Surface Age of Ryugu's Boulders Based on Small Crater Statistics

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The Hayabusa2 spacecraft arrived at the asteroid Ryugu on June, 2018. Detailed observations by Hayabusa2 have revealed a large number of boulders on Ryugu's surface and its low bulk density of 1,190 kg/m^3, suggesting its "rubble-pile" structure [Watanabe et al., 2019; Michikami et al., 2019; Hirabayashi et al., 2019]. Unraveling the lifetime of boulders is important for understanding the surface processes, such as thermal fatigue, impacts and surface flow, and its timescale on Ryugu's surface.

During two touchdown rehearsal operations on October 15 and 25, 2018 (Japan Standard Time) before the first touchdown operation, the Optical Navigation Camera (ONC) onboard the Hayabusa2 spacecraft [Sugita et al., 2019; Kameda et al., 2017; Suzuki et al., 2018; Tatsumi et al., 2019], which took multiple high-resolution images (~1 cm/pixel). Moreover, during the touchdown operations on February 22, 2019 and July 11, 2019, the ONC took even higher-resolution images (~0.1 cm/pixel), showing topographic features of Ryugu's surface on the scale of a few centimeters. Because the characteristic size of the Ryugu's boulder is estimated to be 3 m [Sugita et al., 2019], low-altitude imaging allowed us to observe small craters on the boulder surface.

Using these high-resolution images of Ryugu's surface, we investigated 2,152 boulders and identified 22 several-centimeter-sized circular depressions on the boulder surfaces that are candidates for small impact craters. We also built a cratering chronology model of small craters on Ryugu's boulders, based on the Pi-group crater scaling law under the strength regime [Holsapple, 1993] and the size-frequency distribution model of near-Earth object population [Brown et al., 2002; Suggs et al., 2014].

Based on the size-frequency distributions of small crater candidates and the cratering chronology model for Ryugu's small craters, the surface age of Ryugu's boulders was estimated to 0.01 to 1 Myr, younger than the global surface age of Ryugu (~8 Myr) [Sugita et al., 2019; Morota et al., 2020; Cho et al., submitted]. Moreover, Ryugu's boulders have lower crater density than Bennu's boulders, whose surface age was estimated to be 1.75 ±0.75 Myr [Ballouz et al., 2020]. We will discuss the disruption and resurfacing processes of boulders, based on the estimated survival time of boulders and comparisons with the crater densities of large craters on Ryugu and mini craters on boulder surface of asteroid Bennu.

Keywords: Ryugu, Hayabusa2, crater, boulder

