OXYGEN AND MAGNESIUM ISOTOPIC COMPOSITIONS OF ASTEROIDAL MATERIALS RETURNED FROM ITOKAWA BY THE HAYABUSA MISSION. H. Yurimoto[1], M. Abe[2], M. Ebihara[3], A. Fujimura[2], K. Hashizume[4], T. R. Ireland[5], S. Itoh[1], J. Kawaguchi[2], F. Kitajima[6], T. Mukai[2], K. Nagao[7], T. Nakamura[8], H. Naraoka[6], T. Noguchi[9], R. Okazaki[6], N. Sakamoto[1], Y. Seto[10], A. Tsuchiyama[4], M. Uesugi[11], T. Yada[2], M. Yoshikawa[2], M. Zolensky[12]
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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 [1]. 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 [2].

The spacecraft made the reentry into the Earth's 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 [3]. Although their sizes are mostly less than 10 μm, some larger grains of about 100 μm 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 [2], 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 [4]. 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 will start from the last week of January 2011. Therefore, samples for isotope analyses in this study will start from the last week of February 2011. By the time of the LPSC meeting we will have measured the oxygen and magnesium isotopic composition of several grains. We will present the first results from the isotope analyses that will have been performed.

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 [5]. The grains used in this study will have had their mineral compositions and petrographic textures determined by EPMA/SEM analyses [6]. The SIMS procedures are similar to [7, 8] and will be applied to the measurements for oxygen isotopes and magnesium isotopes, respectively. The analytical precisions will be expected to be ~0.6 permil for oxygen isotopes and ~0.1 permil for ^{26}Mg-excesses using 10μm primary beam although the primary beam size and measurement precisions will be adjusted to the mineral species and the crystal sizes in each grain. For oxygen isotope analyses of implanted solar wind, we will apply procedures similar to [9].

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

Determination of oxygen isotopic compositions of each mineral and their variation. It is well known that each meteorite group has a characteristic chemical composition and oxygen isotopic composition. Therefore, determination of oxygen isotopic composition provides an important means to connect asteroids and meteorites. On the other hand, variations of oxygen isotopic compositions among and between different minerals correspond to the degree of chemical equilibrium. If no variations are observed, Asteroid Itokawa would be composed of igneous or heavily metamorphosed rock.

This is the first opportunity to directly measure oxygen isotope composition of a known, wellcharacterized asteroid. Results of remote sensing observations from the Hayabusa spacecraft [2] suggested that Itokawa is composed of LL5 or LL6 chondrite material. Based on these results, we expect that the oxygen isotopic compositions of the minerals will be equivalent to the LL chondrite values (slightly heavier than terrestrial composition) and distributed in equilibrium among minerals. If this perspective is correct, then we have strong evidence from an isotopic viewpoint that the S-type asteroids are the parent bodies of ordinary chondrites.

Determination of magnesium isotopic compositions and search for ^{26}Al. It is well known that the short-lived nuclide ^{26}Al was present in the early solar system. The initial ratio of $^{26}Al/^{27}Al$ of the solar system is inferred to be $\sim 5\times10^{-5}$ which is observed in CAIs. The $^{26}Al/^{27}Al$ ratio is $\sim 10^{-6}$ or less in chondrules and $\sim 10^{-7}$ or less in achondrites. We can discuss a formation age of minerals in the Itokawa samples assuming homogeneous distribution of ^{26}Al in the solar nebula if we make an isochron among olivine, pyroxene and plagioclase. A model age of ^{26}Al [10] would be possible if we determine magnesium isotopic compositions of olivine precisely.

Determination of oxygen isotopic composition of solar wind. Determination of the mean oxygen isotopic composition of the solar system is a fundamental issue of cosmochemistry because of large variations of oxygen isotopic composition among solar system materials and solar system objects [11]. The origin of these variations is still a controversial topic, but cannot be due to thermodynamic processes. . The oxygen isotopic composition of the sun corresponds to the mean composition of the solar system because the sun concentrates more than 99% of the solar system materials. Solar wind from the sun would have a representative oxygen isotopic composition of the sun. Oxygen isotopic compositions of solar wind have been measured from the metal in the lunar regolith [12, 13], the SiC target of NASA Genesis mission [14], and metal grains in gas-rich chondrites [9]. However, the observed oxygen isotopic compositions of solar wind have not converged on a constant value. An asteroidal regolith is an independent candidate as a target with implanted solar wind. We will try to measure oxygen isotopes of implanted solar wind in the Itokawa regolith if large single grains of metallic iron or iron sulfide of ~100μm sizes are found in the Itokawa sample.

Finally, 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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