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Reconstruction of ancient palm vegetation landscapes using a phytolith approach

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ABSTRACT

Palms (Arecaceae) are a dominant feature of some landscapes in Africa and may provide different subsistence elements for humans such as construction materials, fabrics, fuel, food, medicine, and ornamentals. Palms have been identified through phytolith analyses in different localities and palaeoanthropological levels of Olduvai Gorge (northern Tanzania) dated to approximately 1.8 Ma. Thus, the presence of palms poses some interesting questions mostly related to the information they can provide in terms of ecological and vegetation reconstructions as well as the interaction between these plants and the possible use of them by hominins. We present here the study of modern soils from Serengeti National Park, Lake Eyasi and Lake Manyara, where palms are still present. The main goal is the reconstruction of palm landscapes and their interaction with other geographical factors (palaeolake, fresh water courses, etc.) through phytolith analyses and taking into account preservation conditions. Contrary to what was expected, characteristic palm phytoliths do not accumulate in the same amounts as observed in the palaeoanthropological samples from Olduvai Gorge. The short cell phytoliths of grasses, also common in the area, do not correspond to the grasses growing in the spots where the samples were collected. There are several reasons for these inconsistencies. Preservation of phytoliths is poor in disturbed areas, open grasslands and scarcely vegetated areas. Fresh watercourses may also influence in the number of phytoliths and preservation caused presumably by erosion and water transport. This study reaffirms the idea that the absence in the archaeological and palaeontological/palaeoecological record of some phytolith morphotypes it is not always related to their absence on the past. Most importantly, the presence of plant groups is very significant but the relative abundance is not easily interpreted because of preservation and disturbance.

1. Introduction

Palms (Arecaceae) are commonly found in all tropical and subtropical areas of the world and are also amongst the oldest monocotyledonous flowering plants, with the earliest origins postulated to be around 80 Ma (Eiserhardt et al., 2011) based on molecular phylogenetics or 110 Ma (Janssen and Bremer, 2004; Bremer and Janssen, 2005). The oldest macrofossil evidence is from the Late Cretaceous of France (95 Ma, Turonian; Dransfield et al., 2008) and pollen from the Maastrichtian (Harley, 2006). Where they occur, palms are a dominant feature of the landscape and are critical for pollinator and frugivore communities. In relation to humans, palms provide different subsistence elements such as construction materials, fabrics, fuel, food, medicine and ornamentals (Van Wyk and Gerike, 2007; Eiserhardt et al., 2011).

Palms are also prolific in phytolith production (Bamford et al., 2006). Phytoliths, silica microremains which reproduce the cellular tissue of living plants have been applied to the African continent in recent years, as a tool for vegetation reconstruction (Alexandre et al., 1997; for the Holocene; Barboni et al., 1999; in Awash in Ethiopia; Runge, 1999; Mercader et al. 2000; in Central Africa; Mulder and Ellis, 2000 in the southwest of Africa and centered on the ecological importance of grass leaves). More recently phytoliths have been used to reconstruct the vegetation of well-known palaeoanthropological sites including Olduvai Gorge (Bamford et al., 2006; WoldeGabriel et al., 2009; Barboni et al., 2010; Albert and Bamford, 2012).

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Olduvai Gorge is located in northern Tanzania to the east of the Ngorongoro Crater Highlands and the west of the present Serengeti National Park in the Eastern Rift Valley (Fig. 1). The site became famous worldwide in 1959 after the discovery by Mary Leakey of the skull of *Paranthropus boisei* (OH5; known as "Nutcracker Man" because of its powerful jaw). One year later, a fragment of upper maxilla of *Homo habilis* (OH7) was recovered in the same chronological levels and a few meters to the northeast (Leakey et al., 1964).

Presently at Olduvai Gorge, as in most of northern Tanzania, there are two rainy seasons and two dry seasons each year. The "short rains" which occur approximately from November to January and the "long rains" caused by large monsoonal systems and which take place between February and May. The amount of rain received each year can vary greatly, but averages around 400–600 mm per year (Norton-Griffiths et al., 1975; Cerling and Hay, 1986.).

The vegetation at Olduvai today is characterized by semi-arid (eutrophic) savanna. This is formed by scrubland and wooded grassland with *Acacia* and *Commiphora* trees and a variety of shrubs and succulents, surrounded by the grasslands of the Serengeti Plain (Vesey-Fitzgerald, 1965; Norton-Griffiths et al., 1975; own observations). Palms are absent from Olduvai Gorge today but they can still be found in other close geographical settings such as Lake Manyara, Serengeti National Park and Lake Eyasi. The most common palms here are *Phoenix reclinata* Jacq, from all these sites and *Hyphaene petersiana* Klotzsch ex Mart in the Lakes Manyara and Eyasi areas.

