The Process of Deliquescence Might Allow Methanogenic Archaea to Metabolize on Mars

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Abstract

The process by which a hygroscopic substance absorbs moisture from the atmosphere until it dissolves in the absorbed water and forms a solution is called deliquescence. It has been shown that this process is used by endolithic microorganisms in the hyperarid Atacama Desert, one of the driest areas on Earth, to sustain microbial colonies (Davila et al. 2008; Davila and Schulze-Makuch, 2016). On Mars there exist similar environments where this process may play a role (Heinz et al. 2016). These are known as Recurring Slope Lineae (RSL), interpreted to be briny water flows occurring during certain time periods on Mars (Levy 2012; Ojha et al. 2015). If this interpretation is correct, the process of deliquescence should also occur on Mars. Further, assuming that life evolved to adapt from a warmer and wetter Mars to its current hyperarid state (Schulze-Makuch et al. 2013), then deliquescence could also support life on Mars today. We tested this hypothesis by developing a Closed Deliquescence System (CDS) consisting of a desiccated mixture of Martian regolith analog substrate, salts and microbial cells, which over the course of days became moistened through the process of deliquescence. We monitored the methane produced via metabolic activity for *Methanosarcina soligelidi*, dedicated as a model organism for potential life on Mars (Morozova et al. 2007) as well as two closely related species, *M. barkeri* and *M. mazei*, after exposing them to three different substrates using either sodium chloride or sodium perchlorate as a hygroscopic salt. Our experiments showed that (1) *M. soligelidi* rapidly produced methane at 4 ◦C, (2) *M. barkeri* produced methane at 28 ◦C though not at 4 ◦C, (3) *M. mazei* was not metabolically reactivated through deliquescence nor produced any methane, (4) none of the species produced methane in the presence of perchlorates, and (5) all species were metabolically most active in the phyllosilicate-containing Martian regolith analog. While our results emphasize the importance of the substrate, archaeal species, salt, and temperature used, we show - more importantly- for the first time that water provided through deliquescence alone is sufficient to rehydrate methanogenic archaea and to reactivate their metabolism under conditions roughly analogous to the near-subsurface Martian

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environment. Thus, we suggest that a more important mantra for the search of life on Mars is "follow the salt" rather than "follow the water". Future space missions, including life detection missions, should explore salt-rich regions on Mars as prime targets for astrobiology.
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