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Spectroscopic measurements on a Mukundpura meteorite grain as training for the analysis of Hayabusa2 returned samples

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Sensitive laboratory instruments on Earth are capable of determining the chemical, isotopic, mineralogical, structural, and physical properties of extraterrestrial samples from the macroscopic level down to the atomic scale, allowing to determine the origin and history of the material and answer questions far beyond the reach of current robotic technology. 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. Returned samples can be compared to meteorites and cosmic dust using the same instrumentation, which apart from giving us clues about where those materials come from, potentially increases their scientific value as natural space probes. And finally, returned samples can be preserved for decades and used by future generations. 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].

If Hayabusa2 samples are made available to our consortium, we will use a multi-pronged approach to achieve 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.

To prepare for measurements on Hayabusa 2 returned samples, we selected a small particle from the Mukundpura meteorite, a recently fallen meteorite that is considered as one of the best Ryugu analogs in the meteorite collection [7]. We have chosen a piece with a 4mm diameter, typical of the larger grains available in the Hayabusa 2 sample collection. We manufactured for this purpose a special sample holder for reflectance measurements in the FTIR spectrometer.

Figure 1. (left): 4mm particle and the whole Mukundpura at PSL; (right): the 4mm particle in our sample holder.

Figure 1 shows the small 4 mm selected Mukundpura particle compared with the whole sample available at PSL and its special sample holder. We adapted our standard measurement set-up reducing the aperture to fit the size of the samples. With this configuration we obtained measurements as shown in Figure 2, where MIR spectrum of the 4mm Mukundpura particle, obtained reducing the aperture of our light source beam to the minimum, 0.25 mm is compared with a measurement of the same meteorite acquired with a much larger aperture (4mm, as standard).

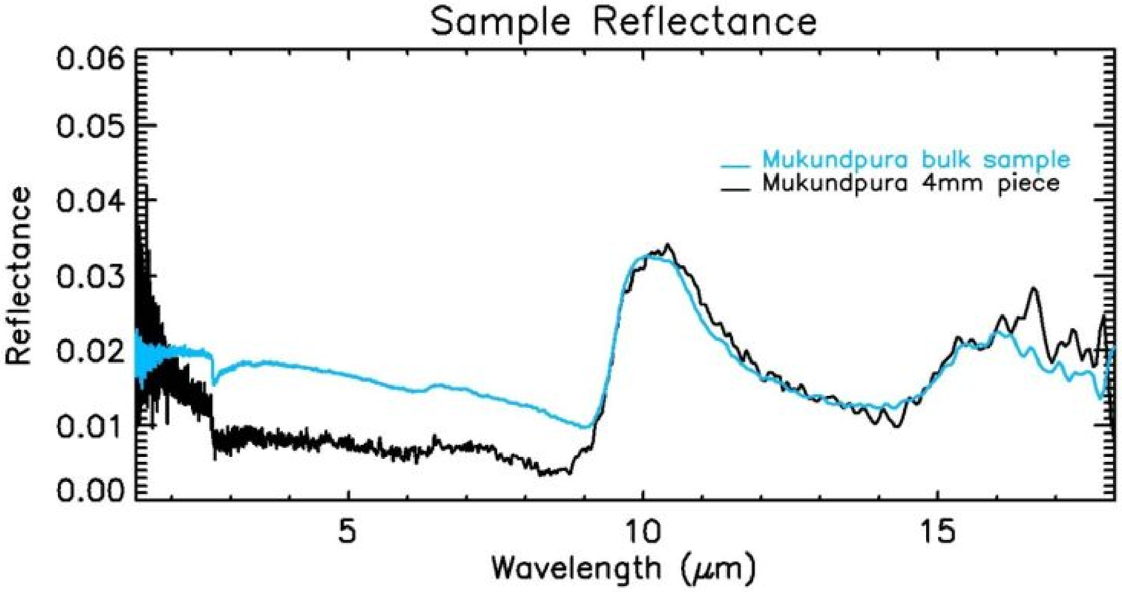

Figure 2. Mukundpura bulk sample measured with traditional beam aperture of 4 mm (light-blue) and with reduced aperture (0.25 mm) on the small 4mm piece of the same meteorite. Below 9 μm we observe a lower reflectance of the piece compared to the bulk - reminiscent of what was observed in the preliminary investigation for the Hayabusa 2 sample.

It's evident that with the reduced beam aperture, we are able to obtain high quality FTIR spectra of an Hayabusa 2 sample by just using our traditional spectroscopic set-up and compare to the thousands of spectra measured at PSL on a wide range of analogs including meteorites.

Raman spectroscopy complements IR spectroscopy in the determination of the mineralogical composition of the sample. It is performed in a contactless manner, and under neutral (e.g. nitrogen) atmosphere thanks to the long working distance objective. Figure 3 shows our tests on the Mukundpura particle; different measurement modes were used to reveal the presence of olivine, carbon, and magnesium silicates.

