PRESOLAR C- AND O-RICH GRAINS IN THE MATRIX AND A CLAST IN ASTEROID RYUGU

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Introduction: Presolar grains formed in the outflows of dying stars and some have been preserved in primitive meteorites, interplanetary dust particles, and comet Wild 2 samples. Presolar silicates are one of the most abundant presolar phases, but are prone to destruction by parent body hydrothermal alteration. Refractory presolar phases, such as oxides and carbides, are more resistant to such alteration. Samples from asteroid Ryugu returned by JAXA's Hayabusa2 mission show evidence for extensive aqueous alteration. To constrain the abundance of presolar grains in Ryugu, we conducted NanoSIMS isotopic mapping of fragments of a C0002 grain from Chamber C, perhaps from the asteroid sub-surface.

Methods: The fragment of C0002 was prepared by pressing into In. A 5 nm Pt coating was deposited on the sample mount and SEM-EDX maps were acquired using a JEOL 7600F field emission SEM at NASA JSC. A ~50 μm-sized clast was identified that was more Fe- and S-rich, and Si- and Mg-poor than the surrounding matrix. Flat regions of the matrix and clast were analyzed for C and O isotopes, ^{28}Si, and ^{24}Mg^{16}O using the CAMECA NanoSIMS 50L at NASA JSC. A ~1 pA Cs$^+$ primary beam focused to ~100 nm was rastered over 20 μm fields of view. Data were corrected for instrumental mass fractionation using graphite and San Carlos olivine.

Results and Discussion: In the matrix, 7 grains having anomalous C isotopic compositions were identified. Six of the grains were enriched in ^{13}C, with ^{12}C/^{13}C ratios ranging from 41 – 78. These ratios are consistent with Mainstream SiC grains from low-mass, ~solar metallicity AGB stars, but additional isotopic analyses are needed to constrain their stellar sources. One grain was depleted in ^{13}C with ^{12}C/^{13}C = 105, consistent with Y grains from AGB stars of ~1/2 solar metallicity. Four of the grains have elevated ^{28}Si/^{12}C ratios as determined by NanoSIMS and are most likely SiC. A total area of 10160 μm^2 was analyzed and we derive a presolar SiC abundance of $19\,^{+15}_{-9}$ (1σ) ppm, consistent within 1σ error with abundances in primitive chondrites [1] and with other studies of Ryugu samples [2,3]. The three remaining grains have low ^{28}Si/^{12}C ratios and could be graphite or organic. The abundance of these grains ($32\,^{+31}_{-17}$ ppm) is greater than that of presolar graphite in chondrites (a few ppm), suggesting some of them are organic. No presolar O-rich grains were found in the matrix.

In the clast, 3 presolar O-rich grains and 9 anomalous C-rich grains were identified. Two of the O-rich grains are ^{17}O-rich and likely have AGB sources. These grains have ^{28}Si/^{16}O ratio similar to the surrounding material and are likely silicates. The other grain is ^{18}O-rich and derived from a supernova. This grain has a lower ^{28}Si/^{16}O ratio and could be an oxide. A total area of 1072 μm^2 was analyzed in the clast and the presolar O-rich grain abundance is $165\,^{+161}_{-90}$ ppm, similar to abundances in primitive chondrites. Three of the carbonaceous grains are likely SiC and are ^{13}C-rich, with ^{12}C/^{13}C ratios 27 – 58, consistent with AGB star origins. We determine an abundance of $148\,^{+144}_{-81}$ ppm. The remaining six grains have low ^{28}Si/^{12}C ratios. Five grains have similar depletions in ^{13}C (^{12}C/^{13}C ~ 115) and one grain has ^{12}C/^{13}C = 81. The abundance of these grains is $684\,^{+408}_{-271}$ ppm. Again these are likely graphite or organic.

Though the uncertainties are large, the clast has resolvable, higher abundances of presolar O-rich and C-rich grains than the matrix, indicating the clast is more primitive, especially given the presence of presolar silicates, or derived from a region of the nebula that was enhanced with presolar grains. Within the clast we also identified Mg-rich silicates that have ^{16}O-rich compositions [4], similar to [5] and [6], which also attest to the primitive nature of the clast.

References: [1] Davidson J. et al. (2014) *GCA* 139, 248-266. [2] Nittler L.R. et al. (2022) *53rd LPSC*, 1423. [3] Barosch J. et al. (2022) this meeting. [4] Nguyen A.N. et al. (2022) this meeting. [5] Liu M.-C. et al. (2022) *53rd LPSC*, 2276. [6] Kawasaki N. et al. (2022) *in prep.*

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