INVESTIGATING THE NITROGEN-NOBLE GAS RELATIONSHIP OF ASTEROID RYUGU AND THE LINK TO OTHER CARBONACEOUS CHONDRITES

M. W. Broadley[1], D. J. Byrne[1], E. Füri[1], B. Marty[1], R. Okazaki[2], H. Yurimoto[3], T. Nakamura[4], T. Noguchi[5], H. Naraoka[2], H. Yabuta[6], K. Sakamoto[7], S. Tachibana[7,8], S. Watanabe[7,9], Y. Tsuda[7], and the Hayabusa2 Initial Analysis Volatile Team. [1]Université de Lorraine, CNRS, CRPG (email: michael.broadley@univ-lorraine.fr), [2]Kyushu University, Japan, [3]Hokkaido University, Japan, [4]Tohoku University, Japan, [5]Kyoto University, Japan, [6]Hiroshima University, Japan, [7]Institute of Space and Astronautical Science, JAXA, Japan, [8]University of Tokyo, Japan, [9]Nagoya University, Japan.

Introduction: Carbonaceous chondrites are thought to be derived from C-type asteroids, and represent some of the most primitive materials found within our solar system. Furthermore, carbonaceous chondrites can contain large concentrations of volatile elements, and so may have played a crucial role in delivering volatiles and organic material to Earth. However, a major challenge of unraveling the volatile composition and alteration history of all meteorites is distinguishing between what features were inherent to the parent body, and what may have been induced by terrestrial weathering. Recently, the JAXA-led Hayabusa2 mission returned to Earth in December 2020, carrying 5.4 g of material collected from the C-type asteroid (162173) Ryugu [1], providing a unique opportunity to analyze material that originated from a carbonaceous asteroid without complications arising from terrestrial contamination. Here, we present the nitrogen and noble gas composition of 2 Ryugu grains analyzed at CRPG Nancy. We examine the composition of Ryugu in the context of other known carbonaceous chondrite groups and discuss the potential new insights into alteration processes occurring on the chondrite parent bodies and the terrestrial environment.

Experimental: Grains A0105-05 (0.140 mg) and C0106-06 (0.168 mg) were collected from the first and second touchdown operations, respectively [1]. Samples received at CRPG were opened in a glove box under a dry nitrogen atmosphere to avoid the samples being contaminated or altered by the terrestrial atmosphere. The samples were then loaded into a double windowed laser chamber and attached to the ultra-high vacuum line. The laser chamber was baked at ~120°C for 48 hours and then pumped for a further 3 days to ensure the blanks were low. Nitrogen and the noble gases were extracted from the grains using a CO_2 laser, with the noble gases being purified and cryogenically separated prior to analysis. A sub-aliquot of the extracted gas was taken during each step for nitrogen analysis, which was purified separately using a CuO furnace cycled between 450 - 900°C and liquid nitrogen cooled cold fingers. Sample A0105-05 was analyzed for He-Ne-Ar-Kr-Xe and N_2 isotopes using a Helix MC+ mass spectrometer. Sample C0106-06 was analyzed for Ne-Ar and N_2 isotopes using a Noblesse-HR mass spectrometer.

Results and Discussion: The concentrations of primordial noble gases ($^{22}Ne_{trap}$, ^{36}Ar, ^{84}Kr and ^{130}Xe) extracted from the Ryugu grains are all in excess of the average CM and CI chondrite values [2,3], suggesting that Ryugu may represent one of the most primitive volatile-rich examples of carbonaceous materials. The $^{36}Ar/^{130}Xe$ and $^{84}Kr/^{130}Xe$ of grain A0105-05 are very similar to phase Q, with no evidence for the presence of an atmospheric component or implanted solar wind, which can be common in CI and CM chondrites. This highlights that the handling procedure successfully limited any modification of the samples by interactions with the terrestrial atmosphere. The Ar, Kr and Xe isotope signatures of Ryugu are also dominated by phase Q. However, the $^{134}Xe/^{130}Xe$ and $^{136}Xe/^{130}Xe$ of all temperature steps are significantly in excess of phase Q, likely highlighting a contribution of presolar Xe-HL.

The N concentration measured in grains A0105-05 and C0106-06 was 885 ppm and 858 ppm, respectively, which in contrast to the noble gases is lower than the range previously measured in CI chondrites (1600 - 2300 ppm; [4-6]) but within the range previously reported for CM chondrites (500 - 1700 ppm; [6]). The $\delta^{15}N$ ratio of A0105-05 and C0106-06 was +18.1 ± 0.9 and +19.5 ± 0.9 ‰ respectively. These values are once again significantly lower than those of typical CI's, which display values around +45 ‰ [4-6] but within the range of CM chondrites (+10 to +55‰ [6]). The noble gas to nitrogen ratio of the Ryugu grains therefore appear significantly higher than CI and CM, and coupled with the difference in $\delta^{15}N$, indicates that the Ryugu grains analyzed at CRPG do not perfectly match the composition of previously analyzed CI and CM chondrites. Potential reasons for these differences will be discussed in detail but may include; (i) the loss of a ^{15}N-rich component from Ryugu during alteration that did not occur on the CI and CM parent bodies or, (ii) Ryugu and the CI/CM parent bodies accreted volatiles from different cosmochemical sources.

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