# Lipid biomarkers in acidic ecosystems: Relevance to early Earth

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Compared to relatively benign carbonate buffered marine environments, terrestrial Archean and Paleoproterozoic life was forced to cope with a broader range of pH values. In particular, acidic terrestrial ecosystems arose from the oxidation of reduced species in hydrothermal settings and crustal reservoirs of metal sulfides, creating acid sulfate conditions. While oxidation of reduced species is facilitated by reactions with molecular oxygen, acidic conditions also arose in Archean hydrothermal systems before the rise of oxygen, expanding the range of time over which acidophiles could have existed on the early Earth. Acidic terrestrial habitats would have included acidic hydrothermal springs, acid sulfate soils, and possibly lakes and streams lacking substantial buffering capacity with sources of acidity in their catchments.

Although acidic hot springs are considered extreme environments on Earth, robust and diverse microbial communities thrive in these habitats. Such acidophiles are found across all three domains of life and include both phototrophic and chemotrophic members. In this study, we characterize the lipid biomarkers produced by microbial communities living in acidic springs in Yellowstone and Lassen Volcanic National Park, USA.

We discovered and isolated an acid-tolerant purple non-sulfur (PNS) anoxygenic phototroph from Lassen that synthesizes 3-methylbacteriohopanepolyols (3-MeBHPs). These compounds were previously thought to be exclusively made by methanotrophic and acetic acid bacteria. Culture experiments revealed that both total BHP and 3-MeBHP increased relative to total membrane fatty acid with increasing pH. We also observed a concomitant increase in cyclopropane fatty acid (cy19), indicating a membrane response to pH stress. Initial compound-specific carbon isotopic studies indicate that the PNS 3-MeBHPs will be distinguishable from methanotrophic 3-MeBHPs in the rock record.