Investigation of potential candidates for a sample return mission

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The Hayabusa2 brought back samples from the C-type asteroid Ryugu to the Earth in December 2020. Since the returned samples have not struggled from thermal alterations during the Earth entry, it is expected that they preserve fragile materials, volatiles, and organic matters. This information is a clue to material evolutions in the early Solar System. Thus, we believe that sample return (SR) missions are keys to understand the planetary formation process. Here we report the evaluation of potential small bodies for a future sample return mission in the 2030s, as a descendant of the Hayabusa2.
To minimize fuel consumption during the cruising phase of a mission, we extracted small bodies with a perihelion of 0.9–1.1 AU and an inclination of <10 degrees from the JPL small body database as the SR candidates. We preferred targets with a diameter >0.3 km and a rotation period >2 hr for the SR feasibility. To evaluate the science value of a target, we examined asteroid spectrum types in the literature (e.g., Binzel et al., 2019) and specific features, such as cometary activity (active asteroid) and satellites (binary/trinary asteroids).
We selected E-type, D-type, active asteroids, and comets as potential candidates for future SR missions. The E-type asteroids are believed to relate to enstatite chondrite and be a remnant of building blocks of the Earth. The D-type asteroids are abundant in Jupiter Trojan and are thought to be enriched in volatiles and organics. Since the active asteroids can be comet-asteroid transition objects, they might preserve volatiles beneath their surface. Comets are composed of silicate dust, ices, and organics which have never been thermally altered materials. We confirmed that some near-Earth objects with these properties could satisfy the mission schedule, such as launch in the early 2030s and return in the early 2040s.

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