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# Zirconium isotope composition of samples returned from the asteroid Ryugu

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The Hayabusa2 mission returned 5.4 g material from the Cb-type asteroid Ryugu. Subsequent analyses of the returned material revealed a striking similarity in chemical and isotopic compositions to CI chondrites [1], yet there are some differences. For example, $\varepsilon^{54}$Cr values vary between different sample aliquots. Additionally, elements such as Ca are enriched in Ryugu relative to CIs due to heterogeneously distributed carbonates formed during aqueous alteration [1-2].

Here we present new Zr isotope data for Ryugu samples, complemented by data from carbonaceous chondrites. Ryugu aliquots (<25 mg, C0108X, A0106S) were measured with ~40-70 ng Zr, requiring challenging analyses on relatively small amounts of Zr. The Zr mass range (mass 90-96) has many molecular isobaric interferences (e.g., Fe- and Cr-argides, Ar-Ar-oxides) [3]. Therefore, baselines and interference levels were carefully monitored.

Our Zr isotope data for Ryugu show $\varepsilon^{96}$Zr excesses relative to Earth, consistent with carbonaceous chondrite data [this study, 4-6]. However, Ryugu data are generally higher in $\varepsilon^{96}$Zr (by ~1-1.5ε) compared to CIs [5-6]. This could be due to incomplete digestion of presolar SiC with low $\varepsilon^{96}$Zr [4] or sample heterogeneity. While dissolution effects cannot be fully excluded, sample heterogeneity due to CAIs [5] is not an issue due to the low CAI abundances in CI-like material. Strikingly, the dispersion of Zr isotope data increases with higher degrees of aqueous alteration [this study, 4-6]. This suggests heterogeneities due to either (i) fluids during aqueous alteration moving and slightly depleting presolar SiC in the small Ryugu aliquots analysed, or (ii) aqueous alteration dissolving and heterogeneously redistributing a labile presolar phase with $^{96}$Zr excesses. The potential presence of such a phase is also suggested by Orgueil leachates [7-8].

This research was conducted in collaboration with the Hayabusa2 initial analysis chemistry team and the Hayabusa2 initial analysis core.

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