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Environmental change and human occupation of southern Ethiopia and northern Kenya during the last 20,000 years

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ABSTRACT

Our understanding of the impact of climate-driven environmental change on prehistoric human populations is hampered by the scarcity of continuous paleoenvironmental records in the vicinity of archaeological sites. Here we compare a continuous paleoclimatic record of the last 20 ka before present from the Chew Bahir basin, southwest Ethiopia, with the available archaeological record of human presence in the region. The correlation of this record with orbitally-driven insolation variations suggests a complex nonlinear response of the environment to climate forcing, reflected in several long-term and short-term transitions between wet and dry conditions, resulting in abrupt changes between favorable and unfavorable living conditions for humans. Correlating the archaeological record in the surrounding region of the Chew Bahir basin, presumably including montane and lake-marginal refugia for human populations, with our climate record suggests a complex interplay between humans and their environment during the last 20 ka. The result may contribute to our understanding of how a dynamic environment may have impacted the adaptation and dispersal of early humans in eastern Africa.

1. Introduction

Climatic change is broadly considered to be one of the major drivers for human migration including the dispersal of early modern humans (Beyin, 2011a; Rosenberg et al., 2011; Richter et al., 2012) and the shift from hunter-gatherers to pastoralism (Garcin et al., 2012; Lesur et al., 2014). However, it is not clear how far climate change has really affected human migration (e.g. Brandt et al., 2012) and how other factors, such as human agency, in the sense of individual self-determination and will, under the pervasive influence of culture, might have been involved (Ahearn, 2001; Dornan, 2002). The same issue applies to the role of climatic change for the emergence of technological and behavioral innovation (Ambrose, 1998; Garcin et al., 2012; Ziegler et al., 2013).

If climatic change is assumed to play an important role and the mode of climatic change could have controlled the way human populations responded to climatic variations, questions arise as to whether this depended on the duration and direction of transitional states. Furthermore, the question is whether short-term events or rather long-term gradual transitions were the relevant drivers. Finally, what type of climatic conditions are associated with human dispersal and whether abrupt changes to unfavorable conditions (e.g. towards increased aridity; deMenocal, 1995; Carto et al., 2009) may have triggered the migration of surviving populations to more favorable locations. Alternatively, a change towards favorable living conditions (e.g., a humid phase; Trauth et al.,

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2007; Kröpelin et al., 2008; Castañeda et al., 2009) may provide sufficient resources to allow the population to grow and subsequently disperse through otherwise ecologically critical zones into larger geographical space over several generations. The current debates on the way climate affects humans are hampered by the lack of continuous high-resolution terrestrial paleoenvironmental records in Eastern Africa (Brandt et al., 2012) and the limited availability of contemporaneous archaeological data of the same region (Basell, 2008; Leplongeon, 2014).

As a contribution to these discussions, we present a continuous high-resolution lacustrine record for the past 20 ka from Chew Bahir, a deep sedimentary basin in southwest Ethiopia. The record is correlated with the available archaeological record of human occupation in the region, as a way of evaluating the impact of different styles of climate change on local terrestrial ecosystems (including human societies) at various timescales (10^1–10^4 yrs). The evidence of human occupation is based on the variations in frequency of radiocarbon dates from archaeological sites in the SW Ethiopian highlands near the Chew Bahir basin and the shores of the lakes in the Main Ethiopian Rift (MER) and the Omo-Turkana basin (Fig. 1). The precipitation-rich highlands and these lakeshores are hypothesized to have been refugia and centers of innovation during times of climatic stress (Ambrose, 1998; Basell, 2008; Joordens et al., 2011; Brandt et al., 2012; Brandt and Hildebrand, 2005). The Chew Bahir basin, today a dried-out saline mudflat providing the climatic archive for our correlation, is situated in a biogeographically highly sensitive transition zone between the Main Ethiopian Rift and the Omo-Turkana basin where the fossils of the oldest known anatomically modern humans were found (e.g. Day and Stringer, 1991; McDougall et al., 2005, 2008; Sisk and Shea, 2008).

