Oxygen- and Magnesium-Isotope Compositions of Grossite-bearing CAIs from DOM 08004 (CO3.1) and DOM 08006 (CO3.0) Chondrites

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Introduction: Ca,Al-rich inclusions (CAIs) in chondrites of petrologic types 2–3 show a bimodal distribution of the initial $^{26}Al/^{27}Al$ ratios [$(^{26}Al/^{27}Al)_0$] with peaks at ~0 and ~5×10□5, most likely indicating heterogeneous distribution of ^{26}Al in the solar nebula during an apparently a brief epoch of CAI formation. Most of these CAIs are uniformly ^{16}O-rich ($\Delta^{17}O$ ~ –24‰) suggesting formation in a gas of ~solar composition. The important exceptions are isotopically anomalous ^{26}Al-poor FUN (fractionation and unidentified nuclear effects) CAIs and PLACs (platy hybonite crystals), and ^{26}Al-poor grossite-rich CAIs in CH chondrites showing a range of $\Delta^{17}O$, from ~ –35‰ to ~ –10‰. Grossite, $CaAl_4O_7$, is one of the most refractory minerals predicted to condense from a cooling gas of solar composition. Grossite-bearing inclusions are a relatively rare type of CAIs in most chondrite groups, except CH chondrites, the only group where they have been extensively studied. Here, we report on oxygen and Al-Mg isotope systematics of grossite-bearing CAIs in DOM 08004 (CO3.1) measured *in situ* with the UH Cameca ims-1280. Isotopic compositions of grossite-bearing CAIs in DOM 08006 (CO3.0) will be reported at the meeting.

Oxygen isotopes: On a three-isotope oxygen diagram ($\delta^{17}O$ *vs.* $\delta^{18}O$), compositions of the DOM 08004 grossite-bearing CAIs plot along ~slope-1 line. All CAIs are isotopically heterogeneous with grossite ($\Delta^{17}O$ = –11‰ to 0‰), and, in most cases, melilite ($\Delta^{17}O$ = –15‰ to –1‰) being ^{16}O-depleted relative to hibonite, spinel, and Al,Ti-diopside ($\Delta^{17}O$ ~ –24‰).

Magnesium isotopes: Hibonite and grossite in two CAIs show no resolvable excess of $^{26}Mg^*$, $(^{26}Al/^{27}Al)_0 < 5.7\times10^{-7}$ and $<6.8\times10^{-7}$, respectively. $(^{26}Al/^{27}Al)_0$ in four other CAIs are $(4.4\pm0.3)\times10^{-5}$, $(4.0\pm0.3)\times10^{-5}$, $(4.5\pm0.3)\times10^{-5}$ and $(4.3\pm0.3)\times10^{-5}$. The lower than the canonical $(^{26}Al/^{27}Al)_0$ is probably due to improper sensitivity factor used for grossite that was assumed to be the same as for hibonite.

Conclusions: DOM 08004 experienced hydrothermal alteration resulting in formation of magnetite, fayalite, Fe,Ni-sulfides, Ni-rich metal, and phyllosilicates. The ^{16}O-depleted compositions of grossite and melilite in DOM 08004 CAIs could have resulted from postcrystallization exchange during fluid-rock interaction on the CO chondrite parent body. The alteration appears to not have unaffected Al-Mg systematics of the CAIs. Therefore, the inferred $(^{26}Al/^{27}Al)_0$ must reflect the primordial, heterogeneous distribution of ^{26}Al in the CAI-forming region. The ^{26}Al-poor CAIs could have formed prior to addition of ^{26}Al to the protoplanetary disk.

Early Formation of Planetary Building Blocks Inferred from Pb Isotopic Ages of Chondrules

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The most abundant component of chondrite meteorites are millimetre-sized chondrules that formed as free-floating molten droplets in the early Solar System. In addition to providing insights into the thermal and physical evolution of the protoplanetary disk, chondrules may have promoted the rapid growth of planetary bodies [1]. Thus, acquiring a statistically-meaningful age distribution of individual chondrules is critical for understanding the early dynamics of the protoplanetary disk, including the thermal history of the material precursor to terrestrial planets.

Our data-set of U-corrected Pb-Pb dates of 22 chondrules define ages ranging from 4567.61±0.54 to 4563.24±0.62 Ma, with ~50% of chondrules having formed <1 Myr after Solar System formation at 4567.30±0.16 Ma [2]. An abundance of chondrules with ages within 1 Myr of Solar System formation suggest that the production of chondrules may have been more efficient at early times. The chondrule ages are correlated to their their initial Pb isotope compositions, with younger chondrules recording evolved compositions indicative of a complex thermal pre-history relative to older chondrules. We infer that primary chondrule production was restricted to the first million years of disk evolution whereas the younger chondrules reflect remelting and recycling of first generation chondrules for ~3 Myr. This is consistent with astronomical observations indicating that replenishment of fresh dust to the disk is limited to the embedded stage of star formation lasting <1 Myr [3]. The energy responsible for chondrule production and subsequent recycling may have shifted from shocks associated with spiral arms in a young gravitationally unstable disk to planetary bow shocks and collisions at later times. Our new chronological framework is in keeping with chondrules being a key ingredient driving the efficient and early formation of planetary objects.

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