NOBLE GAS ISOTOPIC ANALYZES OF THE ASTEROID RYUGU SAMPLES: INITIAL RESULTS OF THE MULTI-STEP PYROLYSIS.

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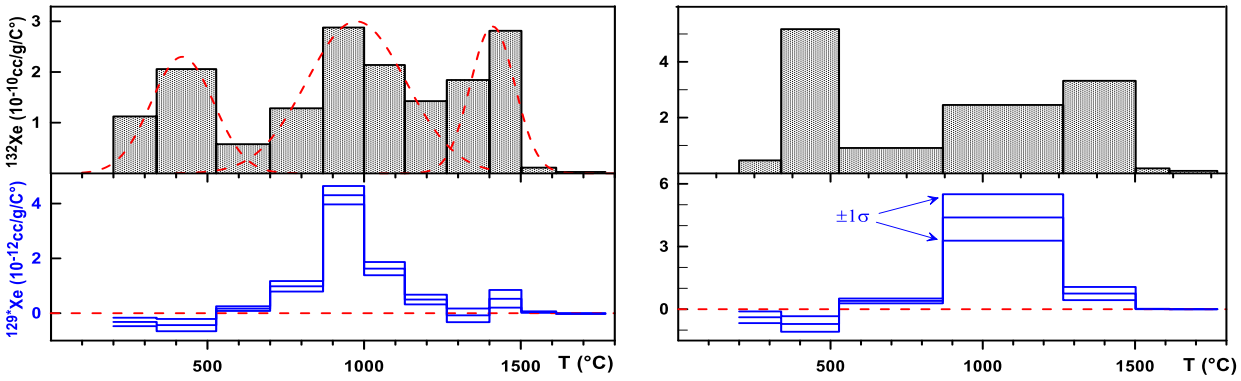
Introduction: Samples returned by Hayabusa missions are the only currently available extraterrestrial material minimally exposed to terrestrial atmosphere. Analyzing these pristine, virtually air-free, samples required significant time and efforts to develop new techniques of sample processing prior to isotopic analyses. In this study we describe instrumental improvements and new technical refinements aimed to extract maximum information from micro-gram samples of asteroid Ryugu.

Experimental: Since precision of noble gas isotopic analyses is limited by counting statistics, for this study we used a Baur-Signer ion source with cylindrical symmetry [1], characterized by nearly 100% ion transmission, ~5 times higher than traditional Nier-type ion source. The sensitivity of the Baur-Signer source (4 mA/Torr @200μA e-emission) is nearly 10 times higher than that of the Nier source (measured at the same 200μA e-emission current).

A new redesigned miniature gas extraction oven and vacuum lock sample system were internally electropolished, thoroughly cleaned and baked at 275°C for two weeks. This allowed us to reach a low procedural blank of ~8×10^5 atoms of ^{132}Xe (collected for 15 min at 1800°C).

Two Ryugu samples were wrapped in Pt-foil, weighted and loaded into the sample system in the dry nitrogen atmosphere following the developed protocol [2].

Results: A combination of high sensitivity and low procedural blank allowed us to analyze isotopic composition of all noble gases in Ryugu samples A0105-04 (173 μg) and C0106-05 (82 μg). Xe release profiles are shown below.



Eleven-step pyrolysis of A0105-04 suggests three major xenon release peaks (left), while the middle and high temperature release peaks for C0106-05 are not resolvable by the seven-step pyrolysis (right). Isotopic composition of Xe and Kr in both samples is close to that in phase Q [3], although the atmospheric Xe is clearly present in the first two extractions. Radiogenic ^{129}Xe in A0105-04 and C0106-05 is released in the same temperature range. No statistically significant excesses due to ^{244}Pu- and ^{238}U-fission or indicative of Xe-HL [4] are observed above 2σ level.

^{84}Kr/^{132}Xe ratios in bulk Ryugu samples are ~0.92 (=27.8 in air, ~8 in blank). All 3-isotope Xe mixing diagrams indicate ~90% atmospheric contribution in the first two temperature fractions that constitute ~1/3 of all released Xe. These apparently contradictory observations indicate that the Ryugu samples either capture atmospheric Xe more efficiently than Kr, or/and they have been exposed to Xe-rich atmosphere (xenon propellant of Hayabusa2 ion thrusters?).

Partially supported by NASA grant 80NSSC22K0590 and by JSPS KAKENHI Grant Numbers JP19H01959 and JP20H05846.

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