Scientific Evaluation on the Asteroid Ryugu in Hayabusa2 Landing Site Selection

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On June 27, 2018, the spacecraft of the Japanese C-type asteroid sample return mission, Hayabusa2, has arrived at the asteroid Ryugu. During its 18-month stay, remote-sensing observations will be carried out with the on-board instruments, Optical Navigation Camera (ONC), Near Infrared Spectrometer (NIRS3), Thermal Infrared Imager (TIR), and Laser Altimeter (LIDAR). Hayabusa2 plans to collect asteroid samples from up to three sites. Based on the remote-sensing data, we will carry out the landing site selection (LSS) in the end of August 2018, for the first touch down (TD1) and for releasing a hopping lander, MASCOT, in the beginning of October 2018. Based on the mission's scientific goals, the most scientifically valuable site for TD1 will be a less altered region where water and/or carbon are abundant.

Seven potential landing sites including equatorial regions (L5, L7, L8, L12) and mid-latitude regions (M1, M3, M4) were proposed based on spacecraft safety and boulder size-frequency by the system engineering team and ONC team. The data products will be obtained at 20 km, 5-7 km and at 5 km in altitude. Shape modeling team produced polygon shape models of Ryugu by two different methods; Shape-from-Motion (SfM) and Stereophotoclinometry (SPC). ONC produces the six types of spectral indices: (i) 0.7 μm absorption depth, (ii) spectral slope from 0.39 μm to 0.95 μm, (iii) spectral slope in ultraviolet, (iv) 0.95 μm absorption depth, (v) scores of PC1 to PC5. NIRS3 produces the spectral feature maps: (i) 3-μm band depth/center, (ii) spectral slope, and (iv) near-infrared albedo. TIR provides the maps of thermal inertia, grain size, and maximum temperature for TD1.

Based on the data products, evaluation and scoring was performed from the three perspectives; Science, Safety, and Sample recovery. Scientific evaluation included the seven topics; 1. Physical properties of surface, 2. Surface age and morphology, 3. Organic carbon compositions and contents, 4. Hydrous minerals distributions, 5. Degrees of heating dehydration, 6. Other minerals and 7. Surface secondary processes.

Distributions of temperature and grain sizes were mostly homogeneous for all the potential landing sites. L7, 8, 12 and M4 are more rough than others. L regions were evaluated as highlands and M regions were evaluated as low lands. The density of craters of Ryugu were comparable to those of Itokawa and Eros, and the surface age of 0.1 to 1 billion years was evaluated. Regarding boulder distributions, L8 and M4 contain less density of large boulders than others.

There was no large variation in the UV-Vis and NIR spectral patterns between all the potential landing sites. Based on the unusual excess of reflectance at 390 nm, the presence of extensively graphitized carbonaceous material is indicated. Assuming that the correlation between v-band albedo (550 nm) and carbon contents is directly applicable, it is estimated that carbon contents of Ryugu is higher than 3%. However there remains uncertainties on the effects of grain size, porosity, and space weathering. Small absorption at 2.7 μm was identified from the NIR spectra of Ryugu, indicating the presence of phyllisilicates. Comparison between the NIR spectra of Ryugu and those of meteorites indicated that the abundances of phyllosilicates are low for all the regions of Ryugu surface. Ryugu could be composed of similar materials to dehydrated C chondrites containing darkening materials, or dark anhydrous material.

The correlation was observed between v-band albedo and b-x slope (480-860 nm). L regions show bluer spectra, while M regions show redder spectra. M1 was particularly red. In the individual regions, L regions are more heterogeneous compared to M3 and M4 regions, showing that wider variety of materials are collected from L regions compared to M regions.

Safety evaluation was complimentarily conducted with engineering safety evaluation, based on the area occupied by boulders, median filter, SPC topograph, Hapke roughness parameter, sigma roughness parameter, and grain sizes. Evaluation of samplability was conducted based on the grain sizes and boulder distributions. Summarying each evaluation, we selected L8, L7 and M4, as the regions that meet both the safety and scientific value for TD1. A variety of topography and geology of Ryugu revealed by the remote sensng observations and LSS scientific evaluation indicates that the mixed samples with different origins would be collected from the selected sites. This would provide the initial sample analysis a great advantage that the origin and chemical evolution of the solar system as well as the formation process and structure of the asteroid Ryugu are comprehensively investigated.