

Secondary corundum-bearing assemblages in Ca,Al-rich inclusions from Allende (CV>3.6) carbonaceous chondrite

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We report on the mineralogy, petrology, oxygen and aluminum-magnesium isotopic systematics of corundum-bearing assemblages in Type B CAIs 3529Z and 3529G and Fluffy Type A CAI ALH-2 from Allende (CV>3.6). In 3529Z and 3529G, corundum associates with secondary alumoåkermanite [(Ca,Na)₂AlSi₂O₇], grossular (Ca₃Al₂Si₃O₁₂), spinel (MgAl₂O₄), kushiroite (CaAl₂SiO₆), and grossite (CaAl₄O₇) (Figs. 1a,b). In ALH-2, corundum associates with secondary grossular and nepheline (NaAlSi₃O₈) (Figs. 1c,d). In Type Bs, corundum and associated secondary minerals are ¹⁶O-poor ($\Delta^{17}\text{O} = -2.2 \pm 1.5\text{‰}$); primary spinel is ¹⁶O-rich ($\Delta^{17}\text{O} \sim -23\text{‰}$); Al,Ti-diopside shows a range of $\Delta^{17}\text{O}$ (from -24 to -15‰); anorthite and melilite are ¹⁶O-depleted to various degrees ($-6.5\text{‰} \leq \Delta^{17}\text{O} \leq -4.5\text{‰}$ and $\Delta^{17}\text{O} = -2.7 \pm 0.8\text{‰}$, respectively) [1]. In ALH-2, $\Delta^{17}\text{O}$ of corundum ranges from -9 to -1‰; primary hibonite and spinel are ¹⁶O-rich ($\Delta^{17}\text{O} \sim -23\text{‰}$); melilite and perovskite are ¹⁶O-poor ($\Delta^{17}\text{O} = -2.6 \pm 1.5\text{‰}$ and $-3.1 \pm 1.3\text{‰}$, respectively). On the Al-Mg isotope diagram (²⁶Mg* vs. ²⁷Al/²⁴Mg), primary Al,Ti-diopside, hibonite, melilite, and spinel in the Allende CAIs studied plot along the canonical isochron with inferred initial ²⁶Al/²⁷Al ratio [(²⁶Al/²⁷Al)₀] of $\sim 5 \times 10^{-5}$ [2,3]. All minerals in the corundum-bearing assemblages have resolved excesses of ²⁶Mg*: corundum, grossite, and alumoåkermanite plot below the canonical isochron, whereas spinel plots above it. An internal isochron defined by secondary corundum and alumoåkermanite in 3529Z has (²⁶Al/²⁷Al)₀ of $(7.5 \pm 2.6) \times 10^{-7}$. We conclude that corundum-bearing and other secondary mineral assemblages (grossular+Al-diopside±forsterite±spinel, grossular+anorthite±spinel, grossular+forsterite±alumoåkermanite, grossular+monticellite+wollastonite±spinel±forsterite) in Allende CAIs resulted from metasomatic alteration of melilite and anorthite ~4-5 Ma after their crystallization. The previously reported model isochrons with (²⁶Al/²⁷Al)₀ ranging from $\sim 5 \times 10^{-5}$ to $\sim 5 \times 10^{-6}$ in some grains of secondary grossular, nepheline, plagioclase, and sodalite [4] cannot be interpreted chronologically, because ²⁶Mg* in these minerals was largely inherited from primary melilite and anorthite. The alteration by

an aqueous fluid having $\Delta^{17}\text{O}$ of $\sim -3 \pm 2\text{‰}$ modified O-isotope composition of primary melilite, anorthite and Ti-rich pyroxene; O-isotope compositions of primary hibonite, spinel and low-Ti pyroxene escaped this modification.

References: [1] Aléon (2016) *EPSL*, 440, 62-70. [2] Podosek et al. (1991) *GCA*, 55, 1083-1110. [3] Simon et al. (2001) *MAPS*, 36, 331-350. [4] Fagan et al. (2007) *MAPS*, 42, 1221-1240.

