

Brightness change of Hayabusa2 SCI crater ejecta observed by ONC-T and its implication to the surface status of asteroid Ryugu

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Introduction:

On April 5, 2019, Hayabusa2 Small Carry-on Impactor (SCI) experiment was conducted to form an artificial crater on the asteroid Ryugu. As a result, a crater with a rim diameter of 17.6 meters was successfully formed on the surface of Ryugu [1]. Comparison of the Hayabusa2 Telescopic Onboard Navigation Camera (ONC-T) [2] image data before and after the impact revealed that the brightness around the crater was darkened by 20% at the maximum due to ejecta rays [1]. Investigating the cause of this darkening and its temporal change will provide important insights into the weathering and alteration process on the asteroid's surface. We conducted a detailed analysis on the brightness of the SCI crater and its surrounding area by using the images of ONC-T v-band (0.55 μm) just before SCI impact and after SCI impact until the end of the proximity phase, Oct. 2019.

The analysis is conducted by two methods: (1) comparison of reflectance at the standard viewing geometry derived from images at a different time and phase angles and (2) evaluation of global

phase-ratio map created by dividing two global mosaics at phase angle 31° and 1° .

Analysis1. Comparison of images over 7 months:

High spatial resolution ONC-T images around the SCI crater was obtained just during the operations of the Hayabusa2 sampling (touchdown) and rehearsals. Thus we used images taken at the altitude of 20 km distance. This dataset contains various solar phase angle ($1-33^\circ$) observations. We used the photometrically corrected reflectance images (Level 2e product) for this analysis. In addition, we normalized each image by the average of a reference area defined far from the SCI crater.

From comparison around the SCI crater over 7 months, we found that the relative brightness of the ejecta and SCI crater varies with solar phase angle, rather than the elapsed time from SCI impact. Since the photometric correction for this Level 2e product did not concern the regional photometric difference, this residual dependency on the phase angle means that the photometric characteristic (surface roughness/texture) around the SCI crater is different from the reference area.

Analysis 2. Phase ratio image: To search the area of hidden ejecta around the natural crater similar to SCI crater ejecta, we made a global phase-ratio map by dividing two global mosaics (phase angle $31^\circ / 1^\circ$). The ratio of two different phase angle images is often used as a method to identify the distribution of a characteristic surface roughness/texture area. In this map image, the SCI crater ejecta deposit is recognized as an area with a lower ratio than the surroundings. However, the results showed that there were no areas similar to the SCI crater ejecta deposit. This may suggest that the natural crater ejecta deposits have been smoothed out over a long time.

Summary:

It was found that the surface roughness/texture may play a major role in the darkening of the SCI crater ejecta deposit. The contribution of the intrinsic albedo is still unknown and needs to be studied in detail. It is also a future issue whether there was any change in roughness/texture or albedo during the 7-month period. However, observation of the natural craters on Ryugu suggests that the darkening area may fade over a long period of time.

References:

[1] Arakawa M. et al. (2020) Science 368, 67. [2] Sugita S., et al. (2019) Science 364, 252.

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