KEYS TO DETECT SPACE WEATHERING ON VESTA: CHANGES OF VISIBLE AND NEAR-INFRARED REFLECTANCE SPECTRA OF HEDS AND CARBONACEOUS CHONDRITES. T. Hiroi[1], S. Sasaki[2], T. Misu[3], and T. Nakamura[3], [1]Department of Geological Sciences, Brown University, Providence, RI 02912, USA (takahiro_hiroi@brown.edu), [2]RISE Project, .National Astronomical Observatory of Japan, 2-12 Hoshigaoka-cho, Mizusawa-ku, Oshu, Iwate 023-0861, Japan, [3]Department of Earth and Planetary Materials Science, Faculty of Science, Tohoku University, Aramaki, Aoba, Sendai, Miyagi 980-8578, Japan.

Introduction: Space weathering is known to change the visible and near-infrared (VNIR) reflectance spectra of asteroidal surfaces. Past studies clearly showed the dependency of the rate of space weathering on iron content or crystal structure [1, 2]. In that respect, it is supposed that HED meteorite parent bodies would be very hard to space-weather, and space weathering of carbonaceous chondrite (CC) parent bodies would be very different from that of S-type asteroids [3]. Investigated in this study are key features useful for detecting space weathering in the VNIR spectra of HED and CC parent bodies.

Experimental: Powder samples of CCs (<125 µm): Orgueil-Ivuna mixture (CI1), MAC 88100 (CM2), ALH 83108 (CO3), and ALH 85002 (CK4), and howardite EET 87503 (<25 µm) were pressed into pellets, and their VNIR reflectance spectra (0.3-2.5 µm) were measured. The pellets were irradiated with pulse laser with energies of 5 and 10 mJ for the CC pellets and 75 mJ for the howardite pellet according to the procedure in [4], and their VNIR reflectance spectra were measured after each irradiation. For MAC 88100 and previously-studied Tagish Lake [3] meteorite pellets, FT-IR reflectance spectra (1.7-25 µm) were also measured.

Results: Shown in Fig. 1 are VNIR reflectance spectra of four CC pellets. The changes in the CO and CK spectra (Fig. 1b and 1c) follow the S-type asteroid space weathering trend, where the shorter the wavelength, the darker the reflectance becomes, and the 1-µm absorption band becomes reduced. On the other hand the CI pellet shows almost unchanged but very slightly darker and bluer spectrum after laser irradiation (Fig. 1a).

This trend of darkening and bluing is clearer in the CM2 and Tagish Lake meteorite spectra in Fig. 2, consistent with C-type asteroid observations [5]. In addition, their 3-µm hydration band seem to weaken while retaining the same band shape. This trend is different from that of thermal metamorphism, where the 3-µm band of CI/CM chondrites changes its shape [6], indicating transformatin of hydrous minerals.

Shown in Fig. 3 is the howardite result, which shows the S-type asteroidal space-weathering trend, similar to that of CO and CK in Fig. 1b and 1c.

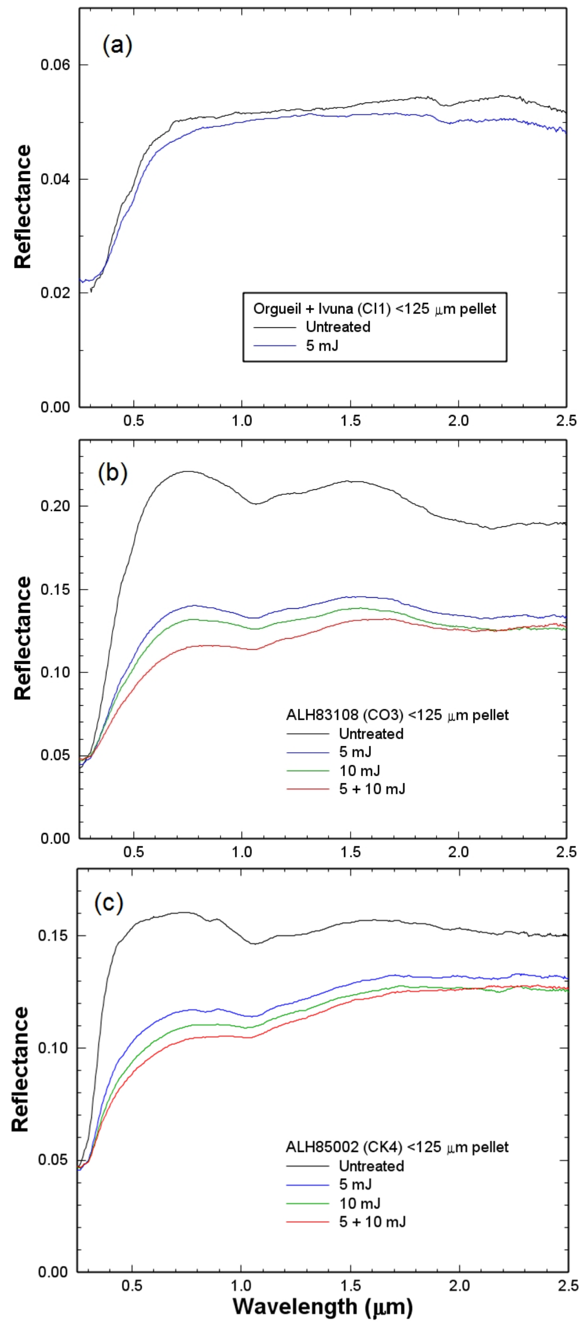

Fig. 1. VNIR reflectance spectra of CC pellet samples of (a) Orgueil-Ivuna (CI1) mixture, (b) ALH 83108 (CO3), and (c) ALH 85002 (CK4) before and after varying degrees of pulse-laser irradiation.

