

Ryugu, Benu, and CI chondrites: Do they serve as reference materials for the Solar System composition?

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Accurate determination of the Solar System composition is critical for advancing our understanding of the formation and evolution of the Solar System objects. The elemental abundances of the solar photosphere have been used to represent the chemical composition of the Solar System, while CI chondrites have long been considered a reference material for the Solar System composition available for analysis in laboratories. Recent initial analyses of materials from the C-type asteroids Ryugu and Benu, collected by JAXA's Hayabusa2 and NASA's OSIRIS-REx missions, respectively, showed that they closely match CI chondrite compositions [e.g., 1-2], indicating that they could potentially serve as another reference for the Solar System composition, complementary to the CI chondrite-derived reference. However, small compositional differences between Ryugu and CI chondrites can be observed for some elements including P, Ca, Mn, Sr, and REEs, especially for touchdown (TD)1 samples (Fig. 1) [3], possibly due to the nugget effect of aqueously-formed minor minerals (e.g., carbonates, phosphates). Given the distinctive, CI-like stable isotopic compositions observed for various elements in Ryugu, it is plausible that the primary building blocks of Ryugu and CI chondrites originated from a common region in the early Solar System. The observed discrepancy in elemental abundances between Ryugu and CI chondrites could be due to either 1) Ryugu samples have CI-like chemical and isotopic compositions, but the measured samples were biased in elemental abundances due to the nugget effect, 2) either the TD1 or TD2, possibly TD2 samples, has CI-like elemental abundances, while both have CI-like isotopic compositions, or 3) asteroid Ryugu as a whole does not have CI-like elemental abundances, but has CI-like isotopic compositions. To further investigate the chemical composition of Ryugu and its connection to CI chondrites, it is proposed to form a new consortium to determine the representative elemental abundances of Ryugu, Benu, and CI chondrites by measuring aliquots from large, homogenized samples using the comprehensive analytical techniques established during the recent initial analyses of Ryugu and Benu.

References [1] Yokoyama et al. (2023) *Science* **379**, eabn7850. [2] Lauretta et al. (2024) *MaPS* **59**, 2453. [3] Yokoyama et al. (2025) *Geochem. J.* in press.

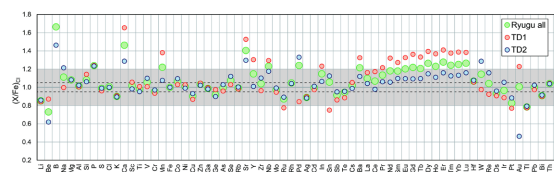


Fig. 1 Fe- and CI-normalized elemental abundances in bulk Ryugu samples from Chambers A (TD1) + C (TD2) combined, Chamber A, and Chamber C alone. The dashed lines and gray shaded area indicate the ±5% and ±20% variation ranges, respectively.