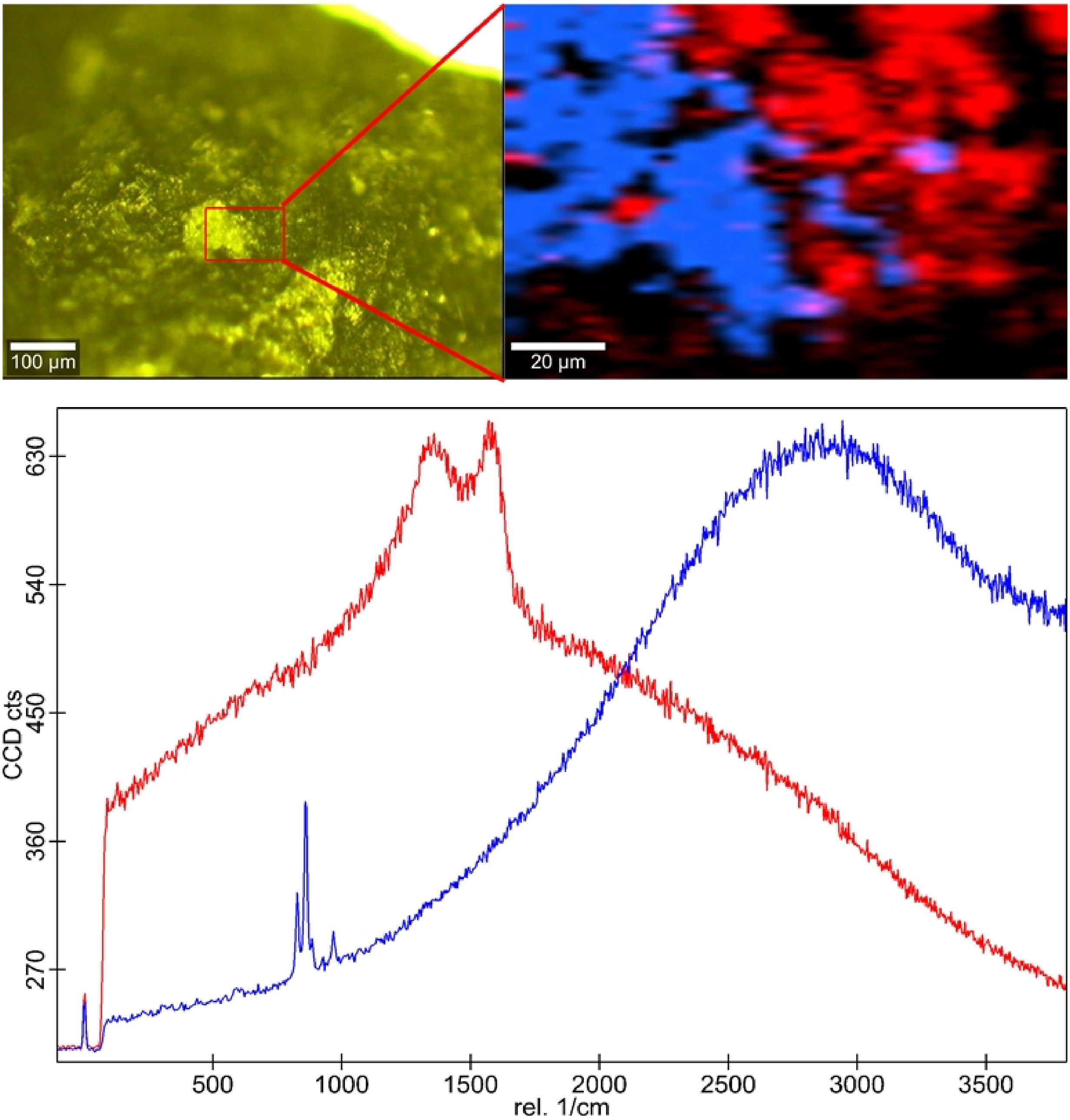

Figure 3. Example using the Mukundpura particle of an image scan of 30 points per line and 60 lines per image on a 120 x 80 µm area. The blue color denotes the presence of the olivine doublet (827 and 859 cm^{-1}) and red the presence of carbon D and G bands (1340 and 1568 cm^{-1}).

[1] Yada, T., Abe, M., Okada, T. et al., 2022. Nat Astron 6, 214–220. [2] Cloutis, E. A., et al., 2011. Icarus, 212:1.. [3] Maturilli, A., et al., 2016a. Earth, Planets and Space 68(1). [4] Maturilli, A., et

al., 2016b. Earth, Planets and Space 68(1). [5] Beck, P., et al., 2018. Icarus 313: 124-13. [6] Yesiltas, et al., 2020. Meteoritics & Planetary Science, 55(11): 2404–2421. [7] Ray, D. and Shukla, A.D., 2018. PSS 151, 149-154.