

REDDENING PROCESS OF THE RYUGU SURFACE BASED ON THE CRATER SIZE-FREQUENCY DISTRIBUTION

*Tomokatsu Morota¹, Yuichiro Cho², Masanori Kanamaru³, Rie Honda⁴, Shingo Kameda⁵, ERI TATSUMI², yokota yasui⁶, Toru Kouyama⁷, Hidehiko Suzuki⁸, Manabu Yamada⁹, Naoya Sakatani⁶, Chikatoshi Honda¹⁰, Masahiko Hayakawa⁶, Kazuo Yoshioka², Moe Matsuoka⁶, Tatsuhiro Michikami¹¹, Hideaki Miyamoto², Hiroshi Kikuchi², Ryodo Hemmi², Masatoshi Hirabayashi¹², Naoyuki Hirata¹³, Naru Hirata¹⁰, Carolyn Ernst¹⁴, Olivier Barnouin¹⁴, Hirotake Sawada⁶, Seiji Sugita²

1. Nagoya University, 2. The University of Tokyo, 3. Osaka University, 4. Kochi University, 5. Rikky University, 6. JAXA, 7. AIST, 8. Meiji University, 9. Chiba Institute of Technology, 10. The University of Aizu, 11. Kindai University, 12. Auburn University, 13. Kobe University, 14. Johns Hopkins University/Applied Physics Laboratory

The Hayabusa2 has acquired the high-resolution images and spectra of the Ryugu surface. Although the Ryugu surface has almost homogeneous reflectance and color at the macro scale, the regional variation in the spectral slope is observed by the telescopic optical navigation camera (ONC-T). The redder materials of the Ryugu surface seem to cover bluer materials. Some small craters excavate the red materials on the surface and penetrate the underlying blue materials, suggesting that the craters are younger than the reddening of the surface (space weathering or deposition of red materials). In this study, we performed the crater size-frequency measurements on the Ryugu surface using the ONC image data to constrain the surface age of the Ryugu and the age of reddening event or the timescale of reddening process of the Ryugu surface.

To identify the craters excavating the red materials we used the b-x slope images calculated from multi-band images obtained in the Mid-altitude operation. We identified 15 craters excavating the red materials. These craters have diameters from 10 to 50 m, suggesting that the thickness of the red material layer is less than 1 m.

The cratering chronology models of asteroids have been numerically calculated from the collision rate with other asteroids and scaling laws for crater formation. In this study, we used the intrinsic collision probabilities P_i for the main belt and the NEAs, the population models of the main belt asteroids and NEAs, the mean impact velocities for the main belt (5.3 km/s) and the NEAs (18 km/s), and the new P_i -scaling law developed by Tatsumi and Sugita to develop the cratering chronology model of Ryugu. Because little is known about the bulk strength of materials on Ryugu, we examined two cases (i) the strengthless target ($Y = 0$ MPa) and (ii) the strength for dry soil ($Y = 0.18$ MPa).

The density of large craters ($D > 100$ m) on Ryugu is lower than the empirical saturation level and its slope is steeper than that of the saturated distribution, suggesting that craters larger than 100 m are not saturated and the size distribution reflects the crater production function. However, craters smaller than 100 m are significantly under-saturated, suggesting that some crater erasure processes such as seismic shaking and armoring effect are active on the Ryugu surface. Based on cratering chronology model for the main belt, the surface age of Ryugu is estimated to be 5–200 Ma from the size–frequency distribution of craters larger than 100 m.

The observed frequency of craters penetrating the underlying blue materials is $\sim 1/50$ of that of craters found on the whole Ryugu. The model age of the reddening is estimated to be 0.1–4 Ma based on the main-belt chronology model and 4–160 Ma based on the NEA chronology model. The NEA model age is roughly close to the median dynamical lifetime of NEAs (~ 10 Ma), suggesting that the reddening of the Ryugu surface may have some connect with the orbital transition from the main belt to near Earth orbit.

Keywords: Hayabusa2, Ryugu, crater