The Role of Biogenic Silica and Microscopic Phytoliths in Advancing Archaeoenvironmental Research

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ABSTRACT

Biogenic silica ($SiO_2 \cdot nH_2O$), particularly in the form of microscopic phytoliths plays a crucial role in advancing archaeoenvironmental research by providing insights into plant-human interactions and broader ecological dynamics. Phytoliths (opal-A), formed through biomineralisation in terrestrial plants, especially grasses, are composed of durable SiO_2-rich structures that often survive long after plant decomposition and/or burning. This resilience allows for their preservation in soils, sediments, and archaeological contexts, offering a valuable record of past vegetation, climate, and human activities. The preservation of phytolith morphology, mineralogy and chemistry is essential, as it enables the reconstruction of environmental conditions over time, even when other organic materials of botanical origin have decayed. Phytoliths are instrumental in interpreting agricultural practices, evaluating water availability, and deciphering space utilisation at archaeological and paleontological sites, thus deepening our understanding of ancient land management and environmental adaptation. The study of phytoliths and chemical element mobility enhances our insight into biogeochemical cycles, particularly the silicon cycle [3], which is intimately linked to both regional and global ecological processes. Phytoliths have been found on various archaeological artefacts, including stone tools, plant-tempered ceramics, and baskets/mats, as well as in ecofacts such as dental calculus and herbivore dung, revealing patterns of human/non-human animal diet, health, behaviour and technological evolution. Advanced laboratory methods [2] and emerging techniques, such as deep learning algorithms [1] are improving phytolith identification, analysis and interpretation, overcoming challenges posed by morphological similarities among phytolith morphotypes. Beyond geoarchaeology, phytoliths have applications in forensic science and bio-inspired nanotechnologies, where their unique physicochemical properties offer potential for innovation in fields such as sensor technology and medical devices. As research progresses, phytoliths continue to provide invaluable data for interdisciplinary studies, advancing our understanding of human-environment interactions and contributing to broader scientific and technological developments.

Keywords: Biogenic Silica; Microscopic Phytoliths; Plant-Human Interactions; Archaeoenvironment; Geoarchaeology

REFERENCES

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