First Global Thermal Images of Asteroid 162173 Ryugu and Implications to Its Surface Thermal Inertia, Grain Size and Roughness

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The Thermal Infrared Imager TIR [1] onboard the Japanese asteroid explorer Hayabusa2 [2], investigating the thermo-physical properties of the surface of asteroid 162173 Ryugu, a C-type near-Earth asteroid. The asteroid was observed by TIR almost daily during the approach in June 2018, finding the asteroid rotation period of about 7.6 hours to be consistent with the ground observations [3]. After arrival at the Home Position, 20 km earthward from the asteroid, Ryugu was imaged by the TIR on 30 June 2018, with about 50 pixels size, covering its rotation in steps of 6 degrees. This is the first set of high-resolved global thermal images of an asteroid. The temperatures on the sunlit area varied from 300 to 370K at 0.986 AU from the Sun. A north-south hemispheric difference in temperature was found, which is a seasonal variation due to the pole declination and consistent with the results of numerical simulations using a high-resolved thermo-physical model of Ryugu [4]. Global maps of thermal inertia and grain size were estimated [5] from the temperature profile at each site on the asteroid, especially prepared for the landing site selection. Diurnal temperature profile shows rather flat pattern, indicating the effect of surface small-scale roughness. Several models with surface roughness have been investigated to interpret the flat pattern, and we estimated the most suitable thermal inertia and consequently the grain size. For the safety assessment of touchdown for sampling, the highest temperatures at the time of touchdown have been predicted using the best fit thermal model, suggesting no critical temperature (below 370K) for the spacecraft. Higher-resolved thermal images were obtained during the descent to the lower altitude: 5km during the "Mid-Altitude" observation, 1 km during the "Gravity Measurement", 60 m during the MINERVA and MASCOT lander release operations, and 10 m for "Touchdown". The surface physical state and temperature at the landing site of MASCOT will be verified by MARA onboard the lander [6]. We also estimated the highest temperatures ever experienced in the past asteroid trajectory, to investigate the possible existence of organic materials in the surface layer of Ryugu. Large scale geologic features such as craters and boulders are also identified in the thermal images by the temperature difference, indicating the physical state of them. Temperature profiles of several large boulders are basically the same as those of the surrounding surface, which implies the materials with high porosity, which is consistent with the rubble-pile asteroid that formed by reacretion and sedimentation of impact fragments from a larger parrent body, and with the desiccated and vacuum-dried surface of originally volatile-rich materials.

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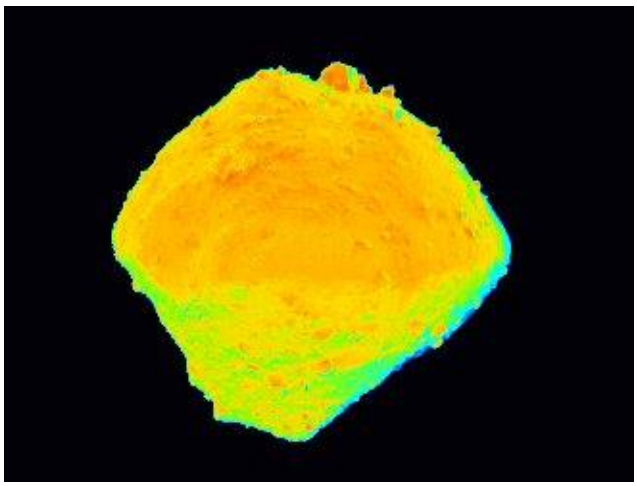

Figure 1 Thermal image of Ryugu observed at 5 km altitude on 1 Aug 2018 (modified from hyb2_tir_20180801_152656_l2a)