Goldschmidt 2025 Abstract
https://doi.org/10.7185/gold2025.27105

Fe, Mg and Si isotope compositions of Ryugu particles

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The Hayabusa2 spacecraft returned samples from the primitive Cb-type asteroid Ryugu. From bulk chemistry and isotopes, Ryugu samples are closely related to CI carbonaceous chondrites [1]. However, Mg isotopes show that Ryugu has a $\mu^{26}Mg^*$ excess of 3.8±1.1 ppm relative to CIs [2]. This difference is well-resolved and cannot be explained by in situ ^{26}Al decay given their $^{27}Al/^{24}Mg$ ratios. Instead, Ryugu and CIs must have formed from material with different initial $^{26}Al/^{27}Al$ ratios or distinct Mg isotopes. To investigate Ryugu's $\mu^{26}Mg^*$ excess, we measured Fe, Mg, and Si isotopes in four small (<1.6 mg) Ryugu particles, namely A0319, A0348, A0369, and A0376

Three particles define a homogeneous $\mu^{54}Fe$ value of 4.1±2.4 ppm, similar to CIs and earlier Ryugu data [3, 4]. In contrast, A0369 records an anomalous $\mu^{54}Fe$ value of 40.4±3.1 ppm, likely reflecting heterogeneous sampling of an anomalous metal phase, as $\mu^{54}Fe$ excesses have been identified in early Ivuna CI chondrite leachates [3]. The three CI-like particles also define an average $\mu^{30}Si$ value of 36.9±3.4 ppm, identical to CIs [5]. A0369 records a more anomalous $\mu^{30}Si$ value of 45.1±2.5 ppm, possibly reflecting heterogeneous sampling of an unknown phase. Present-day $\mu^{26}Mg^*$ values of Ryugu particles range from 6±1.8 ppm to 8±1.9 ppm, agreeing with earlier data [2]. Using each particle's $^{27}Al/^{24}Mg$, we calculate initial (T=0) $\mu^{26}Mg^*$ values of -3.5±3.5 ppm to 11±2 ppm, emphasizing Ryugu's $\mu^{26}Mg_0$ excess. The 15±4 ppm range in $\mu^{26}Mg_0$ is defined by particles with CI-like $\mu^{30}Si$, indicating that $\mu^{26}Mg_0$ heterogeneity is unrelated to Si isotope variability. Since nucleosynthetic models predict much larger Si effects with Mg heterogeneity [2], our data confirm that Ryugu's $\mu^{26}Mg$ excess is radiogenic, reflecting a higher $[^{26}Al/^{27}Al]_0$ ratio in its precursors. These data support ^{26}Al heterogeneity in the early disk, indicating that Ryugu formed from material with a greater $[^{26}Al/^{27}Al]_0$ than any other CCs.

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