EPSC Abstracts
Vol. 18, EPSC-DPS2025-786, 2025, updated on 15 Dec 2025
https://doi.org/10.5194/epsc-dps2025-786
EPSC-DPS Joint Meeting 2025

Space Weathering and Compositional Variations in Ryugu Samples: FTIR and Raman Spectroscopic Insight

Marianna Angrisani[1], Ernesto Palomba[1], Helen Grant[1], Mario D'Amore[2], Martina Romani[3], Xhonatan Shehaj[5], Tiziano Catelani[6], Lavinia Arpaia[7], Andrea Longobardo[1], Fabrizio Dirri[1], Giacomo Viviani[3], Mariangela Cestelli Guidi[3], and Giovanni Pratesi[4]

[1]INAF-Istituto di Astrofisica e Planetologia Spaziali (INAF-IAPS), Roma, Italy (marianna.angrisani@inaf.it)
[2]German Aerospace Center Institute of Planetary Research: Deutsches Zentrum fur Luft- und Raumfahrt DLR Institut fur Planetenforschung
[3]INFN-Laboratori Nazionali di Frascati
[4]Dipartimento di Scienze della Terra, Università degli Studi di Firenze, Firenze, Italy;
[5]Università di Trento, Italy;
[6]Service Centre MEMA, University of Florence, Florence, Italy.
[7]University of Rome "La Sapienza", Physics department, Piazzale Aldo Moro 5, Roma, Italy

The Hayabusa2 mission, led by the Japan Aerospace Exploration Agency (JAXA), represents one of the most ambitious space missions in terms of both technological achievement and scientific return. The mission successfully collected samples from two distinct locations on the surface of asteroid Ryugu, returning approximately 5 grams of material to Earth in December 2020 for laboratory analysis. The first touchdown (TD1) retrieved surface materials stored in Chamber A, while the second touchdown (TD2) collected subsurface materials from approximately 1 meter depth, stored in Chamber C [1].

Preliminary analyses revealed that Ryugu particles share mineralogical similarities with CI chondrites [2], featuring matrices rich in phyllosilicates, iron sulfides (pyrrhotite and pentlandite), carbonates (dolomite and an iron-bearing variety of magnesite known as brunnerite), magnetite, and hydroxyapatite [3,4,5].

In this study, we conducted a comparative analysis of three millimeter-sized particles (A0226-1, A0226-2 (both from Chamber A), and C0242 (from Chamber C) [6]). Sample A0226-2 became detached from A0226-1 during the mounting process. Using a combined FT-IR and Raman spectroscopy approach, we investigated surface differences among these particles.

Methods:

Each particle's surface was characterized in the mid-IR (2.5 – 16 µm) using a Lumos II FT-IR microscope, with 8× magnification in reflectance mode using MCT-LN mapping (256 scans, 4 cm□¹ spectral resolution, 80 µm aperture). A gold plate served as the standard. Measurements were conducted in a nitrogen-enriched glovebox to limit terrestrial alteration.

Raman spectra of graphite within Ryugu particles A0226-1 and C0242 were acquired using a Horiba Jobin-Yvon LabRam IR spectrometer coupled with an Olympus BX41 optical microscope at the University of Firenze, employing a 632.8 nm laser and 1800 gr/mm grating. The maximum laser power was ~ 10 mW (1 mW with a 10% filter) and acquisitions ranged from 10-12 integrations of 5-20s depending on the intensity of spectra and sensitivity of phases, with most measurements comprising 10×10s integrations. All measurements were conducted in an inert nitrogen (N_2) environment to minimize alteration from terrestrial atmospheric exposure.

Results and discussion

Median FT-IR spectral analysis (Fig.1) indicates that particles from Chamber A exhibit greater degrees of space weathering than those from Chamber C. Specifically, the 2.72-μm OH-band depth is ~10% shallower in grains A0226-1 and -2 relative to C0242 (~20% and ~30% respectively), consistent with NIRS3 observations showing deeper 2.72-μm bands in fresher subsurface material [7,8] . Additionally, the Si–O stretching band in A0226-1 is red-shifted by ~150 nm relative to C0242, a shift potentially attributable to space weathering effects [9] .

Figure 1: Median reflectance spectra of particles A0226-1 (blue), A0226-2 (green), and C0242 (orange) over the 2–16 μm range.

Raman spectroscopy revealed notable differences in the D- and G-band profiles between grains from Chamber A and C. Graphites in A0226-1 exhibited higher degrees of graphite disorder, represented by the D-band ~1365 cm^{-1}, suggesting increased amorphization due to space weathering [e.g., 10], while graphites in the subsurface grain from Chamber C had little-to-no noticeable D-bands (Fig. 2). Furthermore, the G-band shows a minor decrease in Raman shift and increase in FWHM between Chamber C and A, indicative of organic matter (OM) disruption as a result of weathering [10,11]. Finally, systematic differences in fluorescence between the two sample sites may reflect variations in thermal metamorphism and/or moisture content within OM, consistent with previous findings [12,13,14].

Figure 2: Median Raman spectra obtained from two Ryugu grains A0226-1 and C0242. Vertical dashed lines are at ~ 1365 cm-1 and 1590 cm-1 to represent approximate locations of D- and G-bands respectively.

Finally, investigations into surface compositional variability are being carried out using spectral clustering. Initially, eight spectral parameters were evaluated, followed by dimensionality reduction to facilitate clustering. The analysis revealed four distinct spectral clusters, highlighting subtle heterogeneities across particle surfaces.

References

[1] Tsuda et al., 2020, Acta Astronautica, 171, June 2020, pp. 42-54.

[2] Nakamura et al., 2022. Science, 379, pp.

[3] Nakamura et al., 2022. Proceedings of the Japan Academy, Series B, 98(6), pp. 227-282.

[4] Nakamura et al., 2022. 379(6634): pp.

[5] Yokoyama et al., 2022 Science, 379(6634): eabn7850.

[6] ASRG, ISAS, JAXA et al. (2022)

[7] Galiano et al., 2020 Volume 351, 113959

[8] Kitazato et al., 2021 Nature Astronomy 5, pp. 246–250.

[9] Brunetto et al., 2018. Planetary and Space Science, 158, pp. 38-45.

[10] Bonal et al., 2006. Geochimica et Cosmochimica Acta, 70(7), pp. 1849-1863.

[11] Rotundi et al., 2008. Meteoritics & Planetary Science, 43(1), pp. 367-397.

[12] Brunetto et al., 2014. Icarus, 273, pp. 278-292.

[13] Henry et al., 2019. Earth Science Reviews, 198, article id. 102936.

[14] Bonal et al., 2024. Icarus, 408, article id. 115826.

[15] Komatsu et al., 2024. Meteoritics & Planetary Science, Volume 59, Issue 8, pp. 2166-2185

Acknowledgments: The Ryugu samples used in this paper were distributed through the 2AO Announcement of Opportunity for Hayabusa2 samples (AO2). These samples were referred to the Ryugu Sample Database at https://www.darts.isas.jaxa.jp/curation/hayabusa2/ .

Funding: This work was supported by the National Institute of Astrophysics (INAF) by the PRESTIGE (Pristine Returned Sample Testing InvestiGation and Examination) project