

EXPERIMENTAL SIMULATION OF DIURNAL WATER VAPOR CYCLES AND IMPLICATIONS FOR DELIQUESCENCE-DRIVEN BRINE FORMATION AT THE MARTIAN SURFACE. R. A. Slank, H. N. Farris, V. F. Chevrier, Arkansas Center for Space and Planetary Science, University of Arkansas, 346 Arkansas Ave., Fayetteville, AR 72701, rslank@uark.edu.

Introduction: In 2001, Mars Odyssey mapped hydrogen distribution across the Martian surface, leading scientists to discover large quantities of water ice bound as ice caps in the polar regions and as well as buried just beneath the surface in the mid to high latitudes [1]. Variability in the parameters of Mars' orbit allows for mass transport of seasonal water vapor from the equatorial regions to the poles. The stability of this water ice on Mars is largely due to the diffusive and thermal properties of the regolith. While diffusion can explain this process over large timescales, it is the dynamics of water vapor for small timescales (day to year), which remain unknown. Local effects, mostly related to phase changes of water, including adsorption [2], formation of liquid [3], interaction with hygroscopic salts, like perchlorates [4, 5, 6] through hydration, deliquescence, and dissolution [3, 6, 7], the presence of an ice layer [2], and the presence of certain minerals, like ferrihydrite (Fig. 1) can all be attributed to this uncertainty. Real-time deliquescence experiments can be conducted in a simulation chamber that can mimic Martian pressure, temperature, and atmospheric composition. These experiments are vital in understanding how the water vapor diurnal cycle can account for the creation of liquid water at the surface of Mars.

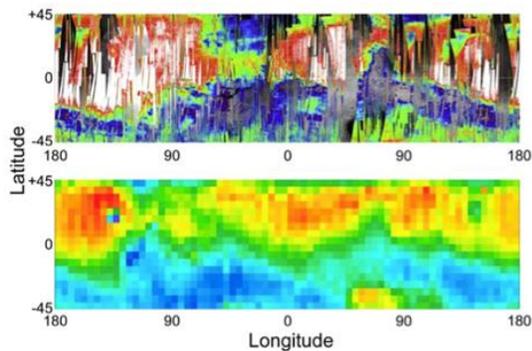


Figure 1: Comparison between *top*: the distribution of nanophase ferric oxides as seen by Mars Express OMEGA (high abundance: white, low: blue) [8] and *bottom*: the humidity in the atmosphere, ranging from 0 (blue) to ~30 (red), as observed by MGS-TES in the equatorial regions [9, 10]. The similarity of both maps suggests the ferric oxides abundant in the regolith could control the atmospheric humidity through adsorption and desorption [11].

Chamber Specifications: The Ares chamber (Fig. 1) is approximately 3 ft tall and 2 ft wide and made of stainless steel. The lower portion is surrounded by coils for cooling and then insulated with ceramic. The lid is raised and lowered by a motor and bolted down to the base for a vacuum seal during experiments.

Chamber Instrumentation: The chamber (Fig. 2) has an iR Photonics fiber optic cable (1 to 5 μ m) connected to a Nicolet 6700 FTIR Spectrometer, an array of six Vaisala hygrometers (identical to those onboard MSL Curiosity) wired to a Fuji Electric digital output, a Logitech webcam, five Omega thermocouples, and an LED light. All the feed-through ports for the equipment were replaced with the proper, stainless steel flanges for low-pressure experiments. This eliminated the air leaks present at various access points around the chamber, allowing us to reach Mars relevant pressures. There are two feed-through ports, which accommodate a vacuum pump, to achieve a desired pressure range, and gas exchange for replacing the atmosphere with N₂ or CO₂. The chamber also has an input and output connected to a Sterling chiller which pumps an ethylene glycol mixture through the cooling coils surrounding the chamber, allowing temperatures to reach -20°C.

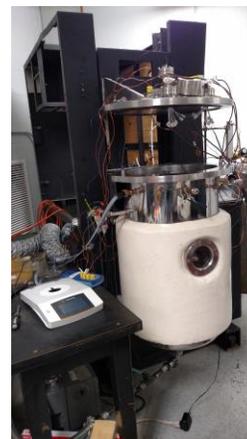


Figure 2: Exterior view of the Ares Chamber

Methodology: A series of experiments were conducted, which focused on calculating water vapor transfer and deliquescence by weight, temperature, electroconductivity, and relative humidity between the atmosphere and a column of regolith: JSC Mars 1 with varying weight % of Ca(ClO₄)₂ (1-5%) and sample

depths (2-10cm). The experiments were conducted to understand the range over which deliquescence may account for brine formation and to isolate the effects of variables like sample depth, salt concentration, presence and depth of an ice layer, and localized effects of minerals like nanophase ferric oxides. By sublimating ice below a column of regolith at depths corresponding to observations by Phoenix (~5-15 cm) [12], we seek to understand the role that heat transfer and phase changes of water play in Martian soils.

