High-Affinity Trace Gas Consumption by Soil Microbial Communities Around Hot Springs in the Andean Altiplano: Implications for the Evolution of Martian Metabolisms. Z. K. Garvin[1], S. R. Abades[2], N. Trefault[2], F. D. Alfaro[2], and T. C. Onstott[1], [1]Dept. of Geosciences, Princeton University, Princeton, NJ 08544 (zgarvin@princeton.edu), [2]GEMA Center for Genomics, Ecology & Environment, Universidad Mayor, Huechuraba, Santiago 8580745, Chile.

Introduction: Whether searching for extant life or for biomarkers of extinct life, one of the fundamental questions driving astrobiological studies of Mars is how putative Martian microorganisms could derive energy for maintenance and growth. Direct comparison of the theoretical development of Martian life with the evolution of life on Earth may be misleading due to the contrasting geological and atmospheric histories of the planets. The early collapse of the Martian magnetic dynamo and significant loss of its atmosphere likely transformed Mars into a hyper-arid desert before a metabolism resembling oxygenic photosynthesis was able to emerge. However, Mars may have still supported habitable surface environments from the late Noachian to early Hesperian in locations where impacts and/or volcanic activity allowed for water to reach the surface and form geothermal springs [1]. Such environments could have provided a source of energy for microbes through emission of trace gases (e.g., CH_4, H_2, and CO) which could be obtained and utilized directly from the atmosphere [2,3] via expression of high-affinity enzymes, as has been observed in bacteria on Earth [4–7]. The potential for the early evolution of these trace gas metabolisms could suggest that they remain a prevalent tactic for modern extant life on Mars.

Field Site: To study the potential for trace gas metabolisms to support Martian life, we sampled soil surrounding the gas-emitting Polloquere Hot Springs in the Salar de Surire [8] of northern Chile. The site represents the high elevation, high precipitation, low temperature, and high UV flux end member of an environmental gradient spanning the Arica-Tarapacá region. These conditions along with the highly saline and sulfurous geothermal waters serve as a compelling analog for the surface environment of early Mars when thermal springs were likely widespread. Soil was collected at 10 meter intervals from the hot spring along 3 transects upwind, downwind, and perpendicular to the wind direction at the time of sampling to assess the influence of hot spring distance and wind direction on the abundance and affinity of trace gas metabolisms.

Methods: Microcosm experiments were performed for soils along the 3 sampled transects to characterize the microbial gas consumption and production. Ten grams of each sample were placed in 160 mL serum vials and exposed to typical Earth atmospheric mixing ratios (2 ppmv CH_4. 500 ppbv H_2, and 100 ppbv CO). Changes in headspace gas composition were measured after 1 week via gas chromatography with FID (CH_4) and RCP (H_2, CO) detectors. Additional short-term microcosms were performed with equal headspace concentrations of CO and H_2 (500 ppbv) to observe changes within 24-hour timescales.

Results: Soils from transects perpendicular to and downwind of the wind direction exhibited significant depletion of H_2 and CO after 1 week. Nearly complete to total consumption of these gases was observed for soils at 20 to 30 m distance from the spring. The short-term microcosms revealed particularly rapid uptake of H_2, achieving total consumption of 500 ppbv within 24 hours. Conversely, samples from the upwind transect displayed limited to no detectable trace gas consumption except for H_2 depletion at 20 and 30 m. The darkest, presumably organic-rich soil along the shore was the only sample to emit gas (6.0 nmol CH_4 and 1.1 nmol H_2) after 1 week.

The observed consumption of H_2 and CO in the direction of the wind supports the plausibility of geothermal springs as sources for trace gas metabolisms in Mars-like environments. The increased gas consumption with distance from the spring suggests a community shift toward microbes with higher affinity enzymes as the emitted gases are depleted. 16S rRNA sequencing of the samples is in progress for correlation of gas uptake with community changes and abundance of trace gas metabolisms. Lipid profiles of each sample are also being evaluated for biomarker potential. These preliminary results suggest that the evolution of trace gas consumption as a means of energy acquisition is a valid model for the development of early life around geothermal springs on Mars, and such chemolithotrophic life could still be actively participating in trace gas cycling in the shallow Martian subsurface.

References: [1] Cabrol N. A. (2018) *Astrobiology*, *18*, 1-27. [2] Atreya S. K. et al. (2007) *Planet. Space Sci.*, *55*, 358-369. [3] Weiss B. P. et al. (2000) *Proc. Natl. Acad. Sci. U. S. A.*, *97*, 1395-1399. [4] Conrad R. (1996) *Microbiol. Rev.*, *60*, 609-640. [5] Quiza L. et al. (2014) *Front. Microbiol.*, *5*, 1-15. [6] Constant P. et al. (2011) *Appl. Environ. Microbiol.*, *77*, 6027-6035. [7] Holmes A. J. et al. (1999) *Appl. Environ. Microbiol.*, *65*, 3312-3318. [8] Tassi F. et al. (2010) *J. Volcanol. Geotherm. Res.*, *192*, 1-15.