THE SIMULATION AND SPECTRA OF ICY REGOLITH. Margaret Raabe[1], Rob Pilgrim[2], and Richard Ulrich[2]. [1]College of Wooster, Wooster, OH (mraabe12@wooster.edu) , [2]Arkansas Center for Space and Planetary Sciences, University of Arkansas, Fayetteville, AR.

Introduction: Regolith is defined scientifically as a layer of pulverized rubble and dust covering the surface of a planet [1]. There is an extensive amount of research supporting the existence of subsurface ice on Mars [2, 3]. However, it is not yet concluded whether separate layers of water-ice and regolith exist, or whether the water-ice is intermixed with the regolith. We study regolith with water-ice mixed in and refer to it as icy regolith.

The purpose of this project is to simulate icy Martian regolith and examine its spectra. Analysis like this gives us the basis for creating models which may predict factors like subsurface temperature and water content. Models created based on this research could be used to compare to actual results of icy regolith if it is found in a future mission.

We analyze the simulated Martian regolith by varying the water content in samples of the frozen regolith and then comparing the spectra of the different samples to each other. Our goal is to find and model the trends of how the spectra of icy regolith change as a function of water content.

Experimental:

Simulation. All simulated regolith samples use JSC Mars 1 simulant given to the Arkansas Center for Space and Planetary Science by NASA.

Based on previous research [4], the current simulation method we use was developed to minimize the amount of water adsorbing to our samples. We make sample groups saturated at various weight percentages based off the saturation limit of the JSC Mars 1, which we calculated. Making each sample involves baking the regolith in an oven to remove all water in the sample, saturating each sample to the desired weight percent, wrapping each sample in foil, and sealing each in an airtight container. We freeze the samples for the same amount of time, at least overnight, in a freezer at about -20°C until we are ready to take their spectra.

Spectra. A Nicolet 6700 FTIR spectrometer from Thermo Scientific was used for all the collection of spectra. The Smart NIR Probe accessory was used with a probe made out of fiber optic cables, along with the FTIR. OMNIC software was used to record and analyze the spectra.

To reduce the condensation of water vapor to the sample and reduce the warming of the sample after it is taken out of the freezer, we created a cooled Styrofoam container shown in Fig. 1. The sample is placed in the center of the container, surrounded by dry ice to keep the sample as cold as possible. Nitrogen flows over the sample to prevent water vapor from forming on the surface of the sample or on the tip of the probe.

Figure 1: Improved Styrofoam chamber used to take spectra. The sample is in the center surrounded by dry ice. The yellow tube allows nitrogen to flow over sample.

To minimize the change in the sample's temperature while spectra are taken, we take only 40 spectral scans. We determined from visual analysis that after about 40 scans of the regolith's spectra, the spectrum hardly changes and more scans would not be beneficial and just result in the sample warming up. This change in temperature could affect the resulting spectra.

The only spectrum which was taken differently was the spectra of the dry regolith. To get the most accurate spectra as possible, the dry regolith was placed on a hot plate of ~103°C for 3 hours with dry nitrogen flowing over it. The hot plate removed any adsorbed water already in the sample and the nitrogen prevented any additional water from adsorbing to it.

Results and Discussion:

There are some obvious trends we observe in our spectral analysis which can be seen in Fig. 2. Both the 1.5 and 1.9 micron bands deepen and broaden as ex-

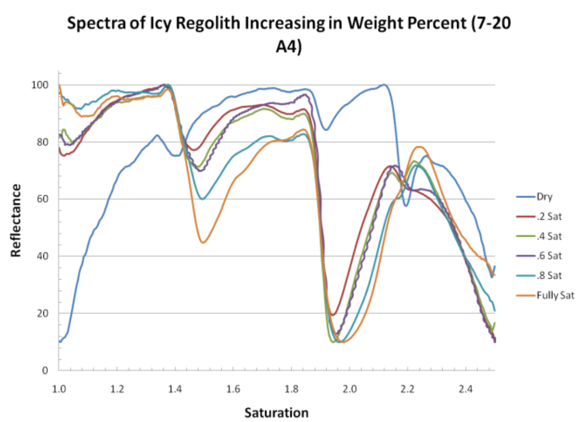

Figure 2: Spectra of icy Mars 1 regolith increasing in saturation at .2 intervals. We look to find the trends of the 1.4, 1.9, and 2.2 micron bands. The spectra were normalized using a function in OMNIC.

pected as the regolith becomes more saturated; however, the trend of the 2.2 micron band is not as obvious.

