

# Geology and geomorphology of asteroids: optical instruments and analysis tools

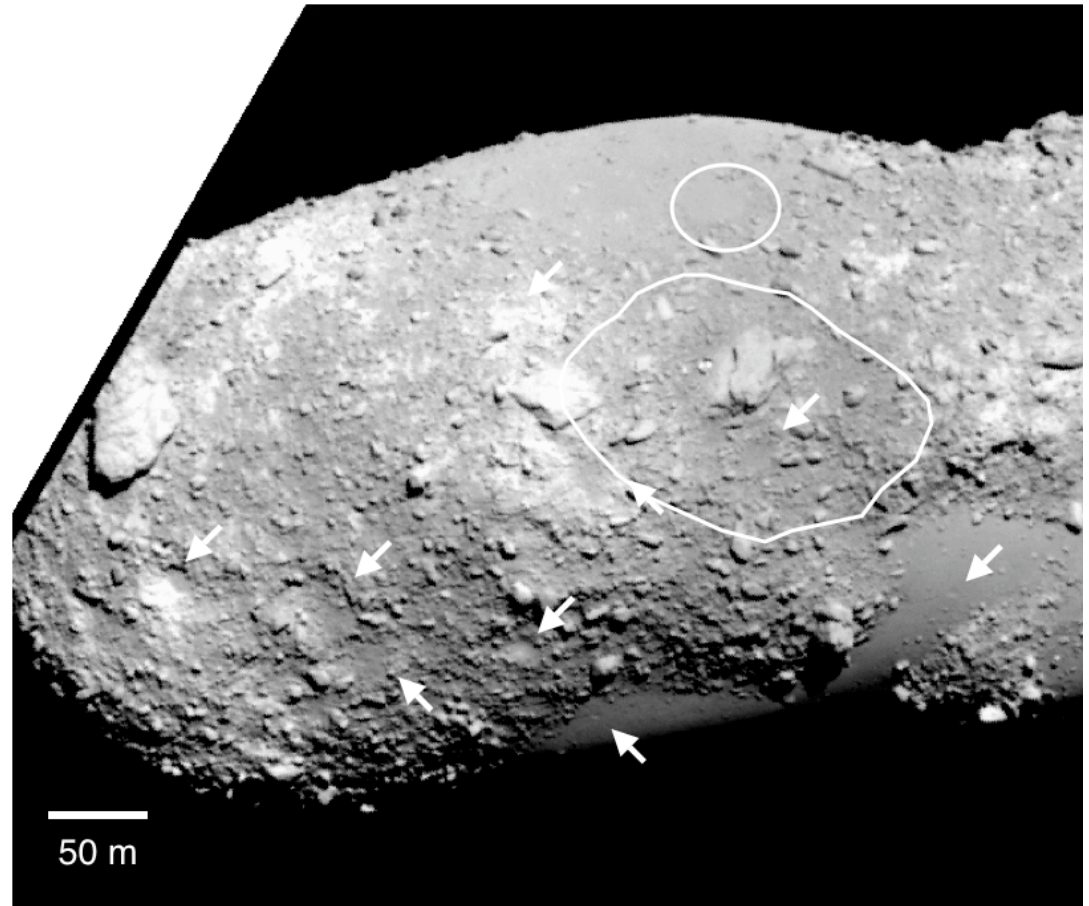
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We present geological features found on the surface of asteroid Itokawa through remote-sensing observations by the Hayabusa spacecraft.



