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Lewis and Clark Fund for Exploration and Field Research in Astrobiology

Survivability of Halophiles through Deliquescence in the Atacama Desert, Chile: Implications for Liquid Water Stability and Habitability of the Martian Surface

Project Report

Background

The Atacama Desert is known as one of the driest places on Earth, making it one of the best terrestrial Mars analog sites. Specifically, the Yungay region in the hyper-arid core of the desert (Fig. 1) has experienced extremely dry conditions, less than 1 mm of rainfall annually; unchanged for upwards of 15 million years. The Atacama is characterized by vast stretches of salt flats (remains of evaporated lake beds) called "salars". These salars are entirely composed of halite (sodium chloride), which grows vertically into large nodules or pinnacles at the intersections of halite polygons that expand in the presence of transient moisture and collide over time (Fig. 2). Despite harsh conditions considered near the dry limit of life and not a living thing in sight, the Atacama is teeming with life. Through the process of deliquescence, hygroscopic salts adsorb water vapor from the atmosphere to form liquid brines, allowing colonies of cyanobacteria to thrive deep within these halite nodules.

Mars Analog

Chloride-bearing evaporites in the driest place on Earth can sustain liquid water in quantities large enough to harbor microbial life. As Mars transitioned from relatively wet to extremely dry, it is fair to assume that chloride-bearing evaporite deposits that have been identified and mapped by Mars Odyssey THEMIS, reported by Osterloo et al. in 2008, may have been or are the last inhabited substrates on the planet. In addition, samples with Mars relevance, identified by Phoenix, were considered for this study due to their low eutectics, such as perchlorate.

Experimental Setup

Preparation of samples was done in the Extremophile Laboratory at the Instituto Antofagasta of the Universidad de Antofagasta. Seven different samples were prepared over the course of two days: magnesium chloride ($MgCl_2$), magnesium sulfate ($MgSO_4$), calcium chloride ($CaCl_2$), calcium sulfate ($CaSO_4$), sodium chloride (NaCl), calcium perchlorate ($Ca(ClO_4)_2$), and a 99 wt% calcium perchlorate/ 1 wt% soil mixture. A kilogram of each compound was heated in an oven at 60 °C for 24 hours to remove any residual moisture. The following day the compounds were added to 10 cm cube Plexiglas boxes (Fig. 3). Two Hygrochron iButtons were inserted at depths of 3 cm, 6 cm, and 9 cm. iButtons are small, round sensors that work wirelessly to collect temperature (± 5 °C) and relative humidity (± 0.5% RH) at user-determined interval. Due to the data capacity of the iButtons, two were necessary at each location in the box, (one to record data every 30 minutes for the first 6 months and a second to record data every 30 minutes after a 6 month delay) in order to collect a full year worth of data at meaningful intervals.

Finally, a HOBO electric conductivity sensor was inserted to approximately the middle of the sample. The samples were deployed in a flat region of Yungay (24°05’267”S, 069°59’682”W) within a few meters of each other. Small nearby rocks were placed around the boxes to ensure security and over wires to improve invisibility (Fig. 4-5). At the time of deployment, the $CaCl_2$ appeared wet, but had an initial electric conductivity reading of EC = 0. This was noted for future analysis. Five days later, I returned to Yungay to make sure everything was working properly and undisturbed and reported no problems. I will return in January 2016 to collect the first 6 months of data and again in June 2016 to collect the second 6 months of data for analysis.

Anticipated Outcomes

Upon data collection in January and June, we hypothesize sinusoidal fluctuations in temperature and relative humidity, diurnally, which will ideally correlate with the presence of brines (electric conductivity readings consistent with liquid water). Measurements of this nature have not been made in situ for Mars-relevant salts. If we can show liquid water formation through deliquescence in the driest place on Earth, we gain traction for isolating conditions under which we could see transient liquid water at the surface of Mars. This has potentially important implications for future human exploration, landing site selection, and astrobiology.

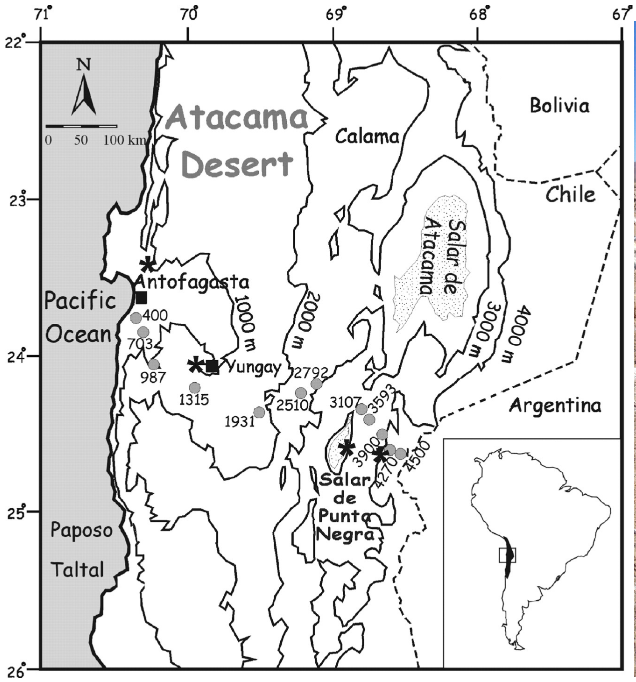

Figure 1 (Left): Topographic map of the Atacama Desert showing locations of Antofagasta and Yungay. **Figure 2** (Right): Halite nodules in Salar Grande.