We analyze the band depth as a function of water content and look for the trend of each band. The trend we determined each band follows is shown in Fig 3. We ran the spectra of many sample groups and determined the bands in every sample follow trends similar to what is seen in Fig. 3. The 1.5 and 1.9 micron bands increase in depth as they increase in saturation and the 2.2 micron band decreases in depth as the regolith increases in saturation.

We also compared how the trends changed for each band with the addition of a container using dry ice and nitrogen to previous samples which did not use nitrogen or dry ice while taking their spectra. Figure 4 compares 6 six groups of samples of regolith, three taken in a simple Styrofoam container, and three taken in a Styrofoam container with dry ice and nitrogen. The three R^2 values italicized and in red are the 3 groups which used dry ice and nitrogen. There does

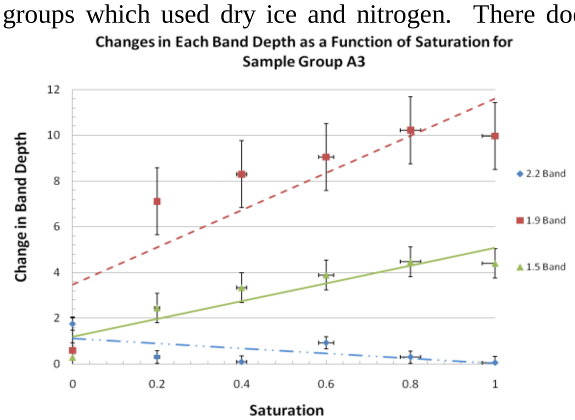

Figure 3: Graph showing the trend of each band in icy regolith. This is showing data from just one sample group, however through extensive data analysis, it was determined that each band follows a similar trend.

not seem to be a large change in the trend of the data or their R^2 values just by visual analysis. After further analyzing data similar to Fig. 3, we found a slight increase in average R^2 values for all three bands present in the spectra, meaning the data is slightly more accurate when using a container which includes dry ice and nitrogen. The greatest increase in accuracy was seen in the 1.5 micron band data which had an 18.5% difference in average R^2 value with the addition of the dry ice and nitrogen, followed by a, 8.4% difference in the 1.9 micron band and a 4.8% difference in the 2.2 micron band. The increase we found in accuracy from the use of a cooled chamber and flow of nitrogen, even though it is slight, reveals that if this container can continue to be improved to keep the sample even colder and prevent any adsorbing to the sample, the data will become even more accurate. All error bars in Fig.

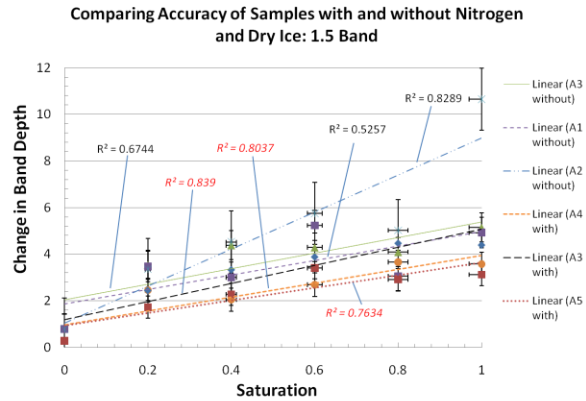

Figure 4: Graph comparing the change in accuracy of data when a container with dry ice and nitrogen is used to take the spectra of samples, specifically for the 1.5 micron band. Values italicized and in red are the samples which were taken in the improved container. The average R^2 values for data were found to increase slightly when using the new container.

3 and Fig. 4 show one standard error on the y-axis and 3% error on the x-axis. The error on the y-axis most likely results from variables such as humidity in the air and the warming of the sample while spectra are taken. The error on the x-axis represents a possible slight change in saturation due to human error while making the each sample, or possible adsorption of water, altering the sample's saturation while it is exposed to the atmosphere.

Conclusion and Future Work:

We have modeled the trends each band follows as its depth changes with the saturation of icy regolith. It has also been determined that the use of a cooler chamber and a flow of dry nitrogen over the samples increases the accuracy of the data.

To further the project, another improved chamber is in the process of design. This will be an air tight, metal chamber with coolant running through it. It will allow us to control the temperature at which the spectra of the regolith are taken and record how the spectra changes with temperature, as well as flow nitrogen over the sample and the tip of the probe. The use of this chamber will minimize any temperature change which may occur while the spectra are being taken. This would likely make the data extremely accurate.

References:

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