# Survey of impact craters on Itokawa

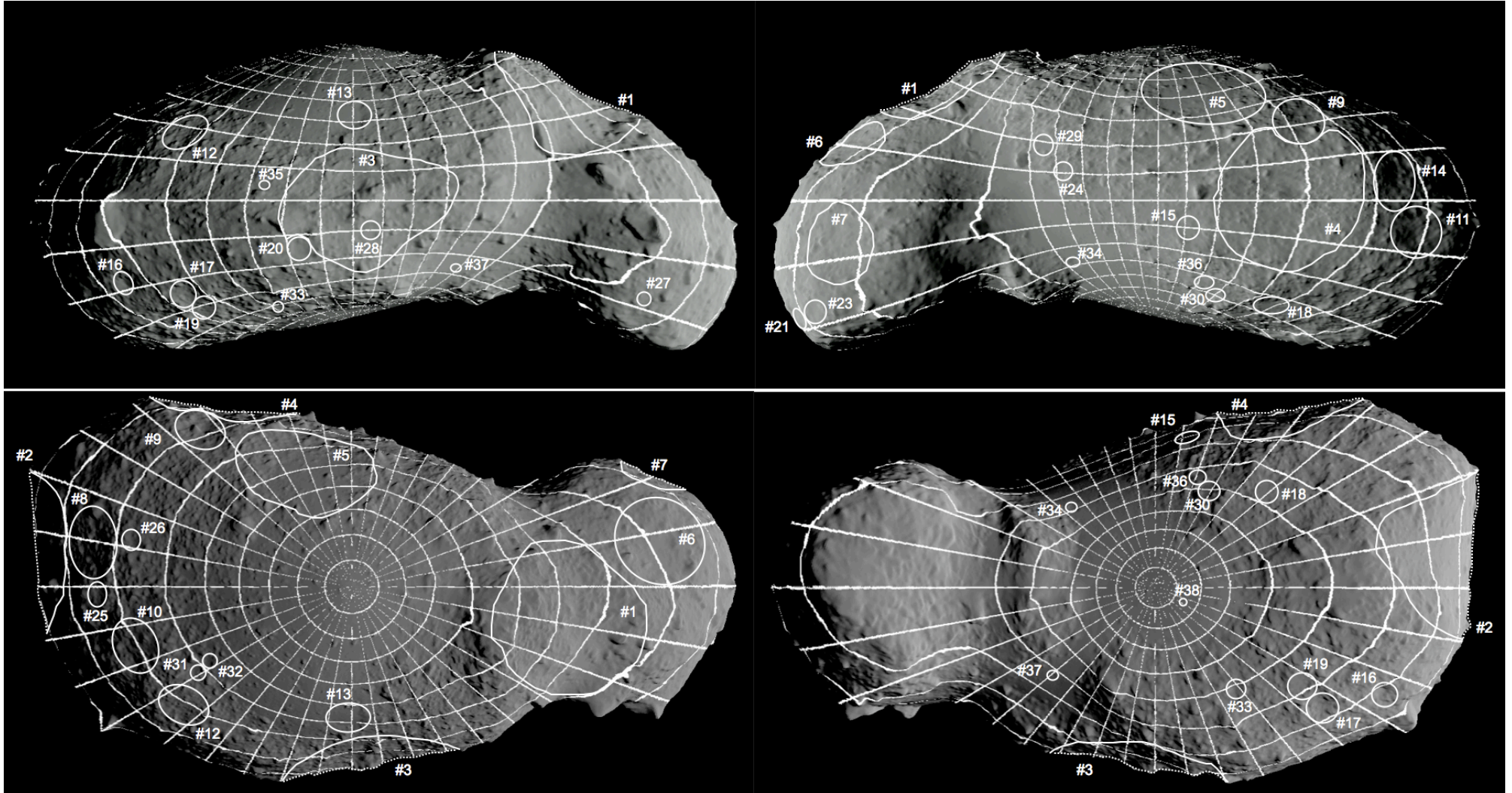
- Crater morphology for asteroids provides information concerning geologic process occurred after the formation, such as impact and surface modification processes.
- From images taken by the Hayabusa spacecraft, we determined the morphologies and dimensions of possible impact craters on Itokawa's surface.
- Circular depressions, circular features with flat floors or convex floors, and circular features with smooth surfaces were found as possible craters.



