MISIP-2024 Project-6 – Understanding Planetary Surfaces: A Remote Sensing and Laboratory-based Approach for Future Mission Planning

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162173 Ryugu is a spinning top Cb-type carbonaceous asteroid explored by the Hayabusa2 spacecraft (Sugita et al., 2019). The low bulk density (1,190 ± 20 kg m^{-3}) and boulder-dominated surface indicate it as a rubble-pile body having accumulated impact fragments (Watanabe et al., 2019). The published geological map of Ryugu lacks significant detail. This study presents one of the most detailed geomorphological maps of Ryugu to understand its geological evolution by investigating its formation, impact history, surface composition. Previous studies based on Hayabusa2 ONC images (Michikami et al., 2019), obtained during the first month after the spacecraft's arrival in June 2018, were only able to produce a coarse resolution map, considering just one-tenth of the boulder distribution (Sugita et al., 2019; Michikami et al., 2019) .

In this study, both 2018 and 2019 ONC images, processed Digital Elevation Model (DEM), and thermal images obtained from Hayabusa2 were considered for mapping. The highest resolution data had a pixel scale of approximately 0.25m (Ho et al., 2021). Forty-one craters with high confidence, 142 potential craters with moderate confidence, and six circular features that are potentially large old craters were identified. Low-lying areas were identified as well as the equatorial ridge. The western bulge was identified from the DEM based on the elevation differences with the surrounding troughs, and then compared with the previous work. This comparison shows that the western bulge, relative to the rest of Ryugu, exhibits deviations in crater diversity, spectral variance, and potential surface consolidation. These deviations point towards either smaller weathering rates or younger age of the western bulge. Rather than previously discussed rotational deformation, another possibility is an impact event (inelastic collision) of a similar Cb-type asteroid composition. In this hypothesis, the central ridge existed and then developed again after the western bulge-forming event due to Ryugu's high spin rate.

Across the midlatitudes (30ºN to 40ºS) of Ryugu, over 48,000 boulders were identified. Major observations include that boulders were fewer in large craters, possibly due to the low gravity of Ryugu. There were fewer boulders (~15%) in the western bulge than in other areas. Boulders showed a strong NE-SW orientation in the northern hemisphere and NW-SE in the southern hemisphere, possibly due to the spin direction of Ryugu (Watanabe et al., 2019). Additionally, boulders were used to determine crater stratigraphy on Ryugu's surface. Crater centered at 16°N, 25°W; 4°S , 68°W; 18°N , 136°E is younger than the ones centered at 1°N,30°W; 10°S , 73°W; 18°N , 149°E respectively. In the future, complete crater stratigraphy relations will be established based on their mutual relationships.

A detailed photogeological map of Ryugu helps to identify previously unidentified features and their spatial distribution for the first time, significantly enhancing the understanding of the asteroid's surface and geological history. Along with this, the study also introduces a novel method for determining crater stratigraphy on small-body asteroids. It will augment further studies, contributing valuable data for future research.

References:

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