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# Oxygen isotopic distribution of Type B1 CAI from the Vigarano

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Ca-Al-rich inclusions (CAIs) in meteorites are the oldest objects in the Solar System. Heterogeneous oxygen isotope distributions among inter- and intra-crystals have been observed for CAIs (e.g., Yurimoto et al., 1998). The heterogeneous oxygen isotope distributions of CAI minerals are interpreted to be the result of thermal processes in the solar nebular with different oxygen isotopic compositions, which are multiple melting, condensation, and solid-state diffusion processes, as well as aqueous and thermal metamorphism/alteration on the parent body (Yurimoto et al., 2008). However, most efficient processes to form oxygen isotopic compositions were different at each mineral and each CAI. In this study, we have conducted systematic oxygen isotope measurements for a large area in a CAI and compared with the petrography, in order to understand the processes to form the heterogeneous oxygen isotope distributions.

A type B1 CAI from the Vigarano was examined. FE-SEM-EDS system (JEOL JSM-7000F; Oxford X-Max 150) was used for petrographic observations. Oxygen isotopic compositions were measured using SIMS of Hokkaido University (Cameca ims-1280HR). Secondary ions ($^{16}O^-$, $^{17}O^-$, and $^{18}O^-$) were measured simultaneously in a multicollection mode. We selected three regions with sizes of 1 x 1 mm and measured oxygen isotopes of 40 x 40 points every 25 micrometers. Measurement time for each spot was 55 seconds including 10 seconds of ion counting time, pre-sputtering, and stage moving.

The CAI is 6.5 x 3 mm and has an irregular and a wrinkled surface. The CAI has a core-mantle structure. The core consists of spinel, melilite, anorthite, and Al-Ti-rich augite, while the mantle is composed mainly of melilite. The Wark-Lovering rim surrounds the CAI. The CAI is a fragment and an entire shape is unclear. A bulk chemical composition corresponds to those for typical Type B1 CAIs (Grossman, 1975). Crystallization sequences from a melt of the CAI composition were spinel, melilite, anorthite, and fassaite (Stolper, 1982).

The oxygen isotopic compositions of minerals in the CAI are distributed along the CCAM line in a three oxygen isotope diagram. Spinel shows a $^{16}$O-rich composition ($\delta^{18}$O $\sim$ -45 permil), while melilite shows a $^{16}$O-poor composition ($\delta^{18}$O $\sim$ 11 permil). Anorthite has bimodal distributions of oxygen isotopic compositions. Fassaite shows mainly a $^{16}$O-rich composition and less spots having a $^{16}$O-poor composition.

The oxygen isotopic compositions of mineral measured are not readily explained by crystallization sequences from the melt, indicating that the heterogeneous oxygen isotope distributions are the results of either multiple re-melting events or any other processes except for the melting event.

Keywords: CAI, meteorite, oxygen isotope, SIMS