EXPERIMENTAL INVESTIGATION OF ADSORPTION KINETICS ON DIFFERENT MARTIAN REGOLITH ANALOGUES R. A. Slank[1], V. F. Chevrier[1], E. G. Rivera-Valentín[2], [1]Arkansas Center for Space and Planetary Science, University of Arkansas, 346 Arkansas Ave., Fayetteville, AR 72701, [2]Lunar and Planetary Institute, USRA, Houston, TX, rslank@uark.edu.

Introduction: Ice at Mars' equatorial regions is unstable at geologically short timescales, due to factors like thermal properties of the regolith and depth [1]. The distribution of ice is governed by thermodynamics and kinetics, which largely depend on diffusive and adsorptive properties of the regolith [2] and are studied through simulation experiments on regolith analogs. Numerical models of water ice stability [3] often require kinetic parameters that are lacking for Mars relevant materials. Previous measurements were limited to clays [4] or did not account for temperature dependence [5]. While diffusive properties of some of these materials are well understood [1;7-9], we seek to determine adsorption parameters, specifically the temperature dependencies for kinetics.

Chamber Specifications: The Ares Mars simulation chamber (Fig. 1A), located at the W.M. Keck Laboratory for Planetary Simulations at the University of Arkansas, 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 has an IR Photonics fiber optic cable (1 to 5μm) connected to a Nicolet 6700 FTIR Spectrometer, an array of three Vaisala hygrometers (identical to those onboard MSL Curiosity) wired to a Fuji Electric digital output, a Logitech webcam, four Omega thermocouples, a Practum toploader laboratory balance 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 pressures of 1 millibar. 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 a minimum temperature of -15°C). However, a liquid nitrogen solution can also be pumped through an internal coil system around the sample, resulting in temperatures as low as -40°C (Fig. 1B). Lastly, 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 N_2 or CO_2.

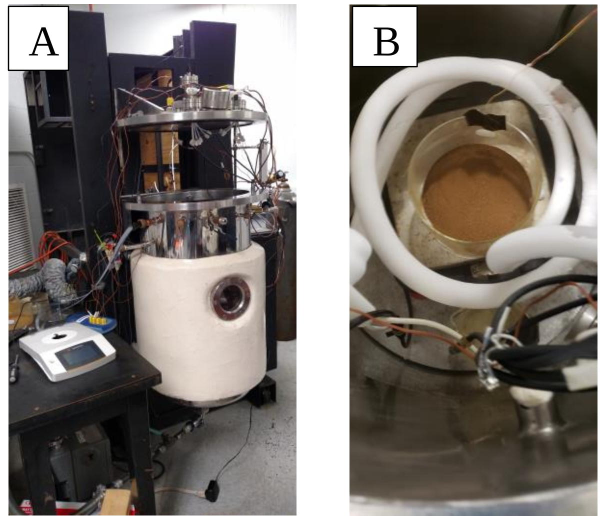

Figure 1A: Exterior view of the Ares Chamber. **Figure 1B:** Interior view of the Ares chamber. The image is taken at the end of an experiment, The petri dish contains of sample of JSC Mars-1 regolith surrounded by the liquid nitrogen internal cooling coils.

Methodology: Measurements of input parameters are performed for different regoliths relevant to observations of the Martian surface: smectite, basalt, JSC-Mars 1, Mojave Mars Simulate (MMS), and nanophase ferric oxides [6]. Adsorption kinetic constants are derived from the change in mass of water adsorbed as a function of time (Fig. 2) on a thin layer (~1 mm thick) of regolith, resulting in minimum diffusion and maximum surface in contact with the atmosphere. The samples are baked for 24 hours at 100°C and then sealed in desiccators placed in a freezer to cool the sample. All experiments are run in the Ares Mars Simulation Chamber. The chamber is evacuated to 1 mbar, filled with dry CO_2 gas to atmospheric pressure, and chilled to the determined temperature. Once conditions are stable, the chamber is opened, the sample is measured and placed in the chamber, and the lid is quickly closed. Although there was a short exposure to the atmosphere while the sample was removed from the desiccator and placed in the chamber, the chamber is filled with CO_2 to help constrain water contamination. The entire exposure time is less than 120 seconds. The chamber is then pulled to vacuum again. The sample is then exposed to a 6 mbar CO_2 atmosphere at various temperatures (-30 to 0°C) and humidities (5 to 80%). To ensure the temperature is as consistent as possible, liquid nitrogen is manually released into the internal coils at regular intervals. Experiments are run for 4 to 8 hours, to allow the sample to reach steady state. During this time, mass, pressure, temperature, relative humidity, and water vapor pressure are recorded.

Results and Discussion: We ran several experiments using JSC Mars-1 at different temperatures between -30 and 0°C. Preliminary data show mass increasing and plateauing after about 60 minutes at 0ºC, similar to previous experiments (Fig. 2A), whereas it doesn't plateau until after 420 minutes for -30ºC. However, these data showed regular spikes, due to the input of liquid nitrogen throughout the experiment (Fig. 3), but we are working on ways to eliminate this variable. We intend to fit data and redo the analysis of our data using a new kinetic BET theoretical treatment that is currently under development. This method will take into account adsorption on the first layer as well as subsequent kinetic exchange between each additional layer.

