

Secular change of oxygen isotope composition in the solar protoplanetary disk recorded in a fluffy Type A CAI from Vigarano CV3 by Al-Mg chronological study

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Fluffy Type A Ca-Al-rich inclusions (CAIs) containing reversely zoned melilite crystals are suggested to be direct condensates from solar nebular gas (MacPherson and Grossman, 1984). We conducted an investigation of ^{26}Al - ^{26}Mg systematics of a fluffy Type A CAI from Vigarano, named V2-01, with known oxygen isotopic distributions of reversely zoned melilite crystals (Katayama et al., 2012); we also conducted oxygen isotope measurements of coexisting minerals. The oxygen and Al-Mg isotope measurements were conducted using SIMS of Hokkaido University (Cameca ims-1280HR). Petrography suggests that the constituent minerals of V2-01 formed in the following order: first spinel and fassaite enclosed by melilite, then reversely zoned melilite crystals, and spinel and diopside in the Wark-Lovering rim. The spinel enclosed by melilite has ^{16}O -rich compositions ($\Delta^{17}\text{O} \sim -24\%$) and an initial value of $(^{26}\text{Al}/^{27}\text{Al})_0 = (5.6 \pm 0.2) \times 10^{-5}$. The fassaite enclosed by melilite crystals shows variable oxygen isotopic compositions ($\Delta^{17}\text{O} \sim -12\%$ and -17%) and plots on an isochron with $(^{26}\text{Al}/^{27}\text{Al})_0 = (5.6 \pm 0.2) \times 10^{-5}$. The oxygen isotopic compositions of reversely zoned melilite showed continuous variations in $\Delta^{17}\text{O}$ along the inferred direction of crystal growth, suggesting that surrounding nebular gas, during the formation of the reversely zoned melilite, changed from ^{16}O -poor ($\Delta^{17}\text{O}$ values larger than -10%) to ^{16}O -rich ($\Delta^{17}\text{O} \sim -25\%$). The six reversely zoned melilite crystals show indistinguishable initial $^{26}\text{Al}/^{27}\text{Al}$ values with an average $(^{26}\text{Al}/^{27}\text{Al})_0$ of $(4.7 \pm 0.3) \times 10^{-5}$, which is clearly distinguishable from the value of enclosed spinel and fassaite, indicating a younger formation age than the enclosed spinel and fassaite. The spinel and diopside from the Wark-Lovering rim shows ^{16}O -rich compositions ($\Delta^{17}\text{O} \sim -23\%$) with $(^{26}\text{Al}/^{27}\text{Al})_0 = (4.5 \pm 0.4) \times 10^{-5}$. The values of $(^{26}\text{Al}/^{27}\text{Al})_0$ are consistent with the formation sequence inferred from petrography. The formation period for the V2-01 CAI is estimated to be 0.18 ± 0.07 Myr from the difference in initial $^{26}\text{Al}/^{27}\text{Al}$ values. These data suggest that the oxygen isotopic composition of solar nebular gas surrounding the CAI changed from ^{16}O -rich to ^{16}O -poor and back to ^{16}O -rich at least recorded as one cycle during the first ~ 0.2 Myr of Solar System formation.

Keywords: Al-Mg chronology, Ca-Al-rich inclusion, SIMS, oxygen isotopes, solar protoplanetary disk