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Reconstruction of a semi-arid late Pleistocene paleocatena from the Lake Victoria region, Kenya

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ABSTRACT

The effect of changing environment on the evolution of *Homo sapiens* is heavily debated, but few data are available from equatorial Africa prior to the last glacial maximum. The Karungu deposits on the northeast coast of Lake Victoria are ideal for paleoenvironmental reconstructions and are best studied at the Kisaaka site near Karungu in Kenya (94 to >33 ka) where paleosols, fluvial deposits, tufa, and volcaniclastic deposits (tuffs) are exposed over a ~2 km transect. Three well-exposed and laterally continuous paleosols with intercalated tuffs allow for reconstruction of a succession of paleocatenas. The oldest paleosol is a smectitic paleo-Vertisol with saline and sodic properties. Higher in the section, the paleosols are tuffaceous paleo-Inceptisols with Alfisol-like soil characteristics (illuviated clay). Mean annual precipitation (MAP) proxies indicate little change through time, with an average of 764 ± 108 mm yr^{-1} for Vertisols (CALMAG) and 813 ± 182 to 963 ± 182 mm yr^{-1} for all paleosols (CIA-K). Field observations and MAP proxies suggest that Karungu was significantly drier than today, consistent with the associated faunal assemblage, and likely resulted in a significantly smaller Lake Victoria during the late Pleistocene. Rainfall reduction and associated grassland expansion may have facilitated human and faunal dispersals across equatorial East Africa.

Introduction

Climate-driven environmental change is a commonly proposed mechanism for the dispersals of humans within and out of Africa through its effects on population distributions and demographics, biogeographic barriers, and resource availability (e.g., Ambrose and Lorenz, 1990; Scholz et al., 2007; Cowling et al., 2008; Blome et al., 2012; Eriksson et al., 2012; Soares et al., 2012; Rito et al., 2013; Faith et al., in press). The earliest fossil remains of *Homo sapiens* are known from East Africa at ~195 ka, and by as early as 80 to 60 ka populations had dispersed throughout Africa and also into Eurasia (e.g., McDougall et al., 2005; Brown et al., 2012; Soares et al., 2012; Rito et al., 2013). Few empirical data on climate or environment at relevant spatial or temporal scales are associated with archeological or early human fossil sites from equatorial East Africa prior to the last glacial maximum (LGM) (e.g., Blome et al., 2012), which limits understanding the ecology of early human populations and the mechanisms underlying their dispersals. Sediment cores from Lake Victoria provide continuous records of regional hydrology and vegetation back to the LGM (Kendall, 1969; Johnson et al., 1996; Talbot and Laerdal, 2000; Stager et al., 2002, 2011; Berke et al., 2012), but paleoenvironmental data prior to the LGM are sparse.

Deposits identified along the northeastern shores of Lake Victoria near Karungu, Kenya, dated to between 94 ka and >33 ka (Tryon et al., 2010; Beverly et al., 2015; Blegen et al., 2015; Faith et al., 2015), have the potential to provide fundamental paleoenvironmental and paleoclimatic information about equatorial East Africa during this critical interval of human evolution and dispersal (Fig. 1A and B). The sediments at Karungu preserve abundant vertebrate fossils and Middle Stone Age (MSA) artifacts (Owen, 1937; Pickford, 1984; Faith et al., 2015), which are considered the archeological signature of early *H. sapiens* in East Africa (McBrearty and Brooks, 2000; Tryon and Faith, 2013). The pre-LGM Karungu dataset complements, refines, and expands those from correlative deposits on Rusinga and Mfangano Islands ~40 km to the north (Tryon et al., 2010; Faith et al., 2011; Van Plantinga, 2011; Faith et al., 2012; Tryon et al., 2012; Faith et al., 2014; Tryon et al., 2014; Faith et al., 2015; Garrett et al., 2015). Previous evidence from MSA archeological and paleontological sites from Rusinga and Mfangano Islands suggests that the contraction of Lake Victoria and expansion of grasslands during the late Pleistocene may have facilitated the dispersal of large-bodied mammals, including humans, across Africa (e.g., Faith

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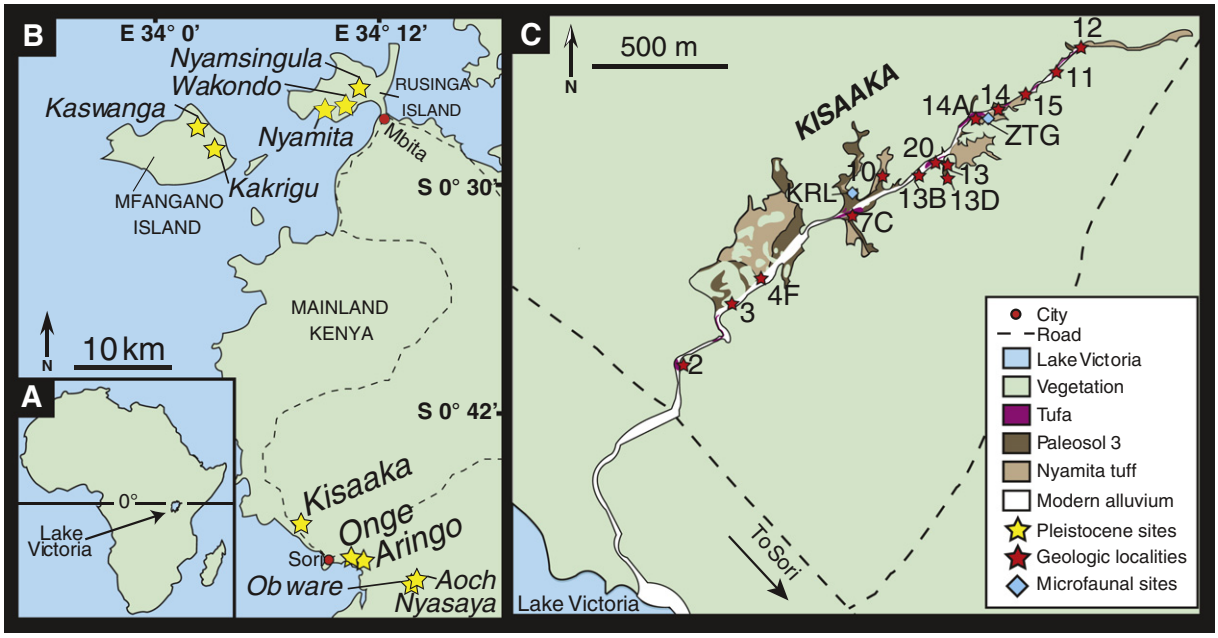

