphotypes are more abundant in replicates grown in water-stress, leaving open speculation on their physiological function. Moreover, differences in the Si isotope signature of bulliforms, correlated with water treatments, have been highlighted, demonstrating that the isotope composition of phytoliths can be a possible proxy for water availability.

The archaeology of plant consumption in coastal hyper-arid contexts: the Atacama desert as a case study

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The phytolith record from archaeological contexts is a powerful tool for understanding past human management of plant resources, while giving information about the ecological context and the environmental conditions.

During the last decades the archaeology of hunter-gatherers has been increasingly investing efforts on archaeobotanical research, with phytolith analysis playing a significant role.

On the other hand, research on the utilisation of plant resources in arid and hyper-arid environments adheres to a similar concept, which suggests these resources are a priori regarded low in abundance and variability, and as a result are assumed to have played a secondary role in the past.

Instead, the amazing well-preserved heritage discovered in Chile's north and conserved in museums reveals a widespread and intensive usage of perishables, with a significant contribution made by various plant materials used for various reasons.

Here, as part of the ARVCODA project (Archaeology of Plant Consumption on the Atacama Coast), which is financed by the PALARQ foundation and run by the CSIC in partnership with Chilean universities, we evaluate sedimentary materials from two coastal hunter-gatherer shell-middens from the Atacama desert coast.

The sites are Zapatero (mid-Holocene) and Morro Colorado (showing a cultural sequence from the end of the Early Holocene until the Late Holocene), both well-known archaeological sites in the area.

As part of a wider trend of growing interest in archaeobotany in the area, this work provides a preliminary understanding of the phytolith record of the region.

Understanding agricultural dynamics and urbanization in the Indus Valley Bronze Age: new phytolith evidence from Sindh, Pakistan

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The Indus Valley Civilisation is the earliest known urban culture of South Asia (2600–1900 BCE). While archaeological research has been conducted in the region for over a century, systematic archaeobotanical analyses are still not widespread, and those carried out have concentrated on the geographical edges of the Civilisation, particularly Gujarat and the eastern Harappan region.

However, the Indus floodplain is an area of special interest as it was the core of an unprecedented urban development. In a transition area between the winter and the summer monsoon systems, archaeological evidence suggests that the people of the Indus Civilization adapted and exploited a variety of environments and they were resilient to climate change and variable hydrologic regimes, through the adoption of diverse agricultural and water-supply management strategies. Therefore, studying the relationship between agricultural dynamics and urbanization in the Indus Valley is key to understand not only the role of the environment in Indus societal transformation, but also the economic basis that allowed the rise of the Civilisation.

We present a comparative archaeobotanical study of two archaeological sites in Sindh, Pakistan. Bhando Qubo is located in the alluvial plain of the lower Indus Valley, while Taloor Je Bhitt stands at the western edge of the Thar desert. Phytolith analyses from grinding stones and soil samples provide data on the cropping regimes, particularly the presence of both wheat/barley (winter crops) and a variety of millets (summer crops), suggesting a more diverse and flexible plant-based economy in the area than what was previously acknowledged.

Potentials and limitations of reconstructing diet from dental calculus

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For the last few decades, Archaeologists have been reconstructing human diet from various proxies that got entrapped in dental calculus. The pioneering studies in the field, especially the ones conducted on prehistoric skeletal remains, have demonstrated that despite the limited numbers of plant micro-remains that are usually recovered from dental calculus, their contribution to our knowledge on plant consumptions is invaluable. Once the study of diet from dental calculus became wider spread and used on remains from later time periods, and populations with diverse subsistence strategies, it became clear that it is important to understand the different mechanisms that control the formation, and degradation of the dietary record in dental calculus, and the potential biases it may contain by developing experimental and ethnoarchaeological studies. With the application of advanced scientific methods such as proteomics and aDNA to the study of dental calculus, it seems that the contribution of plant micro-remains for the reconstruction of human diet is of lesser importance. Yet the use of a multi-proxy approach can contribute to a holistic understanding of human dietary practices. With the increase of popularity of dental calculus as a record of human diet it has become even more important to understand the potentials and limitations of the different proxies that are entrapped in it, and to develop sampling protocols that will allow us to maximize its potential on the one hand, without compromising future studies on the other.

Progress on phytolith taxonomy and devising a protocol for describing and naming phytolith morphotypes

International Committee for Phytolith Taxonomy (ICPT) (Katharina Neumann[1], Caroline A. E. Strömberg[2], Rosa Maria Albert[3], Luc Vrydaghs[4], Linda Scott-Cummings[5] and Chad Yost[6])

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ICPN 2.0, published in 2019, formulates the principles recommended for naming and describing phytolith morphotypes. Following these principles, it presents the revised names, diagnosis, images, and drawings of the 19 morphotypes most commonly encountered in phytolith assemblages from modern and fossil soils, sediments, and archaeological deposits. An illustrated glossary of common terms for description is also provided.