West side of Itokawa

# 38 crater candidates

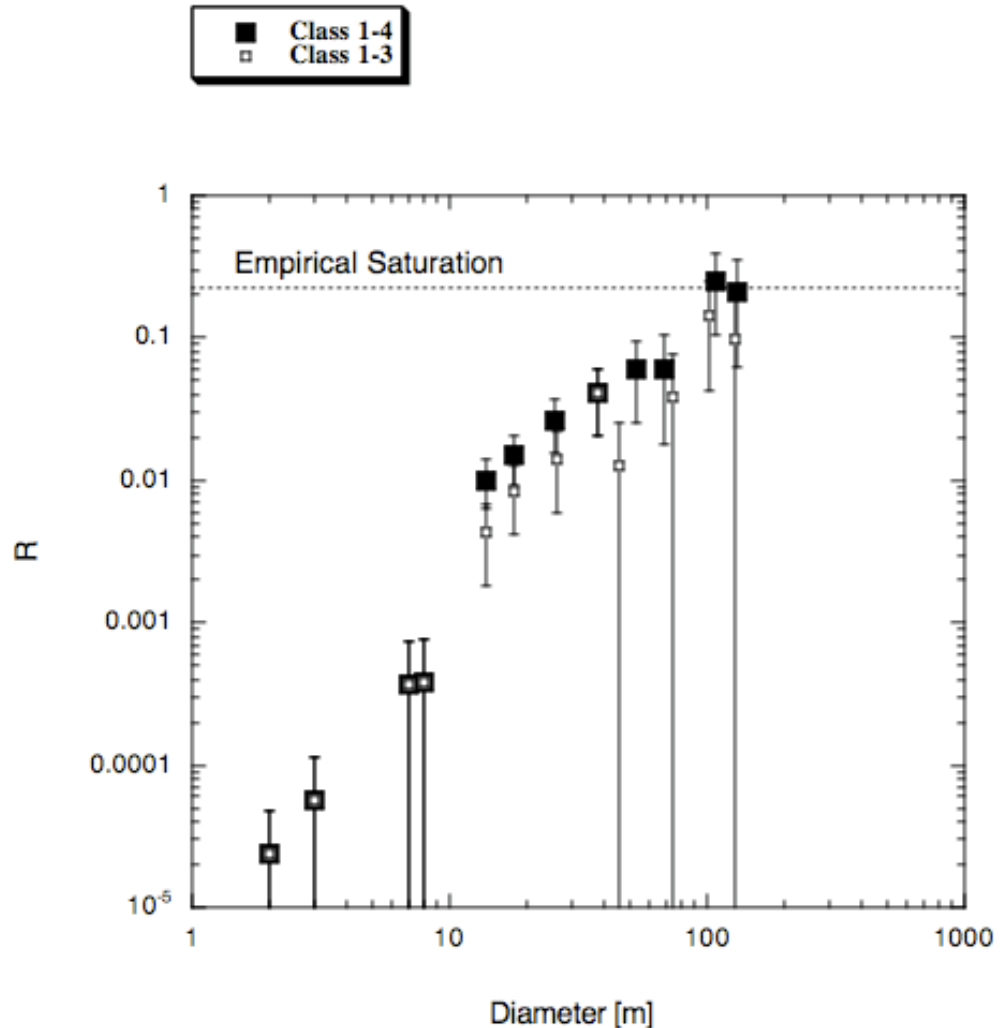
The survey identified 38 candidates with widely varying morphologies including rough, smooth and saddle-shaped floors, a lack of raised rims and fresh material exposures.



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.



