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Farmers, smelters and caravans: Two thousand years of land use and soil erosion in North Pare, NE Tanzania

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ABSTRACT

Slope deposits in North Pare provide evidence of two millennia of anthropogenically driven land clearance, soil erosion and land degradation. Drawing on deposit stratigraphy, soil magnetic parameters, stable carbon isotope composition and radiocarbon dating, three phases of soil erosion are distinguished characterized by distinct surface processes and increasing levels of agricultural land use.

Onset of slope deposit formation in Pare since about 300 BC documents soil erosion as an immediate consequence of new land use practices associated with the spread of agriculture and iron working across northern Tanzania. By AD 500, slope deposits extended into valley bottoms and to middle slopes suggesting catchment-wide land clearance and soil erosion. In the 15th century AD, progressive anthropogenic soil erosion had exhausted the topsoil resource and material changes of the slope deposits reflect widespread subsoil erosion. The exposure of subsoils represents an ecological tipping point and triggered the transition to a new morphodynamic framework dominated by runoff-based erosion processes that are recorded as sand lenses and sand layers. The most recent deposits show ongoing accelerated erosion and severe land degradation whilst cessation of sand lens preservation indicates pre-colonial intensification of agricultural land use. Land use changes and socioeconomic transitions associated with the establishment of the Ugweno chiefdom and the 19th-century caravan trade are discussed as possible responses to imperceptible long-term land degradation in Pare.

The study demonstrates that anthropogenic soil erosion and not external climatic drivers shaped landscape development in Pare and shows that the identification of environmental thresholds is essential for the assessment of resilience in human-dominated ecosystems.

1. Introduction

Despite a long-standing history of human occupation, effects and extent of anthropogenic landscape transformations in East Africa remain poorly resolved. Although few direct palaeoenvironmental evidence for early human activities is available, human agency is assumed to have become a main driver of vegetation and landscape development during the late Holocene (Kiage and Liu, 2006; Marchant et al., 2010). Particularly, the adoption of agricultural subsistence strategies and coeval spread of iron working have been associated with land clearance and environmental degradation in the Interlacustrine Region of East Africa (Schmidt, 1997) analogue to widespread deforestation and soil erosion documented throughout Europe (Butzer, 2005; Dotterweich, 2008; Dusar et al., 2011).

Palaeoenvironmental research in East Africa has focussed predominantly on long-term interactions between global climate dynamics, regional hydrological change and large-scale vegetation dynamics based on palaeoecological and sedimentological studies of high-altitude swamps and large lake basins (*e.g.* Beuning et al., 1997; Bonnefille and Riollet, 1988; Finch et al., 2009; Russell et al., 2007; Schüler et al., 2012; Verschuren et al., 2009). Strong evidence for human–environment interactions is only available from the Interlacustrine Region of Uganda, where Taylor et al. (2000) linked vegetation change during the second millennium AD with climate dynamics and socioeconomic transitions. However, palaeoecological reconstructions struggle to discern between climatic and anthropogenic drivers of late Holocene environmental change and forest decline in East Africa. Continent-wide trends to drier climatic conditions since the mid-Holocene (Gasse, 2000; Kiage and Liu, 2006; Marchant and Hooghiemstra, 2004) have masked the expected environmental impact associated with the spread of pastoralism and later agriculture. Particularly the lack of distinct pollen types of East African crops and the reliance on unspecific disturbance indictors as indirect signs of human activity complicate the identification of anthropogenic components of vegetation change (Kiage and Liu, 2006; Taylor et al., 2000; Vincens et al., 2003).

Terrestrial archives, in contrast, have so far received limited attention in the study of environmental change in East Africa. Undifferentiated hillslope deposits are widespread throughout the semi-arid and humid African tropics (Thomas, 1994). Generally called 'colluvium', these deposits range from widespread large-scale pedisediments along the footslopes of mountain ranges and inselbergs to valley infills

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and small deposits on hillslopes. Whereas the former are well known and thought to result from long-term cycles of climatic and tectonic stability and activity (Botha, 1996; Fölster, 1969; Rohdenburg, 1983; Sørensen, 2001), the latter are poorly understood but potentially important archives of human–environment interactions (Eriksson et al., 2000; Kadomura and Horii, 1987; Kersting, 2010; Mäckel, 1992; Sulas, 2010). As the corresponding archives of soil erosion, these small slope deposits are unique sources for the reconstruction of local landscape development and provide records of past surface processes directly related to vegetation and land use changes.

This study presents a multi-site investigation of colluvial slope deposits in the North Pare Mountains and reconstructs three phases of anthropogenic landscape transformations since the introduction of farming. Drawing on pedological benchmark characteristics, sedimentological features, soil magnetics and stable carbon isotope composition, deposit formation is linked to past slope processes and human land use practices, specifically forest clearance, cultivation and soil conservation measures.

2. Research background

As one of East Africans' 'islands of intensive agriculture' and well known for its terraces and irrigation features (Widgren and Sutton, 2004), the North Pare Mountains are an ideal starting point for the investigation of anthropogenic landscape transformations in East Africa. During the first millennium BC, food-producing subsistence strategies and iron working emerged in the Interlacustrine Region (Clist, 1987; Lane, 2004; Schmidt, 1997; Schoenbrun, 1993; van Grunderbeek et al., 1982). In the coastal regions of Kenya and northern Tanzania, this major socioeconomic transition has been associated with the spread of Kwale Ware, a local pottery tradition, since the first centuries AD (Soper, 1967a). In North Pare, habitation and iron working sites are, however, in their majority Later Iron Age and date to the second millennium AD (Chami, 1995; Fosbrooke, 1957; Odner, 1971; Stump, personal communication; see Walz, 2010 for the wider Pangani basin).

