REGOLITH-ATMOSPHERE WATER VAPOR TRANSFER ON MARS: COMPARISON BETWEEN PHOENIX AND MSL DATA. M. B. Conner[1,2], H. N. Farris[1], V. F. Chevrier[1], [1]Arkansas Center for Space and Planetary Science, MUSE 202, University of Arkansas, Fayetteville, AR 72701, USA, [2]Reed College 3203 Woodstock Blvd, Portland, OR, 97202. mconner@reed.edu.

Introduction: The first relative humidity (R_H) data was returned by Phoenix [1, 2], and it allowed the first detailed investigation of the diurnal water cycle on Mars. Phoenix took its measurements in the north polar region during the martian summer. Much has been discussed with regards to the water cycle on Mars, including an evaporation-adsorption cycle where water molecules alternate between thin layers on the surface of regolith and water vapor in the air (Fig. 1).

The most recent rover to visit Mars, MSL, also returned detailed R_H data in an equatorial region across a full martian year. A comparison of the two data sets is warranted since the two rovers are located in the two geographic extremes of the surface (polar vs. equatorial), so theoretically these two data sets bracket the climate on the martian surface.

This abstract analyzes the Phoenix data using adsorption theories built on the foundation of regolith parameters. The results of this analysis will then be compared to the MSL data.

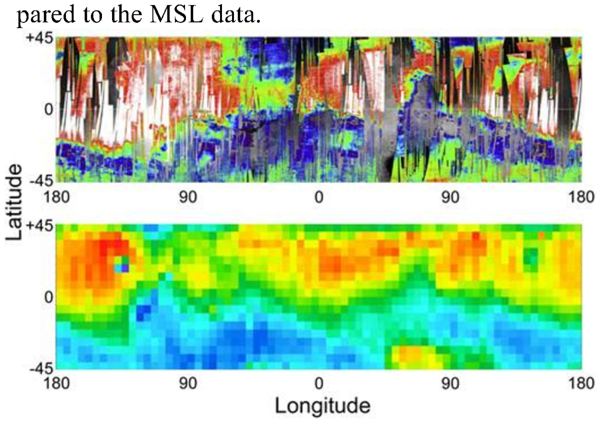

Figure 1. Comparison between **top**: the distribution of nanophase ferric oxides as seen by Mars Express OMEGA (high abundance: white, low: blue) **[3]** and **bottom**: the humidity in the atmosphere, ranging from 0 (blue) to ~30 (red), as observed by MGS-TES in the equatorial regions **[4, 5]**. The similarity of both maps suggests the ferric oxides abundant in the regolith could control the atmospheric humidity through adsorption and desorption **[6]**.

Phoenix data: R_H from Phoenix was taken with the Thermal and Electrical Conductivity Probe (TECP) instrument. The data came from the PDS for sols 0–150. Saturation vapor pressure (P_{sat}) [7] was calculated using the board temperature T (will suffice as the atmospheric pressure). Computing the vapor pressure at the frost point temperature allowed for the calculation of the pressure of water (P_{H2O}). Using these two calculations, R_H (Eqn. 1) could then be found and plotted against the temperature (Fig. 2).

