Spectroscopic Evidence of Parent Body Aqueous Alteration on Ryugu Sample A0112

A. Maturilli[1], E. Bonato[1,2], J. Helbert[1], G. Alemanno[1], Van den Neucker[1], S. Schwinger[1], M. Baqué[1], M. Hamm[3], M. D'Amore[1], [C.] Hamann[2], K. Mahlow[2], M. Patzschke[3], A. Greshake[2], L. Hecht[2,3]

1German Aerospace Center (DLR) – Institute of Planetary Research, Rutherfordstrasse 2, 12489 Berlin, Germany,
2Museum für Naturkunde - Invalidenstraße 43, 10115 Berlin, Germany,
3Freie Universität Berlin – FB Geowissenschaften – Institut für Geologische Wissenschaften Planetologie and Fernerkundung – Malteserstr. 74 – 100 – 12249 Berlin, Germany.

The Japanese Hayabusa2 sample return mission successfully retrieved fragments from the near-Earth C-type carbonaceous asteroid Ryugu (162173). These fragments share similarities in composition with the Ivuna meteorite, indicating a potential classification as a primitive CI-type asteroid [1]. Among the collected samples, the piece A0112 was sent for spectral analyses at the Planetary Spectroscopy Laboratories (PSL) at the German Aerospace Center (DLR) in Berlin.

The A0112 piece is a relatively large sample collected from the first touchdown site [1]: it weighs 5,1 mg and is 3046x1823 µm in size. The sample was contained in a nitrogen-filled sample holder, free of any form of terrestrial contamination after its retrieval from the asteroid. In order to preserve the sample from external contamination, such as the atmosphere, the first set of analyses were performed with the grain sealed within its sample holder. These analyses employed micro-infrared spectroscopy and Raman micro-spectroscopy. In addition, High-resolution 3D images were taken of multiple sides of the grain with the digital microscope Keyence VHX-7000 and VHX-7100 observation system, which allowed a global view of its surface morphology and topography. This approach enabled the determination of the sample's bulk composition and mineralogy beneath the glass without being influenced by terrestrial alteration.

More than 50 point-localized infrared spectroscopy measurements were performed on the A0112 grain with the Hyperspectral Bruker Hyperion 2000 MicroFTIR to assess the general mineralogy of the fragment through the glass window of the sample holder. MIR (1.3 – 5 µm) reflectance point measurements consisted of 1000-2000 scans at an optical magnification of 15x and a resolution of 4 cm^{-1}. VNIR reflectance spectra were also taken to cover the full spectral range. Raman spectroscopy under neutral atmosphere with the WiTec Alpha 300 confocal Raman microscope [2] was used for organic matter and mineral identification, and to generate elemental maps of the grain.

Through the use of FTIR spectrometers (three identical Bruker Vertex 80V) and a special manufactured sample holder it was possible to measure bi-directional reflectance bulk sample spectroscopy of sample A0112 completely under vacuum in the whole spectral range from UV to FIR (0.25 µm to at least 25 µm spectral range).

From the processed images, the sample can be described as a mostly dark fragment with a few micron-sized, bright inclusions on most of its faces. Micro-FTIR measurements revealed an abundant presence of secondary minerals such as phyllosilicates throughout the sample, with a localized area of approximately 30 µm rich in carbonates. This carbonate-rich region was identified as dolomite due to specific absorbance bands at wavelengths of 1.90, 2.21, 2.73, and 4.4 µm, as well as two distinctive sets of doublets at 3.33, 3.47 µm and 3.81, 3.95 µm [1, 3]. Raman spectroscopy measurements also confirmed the presence of dolomite with spectral bands at 175, 300, 727, and 1098 cm-1. This dolomite inclusion appears to be associated with a vein in the grain. The investigation of hydrated minerals formed through aqueous alteration on the parent body provides valuable insights into the evolution of materials characterizing Ryugu and the protoplanetary disk. The presence of carbonates is particularly significant, suggesting the presence of liquid water within the asteroid, which could potentially play a role in delivering water to Earth or other planets [4]. Furthermore, these results confirm that in-situ point measurements, to localize hydrated minerals and organic matter, are still achievable through the glass window of a sample holder.

The identification of carbonates in the sample provides significant evidence of aqueous alteration processes that occurred on Ryugu's parent body.

References

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Acknowledgements

The research results have been obtained through the cooperation between DLR and JAXA.