INITIAL ANALYSIS OF HAYABUSA2 SAMPLES RETURNED FROM C-TYPE NEAR-EARTH ASTEROID RYUGU. S. Tachibana[1], S. Watanane[2], and the Hayabusa2 Project Team, [1]Department of Natural History Sciences, Hokkaido University, N10W8, Sapporo, Hokkaido 060-0810, Japan. tachi@ep.sci.hokudai.ac.jp, [2]Department of Earth and Planetary Sciences, Nagoya University, Furo, Chigusa, Nagoya 464-8601, Japan.

Hayabusa2 and Its Scientific Goal: Hayabusa2 spacecraft will bring back surface samples of a near-Earth C-type asteroid (162173) Ryugu at the end of 2020. Because the C-type asteroids, of which reflectance spectra are similar to carbonaceous chondrites, are highly likely to record the long history of the solar system from the beginning to planet formation including the supply of volatiles to terrestrial planets [1], the main scientific goals of the Hayabusa2 mission are the investigations of (i) the origin and evolution of the solar system and (ii) the formation process and structure of the asteroid. These scientific goals are further subdivided into (1) thermal evolution from planetesimal to near-Earth asteroid (thermal processes in a planetesimal in the early solar system; heating and space-weathering on the surface of near-Earth asteroid at its current orbit), (2) destruction and accumulation of rubble pile body (planetesimal formation; impact processes throughout the solar system history), (3) diversification of organic materials through interactions with minerals and water in planetesimal (origin and evolution of volatile components in the early solar system; final state of organic matter and water prior to their delivery to rocky planets), and (4) chemical heterogeneity in the early solar system (mixing of "fire" and "ice" components during dynamical evolution of the protosolar disk).

To fulfill these scientific objectives, a tight linkage between on-site geologic observations (kilometer to millimeter scale) and return sample analysis (down to atomic scale) is crucial. The scientific instruments on board the spacecraft are a laser altimeter (LIDAR) [2], a multi-band telescopic camera (ONC-T) [3], wide-angle cameras (ONC-W1 and -W2), a near-infrared spectrometer (NIRS3) [4], a thermal infrared imager (TIR) [5], a small carry-on impactor (SCI) [6, 7], a deployable camera (DCAM3) [7], a sampler (SMP) [8, 9], and a lander (MASCOT) [10].

Hayabusa2 Sampler: The concept and design of the Hayabusa2 sampler are basically the same as the original Hayabusa [1, 8, 9]. In order to collect sufficient amount of samples compliant with both monolithic bedrock and regolith targets, a 5-g Ta projectile will be shot at 300 m/s at the timing of touchdown, and the ejecta will be put into a sample catcher through an extendable sampler horn and a conical horn under a microgravity condition. Three projectiles are equipped for sampling at three surface locations.

The sample catcher of the Hayabusa2, located at the top-end of conical horn, has three chambers to store samples obtained at three locations separately [1, 9]. An inlet to the sample catcher is rotatable to select a chamber to store samples at each location. The size of sample catcher is almost the same as that of the original Hayabusa with two chambers, and the total volume is ~45 cm^3. The sample catcher has a design that is easier to be taken apart during curation at the ground than that of the original Hayabusa.

After three sampling operations, the sample catcher is transported into the sample container inside the Earth re-entry capsule and sealed. The container sealing method is changed from double fluorocarbon O-rings for Hayabusa to an aluminum metal seal [8] to avoid the terrestrial air contamination after the Earth return that happened for the Hayabusa container [11]. The new aluminum metal seal is designed to allow only a leak of 1 Pa air for a week at atmospheric pressure. To avoid further potential contamination, volatile components, which might be released from the samples, will be extracted prior to the opening of the container. The container will be attached to a vacuum line, and the bottom of the container, a part of which is thinned, will be pierced with a needle to extract volatiles.

A back-up sampling method is also prepared [1, 9]; The tip of the sampler horn is turned up like the teeth of a comb, and surface pebbles will be lifted up by the tip of the horn during touch down. The lifted pebbles will be put into the sample catcher by deceleration of the spacecraft.

Ryugu Samples: The characteristics of the Hayabusa2 sample container leads to classification of returned samples into three categories; (1) mm-sized coarse grains stored separately in three chambers, (2) <100 μm-sized fine grains that may be mixed in the sample container, and (3) volatiles components that will be released from the samples and will be extracted from the container prior to its opening.