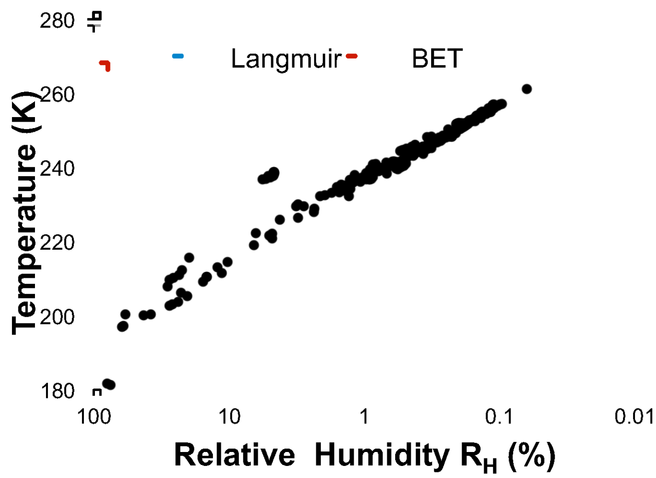

Figure 2. Fit of Phoenix lander data using the Langmuir adsorption theory (blue line) for one monolayer of water molecules, and the BET theory (red line) for multilayer. The fit uses JSC Mars-1 simulant parameters shown in (Table 1) and a $\Delta H \approx 56$ kJ mol^{-1}. The resulting surface coverages are 0.15 and 0.32, respectively.

At first glance of the data (Fig. 2) suggests a logarithmic fit. To explain this relationship, two theoretical paths were taken: Langmuir and BET. Both are theories of adsorption that involve modeling liquids by layers; Langmuir only assumes a monolayer, while the more rigorous BET method allows for a multilayer construction. Beginning with the definition of R_H for a Langmuir isotherm:

$$R_{\mathrm{H}} = \frac{P_{\mathrm{H_2O}}}{P_{\mathrm{sat}}} \quad (1)$$

where P_{sat} has been shown to be a function of temperature and P_{H2O} is the saturation vapor pressure for water ice and is given by rearranging the Langmuir equation:

$$P_{\mathrm{H_2O}} = \frac{\theta}{\alpha(1-\theta)} \quad (2)$$

Here θ is the surface coverage (or the fraction of the surface covered by water) and α is parameter describing the regolith at a specific temperature. Knowing α at one temperature, one can find it at other temperatures with:

$$\alpha = \alpha_0 \frac{P_{\mathrm{sat}}(T_0)}{P_{\mathrm{sat}}(T)} \mathrm{Exp}\left[-\frac{\Delta H}{R}\left(\frac{1}{T} - \frac{1}{T_0}\right)\right] \quad (3)$$

where R is the ideal gas constant, T is temperature, ΔH is the enthalpy, and $P_{sat}(T)$ is the saturation pressure at temperature T. The α_0 values were obtained from (*Beck et al., 2010)* at T = 243K, so α at any temperature could be calculated [6]. With this variable taken care of, a fit of the data could be made by adjusting the only two remaining variables: θ and ΔH. For the regolith JSC Mars-1 ($\alpha_0 = 0.81$), the curve fit the data at values of $\theta = 0.15$ and $\Delta H \approx 56$ kJ (Fig. 2).

A BET approach is analogous. Rearranging the BET equation and solving for R_H

$$R_{\mathrm{H}} = \frac{C+2\theta-C\theta\sqrt{1+\frac{4\theta}{C}-2\theta+\theta^2}}{2\theta(1-C)} \tag{4}$$

Here θ is the volumetric coverage, and C is a constant that is defined as α times the saturation pressure. C can also be expressed as:

$$C = C_0 \exp(-\frac{\Delta H}{RT}) \tag{5}$$

Combining equations (4) and (5), and C values for different regolith types taken from *(Pommerol et al., 2009),* a fit was made where adjustments were made, again, to θ and ΔH [8]. For the regolith JSC Mars-1 ($C = 103.4$ at $T = 243$ K), the curve fit the data at values of $\theta = 0.33$ and $\Delta H \approx 56$ kJ (Fig. 2). Visually, the BET curve fits better than the Langmuir one and it encompasses the data points at the edge of the set.

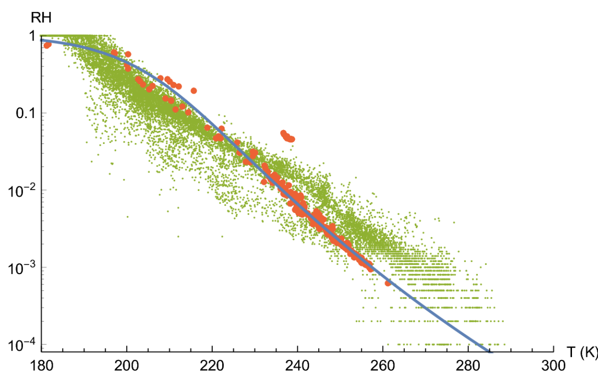

Figure 3. MSL data (green) and Phoenix data (orange) fit using the multilayer BET theory (blue) for JSC Mars-1 simulant parameters shown in Table 1 and, has a $\Delta H \approx 56$ kJ/mol and $\theta \approx 0.329$.

