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Experimental Demonstration of the Formation of Liquid Brines under Martian Polar Conditions in the Michigan Mars Environmental Chamber

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Liquid water is one of the necessary ingredients for the development of life as we know it. The behavior of various liquid states of H_2O such as liquid brine, undercooled liquid interfacial water, subsurface melt water and ground water [1] needs to be understood in order to address the potential habitability of Mars for microbes and future human exploration. It has been shown thermodynamically that liquid brines can exist under Martian polar conditions [2, 3].

We have developed the Michigan Mars Environmental Chamber (MMEC) to simulate the entire range of Martian surface and shallow subsurface conditions with respect to temperature, pressure, relative humidity, solar radiation and soil wetness at equatorial and polar latitudes. Our experiments in the MMEC show that deliquescence of $NaClO_4$, $Mg(ClO_4)_2$ and $Ca(ClO_4)_2$ occurs diurnally under the environmental conditions of the Phoenix landing site when these salts get in contact with water ice. Since Phoenix detected these salts and water ice at the landing site, including frost formation, it is extremely likely that deliquescence occurs at the Phoenix landing site.

By layering $NaClO_4$, $Mg(ClO_4)_2$ or $Ca(ClO_4)_2$ on top of a pure water ice slab at 800 Pa and 190 K and raising the temperature stepwise across the eutectic temperature of the perchlorate salts, we observe distinct changes in the Raman spectra of the samples when deliquescence occurs. When crossing the eutectic temperatures of $NaClO_4$ (236 K), $Mg(ClO_4)_2$ (205 K) and $Ca(ClO_4)_2$ (199 K) [4, 5], the perchlorate band of the Raman spectrum shows a clear shift from 953 cm^{-1} to 936 cm^{-1}. Furthermore, the appearance of a broad O-H vibrational stretching spectrum between 3244 cm^{-1} and 3580 cm^{-1} is another indicator of deliquescence. This process of deliquescence occurs on the order of seconds when the perchlorate salt is in contact with water ice. On the contrary, when the perchlorate salt is only subjected to water vapor in the Martian atmosphere, deliquescence was not observed within the Martian diurnal cycle. This greatly diminishes the possibility of liquid brine formation without water ice contact and has strong implications on future robotic and manned missions searching for liquid water on Mars.

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