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Oxygen isotopic and chemical zoning of melilite crystals in a Type A Ca-Al-rich inclusion of Efremovka CV3 chondrite

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CAIs (Ca-Al-rich inclusions) are composed of high-temperature minerals (Grossman, 1972) and formed in the innermost solar system (MacPherson et al., 2005; Yurimoto et al., 2008). From oxygen isotopic distributions of CAIs, the mixing of ^{16}O-poor and ^{16}O-rich gaseous reservoirs could frequently occur in the inner most solar system where is the CAI-forming region (e.g., Itoh and Yurimoto, 2003; Yurimoto et al., 2008). Reversely zoned melilite crystals in fluffy Type A CAIs are readily explained by direct condensation from a solar nebular gas (MacPherson and Grossman, 1984) so that these crystals are identical to the oxygen isotopic compositions of the surrounding solar nebular gas. In this study, we study the chemical compositions and oxygen isotopic distributions of melilite in a Type A CAI, HKE 01 from Efremovka CV3 chondrite to elucidate the formation processes and variations in oxygen isotopic composition of the solar nebular gas of Type A CAI-forming area.

FE-SEM-EDS-EBSD system (JEOL JSM-7000F; Oxford INCA Energy; HKL Channel 5) was used for petrologic study. Oxygen isotopic compositions have been measured by SIMS (Cameca ims-1270).

HKE 01 is constructed of two domains, each of which has a core-mantle structure. Reversely zoned melilite crystals were observed in the mantle part of both domains. Melilite crystals in one domain have a homogeneous ^{16}O-poor composition on the carbonaceous chondrite anhydrous mineral (CCAM) line of delta-^{18}O = 5-10 permil, which suggests that the domain was formed in a ^{16}O-poor oxygen isotope reservoir of the solar nebula. In contrast, melilite crystals in the other domain have continuous variations in oxygen isotopic composition from ^{16}O-poor (delta-^{18}O = 0 permil) to ^{16}O-rich (delta-^{18}O = -40 permil) along the CCAM line. The oxygen isotopic composition tends to be more ^{16}O-rich toward the domain rim, which suggests that the domain was formed in a variable oxygen isotope reservoir of the solar nebula. Because reversely zoned melilite crystals are thought to be condensed with decreasing pressure (MacPherson and Grossman, 1984), the environment changed from ^{16}O-poor to ^{16}O-rich with decreasing pressure. This situation may correspond to the inner edge region of the solar nebular where ^{16}O-rich solar and ^{16}O-poor planetary gases are encountered and mixed (Yurimoto et al., 2008). The CAI recorded temporal variations of the mixing in the region and spatial variations by the radial transport (Itoh and Yurinoto, 2003; Ciesla, 2007). After the formation of each domain, the domains aggregated to form HKE 01.

Keywords: Type A CAI, melilite, SIMS, oxygen isotopes, solar nebula