Whereas the principles for naming are increasingly adopted by our research community, they do not prevent homonymy and synonymy while naming new types, resulting in name inflation. This causes confusion and is detrimental for phytolith analysis.

The ICPT wants to overcome this naming inflation and believes the way to overcome such naming inflation is to continue publishing more 'official' descriptions. Common and important morphotypes that currently are often subject to renaming and synonymy are those from dicotyledonous angiosperm ('dicot') leaves. Apart from grasses, dicot leaves are the main producers of phytoliths, in particular in soils associated with forest vegetation. The ICPT are working to address this along a new protocol.

Inter- and intra-observer variation in phytolith morphometry

International Committee for Phytolith Morphometrics (ICPM): Welmoed A. Out[1], Rand Evett[2], Kristýna Hošková[3], Robert C. Power[4], Javier Ruiz-Pérez[5], Monica Tromp[6], Luc Vrydaghs[7], Kali Wade[8], Mario Hasler[9]

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Morphometry is increasingly used in phytolith analysis. It is regularly applied to distinguish between phytoliths from closely related taxa, particularly to differentiate and identify crop plants, but also to study grass paleoecology and evolution, for example. Open source morphometric software based on drawing masks of phytolith shapes has been developed as part of an effort to increase methodological standardization of phytolith morphometry (Ball et al. 2016). Several computer-assisted morphometric methods and software programs, using either masks or landmarks, are currently used by phytolith researchers. An important issue that has received little attention to date is inter- and intra-observer variation stemming from manually drawing masks. Are data collected by different researchers equivalent? Are analyses by individual researchers repeatable? These questions are important because researchers need to understand the magnitude of potential sources of error and the repeatability and reliability of results when applying morphometric analysis.

Under the auspices of the International Committee for Phytolith Morphometrics (ICPM), appointed by the International Phytolith Society (IPS), a new study is investigating inter- and intra-observer variation among phytolith specialists from labs around the world. Eight participants measured fifty phytoliths of three morphotypes, repeating their own measurements three times. Results indicate that inter- and intra-observer variation occurs. The issues of whether the observed variation is relevant and how it can be reduced will be discussed.

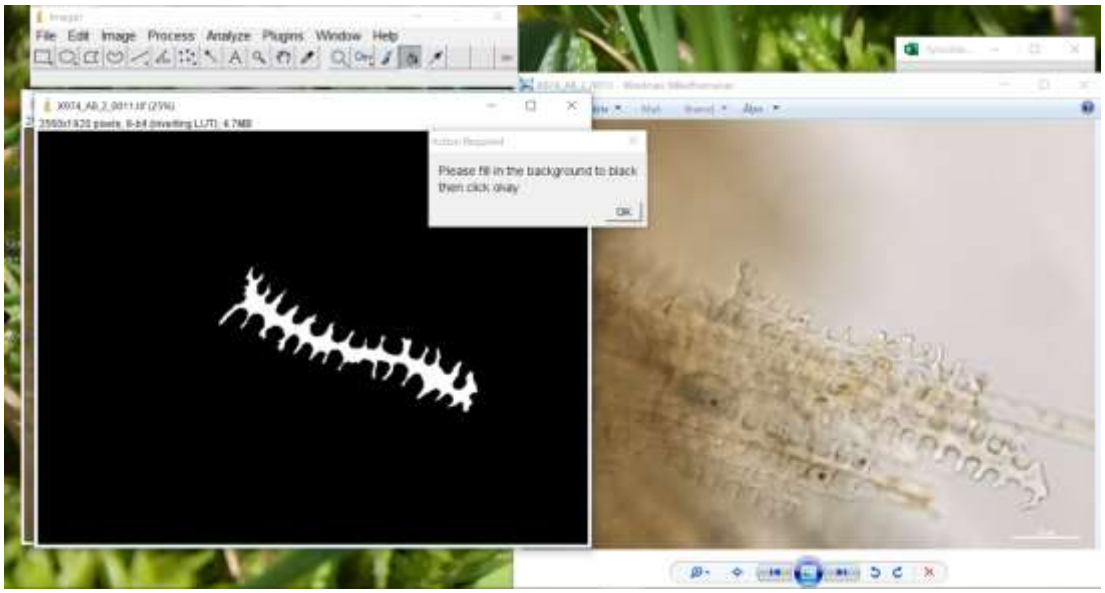

Image: Phytolith morphometry of Viking-age oat using the software developed by the International Committee for Phytolith Morphometrics (Ball et al. 2016).

