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Small-scale Ti isotopic heterogeneity in Ryugu samples influenced by parent-body aqueous alteration

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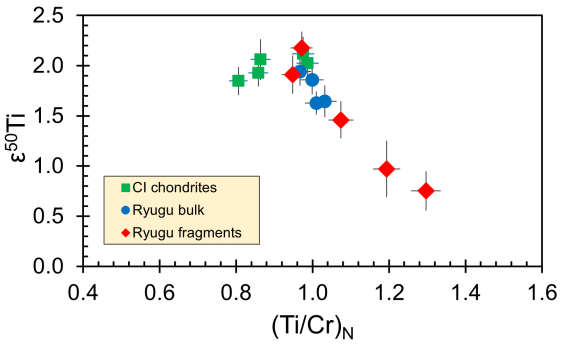

The Hayabusa2 spacecraft collected ~5.4 g of material from the Cb-type asteroid Ryugu [1]. Subsequent sample analyses showed that Ryugu materials have mineralogical, chemical, and isotopic similarities to CI chondrites, including nucleosynthetic isotope anomalies of Cr and Ti [2]. However, Ryugu samples with masses <25 mg showed a variation in ε^{54}Cr exceeding the documented range of literature values for CIs, while the calculated ε^{54}Cr value of the Ryugu composite sample (~90 mg) is consistent with the CI value [3]. This observation suggests the presence of mm-scale ε^{54}Cr variability in the Ryugu samples, which was primarily caused by fluid-driven decoupling via parent body aqueous alteration between Cr in chemically labile phases with a slightly low ε^{54}Cr value and ^{54}Cr-rich presolar Cr oxide nanoparticles [3].

To further investigate the nature of small-scale isotopic heterogeneity in Ryugu samples, we measured nucleosynthetic Ti isotope anomalies in relatively small (1.5-4.3 mg) Ryugu particles provided by JAXA in the 2nd Announcement of Opportunity. The individual particles, weighed in Teflon vials, were dissolved by acids at 220 ℃, a portion of which (~10%) was taken for elemental abundance measurements using TQ-ICP-MS (iCAP TQ) at Tokyo Tech. After chemical separation, the Ti isotopes were measured by MC-ICP-MS (Neptune plus) at U Tokyo. Contrary to previous studies in which the ε^{50}Ti values in bulk Ryugu samples (>12.7 mg) were relatively homogeneous, the small particles showed a large ε^{50}Ti variation ranging from 0.75 to 2.18, which is negatively correlated with the Cr/Ti ratio (Fig. 1). This observation suggests a relative depletion of ^{50}Ti in Ti-bearing secondary minerals (magnetite/pyrrhotite) as a result of physicochemical separation between ^{50}Ti-rich presolar grains (e.g., SiC) and chemically labile ^{50}Ti-depleted phases via aqueous alteration. Although Ti is thought to be less fluid-mobile during aqueous alteration, the isotopic composition was largely influenced by the water circulation of Ryugu, as indicated by the mm-scale ε^{50}Ti variability in Ryugu samples.

References: [1] Yada et al. (2022), Nat. Astron., 6, 214. [2] Yokoyama et al. (2023), Science, 379, eabn7850. [3] Yokoyama et al. (2023), Sci. Adv., 9, eadi7048.