WHAT WE NEED TO KNOW BEFORE ANALYZING ASTEROID BENNU: METEORITES, REMOTE SENSING, AND OSIRIS-REx

H. C. CONNOLLY Jr[1,2], L. P. KELLER[3], D. S. LAURETTA[4], and the Carbonaceous Meteorite and Spectral Analysis Working Groups of the OSIRIS-REx Science Team. [1]Dept. of Geology, School of Earth and the Environment, Rowan University, 201 Mullica Hill Rd., Glassboro, NJ 08028 U.S.A.(connollyh@rowan.edu) [2]Earth and Planetary Sciences, AMNH, Central Park West, New York, NY 11024, U.S.A., [3]Code X13, ARES NASA/JSC Houston, TX77058, U.S.A., and [4]Lunary and Planetary Laboratory, University of Arizona, Tucson, AZ U.S.A.

Introduction: The near-Earth asteroid (101955) Bennu, the target of NASA's OSIRIS-REx asteroid sample return mission, is one of the most heavily investigated astronomical objects to date, including multiple telescope observations from visible out to radar wavelengths [1]. However, our knowledge is currently limited to whole disk spectral and photometric data and spatially resolved radar measurements data. The key to confirming any remote sensing data of Bennu, either ground-based or space-based, is to explore the asteroid with high spatial resolution and return a carefully selected sample for laboratory-based analyses. The major goal of the OSIRIS-REx remote sensing campaign is to determine the optimal site for sample collection using data to produce Sample Site Selection maps that incorporate concepts such as safety, sampleability, and science value. Visible to near-infrared (VNIR) and thermal infrared (TIR) spectra obtained with the OVIRS and OTES instruments will provide key mineralogical and chemical inputs for the science value maps.

A major question related to our ability to effectively use the spectral data collected during real-time asteroid operations for sample site selection is: Are existing spectral libraries (e.g., RELAB database, ASU TIR Spectral Library, etc.) sufficient to interpret OVIRS and OTES data? The bottom-line is that the ability of the science team to accurately interpret the spacecraft data depends on the completeness of the available spectral libraries (in terms of species, compositions, grain sizes, etc.). If these are insufficient to meet the needs of the mission, it is crucial to develop a custom spectral library for the mission to enhance existing ones. Thus, we asked ourselves a second question: How well is the OSIRIS-REx mission prepared for the remote-sensing data analysis during asteroid operations and what additional research is needed? To better assess the need for a custom spectral library and thus understand the level to which the current library and processing methods for spectral data, the OSIRIS-REx Carbonaceous Meteorite Working Group (CMWG) in collaboration with the Spectral Analysis Working Group (SAWG) undertook a two-year investigation to analyze actual meteorite and analog spectra with known constituent proportions using the mission data analysis software, known as 'The Blind Test".

Methods: The CMWG prepared a series of 10 bulk mixtures of known phases, with selected size ranges for each phase. Additionally, seven bulk chondrite samples were also prepared. Known grain sizes were prepared and well mixed for the final bulk compositions. After preparation, samples were sent to Ed Cloutis at the University of Winnipeg for VNIR analysis (0.4 – 4.3 μm) and to Neil Bowles for analysis in the TIR (4.35 – 25 μm). Final data was sent to the SAWG for reduction, phase identification, and abundance determination. The SAWG then sent their final report on the contents of each bulk composition to the CMWG for review.

VNIR Results: Overall the VNIR data correctly resolved the analog samples and meteorites samples into hydrous and anhydrous groups where these were major constituents with only minor deviations. Detection of minor phases at the 5% level (a requirement for the mission) was mixed. Organics in analog samples at the 5% level were correctly identified with only 2 false positives (at the trace level). Curiously, organics were not detected in any of the meteorite samples. Transparent minerals minerals and minerals lacking strong, distinctive absorption features in the visible/near-IR were not detected in the VNIR analyses, including plagioclase, FeNi metal, troilite, and magnetite.

TIR Results: Overall the TIR analyses correctly resolve the analog samples and meteorite samples into hydrous and anhydrous groups where hydrated or anhydrous minerals are major constituents. No information was gleaned from the TIR data for the detection of organic features. In analog samples, olivine and phyllosilicates were consistently identified when they were major constituents of the mixtures, but pyroxene and plagioclase present in the analog samples at the 10 wt.% level went undetected. However, phyllosilicates were not identified in the spectra of the CM chondrites Murchison and ALH 83100. Detection of minor phases at the 5% level was unreliable.

Summary and Path Forward: The CMWG 'Blind Study' was informative and a worthy undertaking. The CMWG made 7 recommendations that will be discussed during the talk to the project for consideration, including the production a custom OSIRIS-REx spectral library. The custom library will enhance the mission's ability to accurately determine phases and their abundances on the surface of Bennu to better inform the ideal location for collection of a sample. Of course, the final ground-truth for any of the remoting sensing data will come from the analysis of the returned sample in September of 2023.

References: [1] D. S. Lauretta et al., (2015) The OSIRIS-REx target asteroid 101955 Bennu: Constraints on its physical, geological, and dynamical nature from astronomical observations. Meteoric. Planet. Sci., 50, 834.