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The Neolithic of the Negev Desert: Stasis or change? New insights from Biqat Uvda

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What do phytoliths from cooking pottery vessels represent? Insights from Neolithic Stavroupoli (northern Greece)

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The analysis of residues from cooking pottery vessels offers the opportunity to study past diet and culinary practices. Starch grains, lipids and proteins recovered/extracted from cooking pottery vessels are generally interpreted as direct evidence of food preparation and consumption activities. However, the presence of phytoliths from plant parts not commonly used for human consumption (e.g., grass leaves) in cooking pottery vessels is puzzling, often raising questions about the potential use of cooking pottery vessels for non-food-related activities. In this study we compare phytoliths recovered from charred food crust and the sediment attached to the inner wall of 20 cooking pottery vessels from late Middle and early Late Neolithic (ca. 5600-5000 cal. BC) Stavroupoli, in northern Greece. Since charred food crust represents the residue of an individual meal, the phytoliths recovered in food crust samples are interpreted as direct evidence of food preparation and consumption activities; which can be then used to interpret the phytolith assemblage from the sediment attached to the inner wall of the same vessels.

Phytolith analysis of an archaeological site Kozholyu-1 (Central Altai, Russia)

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The settlement Kozholyu-1 is an archaeological site which is located in Ongudai region, Central Altai (Russia). Its archaeological assemblage includes ceramics, a bone arrowhead, and a grinding stone. According to typology of the ceramic complex the site was approximately dated as the 2nd part of the I millennium AD or the Early Middle Ages. The site is a part of irrigation systems of Altai used for agriculture practicing by the first farmers since the Early Iron Age, but due to prolonged use and renovations of the main canals, assessing the time of the initial construction is difficult.

Detailed studying of Kozholyu-1 may broaden our knowledge about Middle Age settlements and early agriculture in Altai region. The grinding stone found on the site can be an indirect evidence for agriculture of people groups lived on this settlement, at the same time paleobotanical analyses could provide us with an undoubted proof for its presence. Macroremain study hasn't revealed any seeds or other parts of cultural cereals.

In order to reconstruct environmental conditions of the timing when people settled the site and also to get potentially valuable information about agricultural practices, phytolith analysis was carried out. The results showed the dominance of open steppe spaces during the period of cultural layer sedimentation. One sample taken from the layer which contained archaeological materials showed the presence of cultivates cereals which can be a direct proof for the farming by the people settled the site.

The laboratory part was financially supported by RSF (project №23-28-01347).

3-D shape analysis of ELONGATE DENDRITIC: A tool to refine the botanical attribution of cereal phytoliths?

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The Poaceae (grass) family produces diagnostic phytoliths, including ELONGATE DENDRITIC and ELONGATE DENTATE/DENDRITIC (hereafter, both groups are referred to as ELONGATE DENDRITIC). These morphotypes are commonly formed in the inflorescences of grasses, especially

the domesticated cereals. In archaeological samples, their presence may be attributed to cereals as well as to wild grasses because they very often share similar morphologies. Some scholars have sought to devise methods for improving the taxonomic resolution of the morphotype, but there is as of yet not a reliable method.

In this project, we focus on a selection of ELONGATE DENDRITIC within Triticeae and Aveneae from both cereals such as wheat, rye, oats, and barley, and wild grasses with ELONGATE DENDRITIC that overlap in morphology with those of the cereals. The aim is to investigate the discriminative power of ELONGATE DENDRITIC to distinguish cereals versus wild grasses, as well as the taxonomic level at which these cereals can be differentiated from one another.

Confocal images of ELONGATE DENDRITIC phytoliths were converted into digital 3-D phytolith surface models that can be quantified and analyzed. Because more traditional techniques such as distance-based and landmark-based morphometrics have limitations when it comes to analyzing complex phytolith shapes lacking clear landmarks, we instead use a persistent homology approach. This method is rooted in the field of algebraic topology and shows potential to quantify these complex phytolith shapes. This presentation aims to explore persistent homology as a new tool in phytolith research and to present preliminary results from applying it to discriminating ELONGATE DENDRITIC using a 3-D phytolith model dataset.

Phytoliths reveal the influence of Earth's orbital parameters on eastern African savanna structure: assumptions, limitations, and future directions

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To better understand natural climate variability, an increasing number of studies investigate how changes in incoming solar energy (insolation) driven by Earth's orbital parameters of eccentricity, obliquity, and precession affect climate, vegetation, and fire regimes. Ocean drill core sediments are typically used for these studies because they span orbital timescales (10^4 to 10^6 years) and can be accurately dated. However, drill cores from continental lakes formed along divergent plate boundaries (rift valleys) have similar characteristics. To date, I have extracted and analyzed over 1,300 phytolith samples from eastern African Rift Valley paleolake drill core sediments spanning from 3.5 to 1.3 Ma at millennial and lower temporal resolution. By applying spectral analysis to Iph and D/P phytolith indices, I have detected orbitally-driven changes in both woody cover (tree/shrub vs. grass) and grass community composition (mesic tall-grass vs. xeric short-grass savanna) at precessional (19-21 kyr) periodicities. When poor phytolith preservation precluded index calculations, microcharcoal and leaf wax isotopic records from the same cores provided complimentary lines of evidence indicating orbitally-driven changes in hydroclimate, vegetation, and fire. Despite this success, working with rift valley lake sediments is challenging and requires the use of assumptions that have not been adequately tested. Lakes influenced by insolation can change from freshwater to saline/alkaline systems with partial to total biogenic silica dissolution and the formation of zeolitic minerals resembling phytoliths. Sponge

spheraster can also be numerous and hard to distinguish from palm phytoliths. With additional modern studies, some assumptions can be strengthened and better phytolith indices developed.

