Goldschmidt 2024 Abstract
https://doi.org/10.46247/gold2024.24017

# Kinetic isotopic effects during chondrule crystallization in variable cooling conditions

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Micro-gravity experiments on the Chine Space Station have been achieved with the aim to replicate early Solar System conditions, facilitating the study of the formation mechanisms of chondrules and CAIs. Sixteen Type I chondrule-like samples were subjected to diverse experimental conditions, with samples scheduled for retrieval from the CSS in May for further analysis. To precisely assess gravitational impacts, parallel experiments are required in the ground laboratory.

An electrostatic levitation system in the ground laboratory of Center for Space Utilization, Chinese Academy of Sciences (CAS) was applied to simulate the experimental conditions in the Containerless Material Rack (CMR) on the CSS. As a result, forsterite and enstatite crystallized with the presence of dendritic shapes, consistent with previous observation in [1]. Elemental diffusion in melt glass around minerals was observed via EDAX. To investigate kinetic isotopic effects, Mg isotopic compositions of melt glass and mineral phases were analyzed using SIMS 1290 at UCLA.

Results reveal significant differences in $\delta^{25}$Mg values among samples crystallized under varying heating conditions. The sample with Pt nuclei (QLC-Pt, cooling from 1600 °C with the rate of 1000 K/h ) only displaying barred forsterite crystals shows $d^{25}Mg_{Fo\text{-}melt}$=-3.24±0.18‰. The values of$d^{25}Mg_{Fo\text{-}melt}$in the other two samples (QLC 500 and QLC 1000, no Pt with cooling from 1400 °C with the rate of 500 K/h and 1000 K/h) are -2.40±0.31‰and -2.73±0.43‰, respectively. Barred enstatite was also generated in QLC 500 and QLC 1000. The Mg isotopic fractionation between enstatite and glass vary across the sample with the average of $d^{25}Mg_{En\text{-}melt}$~-2.83‰ and -3.07‰, respectively. This heterogeneity suggests significant kinetic effects during rapid cooling processes. Overall, the crystallization conditions in our ground-based experiments are consistent with those indicated in [2]. Future petrological and isotopic analyses of retrieved samples from the CMR aboard the CSS will enable a quantitative assessment of micro-gravity's impact during chondrule formation and crystallization in the early Solar System.

References:

[1] Faure et al., 2022, Earth and Planetary Science Letters 593, 117649.

[2] Jones et al., 2017, In *Chondrules and Protoplanetary Disk workshop*, #2029.