PHASE 2 CURATION "TEAM KOCHI" FOR HAYABUSA2 RETURNED SAMPLE: *IN-DEPTH* ANALYSIS OF A SINGLE GRAIN UTILIZING LINKAGE MICROANALYTICAL INSTRUMENTS.

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Introduction: Analyses of returned samples from asteroids [1] and comets [2] were essential to understanding their origin and nature as well as increasing our knowledge about the Solar System. The most recent returned sample was from the S-type asteroid Itokawa by Hayabusa mission in 2010. The results reported by previous studies 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.

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.

Missions as Phase 2 curation "team Kochi":

1) We will analyze Hayabusa2 samples utilizing the *state-of-the-art*, original analytical and research in collaboration with several institutes and universities to acquire petrological and chemical characteristics. Our results and techniques are fed back to the initial analysis teams led by Hayabusa2 project, and will be a benchmark that contributes to the international announcement of opportunity and current/future curation works.
2) We will acquire a 2D / 3D high resolution texture of a single grain, molecular structures, chemical species identifications, light element isotopic ratios, major and trace element abundances, microtextural features, and crystal structures. To make this successfully we will apply the sequential analysis protocol from non-destructive analyses at synchrotron radiation facility such as CT (Computed Tomography) and XRD (X-ray diffraction), STXM-XANES (Scanning Transmission X-ray Microscope - X-ray Absorption Near Edge Structure) to destructive analyses such as FIB sample preparations, TEM observations and NanoSIMS isotope imaging analyses [i.e., 7].
3) We will explore *in-depth* of Hayabusa2 samples from the viewpoint of similarities or different characteristics with the current knowledge of extraterrestrial materials (meteorites, micrometeorites, Hayabusa samples) in Antarctic Meteorite Research Center of National Institute of Polar Research and JAXA curation facility. The primary objective will focus on studying of extraterrestrial water and primordial organic components in Hayabusa2 samples.

Technical developments for Hayabusa2 returned sample analysis: 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, then, 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 (namely Okazaki cell) for STXM analysis (Ohigashi T. et al. in preparation), and a sample transport vessel (FFTC: facility to facility transfer container) under vacuum or inert gas (Uesugi K and Uesugi M. et al. in preparation) in parallel.

A test for an Antarctic micrometeorite utilizing the linkage microanalytical technique: We focus on 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 (Fig. 1). In this study, we 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 of "Team Kochi" of Phase2 Curation and our 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., (2018) Meteorit. Planet. Sci. *accepted.*

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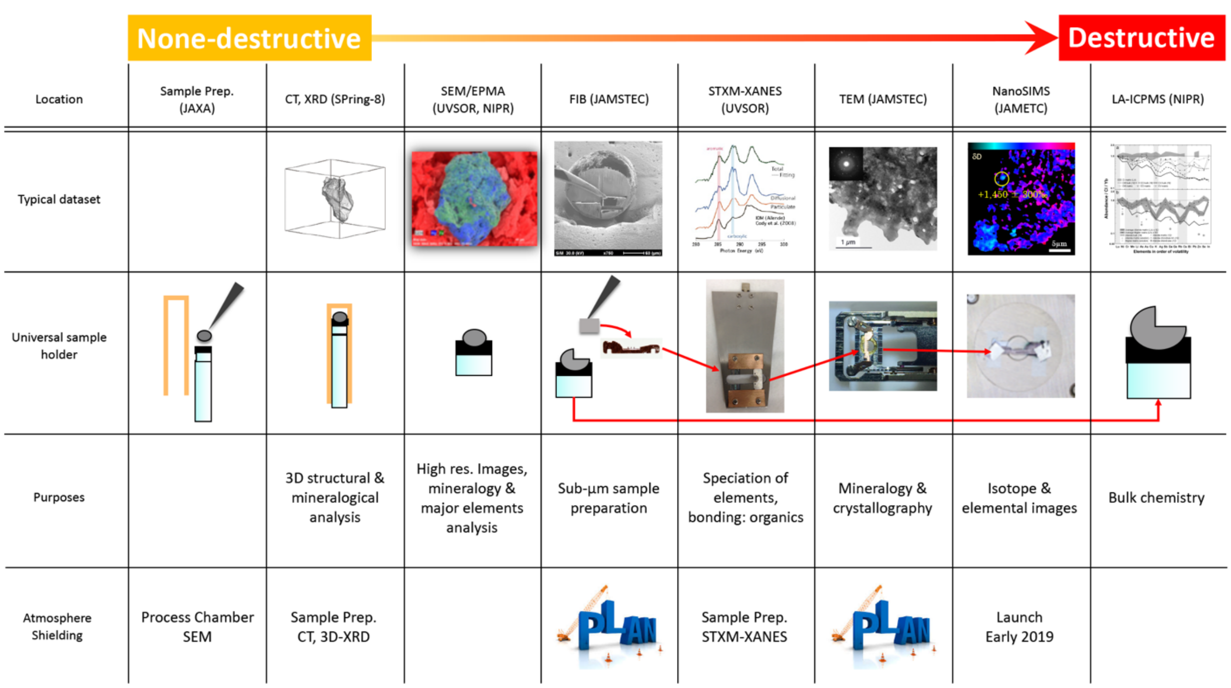

Figure 1. Sample transfer and analytical sequence in Phase 2 curation "team Kochi"