

Close-up thermal and optical observation of asteroid Ryugu

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In 2018, the Hayabusa2 spacecraft successfully carried out four descend operations toward Ryugu's surface. During these operations, we acquired highly resolved optical and thermal images from altitudes below several hundred meters, using Hayabusa2's Optical Navigation Camera (ONC-T) and Thermal Infrared Imager (TIR), respectively. Close-up thermal images by TIR indicate thermophysical properties of the surface materials and its regional difference, which cannot be resolved by higher altitude observations (e.g., home-position observations from 20 km altitude). The temperature depends mainly on the thermal inertia of the observed medium; higher thermal inertia materials have lower daytime temperatures. Optical images by ONC-T show detailed physical conditions of the surface materials, such as particle size distribution of pebbles, surface morphology of small boulders and craters. At the spacecraft altitude of 100 m, for example, TIR and ONC-T have pixel resolutions of 8.9 cm/pix and 1.1 cm/pix, respectively. In this study, we report on a comparison of TIR and ONC images, especially for boulders and craters.

BOULDERS: TIR close-up observations showed various boulders with different daytime temperatures, or different thermal inertia. Typical thermal inertia of boulders is about $300 \text{ J m}^{-2} \text{ K}^{-1} \text{ s}^{-0.5}$, but there are a few boulders with thermal inertia up to $1000 \text{ J m}^{-2} \text{ K}^{-1} \text{ s}^{-0.5}$. The thermal inertia of rocks is mainly controlled by porosity, and porous rock has lower thermal inertia. Therefore, TIR observations show that the porosity of boulders is variable. Furthermore, boulders with high thermal inertia (low porosity) observed by ONC-T were found to be relatively brighter and had a smooth surface. Such variation in porosity, optical brightness, and surface morphology of boulders on Ryugu's surface might reflect the degree of thermal metamorphism (depth of the source) in the parent body. If the constituents of Ryugu originate from variable depths inside the parent body, this supports the idea of a rubble pile formation of Ryugu after the catastrophic disruption of the parent body. This will place important constraints on the thermal evolution of the parent body.

CRATERS: During the MINERVA descend operations at 21st Sep., we acquired highly resolved images of two craters with diameter of less than 35 m by TIR, but both craters exhibit different thermal characteristics. One crater has a hot spot close to the center of crater, where the thermal inertia is estimated to be less than $150 \text{ J m}^{-2} \text{ K}^{-1} \text{ s}^{-0.5}$. On the other hand, there seems to be no hot spot in the other crater. The difference in thermophysical properties between these craters might be attributed to formation age or original surface conditions. Our finding of a hot spot with low thermal inertia indicates the presence of a fine-particle deposit in the crater and regolith generation related to the cratering process on this low-gravity asteroid.

