HIGH RESOLUTION STEP PYROLYSIS XENON ISOTOPIC ANALYSIS OF RYUGU MATERIAL RETURNED BY HAYABUSA2.

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Introduction: The Hayabusa2 mission returned 5.4 g of material from the C-type asteroid (162173) Ryugu on 6th December 2020 [1]. Preliminary analysis shows that Ryugu is similar to CI chondrite meteorites [1]. Here we present high resolution step heating xenon isotopic analysis of Ryugu material collected by the Hayabusa2 mission.

Experimental: Grain A0105-03 (0.100 mg), from the first touchdown site, was pelletized for characterization using Fourier-Transform Infrared (FT-IR) spectroscopy and Field-Emission Scanning Electron Microscope (FESEM) [2, 3], before being wrapped in a foil parcel for weighing and loaded into a small (~2 cm long, 4 mm OD, 2 mm ID) quartz tube. The tube was evacuated (~10^{-2} mbar) and sealed before loading into a sample port attached to the RELAX mass spectrometer [4, 5]. After the port and extraction line were baked (max ~170 ^{o}C, 24 hours), a UV laser (New Wave UP-213, λ = 213 nm) was used to ablate or 'drill' a small hole through the quartz tube, while avoiding the sample parcel, in order to extract and analyze gas trapped in the tube, to assess whether any xenon was degassed from the sample during baking. The grain was then removed from the quartz tube and loaded directly into a sample port for step heating using an infrared laser (JK Lasers JK50FL, λ = 1080 nm), in order to extract the xenon from the sample itself for high resolution xenon isotopic analysis, again using the RELAX mass spectrometer. The sample was handled in a nitrogen atmosphere and not exposed to the Earth's atmosphere throughout the whole processes of the sample preparation, transportation, weighing, sealing in the quartz tube and subsequent removal after analyzing the gas trapped in the tube, and loading into the mass spectrometer. The sample was initially heated with the infrared laser in the foil parcel created for weighing, but was later removed from the foil (again without exposure to atmosphere) because the foil was not coupling well to the heating laser. A total of 155 individual heating steps were performed, and the composition of all nine xenon isotopes analyzed in each step.

Results: A total of ~2.3×10^4 atoms ^{132}Xe (~8.5×10^{-16} cm^3 STP ^{132}Xe) was extracted from the quartz tube after baking. The xenon isotopic composition of this gas was identical within uncertainty to atmospheric xenon. These observations suggest that the baking process did not degas the sample to a significant extent. As the sample was handled under a nitrogen atmosphere before loading, the most likely explanation for the small quantity of atmospheric xenon in the tube is either that it was an impurity in the nitrogen, or a small amount of air was unavoidably introduced into the tube as it was sealed. Two additional grains intended for I-Xe and halogen analyses were similarly sealed in individual quartz tubes prior to artificial neutron irradiation; this analysis demonstrates that the sealed tubes should prevent those samples from being exposed to the atmosphere during the irradiation process, and should trap any isotopes produced during the irradiation that are lost from the sample before step heating analysis.

The measured concentration of xenon in Grain A0105-3 is ~1.8×10^{-8} cm^3 STP g^{-1} ^{132}Xe. This is higher than other CI chondrites [6], but within the range of xenon concentrations measured in other Ryugu grains [2]. The xenon isotopic composition of the individual heating steps can be modelled as mixtures of Q-Xe and solar wind, with variable contributions from Xe-HL. There is no requirement for atmospheric xenon, spallation derived xenon, or the daughter products of ^{244}Pu or ^{238}U fission. Excess ^{129}Xe (^{129}Xe*) from decay of extinct ^{129}I (half-life 16.1 Myr [7]) is observed in most heating steps, with a maximum ^{129}Xe/^{132}Xe ratio of ~1.23 (compared to 1.042 in Q-Xe [8]), and a total concentration of ~5.6×10^{-10} cm^3 STP g^{-1} of ^{129}Xe*, indicating there is some prospect of gaining information from the I-Xe system in analyses of irradiated samples. Assuming an initial solar system ^{129}I/^{127}I ratio of ~10^{-4} [9], this would correspond to an iodine concentration ~32 ppb.

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