

## Hayabusa2 sampling operation at Ryugu and the returned regolith samples

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C-type asteroids have been hypothesized to be parent bodies of carbonaceous chondrites that are primitive meteorites containing hydrated minerals and organic matter. The hydrated minerals and organics in carbonaceous chondrites could be a source of volatiles to the proto Earth. The JAXA's Hayabusa2 spacecraft explored the near Earth C-type asteroid (162173) Ryugu to return its surface regolith samples. During the seventeen-month proximity observation, Hayabusa2 discovered (1) Ryugu is a rubble pile body with a low albedo, darker than typical carbonaceous chondrites (e.g., Watanebe et al., 2019; Sugita et al., 2019; Morota et al., 2020), (2) hydrated minerals are present ubiquitously on the surface (e.g., Kitazato et al., 2019, 2021), and (3) surface pebbles and boulders have lower thermal inertia than meteorites, implying the porous nature of Ryugu materials (e.g., Grott et al., 2019; Okada et al., 2020).

Hayabusa2 landed on Ryugu at two different surface locations for regolith sample collection in February and July, 2019. The second landing aimed at collecting sub-surface samples excavated by the artificial cratering experiment (Arakawa et al., 2020). The basic concept and design of the Hayabusa2 projectile-shooting sampling device are the same as those of the Hayabusa sampling device (Yano et al., 2006). A 5-gram tantalum projectile was successfully shot through a 1-m long sampler horn at an impact velocity 300 m/s at the timing of each touchdown (Sawada et al., 2017). Two landing operations of Hayabusa2 proved for the first time that the projectile-shooting sampling device works at the asteroid surface.

Hayabusa2 delivered its reentry capsule on December 6, 2020 to Woomera, South Australia. Numerous millimeter- to centimeter-sized particles were found in two separate chambers inside the sample container, which were used for two landing operations at Ryugu. The particles are black in color, consistent with the color of Ryugu boulders (e.g., Sugita et al., 2019; Morota et al., 2020). Centimeter-sized grains, close to the maximum collectible size with the sampler system (Sawada et al., 2017), are found in the sample obtained during the second landing operation. The total weight of the sample exceeds 5 g, which is far more than the mission requirement (100 mg) for scientific analysis (Tachibana et al., 2014). All the sample characteristics suggest that the Hayabusa2 sampler system worked efficiently and effectively to collect surface regolith at the Ryugu surface.

The regolith sampling operation and the characteristics of returned particles will be presented and discussed in detail at the meeting.

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