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Microscopic saline ponds are oasis for photosynthetic life in the driest place on the Earth: implications for putative Martian biosphere

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In terms of soil chemistry and liquid water availability, the Atacama Desert represents an exceptional terrestrial analogue to the extreme arid conditions on Mars [1]. The Atacama Desert (North Chile) is considered the driest and oldest desert on Earth. Therefore, the study of terrestrial life in this hyper-arid desert provides a first approximation to assessing the potential for life on Mars.
We have recently shown that primary producers in the Atacama Desert occur within hygroscopic halite crusts [2, 3]. The endoevaporitic microbial communities are represented mainly by cyanobacteria associated with heterotrophic bacteria and archaea [3]. The interior of halite crust provide shelter against extreme temperatures, strong ultraviolet and visible radiation and at the same time favour the cells hydration when the surrounding exterior environment remains persistently dry. We have demonstrated that mineral deliquescence results in briny solutions in the pore space of the halite at relative humidity well below atmospheric condensation levels [4]. These micro-brines form micro-oasis for photosynthetic life within the hygroscopic halite crust. Water vapour adsorption and condensation on the halite surface might also be an important source of liquid water for the endoevaporitic colonies. Cycles of water vapour adsorption, condensation and evaporation are responsible for the shape, porosity, composition and internal structure of the halite crusts, which in turn control the water dynamics. Therefore salt deliquescence and water vapour cycling in the salt are key drivers of the microbial activity of the endoevaporitic community, as well as the habitability of the halite crusts themselves.
Widespread chloride-bearing evaporitic deposits have been detected in the southern highlands of Mars, suggesting that brine pools were relatively common on the surface of the planet in the past. Following the analogy with the Atacama Desert, the deliquescence of hygroscopic minerals such as chloride salts could provide a transient source of liquid water that would be available for microorganisms within the evaporites. Modelling of the climate conditions (relative humidity (RH) and temperature) and evolution of the water activity of the deliquescence solutions in a region on Mars with chloride-bearing evaporites shows that RH often reaches the deliquescence points of chloride salts (NaCl, CaCl2 and MgCl2), and the temperature reaches levels above their eutectic points seasonally, in the course of a Martian year [5]. We propose that this type of deposits may be one of the last available niches for a putative Martian biosphere. This new data could potentially re-direct the focus of future life detection missions.

[1] McKay et al. (2003) Astrobiology 3: 393–406. [2] Wierzchos et al. (2006) Astrobiology 6: 415-422. [3] De los Ríos et al., (2010) Int. Microb. 13: 79-89. [4] Dávila et al. (2008) J. Geophys. Res. 113, G01028. [5]. Dávila et al. (2010) Astrobiology 10: 617-628.