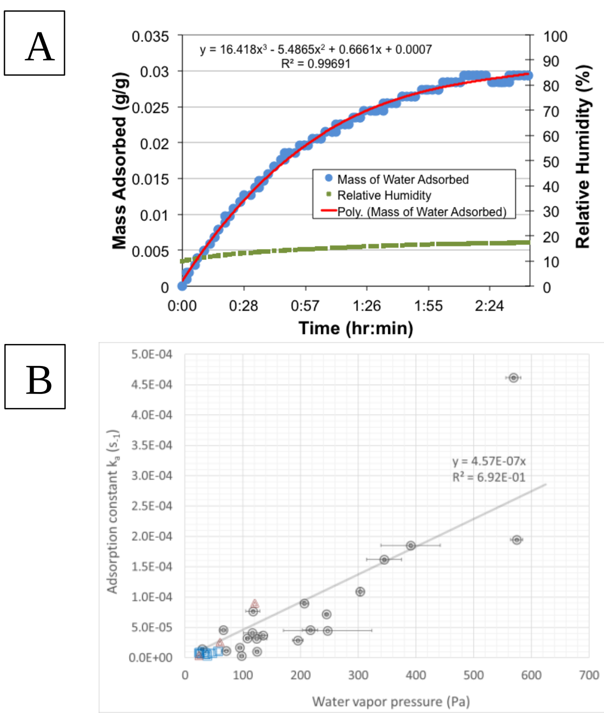

Figure 2 A: Mass loss curve from preliminary experiments of water adsorbed onto montmorillonite under Martian simulated conditions at 276 K, 15% relative humidity. **B**: Adsorption kinetic constant as a function of water vapor pressure. The data for the blue squares are from [2], the grey circles are from [10], and the triangles are from [4].

Implications and Conclusion: Diurnal cycles on Mars pose interesting questions about the surface-atmospheric interactions, such as the interactions of bulk brines, and advance our understanding of long-term stabilities of brines. This methodology could lead to possible insights into the diverse types of regolith and grain size structures studied for future work.

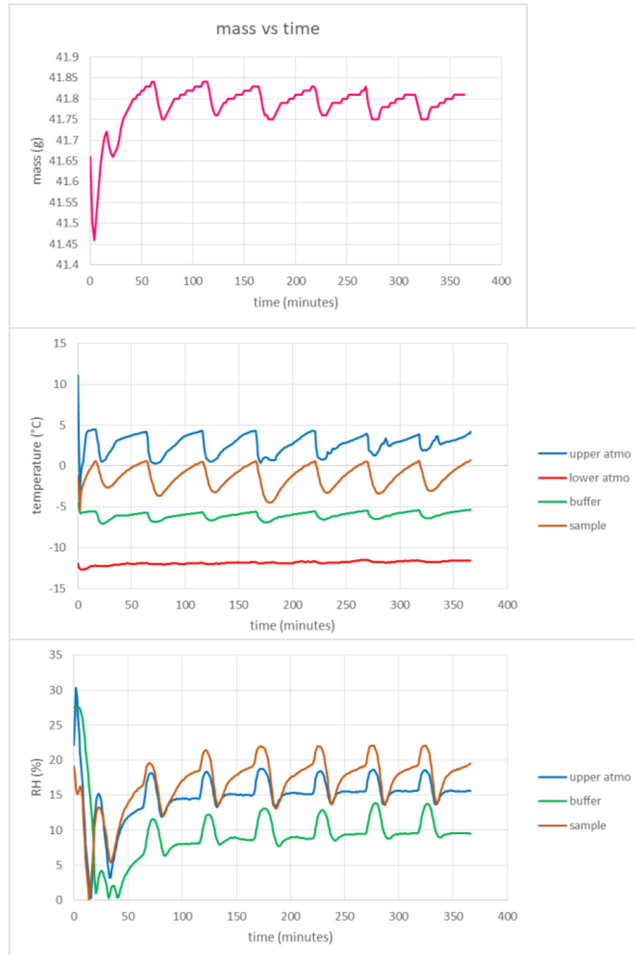

Figure 3: Lithium chloride humidity buffer and JSC Mars-1 regolith simulant at -1°C. Top: mass, middle: temperature and bottom: relative humidity.

Acknowledgements: Acknowledgments: This grant is funded by NASA Habitable Worlds Program award #80NSSC20K0227.

References: [1] Beck, P. et al. (2010) JGR 115. [2] Chevrier, V.F. et al. (2008) Icarus, 196, 459-476. [3] Rivera-Valentin, E. G. (2012) Doctoral Dissertation, University of Arkansas [4] Zent, A.P., et al. (2001) JGR, 106(7), 14667-14674. [5] Beck, P. et al. (2010) JGR 115. [6] Chevrier, V.F. et al. (2006) PSS, 55, 289-314. [7] Bryson, K. et al. (2008) Icarus, 196, 436-458. [8] Chevrier, V.F. et al. (2007) GRL, 34. [9] Hudson, T.L. et al. (2007) JSR 112. [10] Farris, H.N. et al (2014) LPSC XLV, abstract #2332.