A spectroscopic study of high-fidelity simulated primitive asteroid regolith. Z. A. Landsman[1,*], P. T. Metzger[1], A. S. Rivkin[2], D. T. Britt[3], K. M. Cannon[3], C. Hibbitts[2], and K. Stockstill-Cahill[4], [1]Florida Space Institute, Orlando, FL 32826, [2]Johns Hopkins University/Applied Physics Laboratory, Laurel, MD 20723, [3]University of Central Florida, Orlando, FL 32816, [4]Planetary Science Institute, Tucson, AZ 85719. [*]E-mail: zoe.landsman@ucf.edu

Introduction: The composition of the most primitive, volatile-rich asteroids provides constraints on models of solar system formation and surface alteration processes since. Volatile-bearing asteroids, especially those with accessible water and/or hydroxyl, are also of interest as targets of *in-situ* resource utilization (ISRU) efforts.

While rock-forming minerals and some phyllosilicates show characteristic absorption features in visible (0.4-0.8 micron) and near-infrared (0.9-2.2 micron) reflectance spectra, these are generally shallow or absent in the spectra of dark, primitive (e.g., C-taxonomic class) asteroids. Absorption features near 3 microns can diagnose the presence of water ice and/or hydroxyl on asteroids, but the interpretation of this feature is not straightforward. There appear to be several groupings of 3-micron feature shapes, and these groups are likely to be related to composition and degree of thermal metamorphism [1-4; see Figure 1].

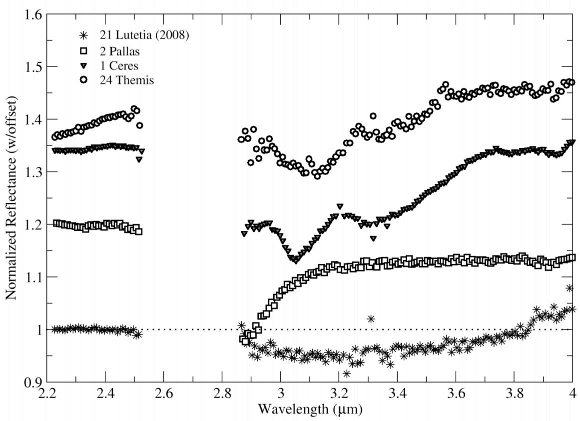

Figure 1. Ground-based reflectance spectra of four asteroids showing the diversity of the 3-micron feature. Figure originally published in [1].

Our aim is to produce and spectroscopcially characterize a number of primitive asteroid regolith simulants in which we vary the quantities of hydrated constituents and the measurement conditions. We will compare these spectra to observations of asteroids, to meteorite spectra, and to linear spectral mixing models. This approach will allow us to study how subtle compositional differences and alteration processes affect the 3-micron spectral region.

Methodology: A University of Central Florida/Deep Space Industries collaboration has resulted in high-fidelity simulants corresponding to carbonaceous chondritic meteorite classes (e.g., CI, CM), Mars, and Phobos [Figure 2; 5-7]. We are building on this experience to fine-tune our primitive asteroid simulant "recipes".

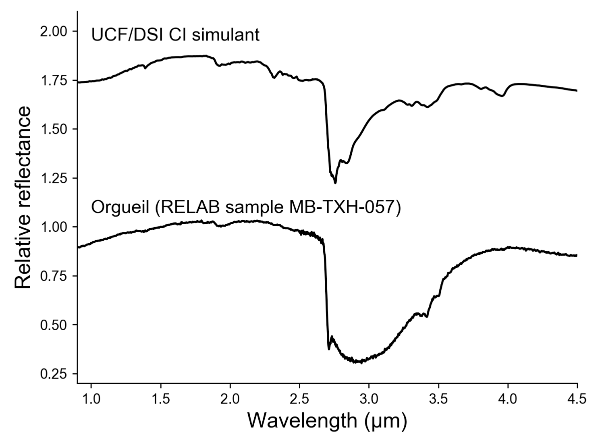

Figure 2. The 3-micron region in reflectance spectra of the UCF/DSI CI meteorite simulant (top) and a RELAB database spectrum of the CI meteorite Orgueil (bottom).

The simulants are produced by combining cleaned, dried, and powdered mineral constituents. The nominal constituents for each recipe are based on laboratory studies of volatile-rich meteorites and studies of asteroid surfaces. Readily available simulant constituents in our library include: the rock-forming minerals olivine and pyroxene; phyllosilicates (antigorite, lizardite, attapulgite, vermiculite); pyrite; magnetite; metallic iron-nickel mixtures; and sub-bituminous coal, which is a safe analog for the carcinogenic organic component (i.e., polycylic aromatic hydrocarbons) typically found in carbonaceous chondrites.

To produce a "regolith" with polymineralic grains, water is added to the dry mineral mix, and the resulting slurry is then dried under low heat and in vacuum. The dried slurry forms a solid puck which we then crush into a regolith with power-law grain size distribution. (Figure 3).

We will verify the modal mineralogy of the simulant mixtures using an X-ray diffraction (XRD) facility at the University of Central Florida. We will obtain reflectance spectroscopy from visible and near-infrared wavelengths at the University of Central Florida, and from 1.7-5.5 microns at the Johns Hopkins University Applied Physics Laboratory [8]. Because the 3-micron spectral region is sensitive to the presence of adsorbed water, and to properly replicate asteroid surface conditions, we will we will heat (~400K) the powdered simulant under high vacuum (~ 1×10^{-8} torr) to dehydrate it before collecting spectra. We will also reduce the temperature to cryogenic (~ 100K) to study how temperaure changes affect the 3-micron feature, including any variations in the spectal nature of adsorbed molecular water at different temperatures.

Figure 3. Powdered meteorite simulant from the UCF/DSI collaboration.

Status and Future Work: Nominal simulant recipe creation and batch mixing are in progress. Once our initial data is collected as described above, we will compare our results to tests of aqueous alteration in meteorites [e.g., 3] and asteroids [e.g., 1,2,4]. Results from nominal batches will inform which parts of our parameter space (e.g., relative quantities of minerals, dehydration protocol, temperature and/or pressure during measurements) we should continue to explore.

References: [1] Rivkin, A. S. et al. (2011) *Icarus*, 216, 62–68. [2] Takir, D. and Emery, J. P. (2012) *Icarus* 219, 641–654. [3] Takir, D. et al. (2013) *Meteoritics & Planet. Sci*, 48, Nr 9, 1618–1637. [4] Rivkin, A. S. et al. (2015) *AJ*, 6, 198. [5] Britt, D. T. et al. (2018), *this issue*. [6] Cannon, K. M et al. (2018), *this issue*. [7] Metzger, P. M. et al (2018), *in prep.* [8] Hibbitts, C. et al. (2012) *LPSC XLIII*, Abstract # 2400.