In order to evaluate how different rates of environmental change affected settlement pattern and cultural innovation for survival and adaptation, we test the extent to which gradual and rapid climatic events in the lacustrine sedimentary record are also expressed in the archaeological record of hypothesized refugia. Traditionally used for places where species survive during cold periods (López-García et al., 2010), the term refugium is used here for areas that might have permitted the survival of human populations during arid phases. We have considered the period since 20 ka BP because it encompasses both, the highest archaeological data coverage for post Middle Stone age assemblages (Basell, 2008) as well as a detailed sedimentary record of dry-wet alternation within a full precessional cycle. This is a novel experiment to compare both the paleoclimatological and archeological evidence directly from the source area of modern humans to test current hypotheses about how climate affects humans. Due to the incompleteness of the archaeological data set, the results are of course very preliminary and hypothetical, but could be an important starting point for further research in this field.

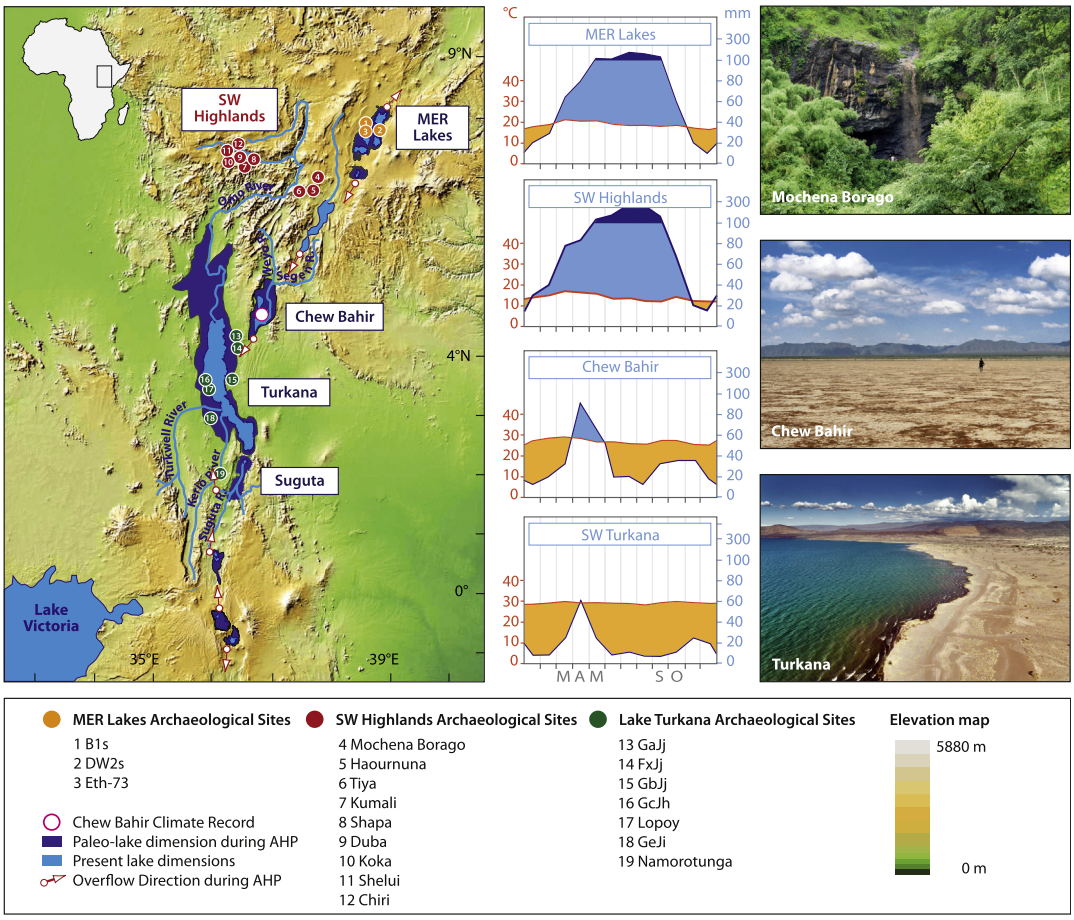

Fig. 1. Setting of the Chew Bahir basin and archaeological sites in potential refugia. Archaeological sites are indicated by colored circles and numbers, that correspond to site names and numbers in Supplementary Table 1, to provide complete sample ID and cultural association. The pink circle marks the site of the Chew Bahir record. Climate diagrams represent monthly temperature means in deg C and precipitation in mm/month (IRI, last accessed 2/2014). Photographs from top: (1) Mochena Borago rock shelter in the SW Ethiopian highlands; (2) mudflats of the Chew Bahir basin, with the Hammar range in the background; (3) aerial shot of Lake Turkana, NE shore. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)