Icy Regolith: Simulation and Spectra

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Introduction:

This research studies planetary regolith which is scientifically defined as “the layer of pulverized rubble and dust covering the surface of a planet” [1]. Specifically, we analyze samples of regolith that has water-ice mixed in which we refer to as icy regolith.

We simulate icy Martian regolith and examine is spectra. The spectra of icy samples with various weight percents are compared to each other in order to find and model the trends of how the spectra of icy regolith changes as a function of water content. We look for ways to best and most accurately simulate this regolith and takes its spectra. Our goal is to be able to use these models to predict the water content of any randomly saturated sample of icy regolith.

Models created based on this research can be used to compare to actual results of icy regolith if it is found in a future mission.

Experimental:

Simulation:

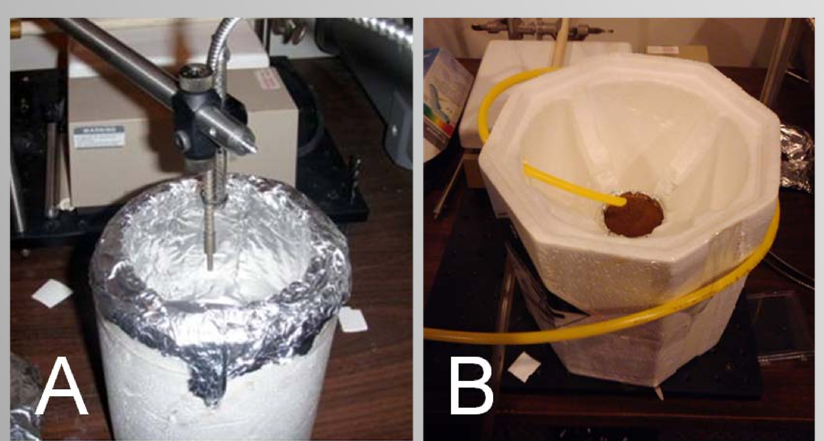
- Important to minimize water adsorbing from the humid atmosphere
- Sample groups are made with varying weight percentages; .2 saturation intervals
  - Dry regolith is baked in oven to remove adsorbed water
  - Sample is saturated to desired weight percent
  - Wrapped in foil and sealed in an air tight container
  - Samples freeze for the same amount of time

Example of icy regolith sample

Spectra:

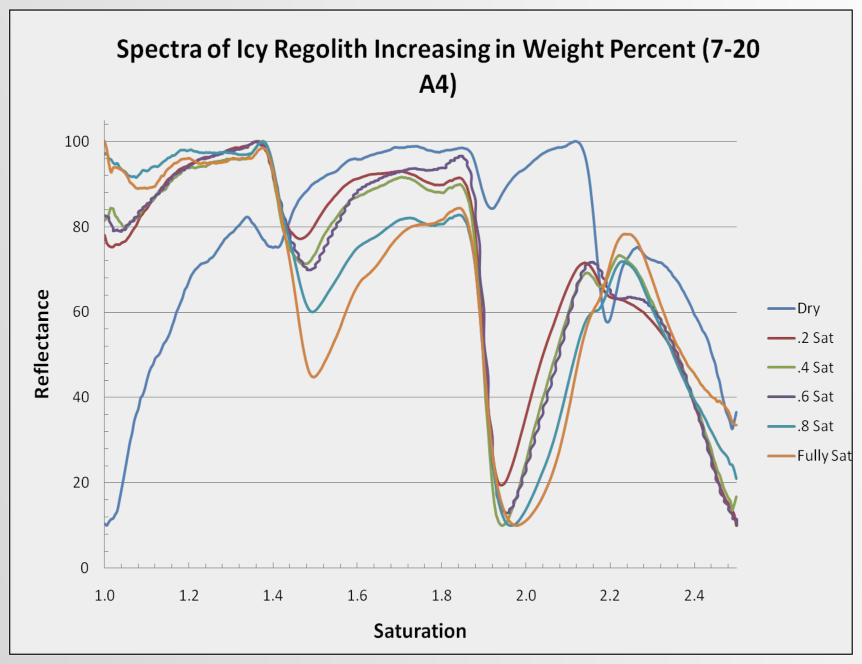
- Nicolet 6700 FTIR spectrometer with Smart NIR Probe accessory
- Experimented with different containers spectra is taken in
- Dry ice and a flow of dry nitrogen prevents water from the atmosphere condensing to the sample or tip of the probe
- Low number of spectra scans minimizes samples change in temperature
- Dry regolith used a hot plate and flow of dry nitrogen to reduce adsorbed water vapor

FTIR spectrometer used for the collection of all spectra. Shown with Smart NIR Probe accessory and the fiber optic probe attached.



