NANOSIMS INVESTIGATION OF H- AND N-ISOTOPE DISTRIBUTIONS IN THE INSOLUBLE ORGANIC MATTER OF RYUGU SAMPLES.

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Introduction: Regolith samples of the carbonaceous asteroid 162173 Ryugu were returned by the Hayabusa2 spacecraft in December 2020. Preliminary investigation of selected grains from each sampling site has revealed the occurrence of an abundant macromolecular insoluble material, similar to that of carbonaceous chondrites [1]. 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.

Isotope composition of organic material found in extraterrestrial samples is a powerful proxy for tracking its origin and evolution during the solar system events [2]. To document the H- and N-isotope signatures of IOM contained in the Ryugu samples, we have used the NanoSIMS installed at the National Muséum of Natural History in Paris. We present here data acquired on the IOM isolated from grains of two touchdown sites. We have imaged between 2800 and 3200 μm^2 of the IOM of chamber A and C, respectively. The comparison with the IOM of carbonaceous chondrites allows for evaluating the influence of space weathering and aqueous alteration on the IOM in carbonaceous asteroids.

Results: *N-isotope distributions:* the bulk $\delta^{15}N$ is +17.4‰ and +30‰ for the IOM of chamber A and chamber C, respectively. These IOMs contain both ^{15}N-enriched and depleted carbonaceous grains, with 180‰<$\delta^{15}N$< 800‰ for hotspots and -380‰ < $\delta^{15}N$ < -180‰ for coldspots. Hotspots define a Poisson distribution with a mode value of +241‰ and +348‰ for chamber A and chamber C, respectively.

Elemental ratios: Bulk N/C, O/C and S/C of Ryugu IOM are 0.035, 0.12, 0.032, respectively, for chamber A and 0.027, 0.04, 0.025 for chamber C. The N/C ratio of individual ^{15}N-rich and depleted grains are comprised between 0.01 and 0.07, with those in the IOM of A0106 being slightly more N rich. Similarly, O/C and S/C ratios are also slightly higher in A0106.

H-isotope distribution : Ryugu IOM exhibits bulk enrichments in D with δD = +306‰ and +440‰ for chamber A and chamber C, respectively. Numerous D-rich hotspots, are observed, with +600‰ < δD < +6000‰. They define a Poisson distribution, with a mode value of +1030‰ and +1374‰ for chamber A and chamber C, respectively. Of note, a few D-depleted organic grains are also observed (-200‰ < δD < 0‰).

Discussion: Subtle differences are observed between the IOM of chamber A and chamber C: the IOM is less enriched in heavy isotopes in chamber A, and more enriched in N, O and S. This may reflect some heterogeneity at the scale of the asteroid, or the influence of sampling depth, hence the influence of space weathering.

However, the elemental and isotope compositions of the IOM in Ryugu are comparable to those of hydrated carbonaceous chondrites. The bulk $\delta^{15}N$ in Ryugu IOM is commensurable to levels reported in CI chondrites, despite the occurrence of hotspots being more ^{15}N-rich in Ryugu [3]. The range of $\delta^{15}N$ covered by these hotspots is, however, consistent with the IOM of CM chondrites and Tagish Lake, but remains in the lower end of the hotspots in CR chondrites. The most notable difference is the bulk δD which is lower than in the IOM of hydrated carbonaceous chondrites. The distribution of δD in Ryugu IOM is consistent with the IOMs in CI and CM chondrites. We did not observe enrichments as large as those reported in CR chondrites and in Tagish Lake [4,5]. The abundance of D- and ^{15}N-rich hotspots appears similar in Ryugu and carbonaceous chondrites. Differences between Ryugu and carbonaceous chondrites may result from different intensity of aqueous alteration or the impact of space weathering, which could have induced a decrease of D/H in organic compounds by H implantation.

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References: [1] Yabuta H. et al. Submitted to Science. [2] Alexander C. M. O'D. et al. 2017. Chemie der Erde - Geochemistry 77:227. [3] Remusat L. et al. 2019. GCA 263:235. [4] Herd C. D. K. et al. 2011. Science 332, 1304-1307. [5] Busemann H. et al. 2006. Science 312 :727.