Results and Discussion: These experiments are heavily dependent on diurnal fluctuations in relative humidity and temperature of the environment. An array of thermocouples and hygrometers enabled us to observe a gradient of temperatures and relative humidities over the height of the column.

Using a lithium chloride humidity buffer experiments at the minimum weight percent and sample depth we found potential deliquescence at the surface. The lithium chloride humidity buffer (Fig. 3) occluded throughout the experiment, suggesting that relative humidity never stabilized and remained constant in the chamber. This could be the reason for the sample temperature fluctuating in temperature (Fig. 4), especially since the other three temperatures remained fairly constant after they stabilized. This temperature swing would allow the perchlorates to deliquesce at different times during the experiment (Fig. 5).

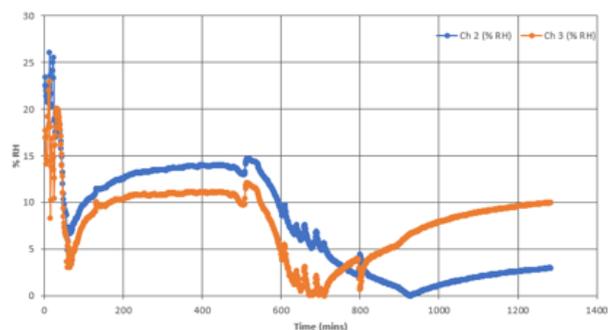


Figure 3: Relative humidity graph for trial run. Only the first 24 hours of the experiment are recorded. Blue illustrates the sample and orange illustrates the atmosphere.

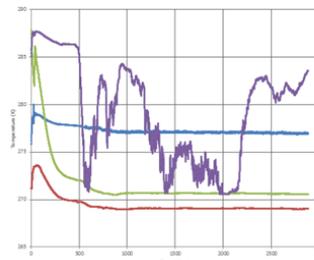


Figure 4: Temperature graph for trial run. The blue illustrates upper atmosphere temperatures, red illustrates lower atmosphere temperatures, green illustrates temperatures above the humidity buffer, and purple illustrates the temperature of the sample. The sample is the only one that does not remain constant throughout most of the experiment.



Figure 5: Left: Image of $\text{Ca}(\text{ClO}_4)_2$ JSC Mars 1 sample after 48 hours in the Ares chamber. The thermocouple is seen in the far right of the image. The darkened areas around the salt is where deliquescence has occurred. Right: Zoomed in image of the deliquescence at the bottom of the sample.

Conclusion: The dark discoloration around the perchlorate suggest wetness and therefore that deliquescence has occurred, although we need other mechanisms to confirm and quantify the deliquescence. Deliquescence at the surface of Mars could account for small amounts of transient, metastable liquid brines. Exposing complex subtleties in diffusion, adsorption/desorption cycles, and deliquescence processes on Mars, specifically the limits to which this liquid formation is possible has important implications for liquid stability and habitability at equatorial regions (MSL), future missions to Mars, and the continuing search for liquid water.

References: [1] Boynton, W.V. et al. (2002) *Science* 297. [2] Chevrier V. F. et al (2008) *Icarus*, 196, 459-476. [3] Sears D. W. G. et al. (2005) *GRL*, 32. [4] Hecht, S. P. et al. (2009) *Science*, 5936, 64-67. [5] Nuding, D. L. et al. (2014) *Icarus*, 243, 420-428. [6] Chevrier V. F. et al (2009) *GRL*, 36. [7] Chevrier V. F. et al (2008) *GRL*, 35. [8] Poulet, F. et al. (2007) *JGR*, 112. [9] Jakosky, B. M. et al. (2005) *Icarus*, 175, 58-67. [10] Smith, M. D. (2002) *JGR*, 107. [11] Pommerol, A. et al. (2009) *Icarus*, 204, 114-136. [12] Mellon M. T. et al (2004) *Icarus*, 169, 324-340.