LATITUDE DEPENDENCE OF SPECTRAL PROPERTIES ON BENNU: RELEVANCE TO SPACE WEATHERING. A. Sen[1], B.E. Clark[1], X.-D. Zou[2], J.-Y. Li[2], M.A. Barucci[3], A. Praet[3], M.K. Barker[4], G.A. Neumann[4], E. Mazarico[4], A.A. Simon[4], D. Trang[5], A.R. Hendrix[2], S.M. Ferrone[1], D.S. Lauretta[6], [1]Department of Physics and Astronomy, Ithaca College, Ithaca, NY, USA (asen@ithaca.edu), [2]Planetary Science Institute, Tucson, AZ, USA, [3]LESIA, Paris Observatory, France, [4]NASA Goddard Space Flight Center, Greenbelt, MD, USA, [5]Hawai‘i Institute of Geophysics and Planetology, University of Hawai‘i at Mānoa, Honolulu, HI, USA, [6]Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ, USA.

Introduction: Asteroid (101955) Bennu is the target of NASA's OSIRIS-REx sample return mission. This near-Earth asteroid has been classified as a B-type [1] and has a gently sloped blueish reflectance spectrum and a low albedo of ~4.5% [2]. Its minerology is dominated by phyllosilicates [3], with its low albedo likely due to opaques such as common carbon phases and/or space weathering products [4]. In general, there is an open question as to how space weathering effects on low-albedo asteroids might alter their visible to near-infrared reflectance spectrum, which could in turn influence their taxonomic classification and make it more difficult to draw genetic links between carbon-rich asteroids and meteorites [5].

Space weathering processes are known from lunar studies to be dominated by solar wind and micrometeorite bombardment [6]. These processes are simulated in the laboratory: solar wind by ion irradiation (H^+ and He^+), and micrometeorite impacts by pulsed-laser irradiation [7]. In this study, we will focus on the possible effects of solar wind maturation on the surface of Bennu.

Context from meteorites: Lantz et al. [8] find that anhydrous meteorites Allende (CV) and Lance (CO) undergo a drop in albedo and spectral reddening when exposed to He^+ ion irradiation (while H^+ is more abundant in solar wind, ion irradiation by He^+ ions is more effective at reducing Fe [9]), whereas hydrous meteorite samples Mighei (CM), Alais (CI), and Tagish Lake (C2) show an increase in albedo and bluing when exposed to the same conditions. Moroz et al. [10] report a slight brightening effect and significant spectral reddening upon pulse laser irradiation of Mighei (CM). Brunetto et al. [11] demonstrate significant similarities between Bennu and an areal mixture of ion-irradiated Mighei and Tagish Lake, suggesting that if these aqueously altered meteorites are reasonable analogs for Bennu, then solar wind effects are more likely to have affected Bennu's spectrum than meteoroid impacts.

Carbonization on Bennu: The orthogonality of Bennu's rotational axis to its orbital plane, along with the asteroid's top shape and equatorial bulge, suggests that Bennu's equatorial region has been exposed most directly to solar wind and thus could be more subject to space-weathering processes than the mid-latitude regions and poles. In other words, Bennu's equator is normal to the Sun, whereas the other regions are more inclined, so therefore the solar wind flux is lower [12–16].

Organics are likely to be ubiquitous on Bennu's surface [17, 18]. Organics are also found distributed in carbonaceous chondrite meteorites [19]. Moroz et al. [20] suggest that ion irradiation of organics causes carbonization (defined as an increase in C/H and C/O ratios in organics due to progressive H loss [20, 7]) and subsequent loss of aliphatic H compounds from the organic materials on a low-albedo asteroid surface that is subjected to solar wind. Spectral reddening has been observed in the equatorial region of Bennu [21–23], as has a decrease in median-averaged 1064-nm normal albedo [24]. This combination of reddening and darkening is more likely to be associated with a preferential loss of H from organics [25] than particle size effects given that a decrease in particle size has been shown to lead to spectral reddening and albedo brightening [26, 27].

Praet et al. [28] find that H abundance has a latitudinal dependence: equatorial latitudes show a 9% decrease in H content as compared to average Bennu. They demonstrate this by showing that the 2.74-μm hydration band is shallower around the equator, and attribute this decrease in band depth to partial dehydration of the surface. However, Simon et al. [17, 29] show that a decrease in band depth is also evident at other wavelengths in the NIR, including 1.05 μm, 1.8 μm, and 3.2−3.6 μm. This suggests that there might be a spectral flattening effect across the NIR, an effect attributed to preferential H loss in organics [20]. Hendrix and Vilas [30] also find an increase in UV reflectance for Bennu, consistent with carbonization of surface organics [7].

These results lead us to hypothesize that space weathering, specifically in the form of carbonization of organics, could neatly unify and explain the aforementioned observations, and might be detectable in spectral data. Space weathering studies on Bennu thus far tell us that spectral changes due to maturation are likely to be subtle and difficult to distinguish from roughness effects [4, 27, 31]. While hydrogen implantation and OH creation due to solar wind bombardment may be working at cross purposes against thermal dehydration, the relative rates of these processes are unknown [32–33]. Similarly, while ion irradiation is also known to create nanophase particles which strongly flatten and redden spectra, we do not currently know the relative rates of carbonization and nanophase particle creation on low albedo asteroids. In addition, while micrometeoroid bombardment may also be latitude dependent [34], the Brunetto et al. study [11] shows an excellent match between Bennu and He^+ irradiated Tagish Lake and Mighei samples in the thermal infrared, indicating the possible importance of solar wind. We propose that the observations of Praet et al. [28], Neumann et al. [24], Brunetto et al. [11] and Simon et al. [17] are all pointing to loss of H, possibly due to carbonization, as a surface process that may be important on Bennu.

In this presentation we will discuss our analysis of Bennu's near-IR spectra, specifically with respect to the latitude-dependence of spectral parameters and the likelihood of an association with dehydrogenation of organics. Up to now, space weathering effects are known to alter a Q-type asteroid to look like an S-type asteroid, however the C-complex asteroids have not yet been 'calibrated' with respect to space weathering alteration of spectral properties. If the spectral signals we find are consistent with space weathering on Bennu, we will extrapolate our results to the low-albedo asteroid population and predict upper limits on the magnitude of space weathering effects on carbonaceous meteorite parent body taxonomic classification.

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