R-plot size frequency for crater candidates on Itokawa

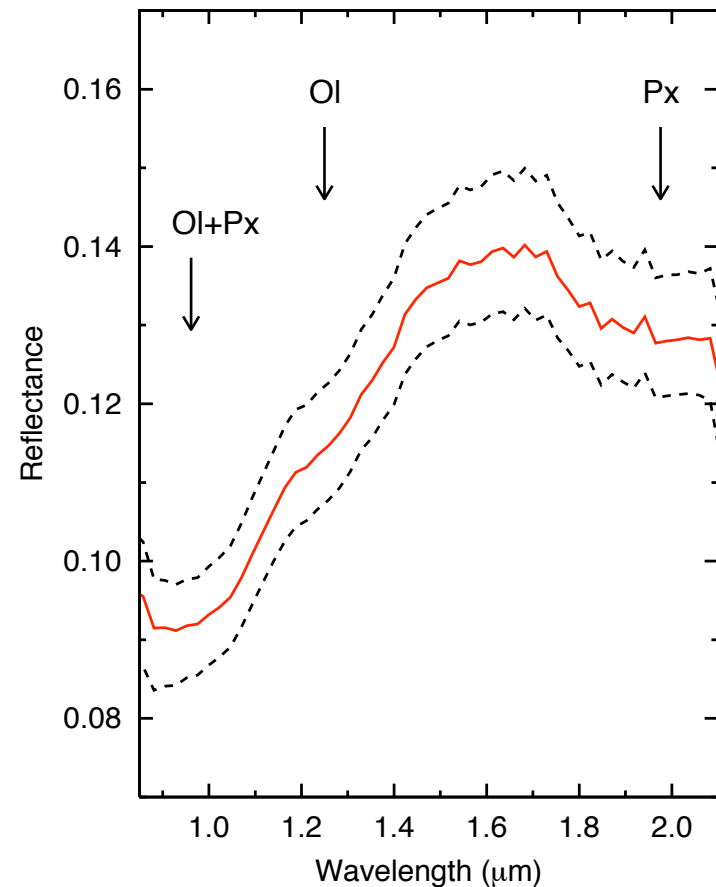
# Space weathering on Itokawa

- 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  $\mu\text{m}$ .
- 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

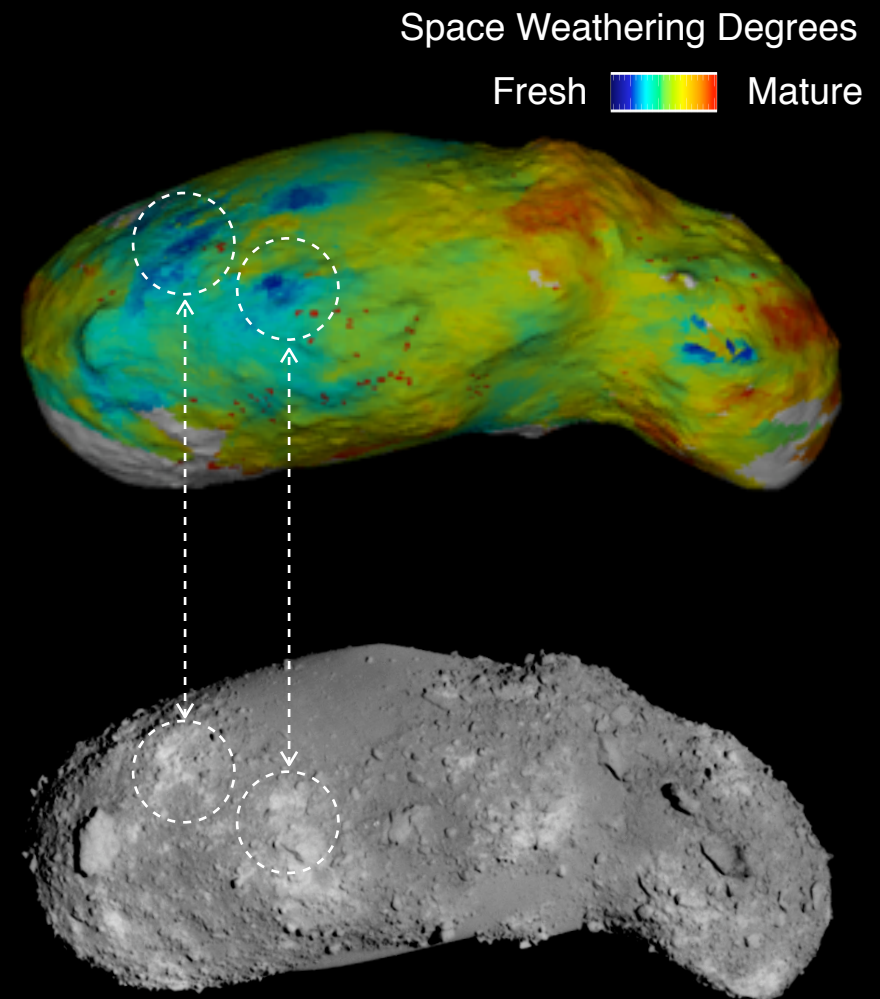
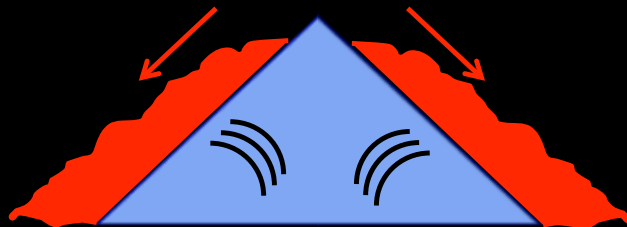


The average (red) and full range of spectral variations seen within the NIRS coverage

