Color Mapping of Asteroid Bennu

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To evaluate relationships between color and morphology on Bennu, we radiometrically and photometrically corrected multispectral images acquired by the MapCam instrument of the OSIRIS-REx Camera Suite (OCAMS) [1-4]. Calibrated images were subsequently mosaicked to develop band-ratio and principal component analysis (PCA) maps. We mapped ~1600 boulders and ~700 craters, extracted their average MapCam spectra, and examined statistically meaningful trends between color, reflectance, and these morphological features. We also compared the global color distribution of Bennu to that of Ryugu.

The color of the largest craters (>100 m) on Bennu is indistinguishable from that of the average terrain. However, many small (≤25 m) craters are redder than average in the visible to near-infrared wavelengths (VIS to NIR; MapCam b′ to x bands; neutral to red spectral slopes). The size distribution of these small reddish craters implies that they are the youngest component of the global crater population, in turn implying that redder colors are related to younger exposure ages [4]. We interpret this finding to indicate that space weathering leads to spectral bluing on Bennu [4].

On the basis of reflectance and color, we have categorized Bennu's boulders into four types [4]: 1) Dark boulders are equivalent to or darker than Bennu's average surface, are subangular, and commonly have rough, undulating surface textures. They encompass a wide range of sizes including the largest boulders on the asteroid (25 to 100 m in diameter) and are the dominant boulder type. 2) Bright boulders are brighter than the average surface of Bennu, have blue spectral slopes in the mid-VIS to NIR (MapCam v to x bands), and exhibit smooth, typically angular textures. They occur only at diameters less than ~10 m. 3) Rare, very bright boulders (reflectance up to 0.26; ~1% in number) show evidence of an absorption at 1 µm (downturn in the x band), which was confirmed to be indicative of exogenic pyroxene using data acquired by the OSIRIS-REx Visible and InfraRed Spectrometer (OVIRS) [5]. 4) Rare boulders (~2% in number) that have an absorption feature detectable above the OCAMS radiometric uncertainty at 0.7 µm (absorption depth of 2 to 10%) are inferred to contain Fe-bearing phyllosilicates. The 0.7-µm absorption has been observed in spectra of primitive asteroids and carbonaceous meteorites and has been attributed to the Fe^{2+}-Fe^{3+} intervalence charge transfer associated with hydrated clay-bearing phyllosilicates [5].

This variety of boulders indicates that Bennu's surface is highly diverse, encompassing primitive material potentially from different depths in its parent body [4], as well as exogenic material delivered to the parent body from another asteroid family [5].

The multi-band cameras onboard the Hayabusa2 and OSIRIS-REx spacecraft use similar photometric filters in the visible wavelengths, allowing for direct comparison of the spectra from each [1, 6]. The variation in reflectance on Bennu is 1.7 times that on Ryugu, and Bennu exhibits a bluer overall color [4]. Ryugu shows large-scale latitudinal color differences, which have been attributed to regolith migration from the equator to mid-latitudes during a period of rotational deceleration [6]. A latitudinal color trend is also observed on Bennu, but the difference is small compared with its overall color variation [4]. Bennu's slightly bluer equatorial region may indicate the presence of more mature material, which is consistent with its increasing rotation rate and the associated global patterns of mass movement across the asteroid [7]. Unlike Ryugu, color variation on Bennu appears to be dominated by heterogeneity at the meter scale, likely driven by individual boulders [4]. This suggests that the extent of recent large-scale mass wasting on Bennu may not have been as widespread as the effect of regolith mixing [4].

References

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