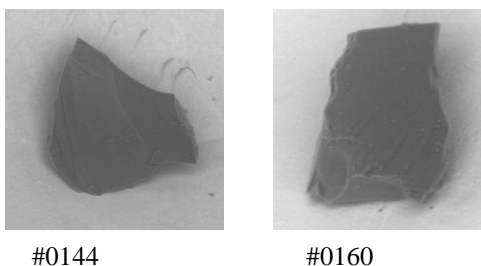


NOBLE GAS ANALYSIS OF TWO HAYABUSA SAMPLES AS THE FIRST INTERNATIONAL A/O INVESTIGATION: A PROGRESS REPORT. K. Nagao¹, R. Okazaki², Y.N. Miura³, T. Osawa⁴, J. Gilmour⁵ and Y. Nishimura⁵, ¹Geochemical Research Center, The University of Tokyo (Bunkyo-ku, Tokyo 113-0033, Japan; nagao@eqchem.s.u-tokyo.ac.jp), ²Department of Earth and Planetary Sciences, Kyushu University (Higashi-ku, Fukuoka, Japan), ³Earthquake Research Institute, The University of Tokyo (Bunkyo-ku, Tokyo, Japan), ⁴Japan Atomic Energy Agency (Tokai-mura, Ibaraki, Japan), ⁵School of Earth, Atmospheric and Environmental Sciences, University of Manchester, Oxford Road, Manchester M13 9PL, U.K.

Introduction: We have reported noble gas data for three Hayabusa samples collected on a smooth terrain, MUSES-C Regio, of the Itokawa asteroid [1] as a initial examination of the Hayabusa samples. After finishing the initial analysis we applied to the 1st international A/O investigation (JAXA). Our proposal was approved and two Hayabusa samples (RA-QD02-0144 and RA-QD02-0160) were allocated for noble gas study. We present preliminary noble gas data as a progress report.

Samples: According to the catalogue data for each Hayabusa grains provided from JAXA (Fig. 1), RA-QD02-0144 (hereafter #0144) is olivine with a size of 54 μm and RA-QD02-0160 (hereafter #0160) is olivine and its size is 45 μm . The mineralogical identification was carried out with SEM at the curation facility in JAXA.



#0144 #0160
Fig. 1. SEM images of the Hayabusa samples.

The samples had been handled after opening the Hayabusa capsule in clean nitrogen gas with low concentrations of noble gases to avoid serious contamination from terrestrial atmospheric noble gases. Weight for the samples seems to be in the range 0.05–0.1 μg . They were transferred from a tray to our sample chamber (Fig. 2) in a globe box of the curation facility using a needle manipulator, to which electrostatic voltage can be applied for picking up the particles.

Expeimental Procedures:

Sample holder. A specially designed sample chamber was prepared. Most of the housing parts were made of stainless steel (SUS 304), in which a sample holder made of quartz block is mounted. On flat surface four pyramidal concavities (opening is 1 mm in

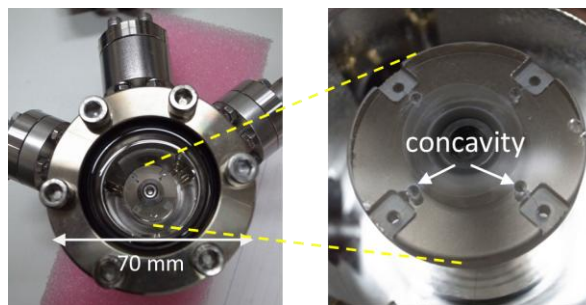


Fig. 2. Sample chamber for the Hayabusa samples.

diameter and 0.5 mm depth) are produced for sample grains. At the bottom of each dip, a thin W-Re thermocouple (25 μm in diameter) is set to measure temperature at the heating of sample for noble gas extraction.

The Hayabusa samples were placed near the thermocouple, then covered with a quartz glass plate not to escape from the cavity, and sealed in nitrogen gas atmosphere. After transfer the sample chamber to the noble gas laboratory at the University of Tokyo, it was connected to a noble gas purification line, then evacuated to ultra-high vacuum. The samples were left for about 40 days in ultra-high vacuum condition at room temperature to reduce possible contamination of terrestrial noble gases.

Noble gas extraction with laser heating. Controlling heating temperature using a Nd-YAG CW laser was performed with a computer programming developed in our laboratory. Output power of the laser beam defocussed to the point of thermocouple is gradually increased to attempted temperature by monitoring output of the thermocouple. It takes 20–40 s to increase temperature ranging from 200 to 1700°C and maintained for 30 s at the desired temperature in this work.

