European Association of Organic Geochemists

HETEROCYST GLYCOLIPIDS: NOVEL TOOLS FOR RECONSTRUCTING CONTINENTAL CLIMATE CHANGE

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Lipid paleothermometers have become an indispensable tool in paleoenvironmental research as they provide qualitative and quantitative information on Earth's climate evolution as well as on the pace of climate change. While the $U^{K'}_{37}$, TEX_{86} and LDI are commonly employed in (pale)oceanographic studies, their application in freshwater settings is generally less robust. There is thus a pressing need for molecular temperature proxies that can bridge this gap and allow for the quantitative reconstruction of temperature variability across continental systems. In this respect, heterocyst glycolipids (HGs) are particular promising. These components are synthesized by N_2-fixing heterocystous cyanobacteria (Nichols and Wood, 1968; Bauersachs et al., 2009), which are oxygenic photoautotrophs and common component of the phytoplankton community in many freshwater lakes worldwide (Whitton, 2012). Previous culture experiments (Bauersachs et al., 2014) and investigations of water column profiles (Bauersachs et al., 2015) have provided compelling evidence that HG distribution patterns are significantly correlated with growth temperature. Hence, the sedimentary distribution of HGs may offer the exciting possibility to reconstruct surface water temperatures (SWT) in lacustrine settings.

In order to validate and ground truth the potential of HGs as a novel proxy in continental climate research, we investigated the distribution of HGs in surface sediments of 44 tropical East African lakes located on an altitudinal transect from 615 to 4237 masl and surface water temperatures varying from 5.8 to 27.9°C. HGs were omnipresent in the studied lakes but their overall distribution changed gradually along the investigated transect, indicating altitude-dependent shifts in the cyanobacterial community structures. The most abundant and widespread cyanobacterial lipids were HG_{26} diol and HG_{26} keto-ol that on average constituted more than 50% of all HGs (Fig. 1). Interestingly, the relative distribution of both components - expressed as the heterocyst diol index of 26 carbon atoms (HDI_{26}; Bauersachs et al., 2015) - was significantly correlated with SWT ($r^2 = 0.93$; $p < 0.001$) and ranged from 0.55 in Lake Speke (4235 masl; 5.8°C) to 0.97 in Lake Albert (615 masl; 27.9°C), providing first proof for a temperature controlled distribution of HGs in lacustrine surface sediments. In addition, we tested the application of HGs in a sediment record of Lake Tanganyika (East Africa), covering the last 30,000 years, and found a downcore decrease in HDI_{26} values from 0.97 at the core top to 0.88 at ~20,000 years BP. Using the temperature calibration of East African lakes, this change corresponds to an overall increase in SWT by about 3-4°C from the last glacial period to the present-day, which is in agreement with temperature estimates based on the TEX_{86} lipid paleothermometer (Tierney et al., 2010).

Our results thus demonstrate that sedimentary HG distribution patterns (1) allow studying changes in cyanobacterial community structures and (2) capture modern and past surface water temperature signals in lacustrine systems. Given that heterocystous cyanobacteria are common in most polar to tropical freshwater environments, the HDI_{26} represents an interesting novel proxy for reconstructing continental climate change, which is presently not or only inadequately achieved by the existing lipid paleothermometers.

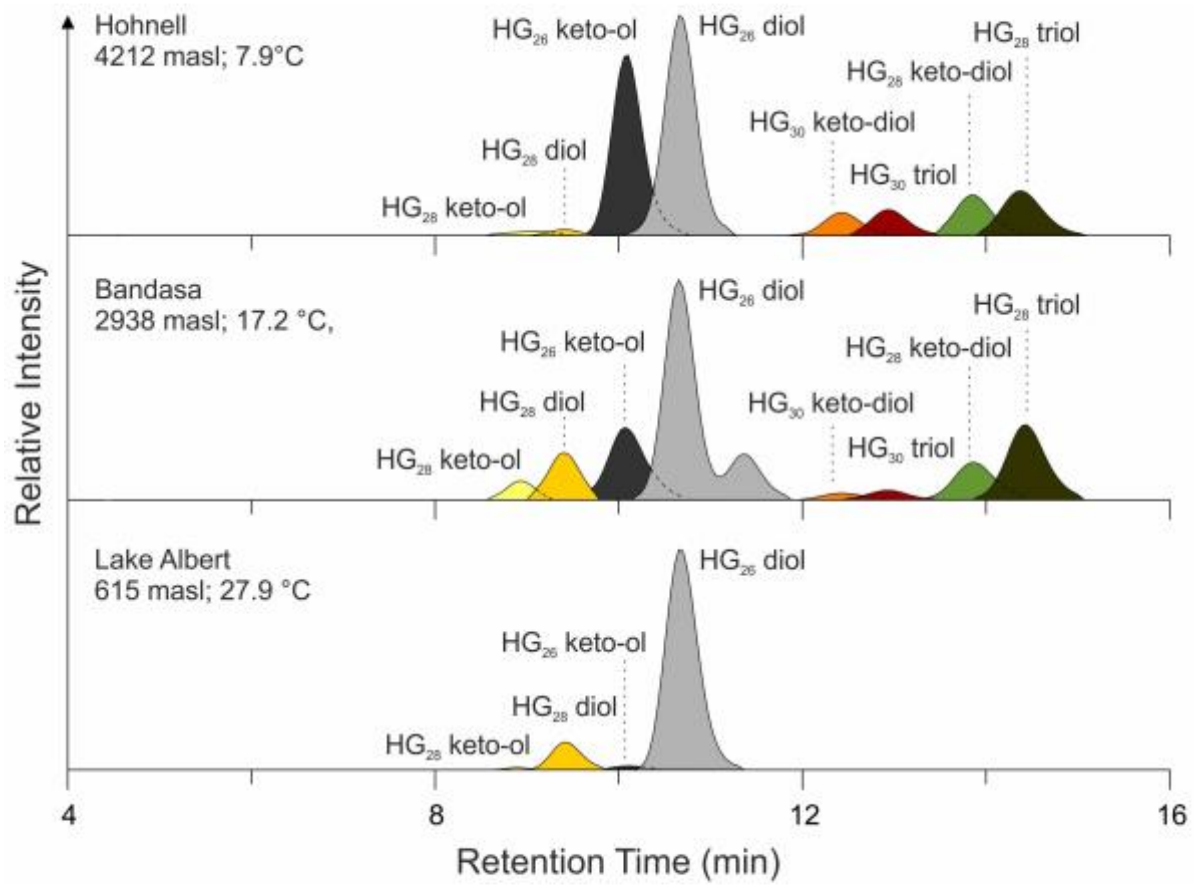

Figure 1. *HG distributions in surface sediments collected from East African lakes of different altitude. Note the increase in the relative abundance of HG diols and triols compared to HG keto-ols and keto-diols with decreasing elevation (e.g. increase of HG_{26} diol in relation to HG_{26} keto-ol) that evidence a strong temperature control on the sedimentary distribution of HGs.*

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