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Distribution of rare-earth elements in fine-grained Calcium and Aluminum-rich inclusions from Allende meteorite.

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Calcium and aluminum-rich inclusions (CAIs) in chondrites are one of the oldest materials in the solar system. The constituent refractory minerals in CAIs suggest that they were formed by direct condensation from nebular gas of solar system composition [1-2]. Unlike coarse-grained CAIs, fine-grained CAIs (FGs) are thought to have escaped remelting. Therefore, the elemental distribution in FG minerals, specifically for rare-earth elements (REEs), provides key information to understand the condensation processes. In previous studies, formation processes of FG minerals have discussed using the CI-normalized REE abundance patterns in fragments FGs consisting of multiple minerals [3-4]. Therefore, the distribution of REEs in individual FG minerals remains unclear.

In this study, we performed imaging measurements for five FGs in Allende meteorite using LA-ICP-MS. The abundances of major elements and REEs obtained by the imaging were analyzed in association with the mineral distribution data obtained by SEM-EDS performed prior to the imaging measurements.

Most of the analyzed FGs showed fractionated REE patterns that are typically observed in FGs. In three out of the five FGs, the REE abundances varied across different minerals with the highest abundances in Ti-rich calcic pyroxene, while individual minerals essentially have similar REE patterns. In contrast, the other two FGs showed different REE patterns for different minerals. In particular, for an FG with layered structure, a unique REE pattern with Gd-Ho enrichment was observed at the layer boundary, which is difficult to explain with previous FG formation models. The diverse REE patterns within single FGs suggests the presence of multiple gaseous reservoirs that contributed to the formation of FGs examined in this study.

References: [1] Yoneda and Grossman (1995) *GCA*, 59, 3413. [2] Lodders (2003), *ApJ, 591, 1220*. [3] Davis et al. (2018) *GCA*, 221, 275. [4] Hu et al. (2021) *Sci. Adv.*, 7, 2962.