

My NASA Early Career Collaboration Award (ECCA) supported travel to Dr. Sebastian Kopf's lab at CU Boulder to conduct research on extremophilic microbes from subaerial hot springs. This project is part of my dissertation research at Dartmouth College. This collaboration advances astrobiology by investigating the hydrogen isotope composition ($\delta^2\text{H}$) of lipids synthesized by thermoacidophilic archaea as a potential biosignature. Archaeal lipids, called isoprenoid glycerol dibiphytanyl glycerol tetraethers (iGDGTs), serve as robust molecular fossils and potential indicators of life in hydrothermal environments on Earth and other planetary bodies. Their $\delta^2\text{H}$ composition may further indicate biogenicity.

For this project, I extracted and analyzed archaeal lipids from the sediments of 20 hot springs collected from Yellowstone National Park (USA) and the El Tatio Geyser Field (Chile). Figure 1A highlights the dynamic hydrothermal landscape in El Tatio, which is in the Atacama Desert near 15,000 feet elevation. Active springs can reach the boiling point and be extremely acidic.

Following extraction of intact lipids from these samples, I traveled to Dr. Sebastian Kopf's lab at CU Boulder to chemically derivatize the archaeal iGDGT lipids into component biphytane (BP) chains suitable for hydrogen isotope analysis. All the objectives of this award were met. Figure 1B shows me operating the GC-FID at CUBE-SIL to identify and quantify individual BP compounds – a critical step for determining the identity and abundance of specific lipid structures prior to isotope analysis.

This project represents the first field calibration of $\delta^2\text{H}$ values in archaeal biphytanes from hot spring environments and contributes to a framework for interpreting compound-specific isotope biosignatures on Mars and other planetary bodies. This work also strengthened my collaborations across institutions and supported my broader research goal of developing stable isotope tools for detecting and characterizing life in extreme environments.

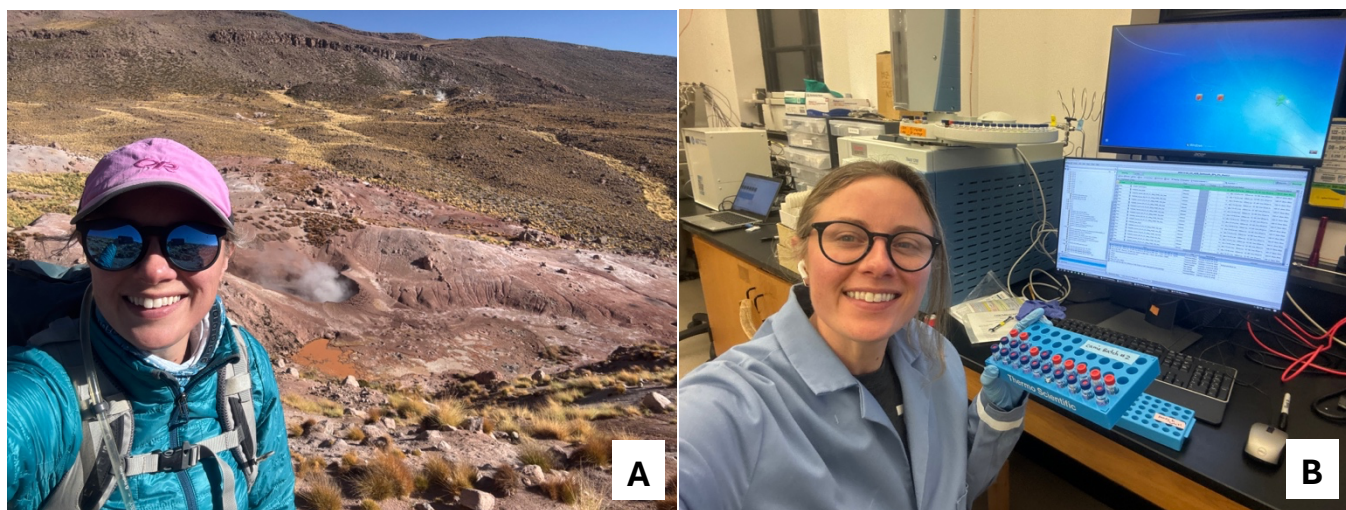


Figure 1. A) Scouting hot springs in the El Tatio Geyser Field in Chile in December 2024. Sampling was performed with permission of the Toconce and Caspana communities. From each spring, I collected sediments which I later extracted and isolated archaeal lipids from and analyzed the lipid-specific H-isotope composition. composition. B) Analyzing archaeal iGDGT-BP lipids on the GC-FID at CUBE-SIL to determine their identity and abundance prior to isotope analysis.