Coarse grains should represent material properties at different locations, and petrologic and mineralogical studies of them will provide important constraints on understanding the history of the asteroid and the solar system.

Fine grained samples will also provide insights into the global average surface features and surface geologic processes such as space weathering and regolith formation.

Volatile components will be the first-returned extraterrestrial volatiles and will be an important analysis target to investigate the origin and evolution of organic matter and water in the solar system and the final evolutional state of organics in asteroids prior to the delivery to the Earth.

Curation and Initial Analysis of Ryugu Samples: Ryugu samples will be first described at the curation facility of Institute of Space and Astronautical Science (ISAS), JAXA (Phase-1 curation). The curation chamber system for the Phase-1 curation is now being designed. The sample container is planned to be opened in a vacuum chamber first, and one lid of the sample catcher and a part of the samples will be stored in vacuum for future analysis. The sample catcher will then be transported in an adjacent chamber filled with clean nitrogen gas, without any exposure to air, for further handling of samples.

After the Phase-1 curation, the initial analysis of Ryugu samples will be done by the Hayabusa2 mission to maximize the scientific achievement of the project for 12 months. The initial analysis should be a good showcase to prove the potential of the samples. Samples will be available for the community after the initial analysis.

Along with the initial analysis, the Phase-2 curation will be done for integrated thorough analysis and description of samples to build a sample database and to obtain new scientific perspective from thorough analysis of samples. The Phase-2 curation will be done both in ISAS and also in several research institutes outside JAXA led by the ISAS curation facility.

Initial Analysis and Sub-Teams: Initial analysis of returned samples will focus on revealing the formation and evolution of Ryugu in the early Solar System. The scientific objectives of sample analysis covers from the presolar history to the current geological activity of the near-Earth asteroid.

The IAT consists of six sub-teams for 1) chemistry (elements and isotopes), 2) petrology and mineralogy of coarse grains (mm-sized grains), 3) petrology and mineralogy of fine grains (<100 μm-sized grains), 4) volatiles, 5) macromolecular organics (insoluble organic matter), and 6) organic molecules (soluble organic matter).

Each sub-team will be an international team led by a researcher (sub-team leader) who can have a research base in Japan at least a year before the delivery of the samples (the end of 2020) and throughout the initial analysis phase (2021–2022). The sub-team leaders should be approved by the Hayabusa2 Sample Allocation Committee (HSAC). The sub-team leaders will make an analysis and work flow plan in their sub-teams with the IAT members to make a best effort in fulfilling the scientific goals of the mission through integration of analytical results from each sub-team and on-site remote-sensing data. The sub-team leaders are also responsible for organizing the analysis team, of which members should also be approved by the HSAC.

The Hayabusa2 project opened a call for nomination of the sub-team leaders in October 2016, for which a nomination letter, a document describing analysis and team plans, CV, and a selected bibliography were requested. All the nominations are now being reviewed by the HSAC. The HSAC will recommend candidates of the sub-team leaders to the Hayabusa2 Joint Science Team (HJST) in March for approval. Once the sub-team leaders selected, their names will be open to the community, and six sub-teams for the initial analysis of Ryugu samples will be built in FY2017.

References: [1] Tachibana S. et al. (2014) *Geochem. J. 48,* 571-587. [2] Mizuno T. et al. (2016) *Space Sci. Rev.* doi:10.1007/s11214-015-0231-2. [3] Kameda S. et al. (2016) *Space Sci. Rev.* doi:10.1007/s11214-015-0227-y. [4] Iwata T. et al. (2016) *Space Sci. Rev.* [5] Okada T. et al. (2016) *Space Sci. Rev.* doi:10.1007/s11214-016-0286-8. [6] Saiki T. et al. (2016) *Space Sci. Rev.* doi:10.1007/s11214-016-0297-5. [7] Arakawa M. et al. *Space Sci. Rev.* doi:10.1007/s11214-016-0290-z. [8] Okazaki R. et al. (2016) *Space Sci. Rev.* doi:10.1007/s11214-016-0289-5. [9] Sawada H. et al. *Space Sci. Rev.* in revision. [10] Ho T-M. et al. *Space Sci. Rev.* doi:10.1007/s11214-016-0251-6. [11] Okazaki R. et al. (2011) *LPS XXXXII,* abstract #1653.