TERRESTRIAL HOT SPRINGS AS ANALOGS FOR HYDROTHERMAL DEPOSITS ON MARS. C. Munoz-Saez[1], [1]University of Nevada, Reno (1664 North Virginia Street, Reno, Nevada 89557, cmunozsaez@unr.edu), [2]B. Black, [2]The City University of New York (160 Convent Avenue, New York, NY 10031, bblack@ccny.cuny.edu), J. Gong[3], [3]Massachusetts Institute of Technology (77 Massachusetts avenue, 54--918, Cambridge, MA 02139, gojian@mit.edu), and A. Perez-Fodich[4], (Plaza Ercilla 803, Santiago, Chile, ali-perez@ing.uchile.cl).

Introduction: Hot springs environments intersect water, thermal and chemical energy to initiate and sustain life [1,2] and are therefore ideal targets for exploration of Mars' habitability. Several opaline silica outcrops have been detected around volcanoes on Mars [e.g. 1,2,3,4,5], including at at Jezero crater, the Perseverance landing site [3]. Textural and morphological characteristics observed in some outcrops are comparable with terrestrial hot springs sinter deposits [5,6]. Sinter deposits on Earth provide powerful records of hot springs habitats and their evolution through time. The El Tatio field in the Atacama, and the Black Rock Desert in Nevada are notable analogs for early Martian climate due similar elevation, evaporation, wind, UV radiance, dryness and day/night temperature variations [5,6]; all factors that influence evaporation, silica precipitation and preservation [6]. Sedimentological studies of silica sinter deposits define different facies and textures accounting for temperature gradient, hydrodynamics, and type of organisms [7,8], but little is known about the influence of climatic conditions, water chemistry, and pH on silica precipitation and the consequent changes in habitability [8]. Despite the large diversity of hot springs settings on Earth, current facies models are mostly based on data derived from locations in New Zealand and Yellowstone, USA [7,9] where the climate conditions are likely a poor representation of ancient Mars. Major gaps remain in understanding the relationship between environmental and chemical factors associated to Earth in the most arid, Mars-like environments. New analytical capabilities hosted by the Curiosity and Perserverance rovers provide powerful tools for generating geochemical data that demand an interpretive framework for hot springs environments under Mars-like conditions. For instance, the Perseverance Mars rover includes an instrument able to measure more than 20 elements (PIXL), including those commonly found in hydrothermal environments (eg. Si, Cl, S, Cu, Ge, and As), Raman luminescence for organics and chemicals (SHERLOC), and high definition cameras.

Objectives: Combining textural and geochemical proxies to differentiate and quantify the effects of climate, biota and hydrodynamics on silica precipitation around hot springs in hyper arid terrestrial Mars Analogs.

Methods: We studied current forming hot-spring sinter deposits and geological records to understand short and long term climatic trends. In El Tatio geyser field, we have collected samples in ancient sinters with well-constrained stratigraphy and radiocarbon ages spanning from modern to 27 ka. We ran in situ silica precipitation experiments for several month to account for seasonal and inter annual variations. We conducted in-situ evaporation rate experiments, and collected water samples. Additionally, we have measured weather conditions continuously since 2017 (air temperature, humidity, atmospheric pressure, wind direction and speed, UV-radiance, rainfall). In the lab we used LA-ICP-MS with a resolution of 100um to stablish the geochemical variation of trace elements in hot spring deposits during the Holocene. To better quantify the composition and effects of biota we employed SEM/EDS, which is a non-destructive imaging techniques that provides a complete characterization of sinter textures down to the nanometer scale.

Preliminary Results: The precipitation rates of silica in arid environments can be twice as high (or more) than in other hydrothermal areas around the world, even though the concentration of silica in the water is similar to or lower than other geothermal systems. For instance, the water in El Tatio has an average 220 ppm of silica and it is unsaturated in silica at high temperatures. Although the temperature of the water and the hydrodynamic primary control sinter facies and textures, our mapping indicates that the evaporations rates of water enhanced in arid environments and wind direction play an important role in the precipitation of silica and the textures preserved in the geological record. Our preliminary chemical data indicate that biology play a role in the distribution and preservation of chemical elements. SEM/EDS analysis from active bacterial mat environments shows different distributions of elements; silica is dominant element except for the internal part of bacterial filaments indicating rapid silicification. Carbon is only preserved in the interior of the bacterial filaments. Na, and Cl are associated with a halite crystal in the inner border of the external sheath of silica around the filament. LA-ICP-MS data in older sinter rocks indicate a strong selective deposition of metals in pore spaces and within biological. Variability in the chemistry of the trace elements can be associated with changes in the water supply and climate.

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