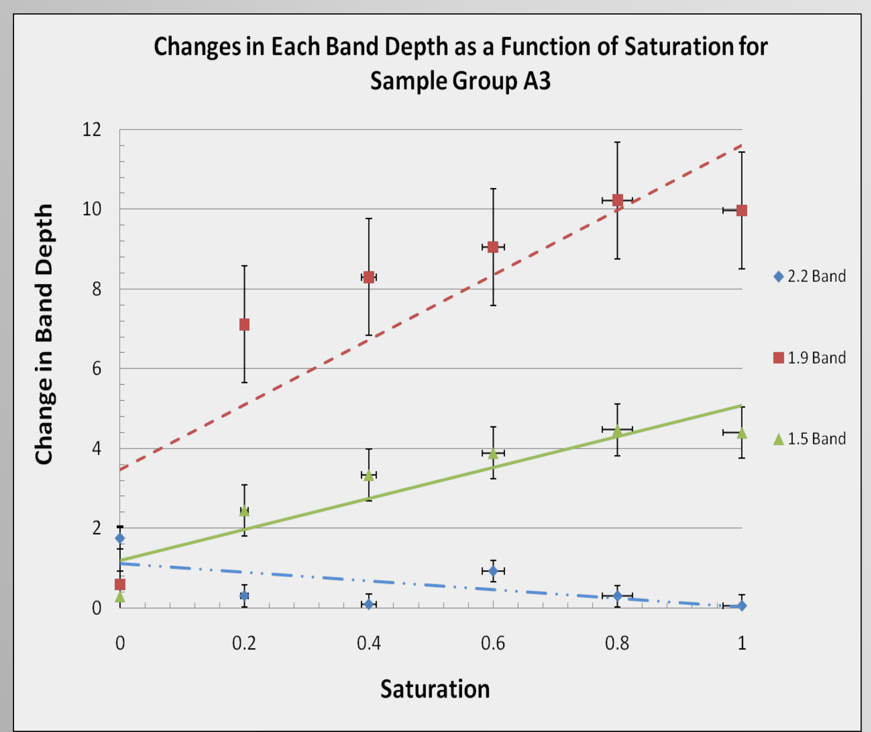
Two containers which were experimented with taking spectra of samples in. Container A is made of Styrofoam and wrapped in foil. Container B is also made of Styrofoam but has the addition of dry ice around and beneath the sample, as well as a flow of dry nitrogen over the sample and tip of the probe to minimize the condensation of water vapor.

Results:



Spectra of icy Mars 1 regolith increasing in saturation at .2 intervals. The spectra were normalized using a function in OMNIC.

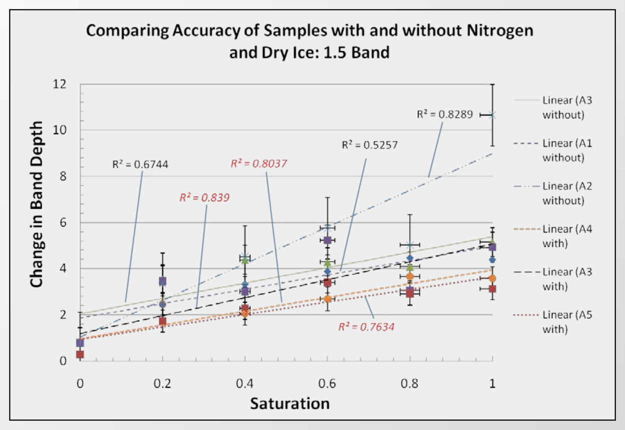
- Model trends of how the spectra of the regolith changes as it becomes more saturated
- Analyze band depths as a function of water content
- 1.5 and 1.9 micron bands increase in depth and the 2.2 micron band decreases in depth with increasing saturation

