

Dynamical environment and spectral slope on asteroid 162173 Ryugu

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Hayabusa 2 spacecraft reached asteroid Ryugu and revealed a top-shaped body, with higher potentials at its equator and both poles [1]. The equatorial cross-section of Ryugu is almost circular, and Ryugu has a short rotation period, which suggests that deformation due to rotation is envisaged [2]. However, the current rotation speed is too slow to cause significant deformation. Thus, Ryugu may have rotated much faster in the past and then slowed down to the current spin rate [1]. The surface of Ryugu shows a red-blue distribution depending on its reflection properties. Morota et al. (2020) showed that asteroid Ryugu has redder and bluer material distributions indicated on a map of the global spectral slope [3]. Hirata and Ikeya (2021) summarized that bluer units are observed in the following four features (1) the equatorial ridge (Ryujin dorsum), (2) near the north and south poles, (3) Tokoyo fossa, and (4) some small fresh craters [4]. Mass wasting and ejecta redeposition should affect the dynamical environment on Ryugu. This study aims to investigate in detail the relationship among the red-blue distributions of Ryugu and dynamic height and slope, changing of the rotation rate.

We investigated the correlation between the red-blue distributions and the dynamical environment on Ryugu. We find that as the rotation speed becomes slower, the overall dynamic slope becomes smaller. Comparing the red-blue distribution map with the dynamic slope maps, we can see that the dynamic slope map, when the rotation speed is less than ~ 3.7 h, has the features (1), (2), and (4) of the red-blue distributions. However, the feature of (3) does not match. The geophysical quantities (x-b ratio and dynamic slope) in the blue region of both maps are different, but their distributions seem to be quite similar. When the rotation speed is 3.7 h, there is a strong correlation between the x-b ratio of less than 0.97 and the dynamic slope map of less than 12 degrees. Thus, the bluer units are concentrated on the gentle slope of 12 degrees or less. On the other hand, when the rotation speed is 7.36 h, there is no correlation between the two. Furthermore, the difference of the dynamic slope between the rotation speed of 3.7 h and 7.36 h shows that the dynamic slope is almost unchanged around the equator and both polar regions. These results suggest that the blue material deposited in the slow-slope region during the period of high rotation velocity has remained on the Ryugu surface without significant movement. We hypothesize an alternative evolution scenario of Ryugu based on this study. When the shape of Ryugu was almost formed, the basic internal structure of Ryugu was also formed, with the blue material inside and red material outside; when an impact event occurred in Ryugu, the blue material inside covered the surface of Ryugu. Later, when Ryugu was spinning at ~ 3.7 h, the blue material remained in the region with a gentle gradient of less than 12 degrees, while the blue material moved away on a steeper gradient, exposing the red material. This scenario explains features (1) and (2) of the blue distribution, but not (3), that Tokoyo fossa is blue. This may be due to the recent formation or deposition of blue material. The blue distribution feature (4) can be explained if we consider that the blue material was trapped in a local gently sloping area at mid-latitudes. In this scenario, the top-shape of Ryugu was formed in the early stage of formation, which is harmonious with the numerical results [5].

[1] Watanabe et al. (2019) *Science*, 364, 268-272. [2] Sanchez and Scheeres, (2016) *Icarus* 271, 453-471. [3] Morota et al. (2020) *Science*, 368, 654-659. [4] Hirata and Ikeya (2021) *Icarus*, 364, 114474. [5] Sabuwalla et al. (2021) *Granular Matter*, 23, 81.

キーワード : Ryugu, Dynamical environment, Red-blue distribution

Keywords: Ryugu, Dynamical environment, Red-blue distribution