Geology and geomorphology of asteroids: optical instruments and analysis tools

K. Kitazato, N. Hirata, Y. Ogawa, C. Honda, N. Asada, J. Terazono, H. Demura
CAIST/ARC-Space, University of Aizu

We present geological features found on the surface of asteroid Itokawa through remote-sensing observations by the Hayabusa spacecraft.
Survey of impact craters on Itokawa

- Crater morphology for asteroids provides information concerning geologic process occurred after the formation, such as impact and surface modification processes.

- From images taken by the Hayabusa spacecraft, we determined the morphologies and dimensions of possible impact craters on Itokawa’s surface.

- Circular depressions, circular features with flat floors or convex floors, and circular features with smooth surfaces were found as possible craters.
The survey identified 38 candidates with widely varying morphologies including rough, smooth and saddle-shaped floors, a lack of raised rims and fresh material exposures.

For the details, please see Hirata et al., Icarus, 200 (2009) 486-502.
Characteristics of crater candidates

- The average depth/diameter ratio was $0.08 \pm 0.03$.

  ➡ Itokawa’s craters are very shallow relative to craters observed on other asteroids that spacecraft visited so far. The probable causes: (1) target curvature influencing the cratering process, (2) raised rim not being generated by this process, and (3) fines infilling the craters.

- The size frequency distribution is shown in the right figure.

  ➡ Itokawa’s surface are lacking in small (<10 m) craters, similarly to Eros. This may be indicative of a depletion of small impactors.

The estimated age of Itokawa is at least ~75 Myr (Michel et al., 2009), if much of them are “real” craters.
Space weathering on Itokawa

- Optical changes of airless body surfaces induced by solar wind ion sputtering and micrometeorite bombardment are known as “Space Weathering”. Although no fine regolith layer was found on Itokawa’s surface, space weathering can progress even on the blocky asteroidal surface.

- The degree of space weathering reflects exposure time to the space environment so that its spatial variation provides information on the resurfacing process.

- Using a near-infrared spectral mapping data from the Haybusa/NIRS, we derived the spatial variations in space-weathering degrees on Itokawa’s surface.
NIR spectral variations on Itokawa

- The photometrically-corrected spectral data, which covers almost entire disk (~85%) of Itokawa, showed the **albedo variation of ~10%** within the wavelength range of 0.8-2.1 µm.

- Although Itokawa was also found to exhibit subtle color variations, the wavelength shift of diagnostic mineral absorption bands were not detected in the spectral data set.

- The mineral composition would be almost homogeneous.

The probable causes of the albedo/spectral variations: (1) space weathering and (2) particle size variations

The average (red) and full range of spectral variations seen within the NIRS coverage
Through an inversion method of spectral modeling with Hapke’s theory (Hapke, 1993; 2001), we estimated the space-weathering degrees and particle size on each area.

- The relatively fresh un-weathered areas are located in the high-albedo patchy spots seen in the visible images.

- The high-albedo, un-weathered areas are frequently seen at the edges of the global shape. This can be considered to have resulted from boulder migration enhanced by shaking energy convergent at the edge.
In March 2009, 14 nomenclatures for Itokawa have been newly approved by the IAU.
Toward Hayabusa follow-on missions

- From the Hayabusa mission, we learned that an imaging system covering the spatial resolution for both global mapping and sampling would be required in the Hayabusa follow-on missions.

- The authors of University of Aizu have been studying on the Fish-eye wide stereo-camera to be equipped with the spacecraft.
Summary

- 38 crater candidates were identified on Itokawa.  
  Inferred age: ~75 Myr  
  More experimental/numerical studies are desired.  
    For more confident identification of craters  
    For better understanding about impact cratering on a boulder layer

- Space weathering on Itokawa was examined from VIS-NIR spectra.  
  Distribution of fresh areas are mostly controlled by the global shape.

- 14 nomenclatures for Itokawa were approved by IAU.