Mid-Pleistocene vegetation of the Elandsfontein Archaeological locality in the Cape Floral Region, South Africa

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Climate change and natural disturbances have shaped ecosystems throughout the Quaternary, influencing biotic communities and critical ecosystem processes. Today, humans are primary drivers of ecosystem change, but it is unclear when past human populations began to rival natural variability as a force of ecological change. This research contributes to this problem through the analysis of phytoliths from Elandsfontein, an open-air dunefield located in the hyper-diverse Core Cape Subregion of the West Coast of South Africa, which preserves large lateral landscapes of palaeontological and archaeological remains dating to the mid-Pleistocene (~1 Ma). Through analysis of samples from six dune bays, our goal is to provide an understanding of the physiognomic structure of ancient vegetation across space and time. Phytolith concentration distribution across bay sections is inconsistent with downward translocation of phytoliths. Our results show a constant low presence of grasses and a high presence of restios, woody, and eudicot leaf phytoliths. This phytolith assemblage, which is characteristic of fynbos and other Cape shrubby vegetation such as sandveld or strandveld, dominates across bays and stratigraphic sections associated with archaeological finds. Though grass phytoliths are rare, microscopic charcoal analysis suggests increased grass abundance may be linked to burning. Our results align with other regional archives that show an absence of grass-dominated vegetation. These results continue to challenge the fossil record of large herbivores, which has traditionally been interpreted as indicating presence of grasslands. Our study thus provides valuable evidence for

evaluating hominin-fauna-vegetation-disturbance interactions on the West Coast of South Africa during the mid-Pleistocene.

The interpretation of the16 ka-long phytolith record of Lake Ngami, Botswana, using modern phytolith assemblages and regional grass phytolith references

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Lake Ngami occupies the southwestern part of the rift that forms the southern overflow catchment of the Okavango Delta. Past studies on paleo-landforms around the lake and paleoecological proxies from the lake suggest extreme changes in prehistoric and historic times. The previously published pollen record provides the pattern of regional and local vegetation change in relation to climatic and hydrological fluctuations, suggesting changes in precipitation patterns related to regional circulation patterns. The more recent phytolith record provides additional information that although concurrent with the pollen record provides additional information regarding responses of grasses to regional and local climatic and hydrological changes. Based on phytolith assemblages in modern depositional analogs across a broader area suggest that the well-defined round saddle, produced by the arid-adapted *Stipagrostis* spp (bushman grass) is a good indicator of aridity. The role of short cells produced by the Chloridoideae and Panicoideae suggests different moisture regimes. This contrasts with the idea that Chloridoideae are indicative of dryness. Likewise, the presence of woody-plant phytoliths relates more to the reduction of lake level and spreading of deep-rooted thorn trees on the lake floor. The study is a contribution to interpreting phytolith assemblages in shallow lakes in the tropics of southern Africa. The study also shows the importance of regional modern phytolith samples and references for proper interpretation of phytoliths in sedimentary records.

Prospects and limits of phytolith analysis in Mongolia: study of modern plants, soils, lake sediments and dung

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The Altay Mountains in Kazakhstan, Russia, and Mongolia present great opportunities for the study of paleoclimate and paleoecology of Central Eurasia, especially from the late Pleistocene and the Holocene

lake and cave sediments, which are quite abundant. However, due to high aridity and consequently low biomass production, many natural archives found here are scarce or not particularly exciting. Pollen can be rare to non-existent, while other proxies have been not as vigorously used. In our multi-year research on the Greater Altay ecoregion, silica phytoliths were extracted from samples of modern plants, soils, lake sediments, and animal dung in the Republic of Altay in Russia and in Mongolia in the summers of 2021-2022. The majority of sample sites come from Southern Chuya Range in Russia and from western Mongolian Altay from high-elevation sites above the surrounding plains. Additional sampling was done at lower elevations around Buuntsagaan Noor, a major lake in central Mongolia and ca. 150 km north of the edge of the Gobi Desert. The results agree in part with those obtained earlier by N. Kiselyova in the 1980s that suggest presence of lightly expressed vegetation gradients tied mainly to the climate variables, but also to the level of anthropogenic disturbance and presence of specific animals from the "Mongolian five jewels", namely yak/cow, camel, horse, goat and sheep. Dung assemblages are broadly similar to those of the modern topsoil in the surrounding vegetation, and many natural communities can be reliably identified based on phytolith records.

