Zinc, copper and calcium isotopic composition of Ryugu's samples

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In December 2020, the JAXA Hayabusa2 spacecraft returned to Earth with the first samples collected from a Cb-type asteroid, (162173) Ryugu [1,2]. Initial analyses showed that Ryugu's composition is close to that of the CI (Ivuna-like) carbonaceous chondrite group [3,4], the chemically most primitive meteorites characterized by near-solar abundances for most elements. Some isotopic signatures (Ti, Cr) of Ryugu overlap, however, with other carbonaceous chondrite (CC) groups. Zinc (Zn) and copper (Cu) are moderately volatile elements (MVE) that display variable isotopic compositions across the different chondrite groups and could be used to further test the Ryugu/CI connection. Furthermore, one notable chemical difference between Ryugu and CI chondrites is an apparent excess of over 50% Ca in the former that may be related to a heterogeneous distribution of carbonates (dolomite and calcite) [3,5]. Given that calcium in carbonates can be isotopically fractionated during aqueous alteration and carbonate precipitation, leading to more than 1‰ variations in the $^{44}Ca/^{40}Ca$ ratio in terrestrial carbonates, it could be a useful tool for investigating the origin of the Ca excesses in the Ryugu samples compared to CI. In addition, Ca exhibits large isotopic variations among bulk carbonaceous chondrites (CC), with the $^{44}Ca/^{40}Ca$ ratio range also spanning a range of 1 ‰, and therefore, Ca stable isotopes could be used to further test the Ryugu/CI connection.

Here we will present the first stable isotopic composition of Zn, Cu, [6] and Ca [7] from two Ryugu sampling sites. We show that Ryugu and CI chondrites have identical Zn and Cu isotopic compositions, demonstrating their common genetic heritage and ruling out any affinity with other groups of CC. Since Ryugu's pristine samples match the solar elemental composition for many elements, their Zn and Cu isotopic compositions likely represent the best estimates of the proto-solar composition. Earth's mass-independent Zn isotopic composition is intermediate between Ryugu/CC and non-carbonaceous chondrites, suggesting a contribution of Ryugu-like material to Earth's budgets of Zn and other MVE. We also show that both Ryugu samples have similar Ca isotopic composition that falls within the range defined by CIs, notwithstanding their higher Ca contents. This similarity likely indicates that the Ca isotopic composition and the Ca budget of CIs and Ryugu samples are dominated by carbonates and consistent with a major event involving precipitation of carbonates in the Ryugu samples that has been dated by ^{53}Mn-^{53}Cr chronology to have occurred ~5Ma after Solar System formation.

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