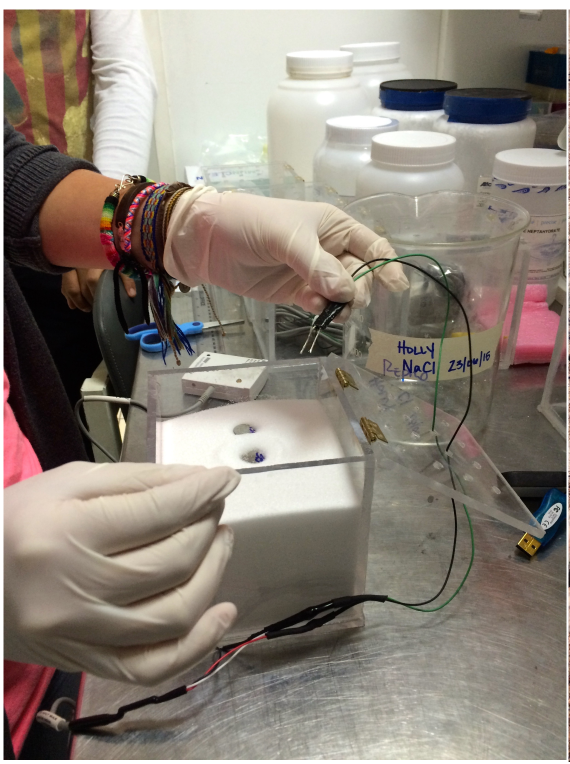


Figure 3 (Left): Installing iButtons and HOBO sensors while preparing samples in the laboratory. **Figure 4** (Right): Using rocks to camouflage electronics while deploying sample in Yungay.

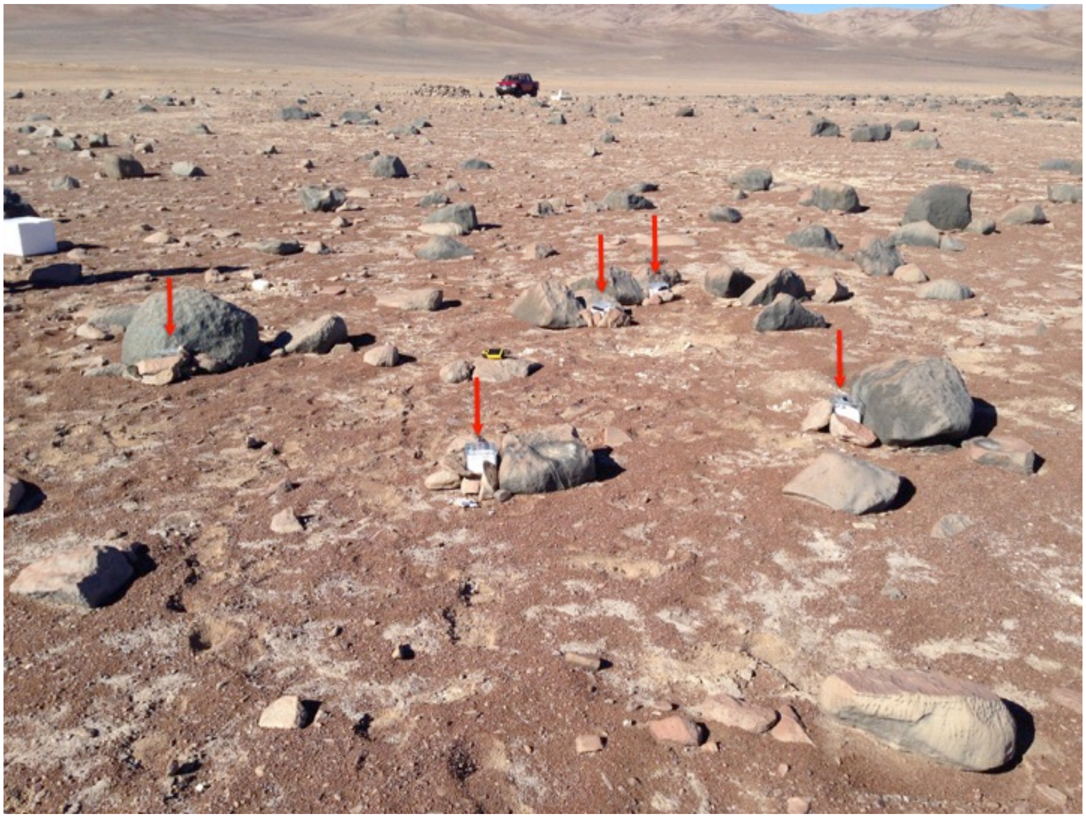

Figure 5: Red arrows indicating the locations of 5 of the 7 samples in Yungay.