Bridging the gap - linking remote sensing, in-situ and laboratory spectroscopy

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Sample return provides us with "ground truth" about the visited body, verifying and validating conclusions that can be drawn by remote sensing (both Earth-based and by spacecraft) and via landed instruments on other bodies. The detailed investigation of the mineralogy and geochemistry of Ryugu plays a fundamental role in the understanding of its formation processes, and thereby gather further knowledge about the building blocks of the solar system. Based on the preliminary data from remote sensing measurements and laboratory-based measurements, Ryugu is rich in hydrated carbonaceous chondrite (CC) like material and more specifically it is very similar to Ivuna-like (CI) carbonaceous chondrites [1]. These meteorites are characterized by a high abundance of phyllosilicates and organic matter [2], which makes them have a low albedo. However, Ryugu seems to be even darker than CIs, as well as being more porous and fragile [1].
Back in August 2022, the Institute of Planetary Research at DLR (Berlin) received a fragment retrieved by the Hayabusa2 mission from asteroid Ryugu. The fragment assigned to us for analyses is sample A0112, from chamber A. Our investigation is based on two main goals. The first goal is to address a fundamental challenge in the interpretation of remote sensing data which was seen during the initial analysis of the Hayabusa 2 samples. Observations of planetary surfaces using spectroscopy have shown subdued contrast compared to measurements performed under laboratory conditions on analog materials. A strong focus of the work performed at PSL over the last decade has been to understand - and if possible minimize – the difference between laboratory and remote sensing observations (e.g. [3, 4, 5, 6]). Simulating the conditions on the target body as well as accurately reproducing the observing geometries have gone a long way towards that goal, however differences remain. A suggested explanation is the difference between terrestrial analog materials including even meteorites and the surfaces of planetary bodies. With Ryugu samples this hypothesis can be tested further, leading to a deeper understanding of the link between laboratory and remote sensing observations and thus benefiting not only the analysis of Hayabusa 2 data but of all remote sensing observations of planetary surfaces using spectroscopy. The second goal building on this is an investigation of the mineralogy and organic matter of the samples collected by Hayabusa 2, to better: a) understand the evolution of the materials characterizing asteroid Ryugu and therefore advance our knowledge of the mineralogy of the protoplanetary disk and organic matter (OM); b) investigate the aqueous alteration that took place in the parent body that lead to its current chemical and mineralogical characteristics; c) compare the results with data collected from pristine carbonaceous chondrite meteorites rich in hydrated minerals and organic matter.

We are currently collecting the first datasets, and for doing so we are applying a strict protocol to maintain the grain as pristine as possible. The first set of measurements is taking place keeping the sample within the N_2 filled sample holder it was delivered in. Just afterwards, we will open the protective holder to transfer the sample in the anaerobe bench to the Hayabusa1 holder (that we hosted in our institute too) and we will repeat those measurements. As a final step, we will remove the sample from this holder and let the sample be in contact with laboratory atmosphere.
Here is a description of the protocol:

1. The first step of our investigation consists in 3D imaging of the sample (Figure 1) with the use of a Keyence VHX-7000 4K High Accuracy digital microscope;
2. Mapping of the sample with Raman spectroscopy (Figure 2);
3. Mapping of the sample with IR microscope in the wavelength range 0.25 – 25 µm;
4. Collection of reflectance data in the wavelength range 0.25 – 25 µm;

