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Salt tolerant bacteria from Tunisia and brine occurrence on Mars – expectations for water uptake in astrobiology

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Abstract

We report our work in progress on the analysis of salt tolerance of extreme bacteria, and expected salt occurrence types at different locations on Mars. The theoretical argumentation shows although it would be difficult to take up water from any Martian brine, better chance and less concentrated salty solutions may be produced by the basal melting of polar caps.

1. Introduction

Below we overview the possible connections between salt tolerance of extremophyles [1], in recent samples from Tunisia and possible brine occurrence types on Mars. During the Chott El Jerid Mars Analog Expedition [2] we collected possible Mars analog organisms to analyze their habitat and realize laboratory based experiments with them.

The shore of the ephemerally water filled salty plain.

2. Salts and brines on Mars

Several types of salts are present on Mars and their occurrence changed during the geological evolution [3]. The most important among them are chlorides and sulfates. Laboratory analysis showed that bulk liquids are probably various brines [4] on Mars. Chlorine salts (chlorides, perchlorates, chlorates) are globally distributed based on GRS data [5] up to 1% in the regolith. Access to bulk water as brine is possible especially during climatic changes and geothermal heating, but the H_2O uptake for any organism is influenced by the salt content and osmotic processes. Although any possible Martina biota is probably highly salt tolerant, for water uptake better chance exists at smaller salt concentration.

Basic concepts and factors that influence the salinity of any melting produced bulk water on Mars:

- *Original composition* and salt concentration in the regolith. This may partly be influenced by sedimentation and at accumulation areas, as both the amount of atmospheric deposited oxidants and earlier evaporation produced salts may be enlarged.
- *Reaction "phase space"*: duration, pH and temperature of the solution in the regolith from the percolation of melted ice do matter.
- *Composition of the impurities* originally deposited together with the ice (clean / dirty ice), influenced by meteorological factors, especially the wind transported dust deposition during ice accumulation.
- *Subsurface residence time* of solution. For juvenile water salt content is expected to increase as more time spent in the porous voids by the liquid.
- *Closed/open characteristic of the system*: where the water is able to seep away from melted ice, lower salt concentration is expected in most cases.
- *Communication with the atmosphere* influencing the evaporation, eutectic freezing, and oxidant accumulation rate at the top of the regolith.

In the regolith evaporation and thin liquid film driven reactions dominate occasionally, and the salt concentration rapidly decreases downward (like at Dry Valleys [6]), most salts are in the top dms or m – except much transported deposits accumulated there. In general the regolith is rich in S, Cl, Br salts, mostly from low pH dissolution, carbonates were probably destroyed [7,8], and water related oxidation increased the amount of sulfides and oxides [9].

Fluids with long residence time close to the surface provide more acidic solutions probably.

Using observations and theoretical argumentation from geodynamic viewpoint (focusing on the connection and interaction with the surrounding area) we preliminary separated 4 environment types that may differ in the content and composition of brines:

1. Atmosphere deposited surface ice (polar caps, mid-latitude ice deposits). Influencing factors: dust settling rate during accumulation phase (larger→more oxidants), sub-ice frozen/dry regolith (frozen→closed circulating system). Regolith below polar caps might be less acidic, as after ice accumulation started, no oxidants were deposited, while early basal melting produced liquids could transport the salts away.
2. Chloride filled depressions at the Noachian highlands (climate driven surface rivers and lakes): evaporation driven concentration of salts according to condensation sequence, surface ice cover might lower the speed of the evaporation and concentration increase. Strong interaction with the atmosphere in shallow regolith is expected.
3. Sulfate deposits (Valles Marineris ILD and crater deposits like in Gale): water ice accumulation there at high tilt angle orbital phase, melting produced high sulphur content.
4. Impact/geothermal heat driven melting (mostly Noachian): at hydrothermal circulation long lifetime favors lower salt concentration, if stable H_2O source also exists. Volcanic heating related waters are often rich in sulfurous compounds and thus somewhat acidic.

3. Salt tolerance and Earth analogs

Part of a larger test series covering cold, salt and UV stresses, we realized salt tolerance analysis on bacteria isolated from the summertime water of the salty pond of Chott el Jerid (midway on the Tarmac road, N 33º55.087', E 08º30.286', at 4 m above sea level; collected on 15th Sep. 2013; site no. 13137). The water has a high osmotic potential as -21 MPa, mainly due to the high concentration of NaCl and corresponds to a salinity of a 5mM NaCl solution. Other salts (as gypsum) in less concentration are also represented, the pH was 6.3. Two genera of bacteria were identified after isolation from the supernatant and the pellet fractions of the water sample. In their original habitat *Leclercia adecarboxylata (Enterobacteriaceae)* and the *Pseudomonas spp.* could tolerate the extremely salty environment. After cultivation the two groups of bacteria were transferred to agar plates containing 5 mM NaCl to test their salt tolerance in laboratory conditions. According to our first results they showed growth response under artificially set conditions, where the osmotic potential was equal with their original habitat's value. Cleaning and isolation of the microbes from the visible colonies after passages to test their various biochemical reactions (for species identification) is still in progress.

In the next experiments we are planning to test the salt tolerance of various cryptobiotic crusts originated from different types of deserts in the Chott el Jerid region, checking their ecophysiological responses.

4. Summary

Connecting the measured salt tolerance and expected ideal site types on Mars helps to orient and focus further research. Some general preliminary findings for the access to low concentration salty solutions on Mars are: Long term presence of liquid water (especially subsurface migrating) helps to decrease the solved salt concentration from close to surface regolith. Accumulation of debris with long term surface exposure increases the total salt amount, while shielding from the atmosphere is helpful in general. Subsurface locations with poor atmospheric interaction and substantial water migration could have low S, Cl salt concentration - like basal melting below the polar caps where evaporation driven salt concentration and atmosphere related oxidant generation was not present for extended period.

5. Acknowledgements

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6. References

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