UNDERSTANDING WATER IN THE SURFACES OF AIRLESS BODIES THROUGH LABORATORY MEASUREMENTS OF THE 3- AND 6-MICRON ABSORPTION FEATURES

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Motivation:

- Water, as H_2O or OH, is ubiquitous in the surfaces of airless solid bodies
- The 3-µm absorption feature provides insight into the hydration states of minerals [e.g. 1,2], meteorite samples [e.g. 3,4,5], and has been used to infer water on asteroids [e.g. 6,7].
- The 6-µm absorption feature, due to molecular water, has recently been detected on the surface of the illuminated Moon [10,11].

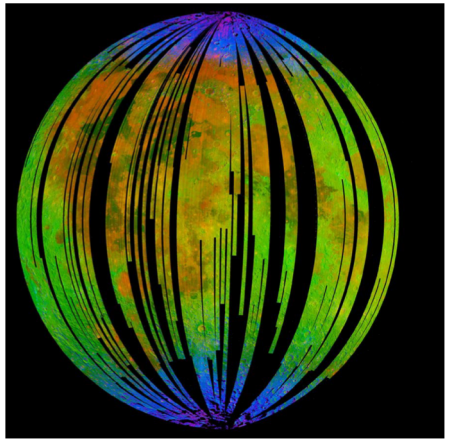
Procedures:

- Bi-direction reflectance spectra of powders for 13 chondrite meteorite and one analog mixture.
- Ambient spectra were obtained at room temperature N_2-purged.
- Desiccated spectra were obtained after heating under ~ $1e^{-7}$ to $1e^{-6}$ torr at ~ 80C for ~12 hours.
- Several spectra suffered from low SNR in the 4 - 8 µm region. We used a fitted curve in subsequent analyses and estimated noise from the least squared errors of the fit.

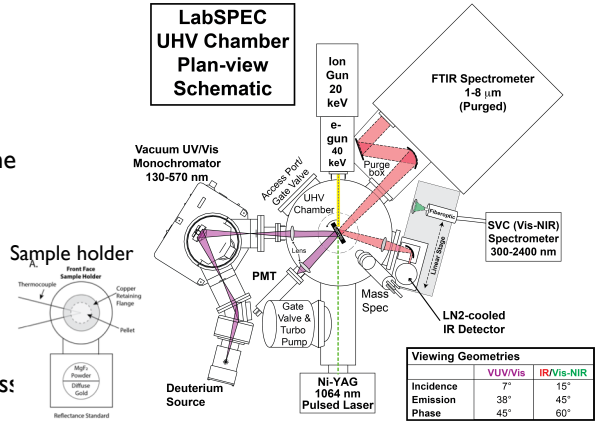
Results:

- Ambient spectra have a more rounded 3-µm band and a deeper 6-µm.
- After desiccation, the 3-µm band can appear indicative of only hydroxyl; however the remaining 6-µm band often demonstrates there is residual molecular H_2O.
- The depths and areas the 3- and 6-µm absorption features are larger in the hydration spectra as observed by previous researchers [4,5].
- The 3-µm band positions consistently shift to shorter wavelength with decreasing abundance of adsorbed molecular water, interpreted as indicative of stronger bonding between the residual water molecules.
- In contrast, the 6-µm band often shifts to longer wavelengths upon desiccation.
- The shift in the 3-µm asymmetric stretch to shorter wavelengths when less water is present has been and adsorbate than is the bond between water molecules themselves; a stronger bond → shorter bond length→ higher frequency and shorter wavelength for the vibration. The mechanism for the opposite shift in the 6-µm symmetric vibration is not yet clear.

