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Quantifying Holocene temperature changes using bacterial and archaeal membrane lipids (GDGTs) in the Swiss Alps

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Currently, Holocene paleoclimate research shows discrepancies in the timing and extent of the so-called Holocene “climate optimum” (1). To better understand this phenomenon in the alpine region, we examine the mean annual air temperature (MAT) record based on the distribution of Glycerol Dialkyl Glycerol Tetraethers (GDGTs) in a 14-m long sediment core from Lake Rot, Switzerland. This small eutrophic monomictic lake is characterized by a seasonally anoxic hypolimnion. An age model based on 20 calibrated ^{14}C dates shows that the top 10 m of sediments reflect the early, middle, and late Holocene (10 cal. ka BP to recent).

To constrain environmental changes, we also look at total organic carbon (TOC), total inorganic carbon (TIC), total nitrogen (TN), and bulk organic matter $\delta^{13}C$ and $\delta^{15}N$ (n = 300). These indices give insight into the sources of organic matter in Lake Rot sediments. A stable and dominantly in-situ produced lacustrine source of organic matter is indicated by the range in C/N values (4-17) and $d^{15}N$ values (-0.37-5.84). Increasing TOC and $\delta^{13}C$ values during the early Holocene (around 10 cal. ka BP), likely reflect elevated primary production in the lake during postglacial climate warming. Subsequently, high TIC values indicate a period with high calcite precipitation (10-8 cal. ka BP). Between 8-1.5 cal. ka BP, high TOC and very low TIC values indicate a dramatic change in the system, reflecting a higher production and/or conservation of organic matter. After this period, TOC decreases, showing a last increase in the top 50cm of the core, presenting signs of eutrophication. Lake Rot thus has experienced large changes in the last 10ka.

From a subset of 63 samples, GDGTs are analysed to reconstruct MAT using the methylation index of brGDGTs (MBT'_{5ME}). Using a lake calibration (2), reconstructed average MAT is 8.4℃ (RMSE = 2.1℃). The absence of large temperature changes during the Holocene highlights that the MBT'5ME-based reconstructed temperatures are not influenced by the large changes in water chemistry recorded by the bulk TOC and TIC values. Instead, the temperature reconstruction reflects stable Holocene temperature ranges, presenting no expressed “climate optimum” in this core. The most

recent reconstructed temperature of 9.7℃ resembles actual measured MAT (10.7℃).

Based on our results, the isoprenoid GDGT TEX86 is not applicable for the reconstruction of temperature in Lake Rot. This matches a recent study of perialpine lakes where the successful application of TEX_{86} was suggested to be limited to deep lakes (>100 m) (3). In addition, we will discuss whether production of in-situ brGDGTs in the water column and seasonality influence the sediment temperature record, as proposed by the authors and other studies (2,4).

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