Elemental and isotopic compositions of organic grains from asteroid Ryugu

Laurent Remusat[1], Maximilien Verdier-Paoletti[1], Smail Mostefaoui[1], Lydie Bonal[2], Hikaru Yabuta[3] and The Hayabusa2-initial-analysis IOM team, Hisayoshi Yurimoto[4,] Tomoki Nakamura[5], Takaaki Noguchi[6], Ryuji Okazaki[7], Hiroshi Naraoka[7], Kanako Sakamoto[8], Shogo Tachibana[8, 9], Sei-ichiro Watanabe[10] and Yuichi Tsuda[8]

[1] Museum National d'Histoire Naturelle, CNRS, Sorbonne Université, Paris, France. [2]Institut de Planétologie et d'Astrophysique de Grenoble, Université Grenoble Alpes, CNRS CNES, Grenoble, France [3]Hiroshima Univ., [4]Hokkaido Univ.,[5]Tohoku Univ., [6]Kyoto Univ.,[7]Kyushu Univ., [8]JAXA, [9]Univ. of Tokyo, [10]Nagoya Univ.

Introduction: Isotope composition of organic material found in extraterrestrial samples is a powerful proxy for tracking its origin and evolution during the solar system events [1,2]. *In situ* investigation of isotope and elemental compositions unravel the heterogeneity and diversity of organic particles embedded within the fine-grained minerals of chondrites and IDPs [3,4]. Understanding the origin of organic matter on carbonaceous asteroids and its subsequent evolution due to secondary processes as well as space weathering is one of the prime goals of the Hayabusa2 sample-return mission [5]. To document Ryugu's inventory of organic material, we have employed NanoSIMS imaging of intact grains, without any chemical treatments, from both Chamber A and Chamber C. We present here the first set of data acquired on the NanoSIMS installed at the National Muséum of Natural History in Paris, and compare the composition of organic particles from the two sampling sites to evaluate the influence of space weathering and aqueous alteration.

Samples and methods: Several fragments of 3 particles from Chamber A aggregates (A0108) and 3 particles from Chamber C aggregates (C0109) were manually selected under a binocular and pressed on diamond windows. After their analysis by Raman and transmission FTIR, samples were gold coated (about 25 nm thick) before NanoSIMS imaging. In the first step, secondary ions of ^{16}O, $^{12}C_2$, $^{12}C^{14}N$, $^{12}C^{15}N$ and ^{32}S were imaged in multicollection mode, to investigate N-isotope distributions as well as N/C, O/C and S/C elemental ratios. A 2-3 pA primary Cs^+ beam with a spatial resolution around 200 nm was rastered over 20 by 20 μm^2, divided into 256 by 256 pixels, in association with an electron flooding gun for charge compensation. Dwell time was set at 2 ms/pixel and about 60 frames were stacked.

Results and discussion: About 11,600 and 9,600 μm^2 surface area were imaged, of Chamber A and Chamber C samples, respectively. Individual organic particles were identified using the L'image software developed by Larry Nittler (Carnegie Institution of Washington). The $^{15}N/^{14}N$ ratios of individual particles are comparable to the values for isotope anomalies in CI and CM insoluble organic matter [3,6,7] whilst samples from Chamber C tend to exhibit a slightly larger ^{15}N enrichment. In addition, bulk organic $\delta^{15}N$ is in the range of IOM in CI chondrites. These values are consistent with independent NanoSIMS measurements of other Ryugu aggregates [8]. The corresponding elemental ratios point to a larger content in N in the organic particles from Chamber A, while the particles from Chamber C are more O-rich. Overall, S content is similar in organic particles from both chambers. It must be noted that O/C and S/C may be biased by the occurrence of fine scale association of oxides/silicates and sulfides with the organic particles, as observed by TEM [9]. The elemental composition of particulate organic matter will be further investigated on insoluble organic matter isolated by acid treatment of Ryugu samples. Our data suggest differences between aggregates from the two sampling sites in terms of elemental and isotope compositions of individual organic particles.

References

[1] Remusat et al. 2010. ApJ 713:1048. [2] Alexander C. M. O'D. et al. 2017. Chemie der Erde - Geochemistry 77:227. [3] Busemann et al. 2006. Science 312 :727. [4] Remusat et al. 2009 ApJ 698 :2087. [5] Tachibana et al. 2014. Geochem. J. 48:571. [6] Alexander et al. 2010. GCA 74:4417. [7] Remusat et al. 2019. GCA 263:235. [8] Nittler et al. 2021. This conference. [9] Stroud et al. 2021. This conference.