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Initial Analysis of Macromolecular Organic Matter in the Asteroid Ryugu samples: Overview

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Organic compounds in asteroids and comets record the chemical history from the protosolar molecular cloud to the early Solar System. They are thought to have contributed to the formation of our habitable planet Earth, through exogenous delivery. Therefore, it is important to reveal the chemical evolution of organic compounds in primitive small bodies for understanding the origins of planets and life.

JAXA's Hayabusa2 mission explored the carbonaceous asteroid Ryugu and collected its sands and pebbles (Tachibana et al. 2022). On December 6, 2020, the asteroid sample was returned to the Earth. Through the curatorial work at JAXA, it was reported that the Ryugu samples contain high abundances of hydrous minerals and organics (Yada et al. 2021; Pilorget et al. 2021). Afterward, the initial sample analysis has started from June 2021 to classify and characterize the Ryugu samples in the context of the Solar System formation. The Initial Analysis IOM Team has aimed to unveil the chemical, isotopic, and morphological compositions of macromolecular organic solids from the Ryugu samples by coordinating spectromicroscopies, electron microscopy, and isotopic microscopy. Chamber A aggregates and Chamber C aggregates collected at the first and second touchdown sites, respectively, have been analyzed.

Macromolecular organic solids are abundant and have complex structure consisting of aromatic carbon, aliphatic carbon, ketones and carboxyls. The functional group compositions correlated with the morphologies of nano-sized organic matter, such as organic nanoglobules and diffuse carbon. These organic microstructures were associated with phyllosilicates and carbonates. Thus the observed functional group diversity likely resulted from aqueous alteration on the asteroid parent body without significant heating. The δD distributions of the isolated organic solids from the Ryugu samples were within the range of primitive carbonaceous chondrites. The $\delta^{15}N$ of bulk C and organic solids from the Ryugu samples showed similar values to those in CI chondrites. Extreme D and/or ^{15}N enrichments or depletions in some C-rich grains could possibly have been derived from the solar nebula or protosolar molecular cloud.