Figure 1. Location maps. A) Inset shows the location of Lake Victoria in East Africa. B) Location of Pleistocene sites along the eastern margin of Lake Victoria. C) Mapped lithologies exposed at the Kisaaka site with key geologic and microfaunal locations identified. Modified from Beverly et al. (2015).

et al., 2015, in press). However, the modeled reduction in the size of Lake Victoria requires a reduction in late-Pleistocene precipitation (Broecker et al., 1998; Milly, 1999), for which we had no direct evidence. Here, we provide the first quantitative estimates of paleoprecipitation through a multi-proxy analysis of paleosols from Kisaaka (Fig. 1C), one of seven Pleistocene artifact- and fossil-bearing

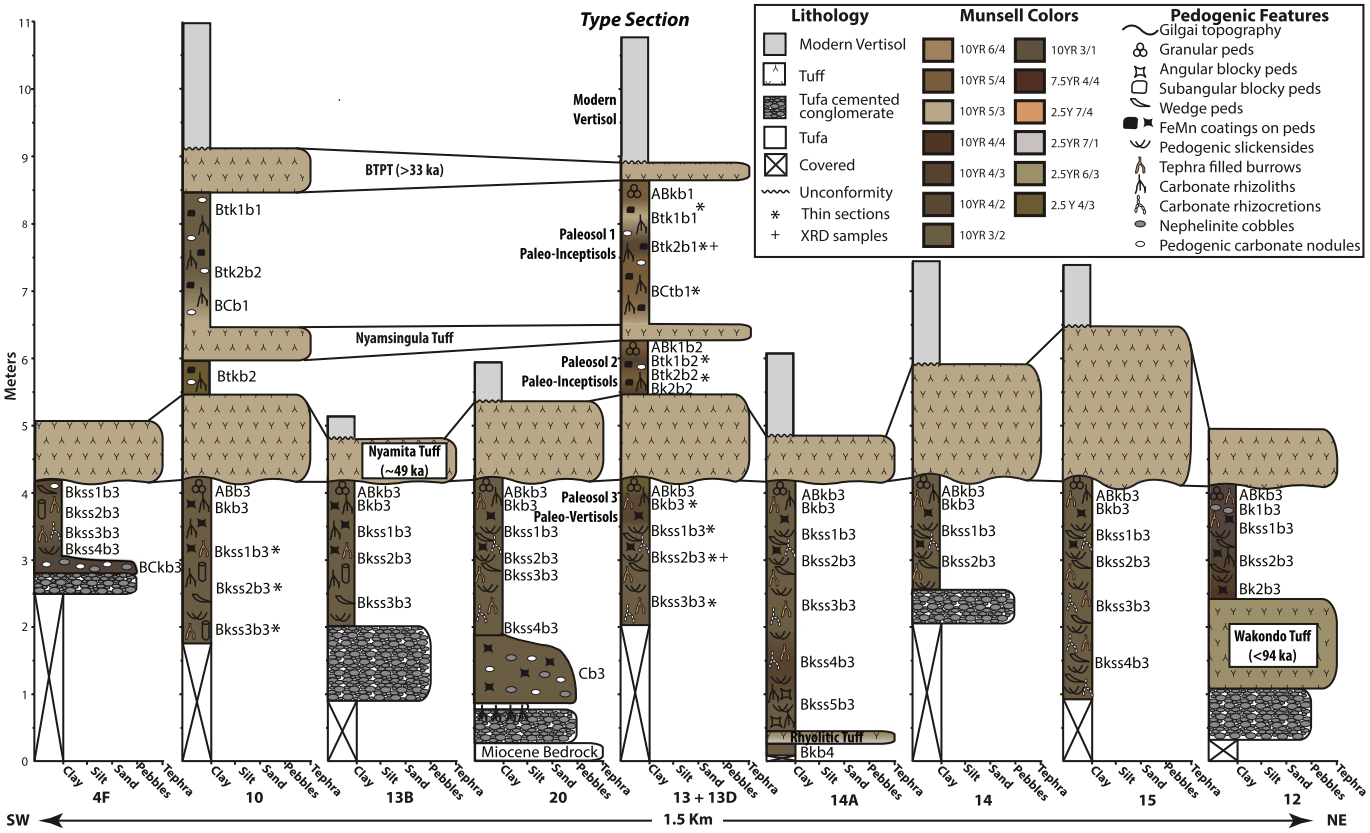

Figure 2. Measured stratigraphic sections from Kisaaka correlated using the base of the laterally extensive Nyamita Tuff as the datum and tephrostratigraphy by Blegen et al. (2015). Localities are arranged from north to south over 1.5 km transect. See Fig. 1 for location of sites. Pedogenic features, soil and tuff colors, soil horizons, and lithology are described in detail with three paleosols identified.