Analysis of the grain from the asteroid Ryugu proposed by the Phase 2 curation “Team KOCHI”

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Returned samples from asteroids and comets have provided unique characteristics to investigate their origin and nature of the Solar System [1-3]. For example, analytical studies of the S-type asteroid Itokawa by the Hayabusa mission provided new insights for the asteroid-meteorite connections, space weathering processes, small asteroidal body formation in the Solar System [e.g., 1, 3, 4]. JAXA Hayabusa2 and NASA Osiris-REx are both on-going sample return missions from the primitive asteroids, Ryugu (C-type) and Bennu (B-type), respectively [5, 6]. Both missions have complementary scientific goals that are to understand the Solar System evolution in the point of view of organics, water, and associated minerals (i.e., hydrous minerals).

Phase 2 curation teams will be acting under the scientific direction and strong ethic of the Astromaterial Science Research Group (ASRG) of JAXA and was authorized 2 institutes by the steering committee of the ASRG in 2017: (1) Kochi Institute for Core Sample Research (KOCHI), JAMSTEC in collaboration with JASRI/SPring-8, UVSOR Synchrotron Facility/National Institutes of Natural Sciences, Institute for Molecular Science, National Institute of Polar Research (NIPR) and Tokyo Metropolitan University, and (2) the Institute for Planetary Materials, Okayama University at Misasa. The JAXA Curation requested us to make an in-depth analysis of a few grains by the state-of-the-art instruments/techniques and nationwide collaborative research activities. We will conduct on analyses in parallel with the initial analysis team led by the Hayabusa2 project.

Recent reports by the Near-IR Spectrometer (NIRS3) on Hayabusa2 spacecraft presented that the asteroid Ryugu may consist of either CM chondritic materials [8] or shocked/heated carbonaceous chondrites [9]. Matsuoka et al. [9] pointed out that the low albedo of the asteroid Ryugu could be explained by a combination of C-rich material, grains size, porosity and space weathering effects on the asteroid surface materials. This implies that the avoiding terrestrial contaminations (i.e., atmospheric water/air, organics) during sample curation, transportation and analysis are important to obtain original chemical characteristics of Hayabusa2 returned samples.

We have developed novel and universal sample holders (KOCHI grid and KOCHI clamp) for a linkage analysis utilizing micro-analytical instruments of FIB, TEM, STXM and NanoSIMS minimizing terrestrial contaminations and sample lost or broken. We also made an additional sample holder (Okazaki cell) for STXM analysis (Ohigashi T. et al. in preparation), and a sample transport vessel (FFTC: facility to facility transfer container; Uesugi K. et al. in preparation) under vacuum or inert gas in parallel.

We have carried out the development of coordinated synchrotron based-CT (SPring-8) –XRD (SPring-8) –FIB (JAMSTEC KOCHI) –STXM (UVSOR Synchrotron Facility) –NanoSIMS (JAMSTEC KOCHI) –TEM (JAMSTEC KOCHI) analysis to obtain complex structure inside of the sample, light element/isotope images to obtain their spatial distributions, speciation of elements: type of bonding, chemical species, redox state and ultra-fine textural observation: mineralogy and crystallography in fine-grained mineral and

organic assemblages in few tens to hundreds of micrometer-scale Hayabusa2 samples. We, therefore, have chosen Antarctic micrometeorites provided by NIPR as analogues of Hayabusa2 sample because of their size (50 to 800 μm, as an example of small particle) and chemical characteristics.

We will report the current status, ethic and motivation of "Team KOCHI" of Phase2 Curation. In addition, we will present newly developed universal sample holders for FIB, TEM, NanoSIMS, STXM, and a sample transport vessel under vacuum or inert gas among nationwide/international universities and institutes.

References: [1] Nakamura T. et al. (2011) Science 333, 1113–1116. [2] Brownlee D.E. et al. (2006) Science 314, 1711–1716. [3] Yurimoto H. et al. (2011) Science 333, 1116–1119. [4] Noguchi T. et al. (2011) Science 333, 1121–1125. [5] Tachibana S. et al. (2014) Geochem. J. 48, 571–587. [6] Lauretta D.S. et al. (2014) Meteorit. Planet. Sci. 50, 834–849. [7] Uesugi M. et al. (2019) Meteorit. Planet. Sci. 1, 1–29. [8] Hiroi T. et al. (2019) 50th LPSC (LPI Contrib. No. 2132), abstract#1129. [9] Matsuoka et al. (2019) 50th LPSC (LPI Contrib. No. 2132), abstract#1534.

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