# Fresh areas implied from space weathering

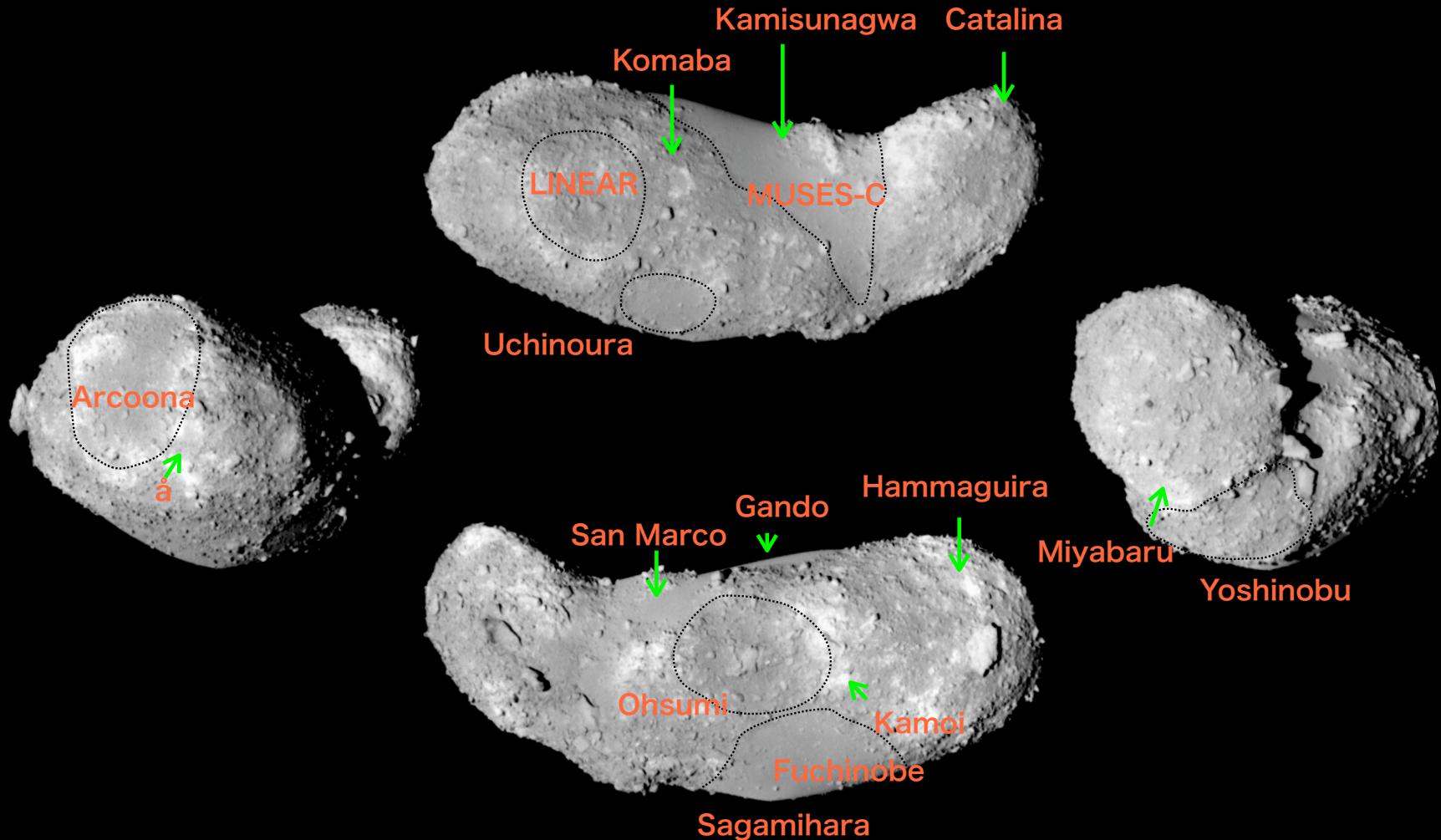
- Through an inversion method of spectral modeling with Hapke's theory (Hapke, 1993; 2001), we estimated the space-weathering degrees and particle size on each area.
  - ➔ The relatively fresh un-weathered areas are located in the high-albedo patchy spots seen in the visible images.
- The high-albedo, 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.



