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Spectral variability on (101955) Bennu from OSIRIS-REx

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Abstract

Visible to near infrared (VNIR) and thermal infrared (TIR) spectral data collected by the Origins, Spectral Interpretation, Resource Identification, Security–Regolith Explorer (OSIRIS-REx) mission have revealed evidence of widespread, hydrated materials across the surface of asteroid (101955) Bennu [1]. Here we describe variability in spectral features identified in data collected since the start of the Detailed Survey phase of the mission.

1. Introduction

OSIRIS-REx carries two hyperspectral spectrometers for measuring mineralogy, chemistry, and temperature on the surface of Bennu. The OSIRIS-REx Visible and Infrared Spectrometer (OVIRS) is a point spectrometer with a 4-mrad field of view (FOV). OVIRS measures reflectance over the range from 0.4 to 4.3 µm with a spectral sampling of 2 nm from 0.392 to 2.4 µm, and 5 nm from 2.4 to 4.3 µm [2, 3].

The OSIRIS-REx Thermal Emission Spectrometer (OTES) is a point spectrometer with an 8 mrad FOV. It measures emitted energy from ~100 to 1650 cm^{-1} (~5.5 to 100 µm) at a spectral sampling of 8.66 cm^{-1} [4]. The OVIRS FOV is within that of OTES but the two boresights are not precisely co-aligned.

2. OVIRS Results

Disk-integrated OVIRS spectra collected during the Approach phase exhibited no rotational variability and revealed a VNIR spectrum that is consistent with similar to the ground-based data of [5], having a blue (negative) slope and no visible features above the level of the noise. We have not yet arrived at any definitive conclusions regarding space weathering because it can cause both blueing and reddening of the spectral slope [e.g., 6]. A 0.55-µm feature observed in OCAMS data [7] is not (yet?) observed in the OVIRS data [1, 8] but detailed investigations of both datasets are ongoing. At longer wavelengths, an unambiguous "3-µm" band is present, consistent with the presence of hydrated silicates, including those contained in petrologic type 1, 1/2, and 2 carbonaceous chondrites. The specific position of this band in OVIRS spectra, 2.74 µm ±0.01, is most consistent with the positions observed in low petrologic subtype CM2 meteorites [9]. As of this writing, roughly mid-way through the Detailed Survey phase, no additional features have been observed with confidence but small variations in albedo and spectral slope are apparent. At this time, we cannot say if these differences arise from composition, particle size, space weathering or some combination of these. The optimal equatorial mapping station for OVIRS observations (in terms of signal-to-noise and spatial coverage) is at a local time of 10:00 am and is planned to occur on 16 May 2019. These data will be used to confirm results to-date and look for evidence of additional features.

3. OTES Results

Spatially resolved spectra at ~80 m/spot that were acquired during the Preliminary Survey phase revealed a spectrum with low contrast (~2%) and a spectral shape that is broadly consistent with carbonaceous chondrites in the CI/CM groups and does not vary with rotation [1]. The silicate bending feature in the spectra has a minimum at 440 cm^{-1} (~22.7 µm) and is indicative of a volumetrically dominant phyllosilicate component (i.e., >55%) based on comparison to laboratory meteorite spectra of analogue CM carbonaceous chondrites [1, 10, 11] and laboratory measurements of the meteorites' modal mineralogy [12]. Potential evidence of magnetite is present in features at 555 and 346 cm^{-1} [1] and is consistent with aqueous alteration. More recent Detailed Survey measurements at improved spatial resolution (~40 m/spot) exhibit spectral variability, primarily in the shape of the silicate stretching feature and the depth of the silicate bending feature. We also observe variability in the emissivity at low wavenumbers (>1100 cm^{-1}; <8 μm) that may indicate previously unresolved spatial variations in the dominant particle size on the surface. These variations are being compared with physical properties of the surface that may correspond to compositional variations, such as thermal inertia, albedo, and boulder density [e.g., 13]. The optimal equatorial mapping station for OTES observations is the 12:30 pm station, which is planned to occur on 9 May 2019 and will be used to confirm results to-date and look for evidence of additional features.

4. Summary and Conclusions

The surface of Bennu not only exhibits evidence of hydrated silicates but appears to be dominated volumetrically by such minerals and is consistent with a composition similar to aqueously altered CM carbonaceous chondrites with a potentially lesser component of CI-like material. Analysis of Bennu's surface geological characteristics indicates that it is a rubble pile that has experienced recent dynamical processes despite also retaining much older surface features [14]. Small-scale (cm to m) variability in albedo and geologic features suggest that multiple compositions could be present [15]. We will continue to search for spectral signatures of differing compositions in our equatorial mapping data, which are scheduled for collection in May 2019.

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