Reconstructing the Paleoclimate and Paleoecology of Butia Palm-Dominated Ecosystems in Coastal Regions: Insights from Bioindicators and Soil Geochemical Analysis

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Butiazal is a typical South American ecosystem characterized as a tree savanna dominated by Butia palm trees. It extends mainly throughout southern Brazil, Uruguay, and Argentina and has significant paleoclimatic implications due to its sensitivity to environmental change. In addition, it possesses significant archaeological importance due to its use by human populations dating back at least 4,000 years, and evidence of anthropogenic manipulation in the dispersal of this ecosystem. This study aims to reconstruct the paleoecology and paleoclimate of Butiazal ecosystems in coastal regions of South Brazil and Uruguay. The main methods used were bioindicators (especially phytoliths, but also sponge spicules and charcoal analysis), soil geochemical analysis, isotopes, ground-penetrating radar, granulometry, and radiocarbon dating. The results indicate that the evolution of Butiazal is closely related to the climatic changes that occurred during the Holocene, as well as variations in sea level. Specifically, the analysis of phytoliths revealed significant changes in the abundance of Butia palm trees in response to shifts in temperature and precipitation patterns. This research provides new insights into the paleoclimatic history of the Butiazal ecosystem and its sensitivity to environmental change in South America.

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Paleobiogeoclimate reconstitution of the altitude swamps of Ceará, brazil: a case study of the Serra de Uruburetama

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This research aims to contribute to the understanding of the evolution of the landscape of Serra de Uruburetama, State ofCeará, Brazil along the Quaternary through multiproxy analyses, such as phytoliths, soil analysis, and dating by 14C-AMS. The study area, a semi-arid region covered by the Brazilian "caatinga", was divided into three geoenvironmental units, namely: wet, sub-humid and dry slope, where a total of 117 soil and 18 plant samples were collected.. The phytolithic analyzes of all profiles showed the same trends, despite variations due to granulometry, and edaphoclimatic conditions of deposition. There were no major changes in vegetation cover in the study area during the Holocene, with a predominance of open vegetation. However, it was possible to observe small climatic pulsations that identified relatively wetter periods in the transition from Pleistocene to Early Holocene with moisture pulses in short periods of heavy rains under dry climatic conditions and drier episodes around 9,000-8,200 cal years BP. From the Middle Holocene to the Late Holocene we had some oscillations between dry episodes and trends towards more humidity, with samples dated at 8184-7713 cal years BP and 8163-7667 and 5583-5577 cal years BP for drier environment and 5022-4417 cal years AP and 4241-3664 cal years AP, for a wetter episode. This last episode also corresponded to the highest tree density observed, indicating a period of greater humidity. The study of biomineralizations associated with the other analyzes proved to be quite effective in understanding the evolution of the landscape and environmental changes.

Phytoliths as indicators of climatic pulsations in the Rio Grande basin, Bahia, Brazil

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The Rio Grande River Basin (RGB) is located in the west of the state of Bahia, being characterized mainly by the altimetric contrast of cuestas and areas of smooth topography. It is a transition area between the Cerrado and Caatinga biomes. This study aims to understand the dynamics and transformation of the landscape in the middle course of the RGB during the Quaternary, based on the investigation of surface covers of river terraces, inferring variations in vegetation and geomorphological processes associated with episodes of climatic pulsations. The methodology consisted of an integrated analysis involving the dynamics and characteristics of the surface covers of river terraces; silica biomineralizations (phytoliths, sponge spicules, and diatomaceous frustules); granulometric and geochemical analyses; and ages obtained from optically stimulated luminescence (OSL) dating. Nine sampling points on the river terraces were selected for analysis. The silica biomineralizations showed similar trends in all the profiles, despite variations between the profiles due to granulometry, hydrodynamic conditions of deposition, and geochemistry. No major changes in vegetation cover were recorded in the middle course of the Rio Grande in the Holocene, with a predominance of open vegetation with the occasional occurrence of forest remnants. However, it was possible to observe small variations that identified relatively drier periods in the Late Pleistocene and the Middle Holocene, wetter conditions around 1,430 years BP, and humidity variations in the last 420 years. The analysis of silica biomineralizations associated with pedogeomorphological properties proved to be highly effective for understanding landscape evolution and environmental changes.

Progress towards open science in phytolith research: the International Committee on Open Phytolith Science

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The *International Committee on Open Phytolith Science* (ICOPS) has been created within the International Phytolith Society to work on increasing the knowledge of and implementation of open science practices in phytolith research.

