EXPERIMENTAL REPRODUCTION OF SPACE WEATHERING OF C-TYPE ASTEROIDS BY HE EXPOSURE TO SHOCKED AND PARTIALLY DEHYDRATED CARBONACEOUS CHONDRITES.

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Introduction: Hayabusa2 onboard spectrometers showed that C-type asteroid 162173 Ryugu is very dark object where the reflectance is (1.60 ± 0.15) % at 0.55μm (standard-measurement condition [1, 2]) and showed a small 2.7μm absorption band indicative of phyllosilicates [3]. All spectroscopic observations suggest that the closest meteorite analogue is hydrated carbonaceous chondrites that experienced heating and/or shock impacts and partial dehydration [1-3]. Ryugu's surface shows color variations, especially in the slope of b-band (0.48 μm) to x-band, (0.86 μm) [2]. Bluer spectral slopes are observed at both poles and on the equatorial ridge, both of which are topographic highs and thus may be flesh material exposed by gradual erosion [2]. On the other hand, many locations conducive to deposition, such as crater floors, exhibit redder and darker colors [2]. These observations suggest that a surface-correlated process is responsible for the color variation, most probably from blue to red, but the mechanism for the change is not yet identified. Space weathering is one of possible mechanism, although the spectral changes of C-type asteroids from space weathering are far from being fully understood. Recent experimental studies using hydrous carbonaceous chondrites show that He exposure (simulating solar wind irradiation) changes spectra to bluer and brighter [4], while laser exposure (simulating micrometeorite bombardments) changes spectra to bluer and darker [5]. In this study, we performed further He exposure experiments using the same experimental procedure applied in [4] using the most appropriate analogue meteorites for asteroid Ryugu. In addition, to explore the effects of physical properties on the spectral changes, we prepared a chip and a powder from the same meteorite.

He exposure experiment and spectra measurement: 20-keV He irradiation with a dose rate of ~10^{13} ions/(sec cm^2) was performed at CSNSM-IAS Orsay, France until total dose reached 1, 3, and 6 x10^{16} ions/cm^2. Shocked CM chondrite MET01072 and partially dehydrated CI chondrite Y 980115, both of which show reflectance spectra similar to Ryugu [2, 3], were used. A 1-cm sized chip with a flat surface with roughness made by a #400 polishing disk was prepared from each meteorite. In addition, a powder of Y 980115 with grain size < 155μm was pressed to 5 tons to make a pellet with a very flat surface, which is the same procedure used in [4]. Reflectance spectra of the same portions of samples were made before and after exposure in the wavelength range from 0.45 to 11.5μm in France. The spectra of the same area of unexposed and exposed (only samples with 6 x10^{16} ions/cm^2) were also measured at wavelengths from 0.4 to 15μm in Japan, which perfectly matched the results of the measurements in France. TEM observations will now be performed on FIB thin sections of all exposed samples.

Results and discussion: Y 980115 shows completely different spectral changes between chip and pellet. Unexposed samples of both chip and pellet show almost featureless spectra in the wavelength range 0.4 to 1.0μm with 6-7% reflectance at 0.55μm. With increasing total dose of He exposure, the pellet shows bluing and brightening. On the other hand, the chip shows only slight reddening of spectra with no significant brightening. This clearly indicates that spectral changes are completely different depending on the physical properties of the C chondrite samples and suggests complex spectral changes occur during space weathering of C-type asteroids. The chip seems to be more porous than the pellet, which is consistent with slightly redder spectra of the unexposed chip than the unexposed pellet. Other interesting spectral changes are observed from the chip of MET01072. This meteorite was compressed by an impact, but retains phyllosilicates [6]. The unexposed MET01072 chip shows featureless and flat spectra in the wavelength range 0.4 to 1.0μm, similar to Y 980115. With increasing He total dose, the MET01072 chip shows bluing and brightening, similar to the Y 980115 pellet, but different from the Y 980115 chip. This indicates that chip samples of hydrous C chondrites responded differently to He exposure, likely due to different physical properties. The same behavior between the MET01072 chip and the Y 980115 pellet could be explained by similar compressed properties of the two samples. Another noteworthy spectral change, although it cannot be explained, is that with increasing total dose, reddening occurs after bluing at < 0.65μm wavelength, in case for the MET01072 chip and the Y 980115 pellet.

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