Reasons To Get Salty

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Abstract

Salts are a commonly found throughout the solar system. Salts can be found in solid phase as evaporites on Mars and meteorites or ejected into space as the products of cryovolcanism on icy moons such as Enceladus. In liquid phase, subsurface brines are hypothesized to be present on Mars as well as icy moons. Salts play a vital role in habitability. Their presence depresses the freezing point of water, helping to maintain the presence of the liquid water needed as a solvent for biochemical reactions under low temperature conditions, such as are suggested for subsurface oceans on the icy moons of Jupiter and Saturn. Conversely, high concentrations of salts can limit all but the most highly salt-adapted organisms, potentially delineating a boundary for "habitable" conditions. In addition to the concentration, the particular composition of the brine can have either stabilizing or deleterious effects on biomolecules such as proteins. Salts also play a key role in the preservation of organic matter and biosignatures. Halite crystals from the Zag meteorite was shown to contain preserved organic matter within the brine inclusions of the halite crystals distinct from the amino acids in the meteoritic matrix [1]. Salt-adapted organisms (halophiles) have shown high levels of resistance to desiccation, ionizing radiation, high hydrostatic pressure, and even space vacuum [2,3]. Our previous work has shown that the salts themselves can protect halophilic microorganisms from ionizing radiation damages [4]. Brine inclusions within halite crystals can even preserve living microorganisms over geological time scales. While the exact duration of survival within the brine inclusions remains controversial, halophilic microorganisms on Earth have been cultured from the brine inclusions of surface-sterilized halite crystals [5,6]. This presents a clear case for the preservation of not only organic material, but also living microorganisms resistant to multiple stresses with astrobiological relevance.

The molecular mechanisms enabling the survival of microorganisms within brine inclusions of halite crystals however remain poorly understood. Studies have suggested a role for modification of the cell envelope (cell membrane and wall) in long-term survival [7]. Cell envelopes represent key structures of astrobiological importance. They form the basic unit of compartmentalization of living cells, as well as the reaction interface with the surrounding environment. Cell envelope components are also important biosignatures (lipids, membrane pigments, S-layer proteins). We therefore decided to determine the effect of salts on the cell envelopes of halophilic microorganisms, particularly in the context of long-duration entombment within the brine inclusions of halite crystals. Here we show the different roles of salt type, salt concentration, and water activity on cell envelope structure of microorganisms entrapped within brine inclusions of halite crystals. These results contribute to our understanding of the preservation of microbial cells in brines and evaporites, and help to inform the selection of potentially habitable environments. However, this represents only a small part of the story of the relationship between salts and microbial life.

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The astrobiological questions concerning origins and co-evolution of life and salts requires a truly interdisciplinary view incorporating chemistry (geochemistry, atmospheric chemistry, biochemistry), planetary geology, hydrology, astrophysics, biophysics, and microbiology. In this presentation, I will present not only our work on the survival of microorganisms and the preservation of biomolecules in salt, but also the open opportunities for large-scale interdisciplinary collaborations within the EANA community to better understand the astrobiological implication of life in salts.

It's time to get salty!

References:

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