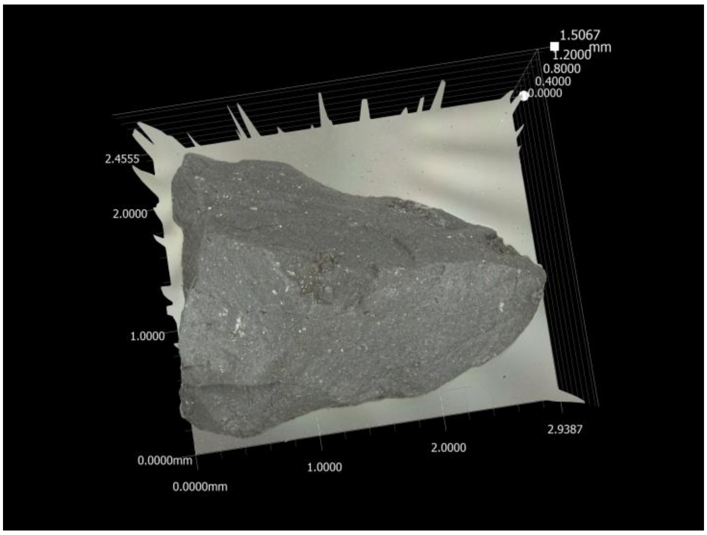

Figure 1: *3D scan of particle A0112 with a Keyence VHX-7000 4K High Accuracy digital microscope.*

5. Transfer of the sample to a dedicated holder previously created for the analysis of Hayabusa1 samples and repetition of the previous steps;
6. Sample open and exposed to air: stored in dry cabinets, spectroscopy measured in vacuum;
7. 3D imaging with the use of a Keyence VHX-7000 4K High Accuracy digital microscope
8. IR data collection in the wavelength range 0.25 – 25 µm
9. Raman mapping: in this case after the acquisition of IR data to minimize the reaction of organic matter with the laser;
10. SEM and EDX mapping at low voltage of uncoated and unprepared sample.

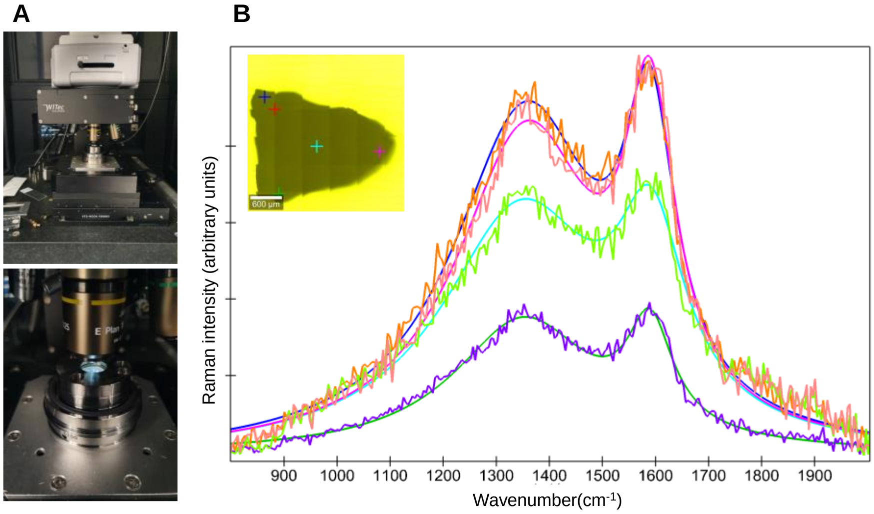

Figure 2: *Raman preliminary results.* ***A.*** *WITec Alpha 300 confocal microscope setup with JAXA's sample holder containing particle A0112.* ***B.*** *Typical Raman spectra of polyaromatic carbonaceous matter measured under N2 atmosphere in the unopened container showing typical D and G carbon bands and fitted with a Lorentz function to extract parameters such as bands' position, full width at half maximum (FWHM), and bands' intensities. Inlet: measurement points on particle's surface.*

Up to now, step 1 has been successfully executed as can be seen in Figure 1. The 3D measurements will help planning the next steps of the measurements. They are also an interesting result in itself as they will allow to determine the volume and thereby the density of this particle.

Step 2 has been started and Raman spectra were successfully acquired on the particle without opening the original container (as was executed for Hayabusa1 particles previously). Preliminary data show the typical carbonaceous matter signature typical of CCs from which their thermal history can be derived [8].

References

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