# Initial analysis plan of soluble organic compounds for the Hayabusa2 sample from asteroid Ryugu

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The spectra of asteroid 162173 Ryugu taken by Near-Infrared Spectrometer (NIRS3) onboard Hayabusa2 are nearly featureless and consistent with carbonaceous chondrites (Matsuoka et al., 2018). The Hayabusa2 spacecraft will collect surface samples of Ryugu and deliver to the Earth during late 2020. The initial analysis of the Ryugu samples will focus on (1) detailed chemical and mineralogical characterization of the samples and (2) understanding the history of Ryugu and the Solar System in order to maximize the scientific achievement of the project and (3) to prove the scientific potential of the samples to the community for the analytical opportunity (Tachibana et al., 2014). We have organized an international team, consisting of 24 members currently, for the initial analysis of soluble organic matter (SOM) for the returned samples.
The primitive asteroidal materials are expected to contain diverse and complex (e.g. elemental, structural, and optical) organic matter all at low concentrations. The occurrence of SOM will provide clues to the origins of organic compounds as well as prebiotic molecules of potential relevance to origins of life on Earth and possibly elsewhere in the Solar System. We propose the comprehensive SOM analyses to reveal the chemical evolution of Ryugu using high-sensitive and high-resolution analytical methods as follows:

1) High-resolution mass spectrometry (HRMS) of various solvent extracts with electrospray ionization (ESI) coupled with or without nano-liquid chromatography.
2) Enantiomerically resolved amino acid analysis using high-resolution column chromatography with high-sensitive fluorescence spectroscopy coupled with HRMS.
3) *In situ* organic compound analysis and molecular imaging using desorption electrospray ionization (DESI) and/or direct analysis in real time (DART) equipped with HRMS.
4) Spatial resolution imaging of organic compounds using time of flight-secondary ion mass spectrometry (ToF-SIMS; Naraoka et al., 2015).

In addition, if the sample is available, we will also perform the following additional analyses:

5) Compound-specific isotope analysis using gas chromatography/combustion or pyrolysis /isotope ratio mass spectrometry (GC/C or pyrolysis/IRMS).
6) Bulk chemical and isotopic analysis of organic matter (C, H, N and S) using nano-EA/IRMS system and laser-tunable FT-IR spectroscopy.

Depending to the sample size available to the initial analysis, we will perform preliminary analytical tests using 30 mg, 10 mg, and 1 mg samples of the Murchison meteorite (CM2, positive SOM-rich), Yamato 793321 meteorite (heated CM2, positive SOM-depleted), and baked serpentine (negative SOM-depleted) as well as procedural blank. The analytical protocol will be discussed in the meeting.

< References >
Tachibana, S. et al. (2014) Hayabusa2: Scientific importance of samples returned from C-type near-Earth

 

asteroid (162173) 1999 JU3. Geochemical Journal. 48. 571-581. 10.2343/geochemj.2.0350.
Matsuoka, M. et al. (2018) Spectral comparison between asteroid (162173) Ryugu and carbonaceous meteorites. American Astronomical Society, DPS meeting #50.
Naraoka, H. et al. (2015) ToF-SIMS analysis of carbonaceous particles in the sample catcher of the Hayabusa spacecraft. Earth, Planets and Space, 67:67. DOI 10.1186/s40623-015-0224-0.
Naraoka, H. and Hashiguchi, M. (2018) *In situ* organic compound analysis on a meteorite surface by desorption electrospray ionization coupled with an Orbitrap mass spectrometer. Rapid Commun. Mass Spectrom. 32, 959-964.

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