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Elemental abundance variations in Ryugu grains from touchdown 1

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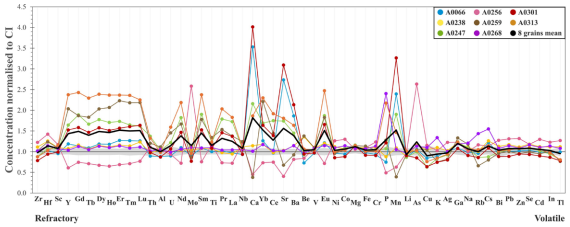

Fig. 1. CI-normalised bulk chemical compositions of the eight Ryugu grains from touchdown 1.

The Hayabusa2 mission retrieved ~5.4 g of materials from the carbonaceous asteroid Ryugu by performing two touchdowns on its surface [1,2]. The recovered samples revealed that Ryugu exhibits chemical, mineralogical and isotopic compositions akin to those of CI chondrites [1-3]. However, small-scale (< 5mg) chemical and mineralogical heterogeneity has been observed both within samples from the same location and between the two landing sites [1], likely stemming from planetary processes such as aqueous alteration [1,3].

To further investigate the small-scale elemental abundance variations among Ryugu samples, we determined the chemical compositions of eight Ryugu grains (1.48–4.33 mg) from touchdown 1, provided by JAXA. The samples were individually weighed into Teflon vials and dissolved by a mixture of acids at 220° C. A fraction of ~10% was taken to measure the abundances of 54 elements using TQ-ICP-MS (iCAP TQ) at Science Tokyo.

The bulk chemical compositions of the eight Ryugu samples exhibit considerable variations, with broader ranges found for P (0.49–2.40×CI), Ca (0.38–4.01×CI), Mn (0.39–3.27×CI), Sr (0.41–3.09×CI) and REEs (e.g., La [0.72–1.83×CI], Gd [0.75–2.43×CI] and Yb [0.73–2.30×CI]; Fig. 1). At milligram scale, heterogeneous distribution of minor mineral phases among samples can lead to large variation in elemental abundances, especially for those strongly incorporated into such minerals (i.e., nugget effect). Thus, the observed enrichment or depletion of the abovementioned elements can be attributed to small-scale uneven occurrence of secondary phases formed during aqueous alteration in the parent body, including carbonates and phosphates.

While the average composition of the eight Ryugu samples aligns within ±20% of the CI composition, enrichments in the refractory elements (e.g., REEs) and wider elemental abundance variations are observed. These differences suggest that either the parent body of Ryugu, formed from CI-like materials, underwent more localised and extensive aqueous alteration, or that the chemical compositions of the parent bodies of Ryugu and CI are different.

References: [1] Nakamura E. et al. 2022., Proc. Jpn. Acad., Ser. B, 98(6). [2] Yokoyama T. et al. 2023. Science, 379(6634), eabn7850. [3] Yamaguchi et al. 2023. Nat. Astron., 7(4).