Open Science is an approach that aims to transform research by making it more reproducible, transparent, reusable, collaborative, accountable and accessible to society. Open Science encompasses different practices such as open data, open methods, open source software, open hardware, open access publishing, citizen science, open education and equity, diversity and inclusion.

Our committee, and the open phytoliths community initiative, therefore embraces these practices and strives to make everything that it does open and transparent to the phytolith community. We aim to engage with the phytolith community regularly and we encourage phytolith researchers to get involved in our training, seminars, discussions and working initiatives.

This talk will highlight the work of ICOPS including:

- FAIR Phytolith project - working to improve data sharing by investigating existing phytolith data and drawing up community-led guidelines for the implementation of the FAIR principles for existing and future phytolith data.
- Phytolith ontology - working to bring together the standard nomenclatures with other lab based nomenclatures to produce a comprehensive ontology that compares existing synonyms for different morphotypes.
- Open Research Training - we have run a series of training workshops including open access, using repositories, GitHub, standard vocabularies and ontologies and FAIR data.
- Open Publishing Guide - our guide puts forward best practice in open publishing and can be found here: https://doi.org/10.5281/zenodo.6803489

Posters

Phytoliths provide evidence for the pre-Columbian swidden cultivation along Canadian East Coast.

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Swidden cultivation technique involves cutting and burning of trees, shrubs, or sod and a subsequent sowing of seeds in the ash-rich layer. The seeds can be entrenched into the soil using wooden sticks and ards, and such surficial scratching of soil results in formation of shallow "swidden horizons." The morphological features of such horizons include: dark-gray color, commonly changing to cinder-gray upon soil desiccation, high concentration of charcoal in the 2-7 mm size fraction (1 charcoal fragment per gram or more), and uniform distribution of charcoal within the horizon. In sandy soils, the lower boundary of the horizons is dotted by a dense network of charcoal-in-filled sweat bee burrows. While soil morphology allows to tentatively identify past swidden sites, the final confirmation is possible if pollen and, especially, phytolith of cultivars are found in the layers. Soil surveying of the Canadian Maritimes revealed soil profiles with the layers identified as swidden horizons based on their morphology; their radiocarbon age varied from 6th century C.E. to 19th century C.E. Cereals' pollen and phytoliths were found in the earliest sites, but it is not clear whether domesticated or wild cereals were growing there. In the swiddens dated by the 11th, 12th, and 14th centuries, *Zea* pollen, diagnostic phytoliths of *Zea*, or both were found, attesting for *in situ* cultivation of maize. Finally, pollen of European cereals and weeds were found in the sites dated from 16th-19th centuries. This is the first known finding of pre-Columbian swidden agriculture in the Canadian Maritimes.

Paleoenvironmental reconstruction of the Lagoa Grande das Queimadas Archaeological Site, Piauí, Brazil

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The state of Piauí, located in a semi-arid region in northeastern Brazil, has worldwide recognition for its archaeological and paleontological legacy. The study area is the Lagoa Grande das Queimadas archaeological site, located in the municipality of Várzea Branca, in southeast Piauí, where geoarchaeological and archaeobotanical research has already been carried out. The use of phytoliths as proxy for paleoenvironmental reconstruction aims to corroborate this interdisciplinary research. The sampling site (lacustrine sediments) was chosen due to the preservation characteristics of the records, which have enormous potential for geoarchaeobotanical, paleoenvironmental, and paleoclimatic research. The results obtained thus far are promising for the purpose of this study, there being a large quantity of phytoliths in excellent preservation conditions. In all the samples, from 85cm deep, dated at 4,400 cal years BP, to the top, it is possible to infer open vegetation, similar to current conditions. The

phytolith assemblages are predominantly composed of mophortypes of Poaceae, mainly BLOCKY, BULLIFORM FLABELLATE, ACUTE BULBOSUS, and ELONGATE, with reduced presence of woody dicots (SPHEROID ORNATE). Phytoliths of Arecaceae (SPHEROID ECHINATE) are also observed throughout the core, increasing from the oldest sample to the most recent, in addition to fragments of sponge megascleres and charcoal. The phytolith results, associated with other proxies studied at this site, will contribute to the construction of information on archaeological sites and their insertion in the landscape, as well as to the understanding of mobility and subsistence models of past human groups during Late Holocene in inland areas of Northeastern Brazil.

Plant use in Central Brazil: Phytoliths from the Lapa do Boquete rockshelter (Central Brazil)

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In the Cerrado biome of Central Brazil, savannah-like vegetation, there are hundreds of archaeological sites dating from the Early to the Late Holocene. Early and middle Holocene sites are found in rock shelters, while late Holocene sites are mostly open-air villages, with evidences of ceramic production and plant cultivation, including the exploitation of domesticates such as manioc and maize. In open-air contexts, the preservation of plant macroremains is hampered by the tropical climatic conditions (high moisture and rainfall). One exception is the Lapa do Boquete site, a karstic rock shelter with a sedimentary sequence starting from the final Pleistocene to the Late Holocene. The site contains several human burials, lithic and bone artefacts, rock paintings and engravings, and pottery in the most recent layers. Lapa do Boquete is well-known for the exceptional preservation of macrobotanical remains, and the presence of baskets made of plant fiber, filled with maize cobs, fibers, palm leaves, small types of coconuts, and other seeds. In this work we present the diachronic analysis of phytoliths from the sediments of Lapa do Boquete, covering the Early to the Late Holocene settlement of the site. Four soil samples from outside the site were also analysed for comparison.

