Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.37472

Methane sourcing at three serpentinite-hosted springs using isotope geochemistry, machine learning, and lipid biomarkers

MARY J. WHELAN[1], GREGORY TODD VENTURA[2] AND **PENNY L. MORRILL**[1]

[1]Memorial University of Newfoundland
[2]Saint Mary's University

The search for extinct or extant extra-terrestrial life requires the selection of accessible and appropriately habitable sites. Subsurface water rock reactions provide chemical energy to support microbial life. For example, the chemical gradients that exist at the surface/near surface of serpentinite-hosted springs provide energy and carbon that may be advantageous for near-surface life. The habitability, metabolisms, and biosignatures of serpentinite-hosted springs on Earth therefore provides and analogue for how similar near-surface systems on other planetary bodies such as Mars, Enceladus, and Ceres may exist. Serpentinization is a water-rock reaction that produces methane (CH_4). CH_4 from serpentinite-hosted groundwater springs may be partly microbial in origin; however, distinguishing between microbial and non-microbial CH_4 remains a point of interest at sites of serpentinization. In this study, springs at the Tablelands (NL, CAN), The Cedars (CA, USA), and Aqua de Ney (CA, USA) were studied to quantify CH_4 flux and investigate microbial and non-microbial origins of CH_4 through stable isotope data ($\delta^{13}C_{CH4}$ and $\delta^{2}H_{CH4}$) and lipid biomarker analysis. Results from duplicate flux experiments varied, indicating controls on CH_4 release that change temporally and spatially. An unsupervised machine learning (ML) algorithm classified CH_4 sources with the stable isotope data. The algorithm produced clusters aligned with global datasets of CH_4 origins and revealed consistent signatures over time at the sites. Lipid biomarker analyses revealed that detectable archaeal lipids are most likely from methanogens at The Cedars, where isotopic signatures of microbially-derived CH_4 were detected. These findings support the co-occurrence of isotopic and molecular biosignatures in serpentinizing environments, and the utility of integrating stable isotope geochemistry, ML, and lipid biomarker evidence to improve CH_4 source classification in serpentinizing systems.