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Nanosims Analysis of Organic Matter in Asteroid Ryugu

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The origin of macromolecular organic matter (MOM) in primitive astromaterials and its evolution during parent body processing, are debated [1]. The goal of the organic macromolecule sub-team (Lead: H. Yabuta) of the Hayabusa2 initial analysis team (Lead: S. Tachibana) is to understand the nature and origin of organic matter in C-type asteroid (162173) Ryugu, and to compare its characteristics and isotopic composition to MOM in primitive meteorites. We used the Carnegie NanoSIMS 50L to study correlated H, C, and N isotope compositions of MOM in particles collected from both touchdown sites on Ryugu. Here, we focus on the analysis of a few dozen ~15–30 µm-sized particles that were pressed into gold foil. We first analyzed C and N isotopes (as $^{12}C_2$, $^{12}C^{13}C$, $^{12}C^{14}N$, and $^{12}C^{15}N$, plus ^{16}O, ^{28}Si, ^{32}S or MgO and secondary electrons) with a ~0.4 pA, ~100 nm Cs^+ primary beam, and then re-analyzed all particles for ^{1}H, D, and ^{12}C isotopes with a ~1.2 pA, <200 nm Cs^+ beam.

So far, we identified ~1,300 C-rich regions of interest (ROIs) in a total of ~7,500 µm^2 area mapped. Relative to Earth, bulk Ryugu MOM is slightly enriched in D and ^{15}N. Most ROI compositions are consistent within errors with average values of δD~+600‰ and $\delta^{15}N$~+50‰, similar to MOM from primitive C chondrites [1]. No obvious differences were observed between particles from both touchdown sites. About 5–10% of the ROIs exhibit much more extreme (i.e., >3σ different from average) D and/or ^{15}N isotopic enrichments ("hotspots") or depletions ("coldspots"), with ranges of isotopic ratios similar to those seen in CI, CM, and CR chondrites (Figure, [1,2]). C-isotope anomalies are relatively rare (~1% of C-rich ROIs). A few presolar SiC grains with large $\delta^{13}C$ anomalies were also detected [3]. Asteroid Ryugu MOM shows the same isotopic diversity on a micron-scale as seen in primitive chondrites [1,2], suggesting similar origin(s) and secondary processing.

[1] Alexander C. M. O'D. et al. (2017) *Chem. Erde* 77, 227–256. [2] Nittler L. R. et al. (2021) *84th MetSoc*, abstr. #6063. [3]Nittler L. R. et al. (2022) 53rd Lunar Planet. Sci. Conf., abstr. #1423.