# Nomenclature for Itokawa

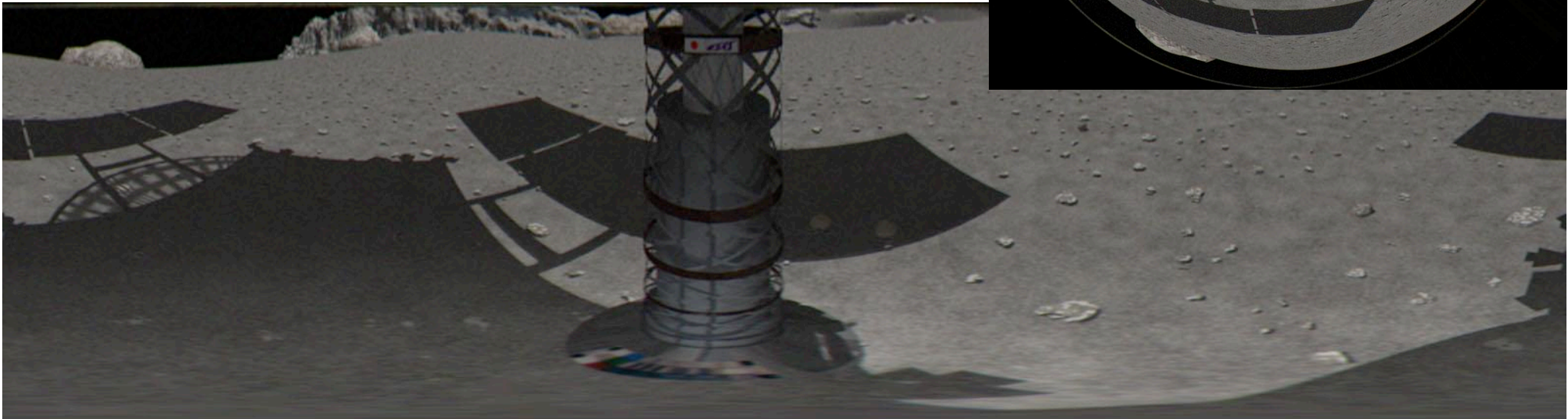
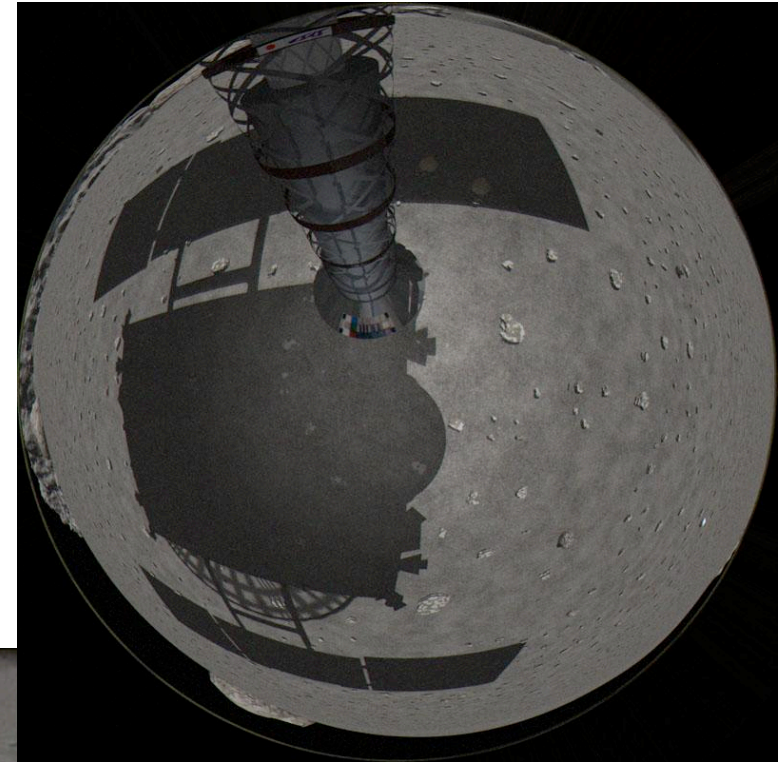
In March 2009, 14 nomenclatures for Itokawa have been newly approved by the IAU.





# 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.