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Al-Mg Isotopic Study of Fine-Grained Refractory Inclusions

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Fine-grained Ca-Al-rich inclusions (FGIs) in carbonaceous chondrites are interpreted as aggregates of direct condensates from the solar nebula that escaped extensive melting [1]. A few high-precision SIMS Al-Mg isotopic studies of FGIs from CV3 chondrites have reported contrasting results [2-4], suggesting that the meaning of variations in $(^{26}Al/^{27}Al)_0$ values inferred from these inclusions is still poorly understood. Here, we report Al-Mg isotopic data of eight FGIs and two fluffy Type A CAIs (FTAs) from reduced CV3 chondrites obtained using the CAMECA ims-1290 ion microprobe at UCLA to provide additional chronological constraints on condensation processes in the solar nebula.

The $(^{26}Al/^{27}Al)_0$ values inferred from four FGIs are broadly consistent with the bulk refractory inclusion value of $\sim5.2\times10^{-5}$ [5]. Four FGIs and two FTAs exhibit distinctly lower $(^{26}Al/^{27}Al)_0$ values than the canonical value, down to $\sim3.5\times10^{-5}$. This observed spread suggests that multiple condensation events occurred in the solar nebula over a time span of at least ~0.8 Ma after initial condensation [4]. Alternatively, the spread may represent multiple thermal events that had reset Al-Mg isotopic compositions in early-formed inclusions after initial condensation [6]. The collective $(^{26}Al/^{27}Al)_0$ range inferred from FGIs, FTAs, and an AOA of probable condensates in CV3 chondrites [2-4, 7, this study] overlap with those obtained from coarse-grained, igneous CAIs [8]. This implies that CAIs were continuously reprocessed in the solar nebula after the canonical value was established. Alternatively, this range may be an indicator of a heterogeneous distribution of ^{26}Al in the CAI-forming region. High-precision SIMS analyses of additional FGIs are underway to better evaluate the distribution of their $(^{26}Al/^{27}Al)_0$ values.

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