Distribution of Glycerol Diakyl Glycerol Tetraethers (GDGTs) in surface soils and Crater Lake sediments from Mount. Kenya, East Africa

Christine Omuombo(1,2), Arnaud Huguet(2), David Williamson(2,3) and Daniel Olago(1)

(1) University of Nairobi, (2) UMR METIS CNRS/UPMC, (3) IRD
Outline of Presentation

• Background information
• Introduction
• Methods
• Results and Discussion
• Conclusions
• We read geological materials: Lake sediments, Marine sediments, Peat, Corals, Ground water, Speleothems, tree rings, ice, etc.
Multidecadal variability hydroclimatic variability in East Africa

- Proxy indicators of relative moisture balance and model simulations

- Indian Ocean drives East African in decadal rainfall variability

Tierney et al 2013, Nature
The use of GDGTs

- The thermal history of the Quaternary period in tropical Africa is unknown in the current climate models. This has resulted in utilisation of robust proxies suitable for the climatic reconstruction.

- One such proxy is based on the molecules called **Glycerol Diakyl Glycerol Tetraethers (GDGTs)**

- **GDGTs** - core membrane lipids that are synthesised by archea (iGDGTs) and some bacteria (BrGDTs).

- BrGDTs - straight or branched alkyl chains linked by ether bonds to the glycerol backbone
Variations of the structure as a function of environmental parameters

Number of cyclopentanes depend on the pH

Number of Methyl groups correlated with air temperature and to a lesser extent with soil pH
Introduction

- Why study the GDGT in soils and sediments
  - ubiquitous lipids in aquatic and terrestrial environments (core lipids - higher persistence in the environment)
  - Temperature and pH proxies increasingly used of the reconstruction of past environmental changes
  - Improvement of the current understanding the temperature changes in Mt. Kenya over the Late Holocene
• Eastern side of the EA rift

• Lakes are linearly aligned on the NW slopes of Mt. Kenya

• Lake Nkunga - 1780m asl
• Sacred Lake - 2350m asl
• Lake Rutundu - 3088m asl
High performance liquid chromatography/atmospheric pressure chemical ionization-mass spectrometry (HPLC/APCI-MS)
Soil pH relationship with the cyclisation index

- Estimated pH vs CBT = determination coefficient of 1
- Lower CBT = higher pH values
Reconstructed Mean Annual Air Temperature (MAAT)

Good linear relationship between the reconstructed MAAT and altitude.

Lapse rate $0.9^\circ\text{C}/100\text{m}$ and $0.5^\circ\text{C}/100\text{m}$

MAAT can be estimated from the Methylation and cyclisation degrees of the GDDTs.
Comparison with Mt. Kilimanjaro record

Good linear relationship

Microclimate and seasonality variations on individual mountains
Lake Nkunga MAAT

Progressive cooling from ~1100 Cal Yrs BP to present by 8°C (Tierney et al. 2010) and 5°C (Loomis et al. 2012)

I : ca. 500 Cal yrs BP- Present
II : ca. 700 - 500 Cal yrs BP
    Transitional period probably aridity transition?
III : ca. 1100 - 700 Cal yrs BP
    Medieval Warming Period??
Tierney et al. 2010 calibration progressive cooling vs Loomis et al. 2012 calibration progressive warming

Other proxies indicate that ca. 4500 Cal yrs marks the beginning of the hot and dry conditions in EA due to the suppression of the monsoon.

Need to re-examine the results to derive conclusive changes.
Do these fluctuations represent the late Holocene climate variability pulsed with precipitation and aridity??

- Huge disparity in the values with a 4 – 12°C difference depending on the calibration
- Progressive cooling from ~4500 to 2500 Cal yrs BP. followed by progressive warming from ~2500 to 1000 Cal yrs BP and some cooling to Present day (Loomis et al. 2012)
Conclusions

• The use of GDGTs as temperature and pH proxies in soils and lake sediments from East African mountains is promising.

• The current calibrations give similar trends although they need conform with available instrumental records.

• The robustness of the MBT/CBT temperature proxy in equatorial East Africa for a large altitudinal range is evident from the results obtained.

• Lake sediment calibrations do not necessarily give the same temperature trends, suggesting that regional calibrations may be needed.
Thank you