Preservation of Lipid Biomarkers Under Prolonged and Extreme Hyperaridity in Atacama Desert Soils

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Abstract text:

Molecular biomarkers are the most direct biosignatures of life on early Earth and a key target in the search for life on Mars. Lipid biomarkers are of particular interest given their ability to survive oxidative degradation and record microbial presence and activity of microorganisms that occurred billions of years ago (*Eigenbrode, 2008*). Environmental conditions that suspend biotic and abiotic degradative processes prior to lithification can lead to enhanced biomolecular preservation over geological time-scales. The hyperarid core of the Atacama Desert in northern Chile offers a unique environment to investigate lipid biomarker taphonomy under extreme and prolonged dryness.

We investigated the accumulation and degree of preservation of lipid biomarkers in million-year-old hyperarid soils where primarily abiotic conditions influence their taphonomy. Soils were extracted and free and membrane bound lipids were analyzed across a vertical profile of 2.5 meters in the Yungay hyper-arid core of the Atacama Desert. Due to the extremely low inventory of biomass in Atacama soils, samples were collected by scientists wearing cleanroom suits to minimize anthropogenic contamination during sampling.

Fatty acids were found to be well preserved in Yungay soils, and were most abundant in the clay-rich soils at ~2 m depth (~750 ng of fatty acid methyl ester/g of soil). These buried clays layers were fluvially deposited approximately 2 million years ago, and have been excluded from exposure to rainwater and modern surficial processes

since their emplacement (*Ewing et al., 2008*).
Monocarboxylic fatty acid, monohydroxy fatty acid, glycerol tetraether, and n-alkane hydrocarbon content was found to change with depth. Lipid biomarker content in deeper soil layers is suggestive of soils having been formed at a time when environmental conditions were capable of supporting active microbial communities and plants. In short, total lipid extracts reveal a remarkable degree of lipid biomarker preservation even in the oldest soils analyzed (ca. 2 Myr) indicating that typical diagenetic processes of lipid destruction are arrested under extreme dryness. This result has implications for the search for molecular biomarkers on Mars, which could have experienced millions to billions of years of extreme hyperaridity.