Investigating the noble gas and nitrogen relationship between Ryugu and other carbonaceous chondrites

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The Hayabusa2 mission of the Japan Aerospace Exploration Agency (JAXA) successfully returned surface material from the C-type asteroid (162173) Ryugu to Earth. This material has now been classified as closely resembling CI-type chondrites, which are the most chemically pristine meteorites. The analysis of material from the surface of Ryugu therefore provides a unique opportunity to analyze the volatile composition of material that originated from a CI-type asteroid [1] without complications arising from terrestrial contamination. Given their highly volatile nature, the noble gas and nitrogen inventories of chondrites are highly sensitive to different alteration processes on the asteroid parent body, and to terrestrial contamination.

We investigated at CRPG Nancy (France) the nitrogen and noble gas signature of two grains collected from the first and second touchdown sites [2] to provide an insight into the formation and alteration history of Ryugu. We find that the concentration of trapped noble gas in the Ryugu grains is greater than the average composition of previously measured CI chondrites. The trapped noble gases are primarily derived from phase Q, although a significant contribution of presolar nanodiamonds Xe-HL is noted. The large noble gas concentrations coupled with a significant contribution of presolar nanodiamonds suggests that the Ryugu grains may represent some of the most primitive unprocessed material from the early solar system.

In contrast to the noble gases, the abundance of nitrogen and $\delta^{15}N$ composition of the two Ryugu grains are lower than the average CI chondrite value. We attribute the lower nitrogen abundances and $\delta^{15}N$ measured in this study to the preferential loss of a ^{15}N-rich phase from our grains during aqueous on a parent planetesimal. The analyses of other grains returned from Ryugu have shown large variations in nitrogen concentrations and $\delta^{15}N$indicating that alteration fluids heterogeneously interacted with material now present on the surface of Ryugu. Finally, the ratio of trapped noble gases to nitrogen is higher than CI chondrites, and is closer to refractory phase Q and nanodiamonds. This may indicate that Ryugu experienced aqueous alteration that led to the significant loss of nitrogen likely from soluble organic matter hosted in our two grains without significant modification of the noble gas budget, which is primarily hosted in insoluble organic matter and presolar diamonds and is more resistant to aqueous alteration.

References

[1] Yokohama et al. 2022 Science DOI: 10.1126/science.abn7850. [2] Okazaki et al. Science, Accepted.