How Dry was too Dry?

Evaluating the Impact of Climatic Stress on Prehistoric Human Populations in southern Ethiopia

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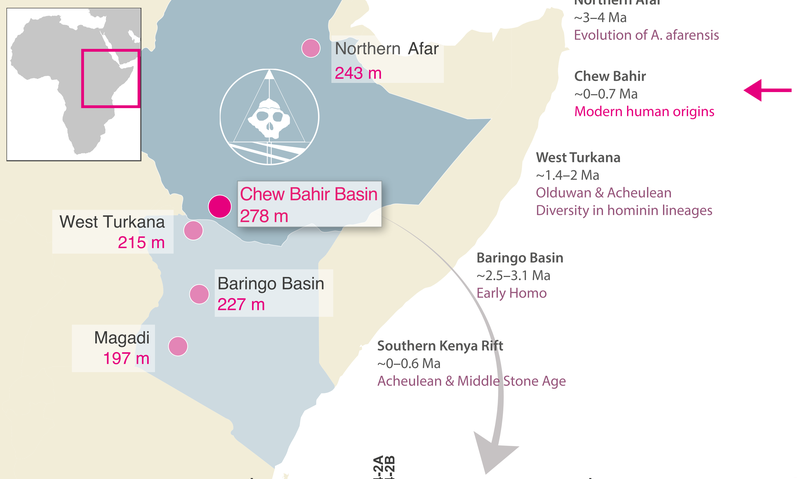
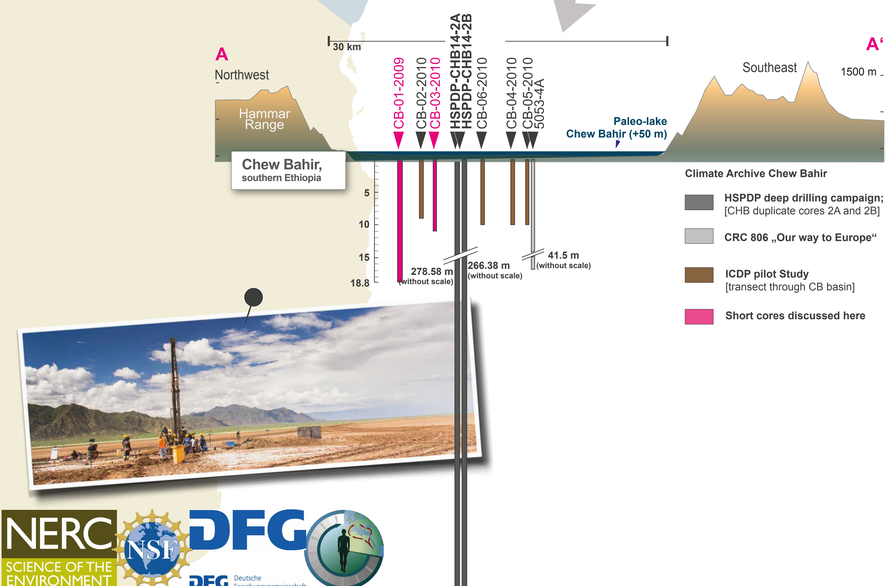
In search of the environmental context of...

In search of the environmental context of the evolution and dispersal of *Homo sapiens* and our close relatives within and beyond the African continent, the ICDP-funded Hominin Sites and Paleolakes Drilling Project (HSPDP) has recently cored five fluvio-lacustrine archives of climate change in East Africa. The sediment cores collected in Ethiopia and Kenya are expected to provide valuable insights into East African environmental variability during the last ~3.5 Ma. Here we present a comparison between the youngest part of our continuous climate reconstruction from the Chew Bahir site in southern Ethiopia and the available archaeological record of human presence in the source region of modern humans for the past 20 ka.

...human evolution and dispersal





Testing the impact of environmental instability

In order to evaluate the effect of environmental instability on human evolution, with their cultural and technological innovations, and with their expansion out of Africa, it is essential to understand how the east African climate switches from dry to wet and back to dry. Determining the timespan of both long-term transitions and climate flickers eventually provides the much needed environmental information how much time early humans had to react (**evolution, migration, adaption**) to the profound changes in their living environment.

Settlement patterns in potential refugia

Figure 1 | Ecologically favourable zones of lake marginal and precipitation rich montane habitats (refugia) are hypothesised to have been preferentially occupied during intervals of climatic stress. (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.

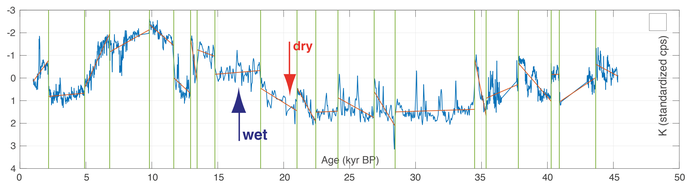


Figure 2 | Determining the timespan of both long-term transitions and climate flickers: **Chew Bahir climate record (short core).** A change point search algorithm shows changes in the trend of the K concentration (indicating aridity): How much time did prehistoric humans have do react to different modes of climatic stress?