Keys to Detect Space Weathering: Based on these results, how can we detect space weathering on CC and HED parent bodies? The key features vary from one meteorite type to another if the space-wethering simulation in this study is valid.

CI, CM, and Tagish Lake: As evident in Fig. 1a and 2, overall darkening and bluing, and suppression of UV absorption seem to be the dominant space-weathering effect, as well as the suppression of the 3-μm hydration band while retaining its band shape. These effects seem to be quickly saturated. Because the continuum slope and the 3-μm band depth also depend on other facturs such as particle size and water/hydroxyl content, detecting space weathering of hydrous CCs requires careful analysis.

CO, CK, and HEDs: As evident in Fig. 1b, 1c, and 3, these meteorite groups seem to follow the S-type asteroid space weathering trend, wherein overall darkening and reddening, and suppression of the 1 and 2 μm bands are observed. For CO and CK the UV absorption also clearly weakens, which can be another key feature. For HEDs the spectral slope change parameter C_b [7] can be a good key indicator s well as the weakening of spin-forbidden bands [8].

Application to Spacecraft Missions: NASA's Dawn spacecraft discovered likely mixing of CCs with HEDs on Vesta and found no clear sign of space weathering [9]. Although the reason may be due to lower micrometeorite and solar wind impact energy or dose on Vesta, mixing of CCs in HEDs may be slowing down the rate of space weathering on Vesta because their spectral alteration trend can be opposite and cancelling each other, and/or CCs may be absorbing micrometeorite bombardment energies.

In addition, subtle signs of space weathering could be overlooked. Weakening of 507-nm spin-forbidden band [8] may be detectable by the Visual and Infrared Spectrometer (VIR) instrument onboard Dawn, and slope change parameters C_b and C_v [7] can be mapped using data by Framing Cameras (FCs) and/or VIR.

Hayabusa 2 and OSIRIS-REx missions both plan to visit a small C-type asteroid and return its samples. If the target consists of CI, CM, CV, or Tagish Lake material, evaluating the degree of space weathering on the asteroid requires assessment of physical properties and composition based on the UV and 0.7-μm absorption band strength and 3-μm absorption band shape and strength, as well as the continuum slope.

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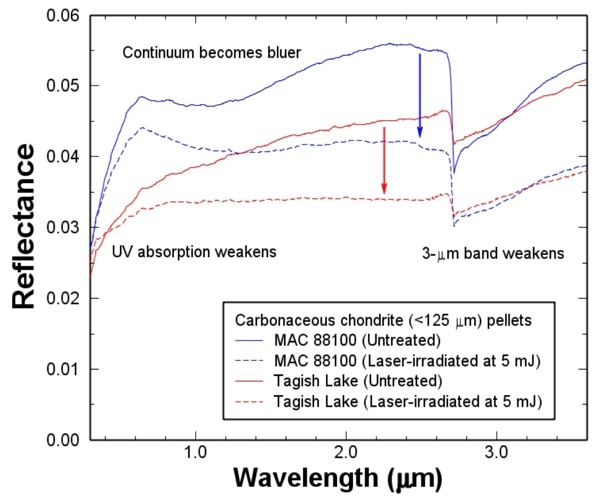

Fig. 2. VNIR+FTIR reflectance spectra of MAC 88100 (CM2) and Tagish Lake meteorite powder pellets before and after pulse-laser irradiation at 5 mJ in energy.

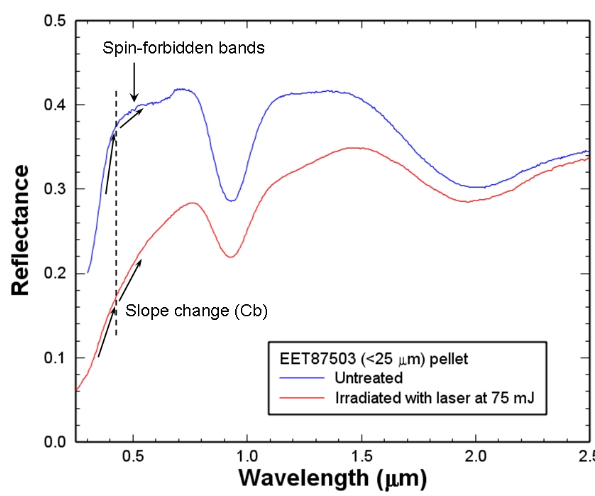

Fig. 3. VNIR reflectance spectra of howardite EET 87503 powder pellet before and after pulse-laser irradiation at 75 mJ in energy.