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Phytoliths from ancient cultivated lands in the European forest temperate zone: opportunities and difficulties in the diagnosis of grain crops

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The aim of this study is to define diagnostic forms of phytoliths found in important species of domesticated grasses within the forest and forest-meadow temperate zone of the European part that can be used to identify ancient cultivated land. Phytoliths extracted from stems, leaves and husks of three species of wheat, rye, oat, millet and barley were studied. To ensure these diagnostic morphotypes are found only in domesticated cereals, they were compared with phytoliths from several wild grasses of meadow communities within the temperate. Even a single occurrence of a phytolith that reliably belongs to domesticated grass (e.g., dendritic and cross-shaped phytoliths) in a sample from either archaeological cultural layer or soil within the forest temperate zone is sufficient to indicate the presence of these domesticated plants in the past. If samples contain only common forms of grass phytoliths with no diagnostic morphotypes of cereals leading to an unacceptably high probability of making a wrong conclusion. Our studies confirmed both the diagnostic significance of Elongate Dendritic forms and their uniformity for a large group of cultivated cereals. Elongate Dibbate forms can also be used for diagnostic purposes. Millet is the only cultivated cereal that forms diagnostic phytoliths type (Cross) that distinguishes it from other cultivated cereals. Our conclusions are only applicable for materials from temperate forest and forest-meadow zones of the European part. In other climates, the same forms can be indicators of other species of cereals or can commonly occur in wild grasses.

The influence of long-term soil erosion on the type and quantity of phytoliths in agricultural soils.

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The influence of long-term anthropogenic erosion on the type and quantity of phytoliths in agricultural soils / Phytoliths as indicators/determinants of soil erosion.

Phytogenic silicon in agricultural soils is one of the primary sources of plant-available silicon. The amount of this form of Si in the soil is dictated by the human factor that limits its contribution, by taking crops from the field and when it exposes the soil to various types of erosion. These include tillage

erosion (tillage of the soil), water erosion (rainfall and surface run-off) and wind erosion (transport of soil particles by the wind, particularly during dry periods).

The aim of the study was to determine to what extent long-term anthropogenic erosion affects the phytogenic silica pools in cultivated soils, and whether, depending on soils' landscape position, there is a depletion or enrichment of phytogenic silica?

The research was carried out at the Carbo-ZALF experimental field near Dedelow (NE Germany); both non-eroded and eroded soils were used for the study: (a) non-eroded soil (Calcic Cutanic Luvisol), (b) strongly eroded soil (Nudiargic Luvisol), (c) extremely eroded soil (Calcaric Regosol), and (d) depositional soil (Endogleyic Colluvic Regosol).

First results showed large differences in phytolith contents. Non-eroded soils contain phytoliths in the first two soil horizons (0.1-0.2 %), eroded soils contain very few (<0.01 %) and colluvial soils contain the most phytoliths (0.1-0.5 %) and phytoliths are present in every horizon up to a depth of 240 cm. Soils also showed differences in the morphotypes of isolated phytoliths. We are currently investigating whether the phytoliths in the colluvium may originate from upslope soils that are subject to continuous erosion processes.

A different kind of archaeology – revisiting the first phytolith study in Israel

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The 13th International Meeting on Phytolith Research in the Dead Sea is an appropriate opportunity to revisit one of the earlier phytoliths in the Levant, by Christian Gottfried Ehrenberg, the man who coined the term phytoliths. Since the original paper included only a table describing the phytoliths using Ehrenberg's nomenclature, I accessed Ehrenberg's original drawings, curated in the Ehrenberg Collection of the Museum of Natural History, Berlin, and described each phytolith morphotype using the modern International Code for Phytolith Nomenclature as best as the drawings allowed. The dominant morphotypes originate in grasses, which are oftentimes dominant in phytolith assemblages due to their large quantities of phytoliths. These include a Panicoid-type short cell, and possibly an undomesticated Triticeae species that fits the Jordan Valley region being a possible cradle of wheat domestication. The assemblage from the Jordan River contains woody leaf phytoliths, which may represent the riparian flora, and one may perhaps belong to a palm, fitting the vast date palm cultivation history of the region. In conclusion, using archived drawings to reinterpret old papers of phytolith assemblages is promising, despite the limitations incurred by the often lack of quantitative data and quality of some drawings. Such archived papers can contribute to our knowledge of past environments, and should not remain confined in archives.

