QUANTITATIVE REFLECTANCE IMAGING OF SAMPLES RETURNED FROM ASTEROID BENNU

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Instroduction: The Origins, Spectral Interpretation, Resource Identification, and Security–Regolith Explorer (OSIRIS-REx) spacecraft arrived at its target, near-Earth asteroid (101955) Bennu, in December 2018. After one year of operating in proximity, the team selected a primary site for sample collection. In October 2020, the spacecraft descended to the surface of Bennu and collected a sample. The spacecraft departed Bennu in May 2021 and will return the sample to Earth in September 2023 [3]. The analysis of the returned sample will produce key data to determine this B-type asteroid's history and that of its components and precursor objects. Bennu's mineralogy, as inferred from spectral characterization [2], is dominated by (1) hydrated silicates, (2) carbonates, (3) magnetite, (4) organic components. Other phases, such as sulfides, that are not spectrally active may also be abundant in the returned sample. The presence of organics on its surface make it an object of astrobiological interest, as it may hold important information early solar system conditions, the origin of organics on Earth, and the delivery of water to Earth.

Preliminary Examination: The Preliminary Examination phase of the mission will begin once the sample canister is opened at NASA's Johnson Space Center (JSC). One of the primary goals of Preliminary Examination is the selection of returned samples for the OSIRIS-REx Sample Analysis Team to address mission science goals (up to 25 wt. percent), and samples archived by NASA (75 wt. percent) to include samples for international agencies (CSA 4 wt. percent and JAXA 0.5 wt. percent), samples for remote storage at White Sands Complex (WSC), and samples for hermetically sealed or cold storage.

Imaging Objectives: Quantitative reflectance imaging of the returned sample will occur soon after the Sample Return Capsule is opened at JSC. This characterization provides quantitative information on the reflectance of the sample for discrete wavelengths comparable to the filter set on MapCam [5] with additional wavelength bands added for more comprehensive broadband spectral characterization. The objective of this investigation is to rapidly assess the lithological diversity using normal reflectance and spectral band ratios, similar to the color imaging of Bennu [1]. After evaluating the number of distinct lithologies, we will organize our scientific investigations with reference to our coordinated analysis investigation plan to ensure characterization of all major lithologies and a subset of minor lithologies, depending the heterogeneity of the material.

Science Operations Proficiency Integrated Exercise 1 (SOPIE-1): A prototype Quantitative Reflectance Imaging System (QRIS) was used at OSIRIS-REx's Sample Analysis SOPIE-1 in February 2022 to image a sample of unknown composition under five wavelengths of light. Through analysis of the SOPIE-1 images, the OSIRIS-REx team identified 6 of the 8 unique lithologies present in the sample.

Following SOPIE-1, we conducted further analysis and identified a candidate stone to represent one of the missing lithologies.

Conclusion: The successful use of the prototype QRIS in this exercise suggests that a similar system, with a more sophisticated camera, mount, and software, will be sufficient for subsequent SOPIEs and the real Bennu sample selection. The detector, lighting, and optics procured during this project will be key components in producing science-quality images at the SOPIE-2 in August 2022.

References: [1] DellaGiustina, D. N., et al. *Science* 370.6517 (2020): eabc3660. [2] Hamilton, V. E., et al. *Nature Astronomy* 3.4 (2019): 332-340. [3] Lauretta, D. S., et al. *Space Science Reviews* 212.1 (2017): 925-984. [4] Lauretta, D. S., et al. in *Sample Return Missions*. Elsevier, 2021. 163-194. [5] Rizk, B., et al. *Space Science Reviews* 214.1 (2018): 26