REFLECTANCE SPECTRA OF BENNU SAMPLES IN THE 3 MICROMETER REGION: INITIAL RESULTS FROM RELAB AND IMPLICATIONS FOR REMOTE SENSING OF PRIMITIVE ASTEROIDS.

R. E. Milliken[1], T. Hiroi[1], C. D. Schultz[1], V. E. Hamilton[2], H. Kaplan[3], E. A. Cloutis[4], D. M. Applin[4], H. Connolly Jr.[5,6,7], D. S. Lauretta[5]. [1]Department of Earth, Environmental, and Planetary Sciences, Brown University, Providence, RI 02912, USA (ralph_milliken@brown.edu), [2]Southwest Research Institute, Boulder, CO, [3]NASA Goddard Space Flight Center, Greenbelt, MD, [4]Centre for Terrestrial and Planetary Exploration, University of Winnipeg, Winnipeg, Canada, [5]Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ. [6]Department of Geology, Rowan University, Glassboro, NJ, [7]Department of Earth and Planetary Science, American Museum of Natural History, New York, NY.

Introduction: Decades of telescopically acquired reflectance spectra of asteroids has revealed a diversity of shapes and absorption features in the 2.5–4.5 μm wavelength region that can be attributed to various volatiles (e.g., OH, H_2O, $CH_{2,3}$, N-bearing species) [e.g., 1]. Spacecraft observations of near-Earth asteroids Bennu by NASA's OSIRIS-REx and Ryugu by JAXA's Hayabusa2 spacecraft have provided up-close verification of such features [e.g., 2-3], with the former exhibiting absorptions interpreted to indicate the presence of carbonate and organic compounds [4-5]. The successful return of pristine samples from Bennu [6] now allows for testing of specific hypotheses about the evolution of Bennu [7], including the degree to which spectra acquired remotely (e.g., by OVIRS [8]) accurately captured the bulk inorganic, organic, and overall compositional diversity of Bennu. Based on OVIRS data, a main hypothesis is that hydrated minerals are present on Bennu, and spectral analysis in the ~2-4 μm region of returned samples can provide a direct test of this and increase understanding of the nature and distribution of hydrated materials on the asteroid's surface. We explore these issues by presenting initial reflectance spectra of bulk particulate Bennu material for the near-IR/mid-IR (~1–13 μm) wavelength region. Data are compared with OVIRS spectra as well as laboratory data of C chondrites and Ryugu samples returned by Hayabusa2.

Samples & Methods: Bennu sample OREX-800029-0 is an unsorted bulk aggregate sample consisting of particles ranging from <5 μm to several millimeters in length with an initial reported mass of 201 mg. Visually, the sample is extremely dark, with the exception of several bright particles and brighter regions on individual particles. The bulk sample was mounted in a black Teflon-coated dish with a 14 mm diameter cavity at the NASA-supported RELAB facility at Brown University for spectral reflectance measurements. Reflectance spectra of the bulk material were acquired over a wavelength range of 0.3 – 100 μm using a custom bi-directional spectrometer and a Thermo Nexus Nicolet 870 FTIR. Reflectance spectra (relative to diffuse gold) for the latter will be presented, whereas the visible/near-IR range is presented by [9]. The FTIR aperture was maximized, corresponding to a spot size of ~4 mm, to acquire spectra that are representative of the bulk aggregate material, and multiple locations on the mounted sample were measured to assess spectral homo/heterogeneity.

Results: The initial data reveal several intriguing observations, including (1) the spectral shape of the sample examined in this study is different (weaker, narrower) than OVIRS data in the ~3 μm region, both for the global average of Bennu and the sampled Nightingale site, (2) the bulk spectral properties of the measured sample are remarkably similar to lab spectra of Ryugu samples acquired at RELAB, (3) the 3 μm region is dominated by a sharp OH^- feature at ~2.71 μm that is consistent with Mg-OH vibrations and exhibits weaker absorptions at ~3.4 and ~3.8–4 μm consistent with carbonates ± organics, and (4) reflectance properties in the near/mid-IR region are generally consistent with those of some previously studied CI chondrites [10].

Discussion: This particular bulk aggregate Bennu sample is remarkably similar in its NIR-MIR spectral properties to particulate material returned from Ryugu, consistent with the material being dominated by Mg-rich phyllosilicates (e.g., serpentine and/or saponite). The absence of a strong feature in the broader 3 μm region indicates the bulk material is quite poor in H_2O. For Bennu, this is intriguing in that OVIRS data indicate a broader 'hydration' band at 3 μm, whereas spacecraft and lab data are quite similar for Ryugu [11-12]. Possible origins of these differences will be discussed, with one option being that brighter materials on Bennu commonly within the field of view of OVIRS may exhibit wider and stronger 3 μm bands but are underrepresented in the aggregate sample measured here. Spectrally disproportionate effects of bright, hydrated material have been reported for CM chondrites [13], and ongoing analyses of additional Bennu samples, including intact small stones, will test this and other hypotheses.

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