LINKING IN-SITU PRODUCED LIPID BIOMARKERS TO SEASONAL AQUATIC COMMUNITY DYNAMICS: A DETAILED STUDY AT LAKE CHALLA, EAST AFRICA

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Lake sediments are important archives of past climate and ecosystem variability, especially in the tropical regions where high-quality paleoenvironmental records are scarce. In November 2016, the ICDP project DeepCHALLA recovered 214 m of laminated mud from Lake Challa, a small crater lake on the border of Kenya/Tanzania. In order to fully understand the to-be-constructed biomarker records of the ~250,000 years of lake and climate history archived in these sediments, we conduct an extensive and unique study to link biomarkers present in the water column to modern-day lake system processes. Here we present data on lipid biomarker distributions in suspended particulate matter (SPM) sampled at 13 water depths (0 to 90 m) over 17 consecutive months (September 2013 to January 2015). We also analysed particulate organic carbon (POC) and dissolved inorganic carbon (DIC) concentration and its stable carbon isotopic composition, bacterial and archaeal 16S rRNA gene composition, and phytoplankton counts in the upper 20 m, thus enabling thorough assessment of the origin of the observed biomarker signatures.

We found biomarkers from a wide range of source organisms, including various groups of phytoplankton, zooplankton, bacteria and archaea. For example, high concentrations of *n*-$C_{23:1}$, *n*-$C_{25:1}$ and *n*-$C_{27:1}$ alkenes correlate with blooms of Chlorophyta species in July-October 2014 that developed at the onset of deep water-column mixing, before the diatom bloom starts (Fig. 1). This indicates that certain species of Chlorophyta are the primary producers of *n*-alkenes in Lake Challa, as previously tentatively suggested by van Bree et al. (2014). These long-chain *n*-alkenes have been identified in many East African lakes, and the link to Chlorophyta may be useful in reconstructing past levels and ratios of essential nutrients available to lake phytoplankton. Different trends in the known diatom biomarkers (iso)loliolide and $C_{20:5}$ fatty acids suggest that it may be possible to differentiate between the two dominant local diatom species *Afrocymbella barkeri* and *Nitzschia* sp. nov. The sum of phytadienes, which are degradation products of chlorophyll-derived phytol, correlate well with total productivity based on phytoplankton counts, and may therefore serve as a biomarker for past changes in lake productivity. Interestingly, there are also compounds that show a distinct seasonal signal but cannot be directly related to any source organism, e.g. the *n*-$C_{19:1}$ alkene peaks between December 2013 and March 2014, at the start of the contemporary shallow mixing period (Fig. 1). Based on this timing and a lack of correlation with the algal phytoplankton groups, we suspect a cyanobacterial origin. Compound-specific $\delta^{13}C$ analysis and ongoing 16S rRNA gene analysis should reveal their exact biological origin. Finally, temporal trends in the abundance and depth distribution of tetraether lipids (brGDGTs) show a strong relation with oxygen availability in the water column, suggesting an aquatic origin. The concentration of brGDGT-Ib and IIb peaks during anoxic conditions, as does the degree of cyclisation, implying that they are likely produced by an anaerobic

microbial community. Notably, the amounts of land-derived biomarkers such as long-chain *n*-alkanes, other plant waxes and soil derived GDGTs are limited in the SPM, even though they are commonly present in the sedimentary record. This absence of land-derived organic matter confirms SPM as a recorder of predominantly water column processes. Analysis of sediment-trap material should shed light on the mechanism of (land-derived) biomarker transport through the water column to the sediment.

This on-going interdisciplinary study on the microbial community inhabiting the modern water column of Lake Challa is very promising in linking specific organisms to specific lipid biomarkers. This strong connection between biology and its molecular remnants will be important in the light of future work on the ~250,000 year DeepCHALLA sediment record and other lake sediments.

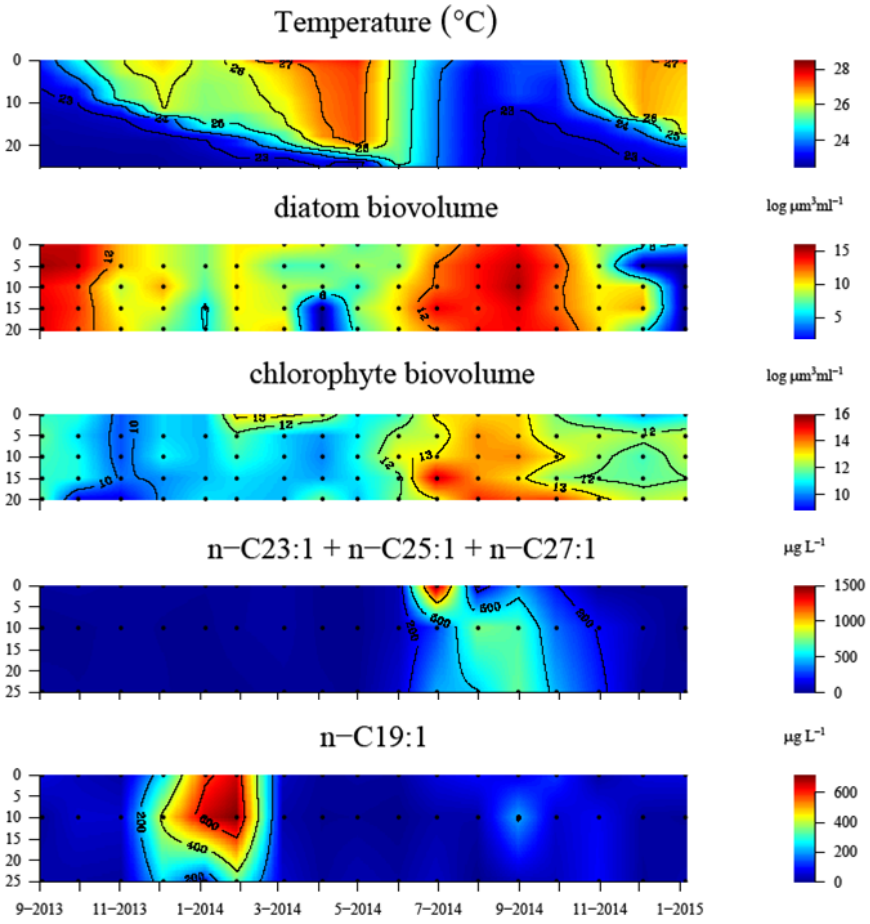

Figure 1. *Depth distributions and temporal changes in the Lake Challa water column. The upper panel shows measured temperature variability in the water column of Lake Challa, indicating stratified conditions during wet seasons, and a long mixing period during dry southern hemisphere winter months. Reconstructed biovolumes of diatoms and chlorophytes are based on microscope counts (log scale), and are compared to the concentration of long-chain n-alkenes and the n-$C_{19:1}$ alkene. Black dots indicate analysed samples.*

References

van Bree, L.G.J., Rijpstra, W.I.C., Cocquyt, C., Al-Dhabi, N.A., Verschuren, D., Sinninghe Damsté, J.S., de Leeuw, J.W., 2014. Origin and palaeo-environmental significance of C_{25} and C_{27} *n*-alk-1-enes in a 25,000-year lake-sedimentary record from equatorial East Africa. Geochimica et Cosmochimica Acta 145, 89-102.