Initial Analysis of Volatile Components in the Hayabusa2 Samples

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The major objectives of the Hayabusa2-initial-analysis volatile team are (1) to determine the pristine volatile components in the parental materials of the returned Ryugu samples, and (2) to elucidate the origin and chronological history of the asteroid Ryugu, as well as the evolution of the solar system through determination of volatile carrier phases and abundances of volatile components (e.g., presolar grain abundances). Our analytical data will be linked with remote sensing (NIRS3, ONCs, TIR, and LIDAR) data and theoretical modeling [e.g., 1-5]. For example, the erosion rate and the degree of gardening of the surface layer of the asteroid Ryugu can be estimated based on trapped solar wind (SW) and cosmic ray produced (cosmogenic) nuclides, which will be discussed in conjunction with the results based on the remote sensing data [3-5]. Taken together, these will provide characteristics of the surface materials, such as the degree and duration of the alteration by SW/cosmic ray irradiation and micrometeorite bombardments.

Our analytical plan for the Ryugu samples consists of three approaches (Fig. 1): One is analyses of native volatiles in the Ryugu samples which have been treated WITHOUT air-exposure throughout the whole process, since the collection from the asteroid Ryugu to the gas extraction in the laboratories. The goal of this work is to quantify the indigenous compositions with as minimal terrestrial (atmospheric, biological, and unintentional man-made pollution) contamination as possible. We will obtain

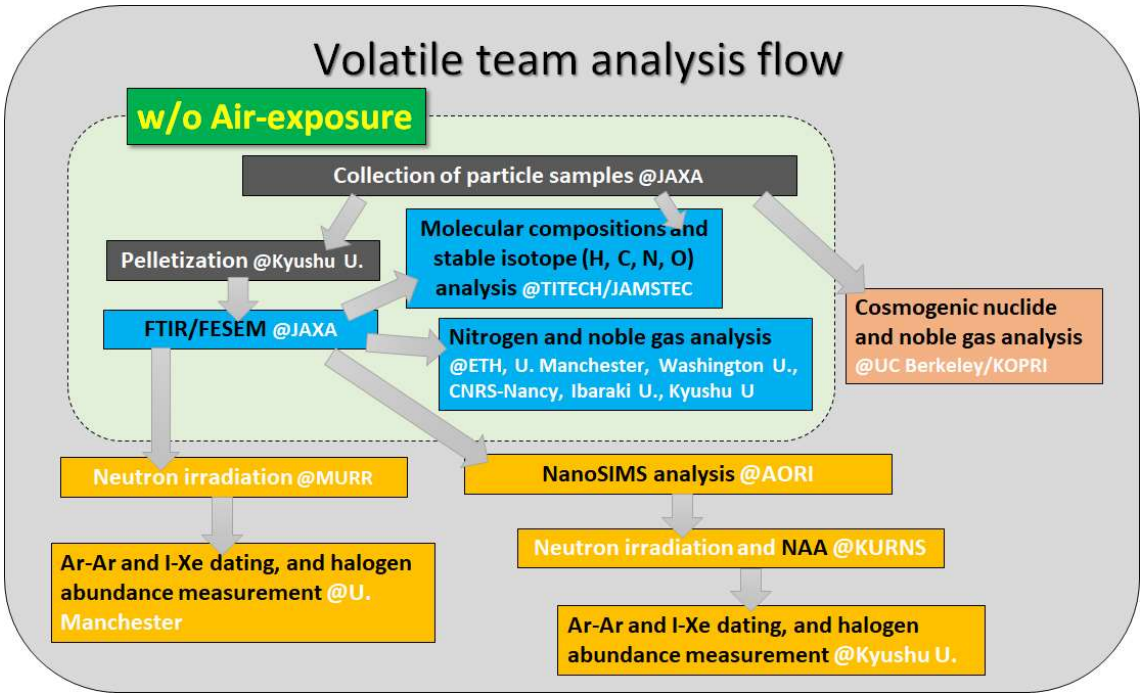

Figure 1. Analytical flow of the volatile team of the Hayabusa2 initial analysis.

the abundances and isotopic compositions of nitrogen, noble gases, and volatile elements (e.g., H and C in H_2, CO, and CO_2, methane, and ethane).

