SIMS Al-Mg CHRONOLOGY OF CR CHONDRITE CHONDRULES: LINKS WITH Mg# AND O ISOTOPES

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Introduction: Assuming homogeneous distribution of early Solar System ^{26}Al, the decay of parent ^{26}Al to daughter ^{26}Mg (half-life: 0.705 Myr) is a measure of the relative timing of chondrule formation. Chondrule $(^{26}Al/^{27}Al)_0$ ratios, established from mineral isochrons, are anchored to the "canonical" $(^{26}Al/^{27}Al)_0$ of primitive CAIs (5.2×10^{-5}; [1]). While pristine LL, CO, and Acfer 094 chondrule $(^{26}Al/^{27}Al)_0$ values correspond to formation 1.5-3 Myr after CAIs [2 & references within], the $(^{26}Al/^{27}Al)_0$ range from pristine CR chondrite chondrules is larger; many suggest formation >1 Myr after LL, CO, and Acfer 094 chondrules [2-4]. Here, we report Al-Mg systematics from 12 pristine CR chondrite chondrules, demonstrating links between $(^{26}Al/^{27}Al)_0$, Mg# (mol. % MgO/[MgO+FeO]), and O-isotopes.

Samples, Methods: Chondrules from QUE 99177,49 (*n*: 9) and MET 00426,46 (*n*: 3) were analyzed by SIMS, using methods in [5]. For plagioclase Mg three-isotopes were collected by a peak switching mono-collection electron multiplier. The primary O^- beam intensity was 30-60 pA (5-10 µm spot). Uncertainty in δ^{26}Mg* was ~1‰ (2SE) per 3 hour analysis (*n*: 4-6 spots per chondrule). All plagioclase is clean (no additional reaction phases from thermal metamorphism). For olivine and pyroxene $^{24}Mg^+$, $^{25}Mg^+$, $^{26}Mg^+$ and $^{27}Al^+$ were measured simultaneously on 4 Faraday cups; the primary O^- beam intensity was 3 nA (15 µm spot); uncertainty in δ^{26}Mg* was ~0.1‰ (2SE) per 8 minute analysis (*n*: 1-4 spots per chondrule). Chondrule Mg#'s range from 99.2 to 94.2. Chondrule O-isotopes plot on the slope-1 PCM line. Δ^{17}O (= $\delta^{17}O - 0.52 \times \delta^{18}O$) values systematically increase, from –5.3‰ to –0.9‰, with decreasing chondrule Mg# [6].

Results, Discussion: Five chondrules have resolvable excess ^{26}Mg, with $(^{26}Al/^{27}Al)_0$ of $(3.9\pm1.7) \times 10^{-6}$ to $(6.2\pm3.9) \times 10^{-6}$. Including uncertainties, this corresponds to formation 1.7 to 3.3 Myr after CAIs, similar to chondrules from other pristine chondrites (see Intro.). These chondrules have Mg#'s > 99 and Δ^{17}O of –4.2‰ to –5.3‰. Seven chondrules have no resolvable excess ^{26}Mg; this result is not due to thermal metamorphism. Their $(^{26}Al/^{27}Al)_0$ upper limits correspond to formation >2.9 to >3.7 Myr after CAIs. Six of these chondrules have Mg#'s of 98.6 to 94.2 and Δ^{17}O of –2.8‰ to –0.9‰; the seventh has an Mg# of 98.7 and a Δ^{17}O of –4.9‰. The decrease in chondrule Mg# with increasing Δ^{17}O suggests addition of oxidized ^{16}O-poor H_2O to chondrule precursors [6]. As such, differences in the formation timing of these chondrules, related to Mg# and Δ^{17}O, are linked to temporal and/or spatial fluxes of protoplanetary disk H_2O.

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