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Early Neolithic plant economy: The grinding stones from Frydenlund, a Funnel Beaker site in Denmark

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In northern Europe, the Early Neolithic begins with the presence of people of the Funnel Beaker culture. Relevant archaeological sites are often characterized by the presence of megalithic monuments, pottery and domesticated plants and animals. Since then, both cultivated and collected plants were exploited, but the relative importance of crops *versus* wild plants is not clear. This contribution aims to shed more light on the role of crops and gathered plants by means of analysis of the grinding stones of the Early Neolithic site of Frydenlund in Denmark.

Frydenlund, dating to 3635+/-5 BCE, is an archaeological site of the Funnel Beaker culture. The site was excavated in 2009-2012 by Odense Bys Museer and Moesgaard Museum. The site consisted of two houses that were turned afterwards into grave monuments. The houses and grave monuments were in use during a period of five to ten years only (Andersen 2015, J. Olsen unpublished data). Earlier analysis of seeds and fruits have demonstrated the presence of crop plants and a large variety of wild plants, including e.g. emmer wheat, naked barley, durum wheat, hazel nut and lesser celandine (Andreasen 2017; Kirleis 2019).

To investigate the plant economy at Frydenlund in further detail, fourteen grinding stones have been subjected to analysis of starch grains and phytoliths. Were all grinding stones used for plant processing? What does this tell about the preparation of cereal food products at this site?

Phytoliths on the edge of the world: production in the Arctic plants of the Lena Delta

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The delta of the Lena River is a major feature of the Russian Arctic and is a strictly protected nature reserve (zapovednik) under a federal law. Studies of the plant communities at the Samoilovsky Island research station at the apex of the delta have been ongoing since 2017, with the major focus being adaptations of plants to the accelerating climate change. Identification of the local grass species in sediments needed for paleostudies can be best accomplished by phytolith analysis. We analysed phytolith production in leaves and inflorescences of 10 common Arctic grass species collected in the summer of 2022. All species belong to the tribe Poeae, but 4 different subtribes. As expected, most of them produce various proportions of CRENATE and RONDEL morphotypes in the short cells and various ELONGATES and ACUTES. However, further differentiation down to the subtribe or even species level may be possible using sub-morphotypes and some simple morphometric measurements. Some of the same species studied previously in Alaska yielded comparable results, allowing us to develop basic keys for plant identification based on the total assemblages of morphotypes from each species that could be applied across Beringia. Inflorescence phytoliths may be a more reliable source of identification than those from the leaves of plants.

First insights into the phytolith analysis of soil thin sections from the tropics. The case of Kuk, Papua New Guinea.

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Phytolith analysis on soil thin sections is a technique that inventories the distribution patterns of the phytoliths within soils and sediments, along with the phytolith morphotypes within each of the distribution patterns. Contrary to the classical phytolith studies performed on bulk samples, thin sections preserve the relative distribution of the phytoliths and their relation to other components. This allows to document their taphonomical histories, and to securely identify phytoliths that share a common botanical origin.

This methodological approach has been systematically applied on preventive archaeological excavations conducted within the Brussels Capital Region (Belgium). It did not only contribute significantly to the deciphering of archaeological units with complex formation processes, but also to reconstruct the (pre-)urban land use.

Despite promising results, the application of this technique to other regions of the world and chronological periods remains limited. Especially the tropics remain poorly studied. The aim of present contribution is to deliver an initial phytolith exploration of tropical soil thin sections. The site of Kuk Swamp in the highlands of Papua New Guinea appears to be especially well suited for such exploratory research because:

- High relevance of Kuk for early plant domestication and the emergence of agriculture in the tropics;
- Extensive complementary analyses in geochemistry and geoarchaeology;

- Extensive phytolith data (bulk analysis) and associated pollen and microcharcoal data.

Preliminary results from phytolith analysis at the Early EpiPaleolithic site Idan VII (Israel)

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In this poster we present the preliminary results of a phytolith study of the Idan VII site (Israel). Idan VII is an open-air hunter-gatherer Early Epipaleolithic (EEP) Levantine site (ca. 24,900 - 23,800 cal BP). The site is located in the Arava Valley, ca. 15 km south of the Dead Sea, where the present climate is hyper-arid with less than 50 mm annual precipitation.

Despite the hyper-arid climatic conditions, the site, which comprises a cluster of ephemeral camps, is located in the vicinity of spring sediment deposits. This indicates that the hunters' camps were concentrated adjacent to water sources close to the shore of the ancient Lisan Lake.

We present results from bulk sediment samples from hearths as well as from different areas of the occupation surfaces, to assess the viability of phytolith research in the area, obtain a general picture of plant utilization, and identify fuel and burnt remains from the hearths.

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