NIR spectral heterogeneity of Ryugu samples due to space weathering
~ Only natural evidence of short timescale space weathering by solar UV radiation ~

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The formation and evolution process of the Solar System has been investigated by remote sensing and analysis of returned samples of asteroids, which are thought to hold information about the early Solar System. The most common observational method is spectroscopy. Asteroids are classified based on the obtained spectra. In particular, C-type asteroids include the Ryugu, which has been investigated by remote sensing (ex. near-infrared spectral observation by NIRS3) and twice touchdown (samples collected on surface into chamber A and on ejecta blanket after SCI impact into chamber C) by Hayabusa2, are rich in water and organics and are therefore candidates for the origin of life and water on Earth. On the other hand, the surface of asteroids that have no atmosphere has been altered since their formation by space weathering caused by micrometeorite impacts, solar wind, and solar UV radiation. As a result, the characteristics of the reflectance spectra have also changed. Therefore, to obtain information on the original composition of asteroids, it is necessary to understand the changes in the spectra due to space weathering, their causes, and mechanisms. NIR spectral features of the Ryugu samples that are expected to change with space weathering are 2.7 μm band originating from OH groups and slope of the continuum around 2.0 μm. It has been suggested that the 2.7 μm band may shift to longer wavelength and decrease in depth by space weathering[1,2]. The slope is reddening and bluing by space weathering. the S-type is known to be reddening, but the C-type is not yet understood. In this study, we compare the NIR spectra (especially the slope and the 2.7 μm band) of 200 Ryugu samples from chambers A and C ('surface' and 'subsurface'). Then, we will investigate the change of the NIR spectral features by space weathering. Finally, we discuss which types and mechanisms of space weathering have changed these spectra on the asteroid Ryugu.

Figure 1 shows a scatter plot of the position vs. depth of the 2.7 μm band. The red dots are chamber A samples and the blue dots are chamber C samples The chamber A samples are distributed in two regions across the chamber C samples. Each is grouped from top left to bottom right as α, C and β, respectively. The spectral slopes of these three groups are found to be α > C ≒ β (α: 5.82 ± 0.16, C: 5.57 ± 0.18, β: 5.57 ± 0.23 [$\%/\mathrm{cm}^{-1} \times 10^{-5}$]). Because space weathering causes the 2.7 μm band reduction and shift, it is possible the order of α < C < β is strongly affected by space weathering. Further investigation and discussion of how each was affected by space weathering was conducted. In particular, we focused on why the chamber C sample: C is more affected by space weathering than the chamber A sample: α. Based on ordinary thinking, C should have been less affected by space weathering as well as α, because they are subsurface samples excavated by the SCI impact. When, where, and how they were affected by space weathering? We expect it to be the result of the effects of solar UV radiation during the period of up to three months from the SCI impact to TD2. However, the timescale of micrometeorite impacts and solar wind, which has been simulated, is 10^{4-9} yr. In this presentation, we will also discuss the simulation of this hypothesis by UV-irradiation experiments on carbonaceous meteorites in Figure 2.

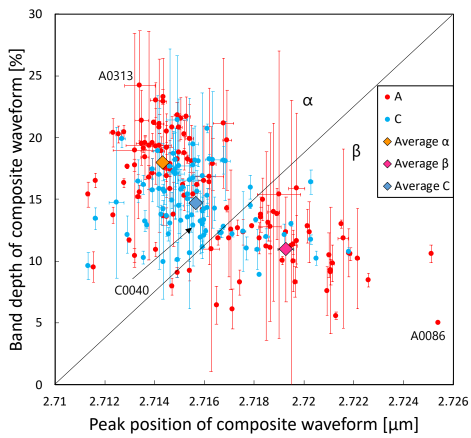

Figure 1. peak position vs depth of the 2.7 μm band.

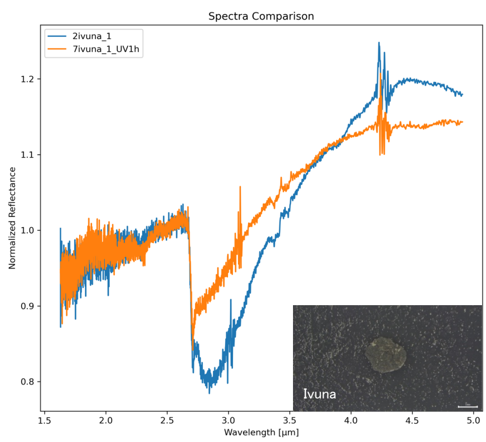

Figure 2. Result of the short timescale UV irradiation on Ivuna.

References: [1]. Noguchi, T. *et al. Nat Astron* (2022) doi:10.1038/s41550-022-01841-6.**,** [2]. Le Pivert-Jolivet, T. *et al. Nat Astron* (2023) doi:10.1038/s41550-023-02092-9.