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Preliminary examination of Hayabusa asteroidal samples: oxygen and magnesium isotopic compositions

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Introduction: The Hayabusa spacecraft made two touchdowns on the surface of Asteroid 25143 Itokawa on November 20th and 26th, 2005. The Asteroid 25143 Itokawa is classified as an S-type asteroid and inferred to consist of materials similar to ordinary chondrites or primitive achondrites. Near-infrared spectroscopy by the Hayabusa spacecraft proposed that the surface of this body has an olivine-rich mineral assemblage potentially similar to that of LL5 or LL6 chondrites with different degrees of space weathering.

The spacecraft made the reentry into the terrestrial atmosphere on June 12th, 2010 and the sample capsule was successfully recovered in Australia on June 13th, 2010. Although the sample collection processes on the Itokawa surface had not been made by the designed operations, more than 1,500 grains were identified as rocky particles in the sample curation facility of JAXA, and most of them were judged to be of extraterrestrial origin, and definitely from Asteroid Itokawa on November 17th, 2010. Although their sizes are mostly less than 10 micrometers, some larger grains of about 100 micrometers or larger were also included. The mineral assembly is olivine, pyroxene, plagioclase, iron sulfide and iron metal. The mean mineral compositions are consistent with the results of near-infrared spectroscopy from Hayabusa spacecraft, but the variations suggest that the petrologic type may be smaller than the spectroscopic results.

Several tens of grains of relatively large sizes among the 1,500 grains will be selected by the Hayabusa sample curation team for preliminary examination. Each grain will be subjected to one set of preliminary examinations, i.e., micro-tomography, XRD, XRF, TEM, SEM, EPMA and SIMS in this sequence. The preliminary examination started from January 21th, 2011. Samples for isotope analyses in this study will start from the last week of February 2011. By the time of this meeting we will have measured the oxygen and magnesium isotopic composition of several grains.

Analytical Techniques: The oxygen and magnesium isotope analyses for the collected grains will be investigated by the Hokudai isotope microscope system, consisting of Cameca ims-1270 SIMS instrument and SCAPS ion detector. The grains used in this study will have had their mineral compositions and petrographic textures determined by EPMA/SEM analyses. The SIMS procedures will be applied to the measurements for oxygen isotopes and magnesium isotopes, respectively. The analytical precisions will be expected to be ca. 0.6 permil for oxygen isotopes and ca. 0.1 permil for ²⁶Mg-excesses using 10 micrometer primary beam although the primary beam size and measurement precisions will be adjusted to the mineral species and the crystal sizes in each grain.

Examination Goals: The basic goals of the preliminary examination of isotope sub-team are as follows:

- (1) Determination of oxygen isotopic compositions of each mineral and their variation.
- (2) Determination of magnesium isotopic compositions and search for ²⁶Al.
- (3) Determination of oxygen isotopic composition of solar wind.

What totally unexpected features have we encountered, and how will we learn to deal with them? We can expect to be surprised.

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Keywords: Hayabusa, asteroid, isotope, oxygen, magnesium