Next Generation small body Sample Return mission: a concept study for a future Japanese mission to a comet

Hiroyuki Kurokawa[1], Yuri Shimaki[2], Naoya Sakatani[2], Ryota Fukai[2], Tatsuaki Okada[2], Yoko Kebukawa[3], Jun Aoki[4], Atsushi Kumamoto[5], Taichi Kawamura[6], Satoshi Tanaka[2], Eri Tatsumi[2], Seitaro Urakawa[7], Yuichi Tsuda[2], Osamu Mori[2], Takanao Saiki[2], The Next Generation Small Body Sample Return WG

[1]*University of Tokyo,* [2]*Japan Aerospace Exploration Agency,* [3]*Tokyo Institute of Technology,* [4]*Osaka University,* [5]*Tohoku University,* [6]*Université Paris Cité/Institut de Physique du Globe de Paris, CNRS,* [7]*Japan Spaceguard Association*

The Next Generation small body Sample Return (NGSR) mission is a future solar-system exploration mission for sample return from a solar system small body under consideration. In February 2023, we newly launched the Science Working Group (WG) for the NGSR mission. The Science WG studies science goals and mission payloads of the NGSR. In collaboration with the Engineering WG, the Science WG aims to propose the NGSR as a strategic large-class mission which will be launched in 2030s by ISAS, JAXA. The strategic large-class mission will be selected in late 2024.

The NGSR targets a comet to bring back its subsurface materials and to explore its surface and internal structure. The Science WG defined the NGSR as a mission to unveil the origin of the solar system, namely, I) the origin of the solar-system "materials" in galactic evolution and II) the origin of the solar-system "bodies" to form planetesimals. For those science goals, we categorize science objectives as follows: Science objective I-1) unveiling the types of parent stars of the solar-system materials and their fractions, I-2) elucidating the origins of cometary organic matters, II-1) clarifying whether comets are rubble-pile or a pebble-pile bodies, and II-2) elucidating the formation environment of comets.

Science Goal I can be mainly achieved by sampling and analysis of subsurface materials of the target comet. In contrast to surficial materials that experienced alteration caused by space weathering and cometary activities, subsurface materials are thought to be pristine record of the original solar-system building blocks and, consequently, of the evolution of materials in our galaxy. Excavating and sampling subsurface materials are needed. Moreover, we are planning to install a mass spectrometer for in situ analysis of volatile materials that will potentially be altered and/or lost before the sample recovery.

Science Goal II can be mainly achieved by physical explorations of the interior structure with a radar and/or seismometer. Pebble-pile bodies (pristine first-generation of planetesimals) and rubble-pile bodies (disrupted and re-accreted planetesimals) should have different interior structures; only the latter are thought to possess meter-scale internal voids. The meter-scale heterogeneity can induce different propagation and reflection patterns for both radio and seismic waves.