In general, *P. reclinata* grows along watercourses, usually above the flood-line but sometimes forming small raised islands in the river channel. Individual trees can grow to a height of 10 m and form dense clumps with younger trees. *H. petersiana* is a single stemmed tree growing to a height of 18 m and occurs along swamps, pans and rivers, in low altitude bushveld and it can form extensive stands.

The Olduvai Landscape Paleoanthropology Project (OLAPP) has focused on the reconstruction of the palaeolandscape and palaeovegetation of Olduvai during the time early hominins inhabited the area. OLAPP's main objective is reconstructing the land use patterns of the hominins who produced Oldowan stone artifacts during Bed I and lowermost Bed II times (LMBII), ca. 1.85–1.79 Ma. The research combines sampling of hominin activity traces over broad spatial scales, throughout exposed deposits of the Plio-Pleistocene Olduvai lake Basin with detailed palaeoenvironmental analysis focusing on terrain, hydrology, and vegetation (Blumenschine and Masao, 1991; Peters and Blumenschine, 1995, 1996; Blumenschine and Peters, 1998; Blumenschine et al., 2003). This research seeks to document, on a broad scale, a major diversity of land uses.

Previous studies based on the pollen spectra, carbon isotopes and fauna have provided a general picture of the palaeoenvironment and vegetation for this period (Bonnefille, 1984; Kappelman, 1984; Sikes, 1994; Kappelman et al., 1997). The results obtained show that at Olduvai Gorge there is a shift from more wooded vegetation cover during Middle and Upper Bed I time to more open vegetation by uppermost Bed I, to woodland mosaics in Lower Bed II. Over this time, the landscape and vegetation would have been strongly influenced by the presence of a highly saline-alkaline lake. The lake decreased its extension during Bed II times until its complete disappearance by the time the uppermost levels of this Bed were deposited (Stanistreet, 2012).

Aside from pollen recoveries, Hay (1976) noted the presence of both phytoliths and silicified macroplant remains in the sediments from the area, but detailed work was not carried out until more recently. Phytolith studies carried out by OLAPP members were based on comparative studies with modern samples from analogous ecosystems present today in the region. In order to reconstruct the landscape at Olduvai based on phytolith analyses, the following steps were taken:

1) Actualistic studies of modern analogous landscapes based firstly on a detailed description of the vegetation and a systematic

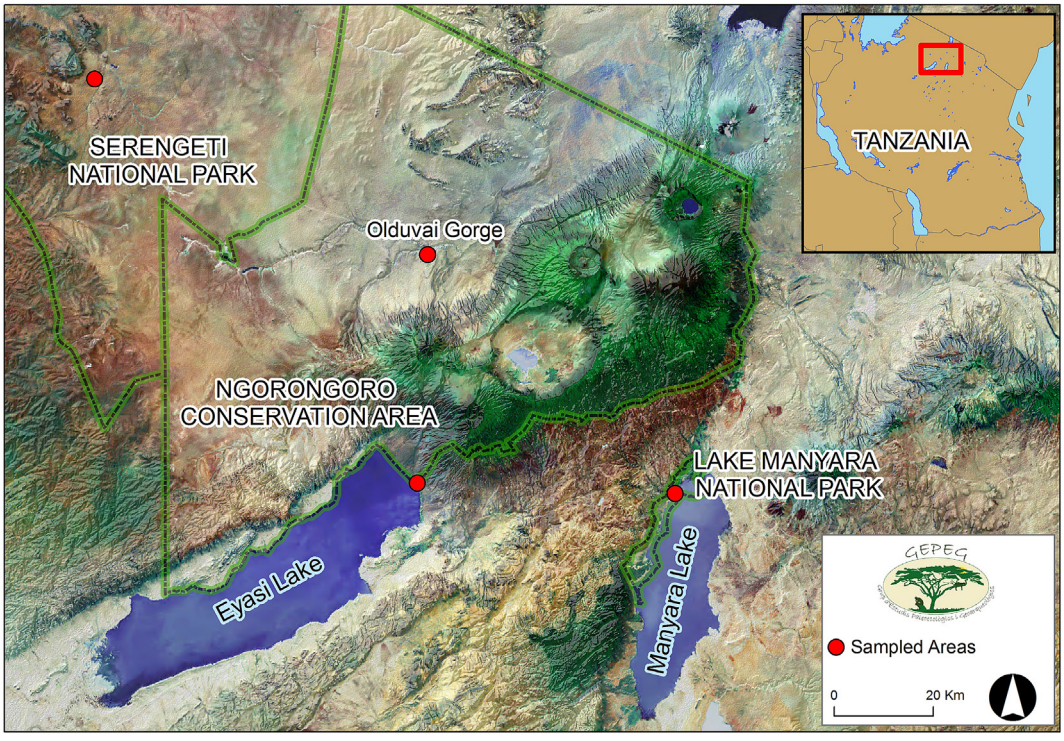

Fig. 1. Map of the Olduvai Gorge area in northern Tanzania in relation to the location of the modern study areas.