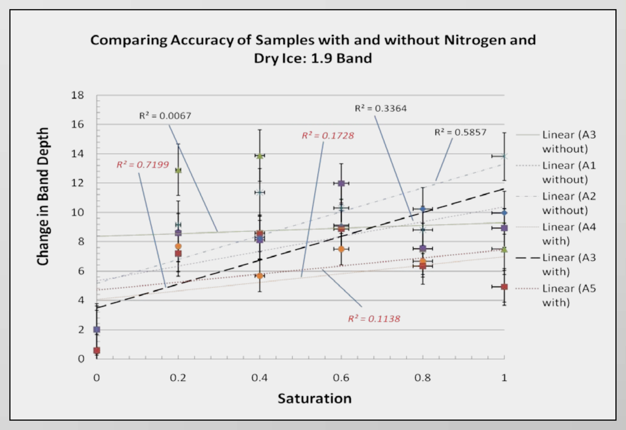


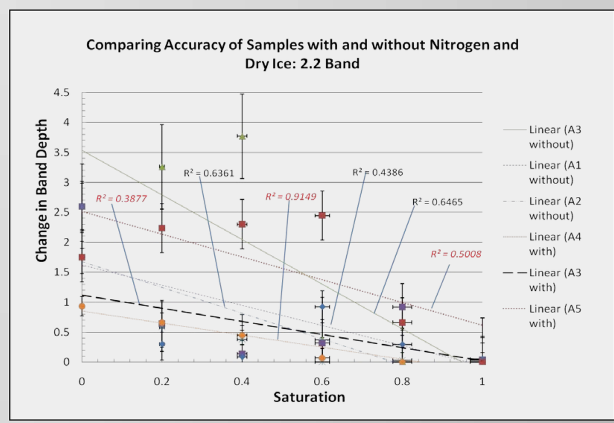
Trend the band depths of each band follows with increasing water content. The two water bands 1.5 and 1.9 micron bands increase in depth with increasing water content and the 2.2 micron band decreases in depth with increasing water content.

- Compared use of two different containers-
  - A : Styrofoam, covered in foil (old)
  - B: Styrofoam with dry ice surrounding sample and dry nitrogen flowing over sample and tip of probe (new)
- New container was designed prevent warming of the sample during spectral scans and to prevent water from condensing onto the sample or tip of the probe
- Analyzed difference in accuracy of samples in old container and new container
- Averaged R^2 values of data for each band in each sample group
- Found increase in average R^2 values for all three bands present in the spectra
  - 1.5 micron band increased 18.5%
  - 1.9 micron band increased 8.4%
  - 2.2 micron band increased 4.8%
- Improved container increased accuracy slightly -- an even greater improved container could drastically improve results
- Error bars on all graphs are one standard error on the y-axis and 3% error on the x-axis
  - Due to a possible slight change in saturation from to human error while making the each sample
  - Possible adsorption of water, slightly altering sample’s saturation while it is exposed to the atmosphere.

Old Container vs. New Container:







Each graph shows six sample groups and displays the trend of each band as its depth changes with saturation. The lines with a red R^2 value had spectra taken in the improved , cooled container. Each average R^2 value improved with the new container. The average R^2 value for the 1.5 micron band, 1.9 micron band, and 2.2 micron band increased 18.5%, 8.4%, and 4.8%, respectively.

Conclusion and Future Work:

- Band depth of the 1.5 and 1.9 micron bands increase and the 2.2 band decreases with saturation of icy Martian regolith
- Keeping the spectra as cold as possible and using dry nitrogen in the container results in more accurate models which predict the characteristics of the spectra
  - Minimize temperature change of sample while taking spectra
  - Minimize water from condensing from atmosphere onto samples
- Data will be improved by designing an even better chamber to put the samples in while taking spectra
  - Air tight, metal chamber with coolant running through it
  - Experimenter will be able to measure and control the exact temperature at which spectra is taken and analyze how characteristics of the spectra change with temperature
  - Probe will enter through hole on top, nitrogen will enter through two holes on the sides of the chamber
  - Minimize change in temperature of sample and adsorbing water vapor while spectra is taken

References:

[1] de Pater and Lissauer, 2001, Planetary Sciences, [2] Pilgrim, Rob. University of Arkansas Center for Space and Planetary Sciences

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