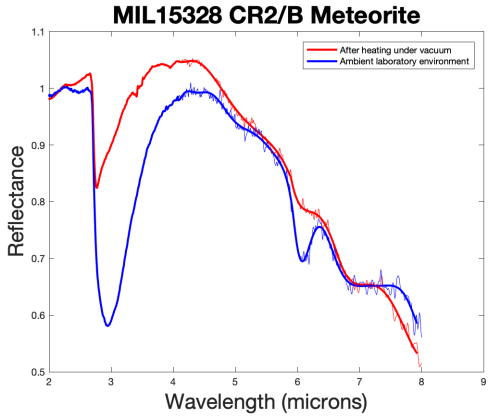
References: [1] McCord et al. 1998; [2] Orlando et al., 2005; [3] Brown and Hand, 2013; [4]Carlson et al. 1999; [5] Ligier et al., 2016; [6] Hanley et al., 2014; [7] Shirley et al., 2010; [8] Shirley et al., 2016; [9] Dalton et al., 2013; [10] Cassidy et al., 2013; [11] Fischer et al., 2015; [12] Prockter et al., 2017; [13] Hand and Carlson, 2015; [14] Hibbitts et al., 2018; [15] Paranicas et al., 2001; Pieters et al., 2009

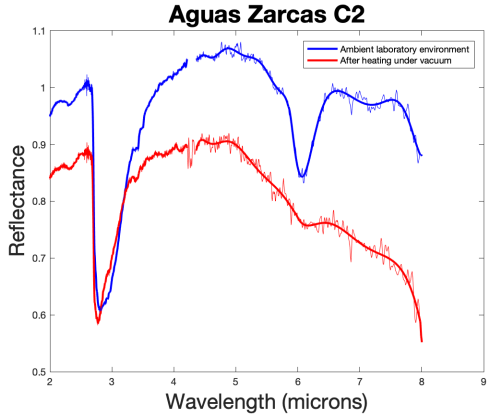


Map of ~ permanent lunar surface hydration (blue); other mineralogy (red/green); [16].

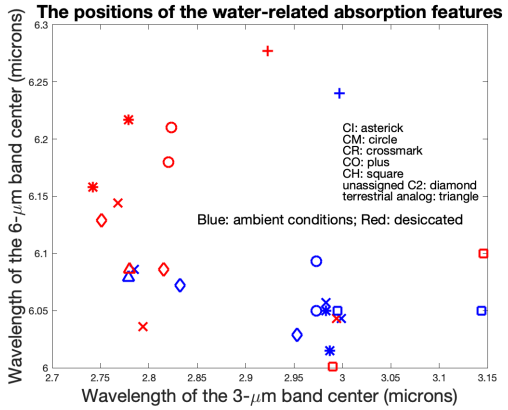


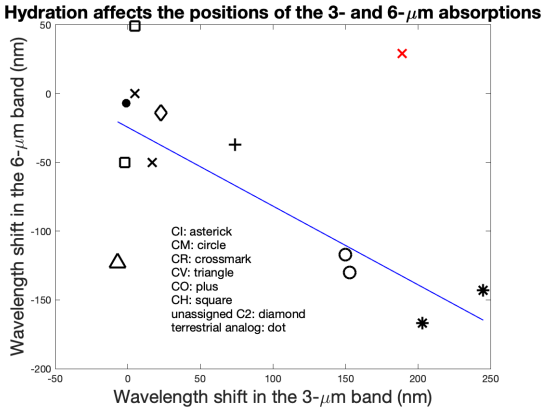
LabSPEC facility at JHUAPL where these spectra were collected will in future experiments explore the UV characteristics and effects of space weathering that is simulated with high energy electron, proton irradiation, and pulsed laser irradiation.





Example Spectra. Thick line (mathematical fit). Thin line (data). Desiccation decreases the depth of both the 3-and 6-µm band and affects their shapes, though differently. The 6-µm band is only sensitive to H_2O, whereas OH can be at least partially responsible for a 3-µm band.





Left: Desiccated meteorites generally have a shorter wavelength 3-um band and a longer wavelength 6-µm band than when more hydrated.
Right: The shift in position of the absorption centers for the 3 and 6– µm bands is ~ linear.