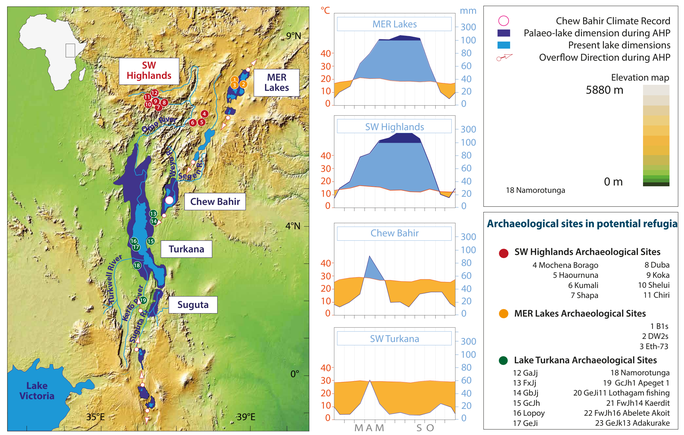


Figure 3 | Prehistoric settlement patterns are derived from radiocarbon frequency at archaeological sites in potential refugia: the precipitation rich SW Ethiopian highlands; Main Ethiopian Rift Lakes and Rift Lake Margins around Lake Turkana. Archaeological sites are indicated by colored circles and numbers. 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 (after Foerster et al., 2015).

Climatic stress and migration

Despite the fact that human decision-making within certain environmental boundaries plays an important though incalculable role, our analysis tends to support the hypothesis that ecologically favourable zones of lake marginal and precipitation rich montane habitats (refugia) were preferentially occupied during intervals of climatic stress during the last 20 ka BP (Fig.).

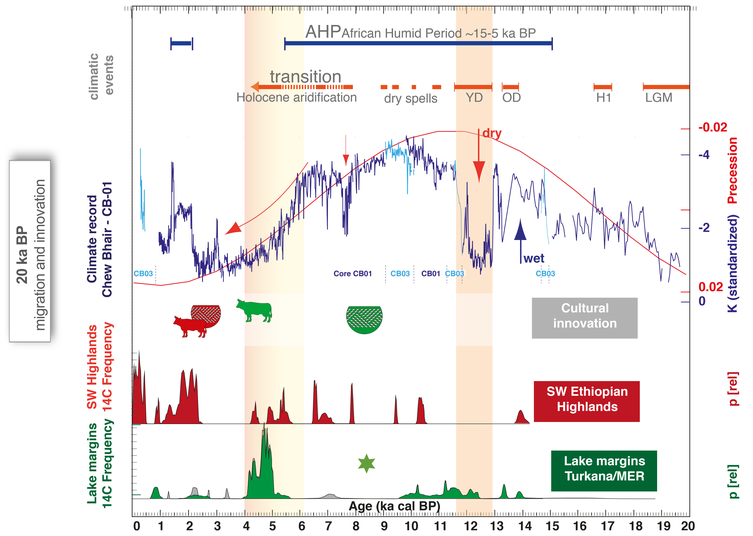


Figure 4 | Comparison of **(A)** the 20 ka Chew Bahir climatic record (K content as a proxy for aridity) and the variations with the earth's precession with **(B)** settlement in the SW Ethiopian Highlands and around lake margins. Settlement activities in both potential refugia are indicated by radiocarbon frequency of archaeological finds (Foerster et al., 2016).

Environmental change and innovation

Cultural innovation is indicated by first documented wavy-line pottery (pot symbol) and the introduction of pastoralism (cow symbol); red or green colors refer to SW highlands or lake margins respectively. An adaption to a changing environment by changing the subsistence strategy is sometimes assumed to be the beginning of herding in the Late Holocene period and can only be a long-term process, eventually caused by long-term climatic shifts.

How dry was too dry?
Climatic stress on timescales of human evolution

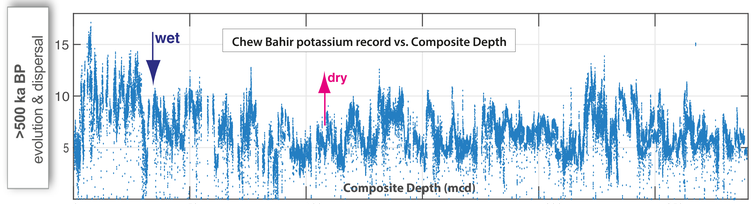


Figure 5 | The HSPDP **Chew Bahir long core covering >500 ka BP**: The K record shows pronounced climatic change on different time scales. Which environmental thresholds and which transitions fuelled human evolution? What was the impact of climatic stress on dispersal and migration?