Surface Flow Analysis Based on Spectral Distributions around Larger Boulders on Ryugu

*Naofumi Takaki[1], ERI TATSUMI[1,2], Tomokatsu Morota[1], Yuichiro Cho[1], Kazuo Yoshioka[1], Hirotaka Sawada[3], yokota yasuhiro[3,4], Naoya Sakatani[3], Masahiko Hayakawa[3], Rie Honda[4], Shingo Kameda[5], Moe Matsuoka[3], Manabu Yamada[6], Chikatoshi Honda[7], Toru Kouyama[8], Hidehiko Suzuki[9], Kazunori Ogawa[3,10], Hideaki Miyamoto[1], Naru Hirata[7], Naoyuki Hirata[10], Seiji Sugita[1]

1. The University of Tokyo, 2. Instituto de Astrofísica de Canarias, 3. Japan Aerospace Exploration Agency, 4. Kochi University, 5. Rikkyo University, 6. Planetary Exploration Research Center Chiba Institute of Technology, 7. The University of Aizu, 8. National Institute of Advanced Industrial Science and Technology, 9. Meiji University, 10. Kobe University

Global observations of Ryugu by Hayabusa2 found various geomorphological features, such as high abundance of boulders, depletion in small craters [1], and the presence of a circular circum-equatorial ridge [2]. Furthermore, evidence for mass movement have been found on both sides of the equatorial ridge [1]. Ryugu has a globally uniform spectral distribution, but spectral slope distribution shows regional differences. The equatorial ridge and poles have blue spectra while mid-latitude regions have red spectra [1]. This global spectral variation may be due to surface flows from the equator to mid-latitude regions [1,3]. Ryugu might have the stratigraphic architecture of redder surface materials covering bluer subsurface materials. The spectral variation has been proposed to be caused by surface flow, which removed a reddish top layer and exposed subsurface bluer materials [3]. However, the degree of such surface flows is poorly understood yet. In this study, we search the Ryugu surface for possible surface flow features using spectral slope. Then, we quantitatively investigate both degrees and direction of surface flows.

Wake-like features have been found around large boulders on the equatorial ridge slopes. Although downstream regions of boulders do not have clear and geomorphological flow features, the downstream regions have bluer spectra than their surrounding surface. If a boulder is sitting in the surface flow from the equator, surface redder materials in the downstream region of the boulder would flow away to mid-latitude regions, and the boulder prevents redder materials in the upstream region from flowing into there. Consequently, subsurface bluer materials in downstream regions would be exposed. We measured the length (longitudinal length) and width (latitudinal length) of the flow features. We also measured the lengths of flow features on the equatorial ridge. The color analysis has been conducted based on the calibration obtained with inflight observations of Hayabusa2 [4].

As a result of the survey, we found 20 boulders with wake-like features (i.e., bluer downstream regions associated with boulders). The average width and length of the flow features associated with boulders are 22 ±12 m and 16 ±10 m, respectively. The width and length of the flow features show a good correlation with boulder width. Most of the boulder-associated flows are generally shorter than the flows around the equator. The longitudinal length of the blue band surrounding the equator, suggestive of continuous flows from the equator toward higher latitudes, is 51 ±18 m over different longitudes. However, we found that the length of the boulder-associated flow does not have a correlation with topographical slope or surface potential.

The correlation between the width of boulders and the width and length of flows suggests that the

boulders prevented the surface materials from flowing into higher latitudes, because otherwise the widths of bluer regions are independent of the boulder width. The lack of strongcorrelation between the flow length and topological slope or surface potential suggests that these parameters where a boulder occurs are irrelevant to the flow lengths. On the other hand, the correlation between the width of boulders and the length of flows suggests that the flow lengths associated with boulders may be controlled by boulder size.

The thickness of red surface layer may be from 10 cm to ~1 m if change in spectral slope is resulted in by solar heating [3]. The thickness of fluidized layer is needed to be thicker than that of red surface layer at least. On the other hand, the maximum thickness of fluidized layer may not reach to 10 m because the flow feature areas do not have large depressions.

[1] S. Sugita et al. (2019) Science, aaw0422.

[2] S. Watanabe et al. (2019) Science, aav8032.

[3] T. Morota et al. (2019) JpGU 2019, Abstract PPS03-08.

[4] E. Tatsumi et al. (2019) Icarus, Vol. 325, p. 153-195.

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