A reshaped rubble-pile asteroid Ryugu as observed by Hayabusa2

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After a 3.5 year outbound journey the Hayabusa2 spacecraft arrived at C-type near-Earth asteroid (162173) Ryugu on June 2018. This presentation reviews the scientific results from the first half year proximity operation around the asteroid. After a month approach phase in June, the spacecraft reached its home position (HP), about a 20 km altitude from the sub-Earth point of the asteroid's surface, and hovered. The onboard remote-sensing instruments for science are a multi-band visible camera ONC-T, a thermal infrared camera TIR, a NIR spectrometer NIRS3, and a LIDAR altimeter. The most of the sciece observations are performed from HP, but several observations from lower altitudes (5-7 km alititude) as well as a tour campaign to look into the pole resions of the asteroid was done. Shape models using Stereo-photoclinometry and Structure-from-Motion were constructed from ONC-T images.

The observations from HP revealed that the bulk mean density of Ryugu is as low as 1.2 g cm^{-3}, indicating a very porous and strenghless interior. The low bulk density and the abundant boulder appearance (largest one near the south pole is ~130 m across) suggest Ryugu is a rubble-pile body having accumulated impact fragments from the parent planetesimal. The prominent feature of Ryugu is its top-shape with a circular narrow equatorial ridge of ~500 m radius. There are several top-shaped asteroids have been identified from ground radar observations. Bennu, the target of OSIRIS-Rex mission is one of them. Contray to Ryugu having a rotation period of 7.632 hr, however, most of the top-shaped asteroids are rapid rotators with rotation periods less than 4.3 hr. Thus, it has been unexpected that Ryugu has a top shape. After the formation Ryugu should be reshaped by the past rapid rotations, the state of which may obtained by the initial accretion of fragments of the parent body or YORP-induced spin-up. The internal failure of the early Ryugu by ripid rotation made the circular equatorial ridge. Ryugu spins retrogradely around an axis almost perpendicular to the orbital plane (obliquity is ~172°), which is consistend with one of the final spin state of the YORP evolution.

The most of the surface has very low reflectance and flat featureless reflection spectra in visible and NIR wavelength ranges, and no clear 0.7-μm and 3-μm absorption bands indiacing the presence of hydrated minerals have been found so far. Such features may possibly correspond to meteorites like moderately dehydraed carbonecious chondrites by heat or shock. The equatorial ridge is bright and bluish compared with mid-latitudinal zones, suggesting its fleshness or less organic materials.

After the landing site selection Hayabusa2 will try to touch-and-go the surface and collect materials as a return sample. Landers MASCOT and MINERVA-II will descend and land on the surface performing in-situ various observations. The many boulders on the surafce of Ryugu would make the sampling difficult. Thus, in-situ information obtained from the landers as well as low-altitude observations of the surface during descents to deploy landers are very important to develope a strategy to get a sample safely from the "fort of boulders". The remote-sensing and in-situ observations of Hayabusa2 and laboratory analyses of the return sample will clarify the origin and history of this small body, early solar system environment around the snow-line, and material supply inventory from the Main Belt to Earth.