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Noble Gas and Nitrogen Isotopes in the Ryugu Samples

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Volatile elements and compounds in asteroids and comets are one of the clues to elucidate the evolution of planetary material in the Solar System. We have measured noble gas and nitrogen isotopes extracted from individual grains of the Ryugu samples [1, 2] that were collected during the 1st and 2nd touchdown operations [3]. Ryugu A samples are material from the surface layer of Ryugu, while Ryugu C samples may contain the subsurface material excavated by the small carry-on impactor [4].

Isotopic compositions of Ne and Xe are similar to those of those of CI chondrites, with smaller contribution of cosmogenic components. Primordial (P1 or Q) and presolar (HL) gases are dominant components, and the concentrations of P1 gas are higher than those in CI chondrites. Nitrogen in the Ryugu samples exhibits variable differences from CI chondrites' compositions. Some of the grains are depleted in nitrogen and have lower $\delta^{15}N$ values, which could have resulted from decoupling of N-rich phases. Clear signs of solar wind-derived He and Ne were seen only in two grains (out of 16) Ryugu-A grains. Average concentrations of ^{21}Ne produced by galactic cosmic rays for each of the Ryugu A and C samples both correspond to ~5 Myr exposure. This duration is in good agreement with the regolith residence time in the top 1m layer of Ryugu's surface for near-Earth bombardment rates [e.g., 5]. The isotopic compositions of noble gas and nitrogen in the Ryugu samples record the sources of volatiles, and changed with recent surface evolution.

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