Global distribution of sub-meter boulders measured with texture analysis of Ryugu images

*Naoya Tanabe[1], Yuichiro Cho[1], ERI TATSUMI[1], Tomokatsu Morota[4], Chikatoshi Honda[9], Tatsuhiro Michikami[11], Patrick Michel[12], Carolyn Ernst[13], Olivier S Barnouin[13], Kazuo Yoshioka[1], Sawada Hirotaka[2], yokota yasuhiro[2,3], Naoya Sakatani[2], Masahiko Hayakawa[2], Moe Matsuoka[2], Rie Honda[3], Shingo Kameda[5], Manabu Yamada[6], Toru Kouyama[7], Hidehiko Suzuki[8], Kazunori Ogawa[10], Seiji Sugita[1]

1. University of Tokyo, 2. JAXA/ISAS, 3. Kochi University, 4. Nagoya University, 5. Rikkyo University, 6. Chiba Inst. Tech., PERC, 7. AIST, 8. Meiji University, 9. University of Aizu, 10. Kobe University, 11. Kindai University, 12. Observatoire de la Côte d'Azur, 13. Johns Hopkins University APL

The spacecraft Hayabusa2 arrived at a C-type asteroid Ryugu on June 27, 2018 and is currently conducting both global and high-resolution observations. These observations have revealed that Ryugu has a very high abundance of boulders; the number density of boulders >20m in diameter is about twice that on Itokawa. However, the sizes of boulders detected in global and regional observations are limited to several to ten meters because the image resolution is 0.5 –2 m in these observations.

In this study, in order to push the limits of boulder detetion, we developed a method that automatically evaluates the abundance of small boulders (sub-pixel to a few pixels in diameter) and applied it to both Ryugu and Itokawa.

The analysis results show that Ryugu has a relatively uniform distribution of boulders over its globe. More specifically, both the power-law index and the coefficient for the boulder cumulative size frequency distribution are very uniform over the entire surface. The power-law index average is -2.53 and the standard deviation due to regional scatter is 0.03 over the globe for boulders > 75 cm. This power-law index is consistent with the result (-2.65 ±0.05) of visual counting for boulders > 5 m [Michikami et al. 2019]. In contrast, Itokawa has a very heterogeneous boulder distribution. The power-law index average is -3.6, and the standard deviation due to regional scatter is 0.83 over the globe. This large regional variation of boulder size distribution on Itokawa strongly suggests the presence of size sorting on its surface, which may be induced by granular convection [Miyamoto et al. 2007].

More detailed analysis has revealed a large variation in boulder number density in both longitudinal and latitudinal directions. In the longitudinal direction, dichotomic contrast in boulder abundance is seen. The boulder density of the eastern hemisphere is ~1.4 times higher than that of the western hemisphere. A similar dichotomic pattern is seen in crater number density [Cho et al. 2019 LPSC] and v-band albedo distribution [Sugita et al. 2019]. Furthermore, the boulder number density is the lowest in troughs surrounding the western hemisphere. The troughs are bluer in the visible wavelengths, similar to the equatorial ridge and polar regions, where newer surfaces are expected to be exposed because of their high geopotential. These lines of evidence suggest that the western hemisphere may be separated from the eastern hemisphere by high mobility zones.

Global observations have revealed that Ryugu exhibits a small but significant latitudinal size sorting in boulders; a larger number of boulders is found at higher latitudes [Sugita et al. 2019]. Our new analysis found a more detailed trend in latitudinal direction. The top of the equatorial ridge exhibits a higher boulder number density, and both southern and northern slopes of the ridge have lower boulder density.

This trend is opposite from the general trend from the equator to the poles and is more pronounced in the eastern hemisphere. We found a significant correlation (R ~ -0.73) between the boulder abundance and the topographic slope with respect to the geopotential. This suggests that the observed boulder distribution is controlled by the current geopotential and not by the paleo-geopotential during a possible past high-spin-rate era.

Keywords: Ryugu, Hayabusa2, boulder

