Preliminary results from FTIR hyper-spectral imaging campaign on Ryugu small grains and fragments.

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Introduction: Hayabusa2 is the first sample return mission to study and return samples from a primitive carbonaceous asteroid. It thus allows the study of the same small body at very different scales, from the km down to the atomic scale. Infrared (IR) spectroscopy plays a crucial role in this respect, helping to build a bridge between the remote sensing observations of the asteroid's surface, performed by NIRS3 [1,2] and the chemical and physical processes operating at a smaller scale and characterized in the laboratory on the returned samples. In December 2020, the Hayabusa2 reentry capsule delivered 5.4 g of material coming from asteroid Ryugu. This extremely precious material was then recovered by JAXA and pre-characterized inside the ISAS curation facility [3,4]. A fraction of this material was then given to six Initial Analysis sub teams, including the "Stone" team led by T. Nakamura which studies mineralogy and petrology at a large scale [5].

Material and Methods: We will present the result of FTIR hyperspectral imaging on six micrometric Ryugu fragments (ranging from 30 to 80 µm in size). These fragments originate from 2 bigger millimetric grains (A0064 and C0046). We analyzed these small grains in multiple configurations (see detailed analytical plan and transportation issues in [6]). After the first characterization in reflectance mode on their gold substrate, we mounted these small grains at the top of metallic needles to analyze them at different rotating angles both in transmission and reflection modes. The obtained data in transmission mode, IR-CT [7] (Infrared Computed Tomography), were then analyzed to reconstruct 3D distributions of the molecular components inside the grains, while reflectance data were projected on a 3D shape model of the grains. In this case, the fragments were treated as a planetary surface, which will also help to reinforce the link between remote sensing and laboratories measurements. Taking advantage of each configuration, the preliminary results of the combination of the different measurements will be shown and discussed.

Results and Discussion: We will present the average spectra in the 2.5 – 30 µm range. Several grains have IR signatures at 2.7 µm, 3.0-3.1 µm, 3.4 µm, and 3.9 µm, in a good agreement with the bands identified by NIRS3 or by MicrOmega and FTIR in the JAXA curation facility [3, 4], plus several mid-IR signatures of great interest, such as bands attributed to Si-O stretching in phyllosilicates, and C=O stretching in organics and carbonates. A comparison of the IR spectra of the different grains with those of a large variety of carbonaceous chondrites acquired with the same set-up will be presented. Finally, we will discuss the heterogeneity within individual grains, with particular emphasis on the following issues: (i) detection and heterogeneity of the 2.7 µm band (ii) spatial correlation between phases (phyllosilicates, carbonates, opaque phases, organics) and (iii) identification and quantification of the carbonates. These spectral observations and parameters will help to better constrain the 3D µm-scale assembly of minerals and organics in Ryugu, and will provide information on the origin and evolution of Ryugu.

Perspectives: Our multi-analytical sequence started with non-destructive IR hyperspectral imaging and continues now with more destructive techniques. One grain has been sliced into 3-µm thin sections and will be analyzed in 2D with higher resolution IR hyperspectral imaging and complementary analyses [8]. The rest of the samples have been sent back to Japan, to be analyzed at the BL47XU of SPring-8 synchrotron by XCT [9] in order to obtain complementary information concerning the 3D physical, chemical and morphological properties.

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