Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.35934

Linking Lipidomics and Metagenomics: Novel Tetraether Lipids Found in a High-CO_2 Geyser

LEONIE WITTIG[1], JANINA GRONINGA[1], FERIEL BOUDERKA[2], TILL BORNEMANN[3], JULIUS SEBASTIAN LIPP[1], FLORENCE SCHUBOTZ[1], SASKIA KEDEN[1], ALEXANDER JOSEF PROBST[3] AND KAI-UWE HINRICHS[1]

[1]MARUM – Center for Marine Environmental Sciences, University of Bremen, Germany
[2]Environmental Metagenomics, Research Center One Health Ruhr of the University Alliance Ruhr
[3]University of Duisburg-Essen

Glycerol dialkyl glycerol tetraethers (GDGTs) are common and widespread archaeal lipids and important biomarkers to reconstruct past and present biogeochemical conditions. They are composed of two biphytane side chains linked to two glycerol backbones by ether bonds. Over the last decades, numerous structural modifications have been reported within the archaeal lipidome, especially in extreme environments. Examples for typical archaeal membrane lipid adaptations include the incorporation of cyclopentane rings within the side chains as well as unsaturation.

The CO_2-rich, nutrient-limited, cold-water Geyser Andernach in Germany is dominated by the archaeal community member *Candidatus* (*Ca.*) Altiarchaeum [1]. During our ultra-high-resolution mass spectrometry studies on the lipidome of this geyser, we identified tetraether lipids with an asymmetrical addition of up to two isoprenoid units to one of their side chains. Additional screening of the Geyser Andernach metagenome confirmed the presence of tetraether synthase genes (*tes*) and therefore the capacity for GDGT synthesis by *Ca.* Altiarchaeum and its apparent inability to form cyclopentane rings indicated by the absence of GDGT ring synthase genes (*grs*). Given their dominance in this habitat, they are the most plausible source of both typical and extended tetraether lipids, providing first support for their predicted ability to synthesize tetraethers based on metagenomic evidence from previous studies [2]. The synthesis of these lipids represents an overlooked adaptation mechanism in archaea.

These findings add insight into the adaptation of microorganisms that thrive in CO_2-rich subsurface environments and may be a potential molecular indicator for CO_2-dominated microbial habitats. They are therefore of interest for our project on relicts of ancient cellular biochemistry in high-CO_2 subsurface ecosystems. This project aims to enhance the understanding of microbial communities that live under high-CO_2 conditions, exploring their role in the carbon cycle, and uncovering ancient CO_2 fixation pathways by combining biogeochemical and microbiological approaches.

[1] Bornemann et al. (2022), *Nat. Commun.,* 13, 1, 284.
[2] Zeng et al. (2022), *Nat. Commun.,* 13, 1, 1545.