During the last centuries, the Ugweno chiefdom established a hierarchical society renown for the production and export of iron tools (Kimambo, 1969). Partly abandoned terraces and irrigation features are evidence of intensive agricultural land use in pre-colonial Pare (Sheridan, 2002) and scholars believe that agricultural intensification and extension have been stimulated by an economic boom in the wake of the 19th-century caravan trade (Håkansson and Widgren, 2007). Early European travellers von der Decken (1869) and Meyer (1890) confirm widespread agriculture in the 19th century and report not only cultivated fields but an open landscape, bare hills, few trees, low bushland and scattered forest patches. The latter prompted Baumann (1891:200) to suggest that forests once covered the mid-altitudinal cultivation zone. Pre-colonial land degradation is also reported from several other agricultural areas in Tanzania. In the Irangi hills and in Ugogo county, for instance, 19th-century European travellers and later colonial officers identified soil erosion and land degradation as a severe threat for agricultural production (see Berry and Townshend, 1972; Christiansson, 1981; Temple, 1972).

Based on palaeoenvironmental reconstructions, the present research addresses key questions of past human–environment interactions in Pare. Whereas land clearance and early landscape transformations can be linked to the introduction of agriculture and iron smelting, progressive anthropogenic soil erosion is identified as the trigger for land degradation, land use change and possibly also for socioeconomic change in pre-colonial Pare and later agricultural intensification during the 19th-century caravan trade.

3. The North Pare Mountains

The uplifted fault blocks of the Pare Mountains are part of the asymmetrical west-facing Pare–Usambara horst structure bounded by the extensional fault system of the Pangani rift (Fig. 1). Rocks consist of an undifferentiated granulite–gneiss complex developed during Proterozoic high-grade metamorphism (Bagnall, 1960). The occurrence of amphibolites, meta-gabbro, ultrabasic rocks and particularly quartz magnetite/ilmenite provides iron-rich raw material that was essential for the establishment of a prosperous pre-colonial iron industry. Block faulting preserved fragments of a former, probably Upper Cretaceous-Lower Tertiary, land surface (African surface) that shaped the current plateau morphology (Bagnall, 1960; Mutakyahwa et al., 2003). As a consequence, small watercourses and oversized hanging valleys on the undulating plateau (1200 m–1500 m a.s.l.) contrast with few deeply-incised streams along structural faults (Fig. 2). This general lack of entrainment on the Pare plateau facilitated aggradation and the accumulation of valley deposits.

Precipitation is controlled by the interplay between convectional rainfall during the north–south migration of the Intertropical Convergence Zone and thermally stable monsoonal air masses from the Indian Ocean (Flohn, 1964; Nicholson, 1996). In North Pare, a bimodal rainfall pattern prevails with long rains falling in March/April and short rains in November/December. The mid-altitudes of Pare receive annual rainfall between 1200 and 1300 mm yr^{-1}, in contrast to only 500 to 700 mm yr^{-1} at the eastern and western lowland plains (Heckmann, 2011).

Open Acacia-Commiphora woodland (Lovett and Pócs, 1993; White, 1983) on the lowland plains grades into secondary semi-deciduous woodland and dry forests on the steep slopes of the escarpment. The agriculturally important upland areas are densely populated and under cultivation. Smallholder agriculture prevails based on maize, banana, beans, cassava, yams and stall-fed cattle. Dispersed forest patches traditionally protected as sacred groves (Sheridan 2009) are remnants of a former submontane forest cover. Only the highest peaks Kindoroko (2112 m a.s.l.), Kamwalla, Mramba, and Ngofe are still covered by humid montane forests and are protected as forest reserves (Lovett and Pócs, 1993). Despite soil conservation programmes promoted by colonial and later development agencies, most of the Pare upland is strongly eroded. Land degradation and widespread exposure of subsoil

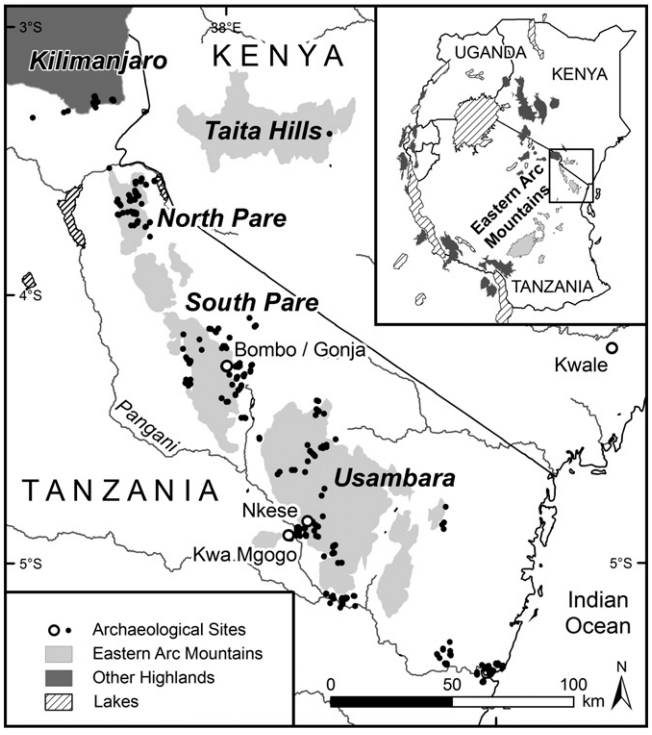

Fig. 1. Location of the study area and archaeological sites in north-eastern Tanzania.