

Grain scale heterogeneities in Ryugu samples as observed by MicrOmega: a key to understand aqueous alteration and space weathering.

Tania Le Pivert-Jolivet¹, Rosario Brunetto¹, Cedric Pilorget¹, Jean-Pierre Bibring¹, Aiko Nakato², Damien Loizeau¹, Lucie Riu¹, Vincent Hamm¹, Cateline Lantz¹, Kentaro Hatakeda^{2,3}, Kasumi Yogata², Donia Baklouti¹, Toru Yada², Tatsuaki Okada², Tomohiro Usui², and the MicrOmega IAS/ISAS Curation Team.

¹IAS, Université Paris-Saclay, CNRS, France, ²Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, ³Marine Works Japan, Ltd

Introduction: Hayabusa2 is the first space mission to study and collect samples from a C-type asteroid. In December 2020, the spacecraft brought back to Earth ~5.4g of materials from the surface of asteroid (162173) Ryugu. The samples were collected from two different sites TD1 and TD2 [1] at the surface of the asteroid. The second touchdown was performed near the artificial crater created by the small carry-on impactor [2] to collect both surface and subsurface materials. The samples were delivered to JAXA (Japan Aerospace eXploration Agency) Extraterrestrial Curation Center for preliminary analyses. The samples were extracted from chambers A and C, corresponding to TD1 and TD2 respectively, weighed and analyzed in a controlled N₂ environment by an optical microscope, a FTIR, and MicrOmega, a near-infrared (0.99-3.65 μ m) hyperspectral microscope. MicrOmega acquires images of 256x250 pixels with a spatial resolution of 22.5 μ m. The total field of view covers ~5.7x5.7mm² [3]. The first spectral characterization of the bulk samples within the Curation Facility [4,5] showed that the grains are extremely dark and exhibit absorption features at 2.72 μ m, 3.1 μ m and 3.4 μ m due to phyllosilicates, NH-rich compounds and organics and/or carbonates respectively. The 2.72 μ m feature was also observed on the asteroid's surface by the NIRS3 spectrometer [6]. In addition to the bulk samples, observations of individual grains, extracted from the bulks, were performed with MicrOmega. We investigate here the variations of the 2.72 μ m feature at the individual grain scale, on 177 grains from chambers A and C.

Methods: In order to extract an average spectrum of each individual grain (typical size 1-7 mm), we developed a novel procedure using thermal emission maps measured by MicrOmega. First, each grain was isolated from the rest of the field of view (the sample holder) thanks to their difference in terms of thermal emission. Then the spectra of every pixels within the grain were average to obtain a mean spectrum of each grain. The final spectrum was obtained by averaging observations obtained at different azimuth angles to avoid potential photometric biases. Two spectral parameters were calculated to characterize the position and the depth of the 2.72 μ m OH feature. The position was calculated using a gaussian fit on the 2.72 μ m band and the band depth was calculated between the minimum of reflectance and a linear continuum.

Results: The position of the 2.72 μ m OH feature is consistent with the position found in CI chondrites and highly aqueously altered CM chondrites [7]. Contrary to the bulk spectra where the 2.72 μ m OH feature was very similar between chambers A and C [5], the position of the OH varies within an interval of 10 nm at individual grain scale. Importantly, our results show that the distribution of the 2.72 μ m band position varies between the two chambers: there is an excess of grains from chamber A with a position at longer wavelength. Another difference is that the band depth of the grains varies with a larger interval in chamber A than in chamber C. The OH feature position can change with the Mg/Fe ratio in phyllosilicates [8]. Moreover, space weathering experiments on carbonaceous chondrites [9] have shown that the band position was shifted towards longer wavelength after irradiation. A shift has been observed on Ryugu's surface spectra, between the artificial crater and the surrounding surface [10]. Our results suggest that space weathering processes are probably recorded in the returned samples, in agreement with results presented by the Initial Analysis team [11]. We will discuss the spectral differences between the collected grains, in particular between chambers A and C, and what information they carry about the composition of the phyllosilicates and the space weathering processes affecting Ryugu's surface materials.

References: [1] Tachibana et al. (2020) LPS XXXXXI Abstract #2027. [2] Arakawa et al. (2017) Space Sci. Rev. 208, 187-212. [3] Bibring et al. (2017) Space Sci. Rev. 208, 401-412. [4] Yada et al. (2022) Nat Astron, 6, 214-220. [5] Pilorget et al. (2022) Nat Astron, 6, 221-225. [6] Kitazato et al. (2019) Science, 364, 272-275. [7] Takir et al. (2013) M & PS 48, 1618-1637. [8] Besson and Drits (1997), CCM, 45, 158. [9] Lantz et al. (2017) Icarus 285, 43-57. [10] Kitazato et al. (2021) Nat Astron, 5, 246-250. [11] Noguchi et al. (2022) LPS XXXXXIII Abstract #1747.