MSL data: R_H from MSL was taken with the Rover Environmental Monitoring Station (REMS) instrument. The data showed a similar trend of increasing humidity with decreasing temperature, though the trend of the data is much broader than the Phoenix data (Fig. 3). Even when only looking at the MSL data from the same season as the Phoenix data (summer), this difference persisted. Indeed, neither the Langmuir nor the BET theories produced satisfying fits, despite how freely the θ and ΔH parameters were adjusted.

Because the data are much less clustered at the MSL landing site, it can be inferred that the water cycle behavior at this site is more complex than the behavior at the Phoenix site (i.e. it is likely that many more variables affect humidity at the MSL site than at the Phoenix site). It should also be noted that since MSL is travelling, it could encounter a variety to different climates and regolith types, which might disperse the data. Organizing the MSL data by solar longitude (Fig. 4) shows that humidity is lowest in the winter months, and much higher humidity during the summer months (as expected).

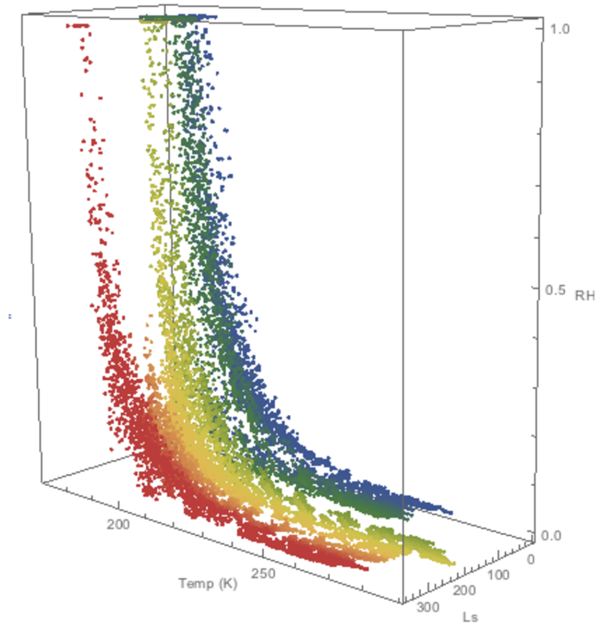

Figure 4. R_H vs. temperature compared by their solar longitude (color coded by solar longitude). Presenting the data this way highlights the low humidity values present from a solar longitude of about 200° to 300° (winter).

Conclusions: The trend in the data collected with Phoenix can be explained with the multilayer BET theory. This explanation breaks down when applying it to the MSL data, which suggests more factors affect adsorption processes in the equatorial region of Mars than in the polar region.

The BET model describing the Phoenix data points, results in $\theta \approx 0.3$ layers, which suggests liquid water can adsorb onto the surface, but in very small amounts.

References: **[1]** Hecht M. H. et al. (2009) *Science* 325, 64-67. **[2]** Chevrier V. et al. (2008) *Icarus* 196 (2), 459-476. **[3]** Poulet F. et al. (2007) *Journal of Geophysical Research*. 112. **[4]** Jakosky B. M. et al. (2005) *Icarus*. 175, 58-67. **[5]** Smith, M. D. (2002) *Journal of Geophysical Research*. 107. **[6]** Pommerol et al. (2009) *Icarus* 204(1), 134-136. **[7]** Feistel R., W. Wagner (2007) *Geochim. Cosmochim. Acta* 71, 36-45. **[8]** Beck P. et al. (2010) *J. Geophys. Res.* 115 (10), 1-11.