NOBLE GASES OF THE ITOKAWA SAMPLES RETURNED BY THE HAYABUSA MISSION.

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Introduction:

Samples returned from the asteroid Itokawa by the Hayabusa spacecraft will provide us with the first chance to measure materials from a known asteroid. The samples available to noble gas study will be several grains smaller than 1μm (< μg). From a point of view of noble gas analysis, the returned materials are free from terrestrial noble gas contamination, which is essentially different from meteorites and cosmic dust particles collected on the Earth. The samples are treated under condition of nitrogen gas with low concentration of noble gases [1]. Accordingly, we can expect low contamination of terrestrial noble gases for the samples.

Surface materials of asteroids are exposed to solar gases, and some of them are implanted into surface layer of the materials. The asteroidal surface materials are also bombarded by galactic cosmic-rays (GCR), producing noble gases with characteristic isotopic compositions through nuclear reactions. Therefore, noble gases of the Itokawa samples would be a mixture of several different origins, e.g., trapped, radiogenic, cosmogenic, and solar gases. The cosmogenic and solar noble gases will provide us with information about the cosmic-ray irradiation, surface gardening, and surface erosion histories of asteroidal surface materials. The cosmic-ray exposure ages of the samples may also gives a constraints on the origin of cosmic dust particles, which have generally short cosmic-ray exposure ages (< Myr) [2–6]. If the returned samples have long exposure ages, surface materials of the asteroids would not be a source of most cosmic dust particles.

Noble gas analytical techniques for small samples:

Noble gas analytical techniques applicable to small size samples have been developed in our laboratory. Detection limits of our mass spectrometers for ^{3}He and ^{132}Xe are ca. 1×10^{-15} and 1×10^{-16} cm^{3}STP, respectively, which correspond to the number of atoms in the order of 10^{4} and 10^{3}. Noble gas extraction system using a Nd-YAG laser performs extremely low blank levels (in cm^{3}STP); 7×10^{-12} (^{4}He), 1×10^{-13} (^{20}Ne), 5×10^{-12} (^{40}Ar), 2×10^{-16} (^{84}Kr), and $<1\times10^{-16}$ (^{132}Xe). The analytical techniques have been applied to a large number of micrometeorites from Antarctica to measure all noble gases (He, Ne, Ar, Kr and Xe) extracted from single grains weighing ca. 1 μg each [2-6]. Measured amounts of noble gases extracted from single grains with carbonaceous chondritic character were $(10-10000)\times10^{-12}$ cm^{3}STP for ^{4}He and $(1-10)\times10^{-15}$ cm^{3}STP for ^{132}Xe. The results showed high concentrations of solar noble gases implanted in most micrometeorites, suggesting an importance of solar gas implantation for small grains.

Analyses of small amounts of the Itokawa samples:

Histories of crystallization, accumulation of radiogenic noble gases, cosmic-ray irradiation, and solar gas implantation are expected to be variable among the grains as indicated by the single grain analysis of micrometeorites [2−6]. Solar ^{4}He and ^{20}Ne in micrometeorites weighing ca. 1 μg are in the range $10^{-8}-10^{-10}$ and $10^{-10}-10^{-12}$ cm^{3}STP, respectively. The amounts of solar gases are measurable with our mass spectrometry system. Consequently, we will apply our laser extraction system to single grain analysis. For smaller grains (≤ 10 μm) stepwise heating noble gas extraction [7] will be applied to detect solar noble gases implanted in uppermost layer of the grains with low energy, which can not be detected for micrometeorites and stratospheric particles because they experienced frictional heating during passage through the atmosphere.

References: [1] Okazaki et al. (2011) *in this volume*. [2] Osawa T. et al. (2000) *Antarctic Meteorite Research* 13, 322-341. [3] Osawa T. and Nagao K. (2002) *Antarctic Meteorite Research* 15, 165-177. [4] Osawa T. and Nagao K. (2002) *Meteoritics & Planetary Science* 37, 911-936. [5] Osawa T. et al. (2003) *Antarctic Meteorite Research* 16, 196-219. [6] Osawa T. et al. (2003) *Meteoritics & Planetary Science* 38, 1627-1640. [7] Bajo K. et al. (2010) *Earth, Planets and Space* (submitted).