Non-destructive analysis and curation of Bennu samples without atmospheric exposure

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Introduction

The study compares the asteroid samples from Ryugu and Bennu to better understand the material distribution and compositional diversity of asteroids in the main belt and near-Earth regions. Remote sensing data obtained from optical cameras show a similarity between Ryugu and Bennu, suggesting that both may have originated from a similar asteroid family. This hypothesis will be evaluated through isotopic and elemental compositions, as well as mineralogical data. Additionally, comparing these asteroid samples will provide insights into the thermal history of their parent bodies. A crucial aspect of the study is examining how boulders from exogenous planetary bodies are represented in the returned samples, especially without any terrestrial alteration or contamination. This paper focuses on the representativeness of Bennu samples delivered to JAXA and compares these samples with data from NASA’ s OSIRIS-REx team to facilitate future studies on Ryugu and Bennu.

Methods

Samples of Bennu delivered to JAXA were selected to meet specific weight criteria, constituting 0.5 wt.% of the total mass of the returned samples (121.6 g). The selected samples were processed in clean chambers dedicated to Bennu samples. Key equipment used in the analysis included an optical digital microscope, a microbalance for precise measurements, a visible multispectral microscope, an infrared spectroscopy, and a near-infrared hyperspectral imaging microscope.

Results

Five individual dishes were analyzed, with weights ranging from 0.047 g to 0.183 g. Mapping data of the bulk samples were collected using the digital microscope, identifying approximately 30,000 particles within these dishes. The reflectance spectra of the samples were obtained across a broad wavelength range (visible to infrared), revealing an average reflectance of 0.0231 ±0.0008 at 550 nm. The spectra showed a positive spectral slope, consistent with typical asteroid compositions. The near-infrared data revealed absorption bands at around 2.7 μm, attributed to the stretching vibration of -OH groups, and around 3.4 μm, related to -CH bonds. Additionally, the spectra indicated the presence of carbonates, with absorption features at 3.4 μm and 3.95 μm. The IR spectra also displayed a Christiansen feature at 9.07 μm and Reststrahlen bands at 9.78 μm.

Discussion

The representativity of the Bennu samples was assessed by comparing their spectra with previous data from the OSIRIS-REx mission and the OREX-800029-0 sample. While the Bennu samples were found to be about 10% brighter than the OREX-800029-0 sample, the spectral shapes of the samples were closely aligned, with a deviation of less than 0.5% across the 0.39–0.85 μm range. This suggests the Bennu samples provided to JAXA represent the asteroid's composition.

When comparing the Bennu samples with those from Ryugu, several similarities and differences emerged. The visible reflectance of the Bennu samples was found to be within the range of variation observed in the Ryugu samples. Both asteroids share a similar spectral shape, including positive spectral slopes and a lack of distinct absorption bands in the visible range. The absorption band at 2.7 μm in the Bennu samples is similar to that observed in the Ryugu samples, suggesting the presence of Mg-rich phyllosilicates.
However, the spectral shape of the Bennu samples was broader than that of Ryugu, with the Christiansen feature in Bennu samples slightly shifted to a shorter wavelength compared to Ryugu samples. These spectral differences could be due to variations in the mineralogical composition or physical properties of the samples. Further studies are required to better understand these discrepancies.
This study highlights the similarities and differences between the Bennu samples in JAXA and the bulk Ryugu sample. Also, subtle differences in spectral features could be helpful to investigate the comparative studies for these return samples.

Keywords: Bennu, curation, Ryugu