The second approach is analyses of the neutron-irradiated samples to determine the Ar-Ar and I-Xe ages and halogen abundances by noble gas isotope measurements at U. Manchester and Kyushu U., and to obtain abundances of minor/trace elements (e.g., Co, Ni, and Ir) by neutron activation analysis (NAA) at KURNS. Prior to neutron-irradiation, nanoSIMS analysis will be carried out at AORI on the same samples that are used for the Ar-Ar/I-Xe/halogen analysis at Kyushu U. to understand the distribution and isotopic compositions of volatile elements (H, C, N, and O).

The third approach is measurements of cosmogenic long-lived nuclides and noble gas isotopes, which are performed for different samples prepared under an atmospheric environment. The preliminary result of cosmogenic nuclides is reported by [6].

Most of Hayabusa2 samples allocated to the volatile team have been transported to Kyushu Univ. from JAXA, and located in a N_2 glove box installed at Kyushu Univ., and pelletized without air-exposure in June 2021, except for two particles for the volatile element analysis at TITECH/JAMSTEC and five samples for cosmogenic nuclides which were directly allocated to Berkeley U. from JAXA. Twenty four pellets have been prepared (Fig. 2), and sent back to JAXA to perform FTIR and FESEM observations. After these observations, 16 out of 24 samples have been distributed to our team laboratories, ETH, U. Manchester, Washington U., CNRS-Nancy, Ibaraki U., TITECH/JAMSTEC, and Kyushu U. to measure native volatile compositions. Before analysis, we measured the sample weight without air-exposure by using a small weighing container (Fig. 3). These careful operations enable us to obtain the most intact, fresh volatile compositions of the asteroid Ryugu.

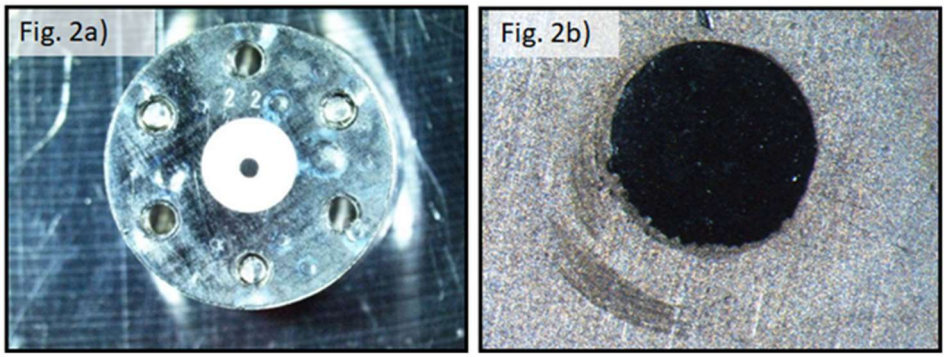

Figure 2. The Hayabusa2 samples pelletized onto a Cu disk without air-exposure (2a). The Cu disk is installed in a metal holder for NanoSIMS analysis and transportation. Enlarged view of the sample is shown in Fig. 2b.

Figure 3. The small weighing container developed for the Hayabusa2 initial analysis.

The remainder of the samples, six pellets have been transported to Tohoku U. and coated with Os and Pt as an antistatic treatment. These samples have now been exposed to the atmosphere. After coating, the 6 samples were shipped to AORI and investigate with NanoSIMS in August 2021. The result of the nanoSIMS analysis will be reported by Drs. Hashizume and Ishida somewhere else.

Following NanoSIMS analysis, the 6 pellet samples were transported to Kyushu U. for installation in diamond container for the NAA. The neutron irradiation and NAA are scheduled to be completed in October. After the NAA, the 6 samples will be analyzed for Ar-Ar age dating. For I-Xe dating and halogen analysis, two other pellet samples, different from the 6 samples that have been analyzed for nanoSIMS and NAA, have been distributed to U. Manchester in July. Now all of these preparatory steps are over and the Ryugu samples are ready for the experiments. We believe that all analyses will proceed successfully.

References

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