Noble gas analyses. We are trying to measure lighter (He, Ne and Ar) and heavier (Kr and Xe) noble gases separately with a modified VG5400 (MS-3) at the University of Tokyo and the ultra-high sensitive machines at the University of Manchester, respectively. The modified VG5400 (MS-3) had been used for the Hayabusa samples as the initial analysis [1]. For RELAX (Refrigerator Enhanced Laser Analyser for Xenon) and RPMS (Resonance Photoionisation Mass Spectrometer) see references [2,3].

Heating temperatures for noble gas extraction adopted in this work are 200, 300, 800, and 1700°C for each grain. Noble gases are purified with a SAES getter (NP10), and then trapped on a porous sintered stainless steel cooled down to 20K to trap Ne–Xe. He is introduced into the modified VG5400(MS-3) mass spectrometer to measure abundance and isotopic ratio with a single collector in ion counting mode. Ne and Ar released from the trap at the temperatures 50 and 110K are successively measured with the ion counting.

Kr and Xe are released at 230K, then 54% of total Kr and Xe are trapped in an Au-tube by cooling the tip of the Au-tube (3.6 mm inner diameter) attached to the purification line with liquid nitrogen. About 2 cm long from the tip of the tube is cut to store the Kr and Xe. The tubes are sent to the University of Manchester for analysis. 46% of Kr and Xe remaining in the purification line are measured for absolute abundances and isotope ratios, although the abundances are close to the blank levels.

Results and discussion: Blank levels (ccSTP) for all temperature steps are almost same and are; ^4He $\sim 1 \times 10^{-12}$ or less, ^{20}Ne $\sim 5 \times 10^{-13}$, ^{40}Ar $\sim 2 \times 10^{-11}$ or less, ^{84}Kr $\sim 2 \times 10^{-15}$, and ^{132}Xe $\sim 5 \times 10^{-16}$ or less.

We have measured the sample #0160 for all heating steps, 200, 300, 800, and 1700°C. Appreciable amounts of solar-like He, Ne and Ar [4] were observed in the 200°C fraction. Concentration of ^4He can be estimated as in the range of 10^{-3} ccSTP/g and its $^3\text{He}/^4\text{He}$ is ca. 2.5×10^{-4} . High $^{20}\text{Ne}/^{22}\text{Ne}$ (~ 13) and low $^{40}\text{Ar}/^{36}\text{Ar}$ (< 40) are also measured. At the higher heating temperatures, on the other hand, amounts of released gases decreased to near the blank levels. The release profiles of noble gases are similar to those of the Hayabusa sample RA-QD02-0065 [1], although the gas concentrations in #0160 are much lower than those in RA-QD02-0065. Cosmogenic ^{21}Ne in #0160 is almost negligible, suggesting short duration for cosmic-ray irradiation.

About the #0144 sample, only 3.5% of ^4He compared with that from #0160 was released at 200°C, although observed $^3\text{He}/^4\text{He}$ ratio was similar to that of solar wind [4]. Amounts of other gases were in the blank levels. When heating temperature was increased to 300°C, no appreciable amounts of noble gases were detected. Hence, we are now searching the sample or fragmented particles of the sample to identify them in the tiny cavity, from which particle(s) may have no chance to escape. After identifying the sample we will heat it at higher temperatures (800 and 1700°C) to measure noble gases.

In summary, we detected noble gases of solar origin for two Hayabusa samples (#0144 and #0160). The observation confirms that the samples were collected on Itokawa's surface where the grains were irradiated by solar wind. The grains may not be derived from matured regolith or surface layers with high concentrations of solar particles had been removed from the grains. Concentrations of galactic cosmic-ray produced noble gases, e.g., ^3He and ^{21}Ne , were low, which indicates relatively short cosmic-ray exposure age. These data are, on the whole, consistent with those reported in [1] for the three Hayabusa sample.

References: [1] Nagao K. et al. (2011) *Science*, 333, 1128–1131. [2] Crowther S. A. et al. (2008) *J. Anal. At. Spectrom.*, 23, 938–947. [3] Web site: <http://www.seaes.manchester.ac.uk/our-research/researchgroups/isotopegeochemistryandcosmochemistry/facilities/rpms/> [4] Heber V. S. et al. (2009) *Geochim. Cosmochim. Acta*, 73, 7414–7432.