Introduction

The climate of East Africa is driven by the position of the Intertropical Convergence Zone (ITCZ). The intensity and position of the ITCZ related tropical rain belt changes depending on the interhemispheric temperature gradient (Broccoli et al., 2006). During the early Holocene boreal summer insolation maximum, the mean position of the tropical rain belt shifted north leading to increased precipitation across northern Africa (Gasse, 2000). Additionally, an increased land-ocean temperature gradient caused a strengthening of the West African Monsoon (WAM) and Indian Summer Monsoon (ISM) generating a water level rise in African lakes (Junginger et al., 2014; Lezine et al., 2014). This shifted to a more pluvial early-mid Holocene (12.5 ka), termed African Humid Period (AHP) (DeMenocal et al., 2000), which was particularly intense in North Africa and extended south until 10° S in East Africa (Gasse, 2000). While the general mechanisms for the orbitally-forced AHP are well understood the spatial and temporal patterns are highly debated.

As part of the Research Unit FOR 2358 ‘The Mountain Eisle Hypothesis’, we address the question of how humans benefited from and reshaped African high-altitude ecosystems during Quaternary climate changes. Therefore, we investigated the high-altitude, small catchment, cirque lake Garba Guracha at 3950 m asl - an ideal sedimentary archive for reconstructing allo-palaeoclimates.

We show geochemical, biomarker and diatom isotopes (δ¹³C and δ¹⁸O) results for the Late Glacial and Holocene. Specifically, we aim to:

1. develop a robust chronology,
2. reconstruct the sedimentary history and
3. the climate and lake level history since the Last Glacial.

Discussion

Methods

We analyzed the sediments of Garba Guracha (15.5 m core):

- XRF analysis was performed at Aberystwyth University using the FRAXX core scanner.
- Total carbon (TC), total nitrogen (N) and stable carbon and nitrogen isotopic composition (δ¹³C and δ¹⁵N, respectively) were determined for 110 mixed sediment samples covering roughly 10 cm intervals.
- TC is equal TOC.
- 88 samples were analyzed for δ¹³Cwater and δ¹⁸Owater.
- 20 samples were analyzed for δ¹⁸Owater.

Chronology

For radiocarbon dating, we took a total of 27 samples. Apart from 14 bulk sediment ages, we obtained ¹⁴C ages from 8 bulk n-alkanes and 5 charcoal samples from the organic-rich top 9 meters of the core.

All ¹⁴C ages are in stratigraphic order. The bulk n-alkanes and the charcoal samples, both obtained from the same core centimeters, yielded similar ages without any systematic age offset. Additionally, there is no age offset for the two charcoal ¹⁴C ages. The surface core top (70 cm) was ⁴¹⁹Pd dated. Tephra layers were analyzed and correlated.

Environmental implications

Phase 1 (Fig. 2): High sedimentation rates, high minerogenic input and low TOC values point to fast filling lake bed with low a vegetated catchment. Low TOC/N values and relatively positive δ¹⁸O values point to aquatic algae as dominant organic matter source.

Phase 2: The time period of the northern hemisphere Younger Dryas (YD) is marked by a decrease in sedimentation rates by ~80% indicating a dry or and cold phase.

Phase 3: With increasing insolation TOC and TOC/N reach the highest values between the Holocene onset and 4.3 ka (ca. African humid period) - AHP pointing to a phase of favorable growth conditions. Most negative δ¹⁸O values support high rainfall amounts (amount effect), a different moisture source (source effect) or an intermediate P/E value and an overflowing lake. North-hemisphere cold spells (8.2 and 6.5 ka event) are visible in different proxies.

Phase 4: A rapid change in TOC, TOC/N concurs with the 4.2 ka event known as a shift to dryer conditions.

Conclusions

- Dating of compound class n-alkanes is a valuable tool for lake sediment dating in small catchment areas.
- The minimum age of deglaciation is ~16000 cal. yrs BP.
- δ¹⁸Owater can be used as proxy for δ¹⁸Owater,
  - δ¹⁸Owater as aquatic signal supports this finding.
  - Most negative δ¹⁸O values agree with other records from the region (Fig. 3) pointing to increased precipitation or a different moisture source.
  - Moreover, the range of δ¹⁸Owater can not be explained by source and amount effect alone. Epavrophic enrichment must be considered by interpreting the δ¹⁸Owater record.
- Most negative δ¹⁰ values between 10 and 7 ka concuring with the AHP indicating a high P/E ratio and an overflowing lake.
- Northern hemisphere events (8.2, 6.5, and 4.2 ka) are visible in the Garba Guracha record

References