Quaternary Newsletter
Report
Quaternary Research Association

RECONSTRUCTING PALAEOENVIRONMENTAL CONDITIONS IN THE EGYPTIAN NILE VALLEY USING SOIL RHIZOLITHS

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Abstract

Since the mid-Holocene, the Nile valley in Egypt has experienced major changes in river behaviour and environmental conditions. There is a wealth of archaeological analysis, particularly around the cultural centre of Thebes (Luxor), but palaeoenvironmental records in this region are scarce. Soil rhizoliths are abundant in the floodplain sediments around Luxor. These secondary carbonates offer valuable insights into environmental change at the time of formation. Here we present preliminary analysis of rhizoliths from borehole sediments on the Nile floodplain at Luxor from ~5 ka to present. Rhizolith macromorphology shows clear variations down-core. On-going micromorphological analysis will provide further insights into rhizolith structure and formation and may therefore unlock an important palaeoenvironmental archive in this environmentally and culturally significant region.

Background and rationale

Sedimentological analysis near Luxor, Egypt shows large fluctuations in river Nile discharge and channel position since the mid-Holocene, linked to both natural and human causes (Toonen *et al*., 2018; 2019). Luxor (Thebes) was a major centre for ancient Egyptian civilisations. There is a long history of archaeological analysis, including evidence of a close coupling between human activity and the natural environment (Toonen *et al*., 2019). However, detailed palaeoenvironmental reconstructions from this part of the Nile Valley are scarce.

Importantly, Luxor alluvium is abundant in rhizoliths; secondary carbonates that form in and around plant roots. They are typically cylindrical but may also display bifurcations and nodules. They have been widely studied in Quaternary sequences (e.g. Sun *et al*., 2019; Brazier *et al*., 2020) where they have been reported to measure between a few centimetres to a few metres long, and from sub-millimetre to tens of centimetres in diameter (Klappa, 1980).

The macro- and micro-structures of rhizoliths capture environmental conditions at the time of formation, such as aridity and vegetation type (e.g. Huerta and Armenteros, 2005). Secondary carbonates in the broader sense (e.g. calcretes, rhizoliths, tufa) have been successfully used in arid-zone palaeoenvironmental reconstruction globally (e.g. Spain – Adamson *et al*., 2015, India - Achyuthan *et al*., 2012), including stable isotope analyses of carbonates in Sudan (McCool, 2019), but such datasets do not currently exist for Egypt.

Macro- and micro-morphological analyses of soil rhizoliths in Luxor will address two aims:

1) Produce a morphological framework of rhizolith development in the region.
2) Examine palaeoenvironmental conditions under which the rhizoliths formed.

Here, we present preliminary findings of rhizolith macromorphology and indicate future research objectives.

Study site and methods

Sediment boreholes (~8-10 m deep) were obtained from the Nile floodplain near Luxor by the Theban Harbours and Waterscapes Survey (THaWS) team. Borehole sediments are predominantly overbank silts with some sand. Sediments were sampled at ~10 cm intervals and sieved to isolate rhizoliths. OSL dating provides age control on the sediments (Peeters *et al*., In Prep).

Seven boreholes were selected for further rhizolith analysis, and the results from one (borehole AS107) are outlined here. AS107 rhizoliths were analysed using a light microscope to ascertain key characteristics: length, width, morphology, apertures, and texture. A total of 69 horizons were analysed, containing over 1,000 rhizoliths. Representative samples from each horizon were used for thin section manufacture, and micromorphological analysis is underway.

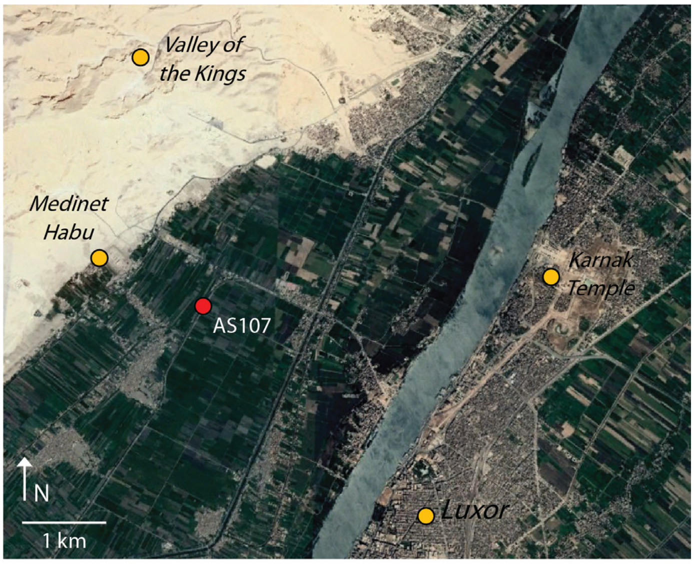

Figure 1. Map of the study area near Luxor, Egypt. Key archaeological sites (yellow circles) and the location of borehole AS107 (red circle) are indicated.

Preliminary results and further research

The Luxor rhizoliths fall into five dominant morphological categories (Fig. 2), largely comprising root tubules and nodules typically measuring 3-10 mm long, 2-5 mm diameter (Fig. 2). They are therefore smaller than those reported elsewhere (e.g. Sun *et al*., 2019) likely reflecting the small root size of the source vegetation, short formation windows between Nile flood events, fragmentation of larger rhizoliths, and/or reworking of pre-existing secondary carbonate material (McCool, 2019).

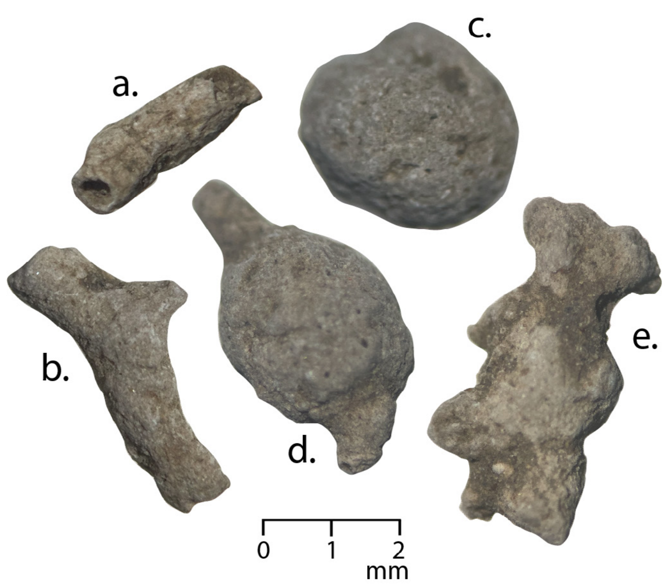

Figure 2. The five typical rhizolith morphologies found in floodplain sediments close to Luxor: a) tubular; b) tubular – branching; c) nodular; d) nodular – branching; e) composite.

There are down-core variations in rhizolith size, morphology, and texture, often corresponding to changes in the host sediment. Such morphological variation may be indicative of palaeoenvironmental conditions at the time of formation, including vegetation type, sediment accumulation, soil moisture, and aridity. Further investigation, using micromorphology and stable isotope analysis, will allow us to explore these rhizolith variations, and their palaeoenvironmental significance, in more detail,

Acknowledgments

We would like to thank the QRA for funding via the QRF scheme and Ade Palmer for his advice and unrivalled patience during thin section manufacture. Thanks also to the QRA INQUA conference fund for assistance presenting more of our findings at the INQUA Congress in Rome 2023.

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