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Oxygen and Al-Mg isotopic compositions of a barred olivine chondrule from NWA1152 C3-ungrouped chondrite

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Introduction: The evolution of oxygen isotopes in the early solar system has been discussed as follows; the existence of 16O-rich reservoir from the observations of 16O-rich fine-grained CAIs and AOAs, and 16O-poor solid phases made by melting episode in the 16O-poor gas (e.g., [1]). With the discovery of the existence of 16O-rich reservoir in the chondrule formation region (e.g., [2]), the oxygen isotopes evolution among the CAIs and chondrules are controversial, contemporaneous formation of chondrules and CAIs, that is, not only from 16O-rich to 16O-poor but also from 16O-poor to 16O-rich (e.g. [3]), especially that of chondrule forming region is unclear [e.g., 4].

Layered chondrules may have recorded evolution of oxygen isotopes of solar nebula materials in the chondrule-forming region (e.g., [5]). In this study, we report the petrography, high precision oxygen and Al-Mg isotopic compositions in the Al-rich barred olivine chondrule from NWA1152 C3-ungrouped chondrite, in order to estimate the oxygen isotopes evolution between CAIs and chondrules in the early solar system.

Experiment: The sample used in this study is a polished thin section from the primitive NWA-1152 C3-ungrouped chondrite. We carried out a petrographic study of a barred olivine chondrule, C1m, in thin section. Petrologic and mineralogical studies were examined by a petrographic microscope and by X-ray microanalysis using SEM-EDS at Titech and NHM.

In-situ oxygen and Al-Mg isotopic analyses were performed by the Cameca ims-1270 SIMS instrument; originally installed in TiTech and now in Hokkaido Univ. (Hokudai). sdddd In situ oxygen isotope analyses were applied to the mono-collection system and Al-Mg analyses to the multi-collection system.

Results: The C1m chondrule in a barred olivine chondrule (1.5mm across) surrounded by porphyritic igneous rim (200 micro meter in width). The barred olivine chondrule consists of platy olivine crystals (Fo99) and blocky subhedral spinel grains (Mg-sp) embedded in a mostly subhedral large crystalline Al-rich diopsides (Di) and mesostasis. The igneous rim mainly consists of pigeonite phenocrysts embedding euhedral olivine crystals and Fe-Ni metals.

The oxygen isotopic compositions of the barred olivine part are distributed around SMOW value (delta17, 18OSMOW= 0 permil), while the igneous rim of pigeonite and olivine crystals are slightly enriched in 16O (delta17, 18OSMOW= -5 to -12permil) relative to the barred olivine part.

The Al-Mg isotopic compositions of spinel, olivine, Al-rich diopside and rim of pigeonite grains were measured. The spinel only shows the clear excesses of 26Mg isotope.

Discussion: The oxygen isotope disequilibrium between the core and igneous rim suggests that the formation process of C1m results from the multiple heating. Based on the chemical composition and oxygen isotopic compositions in igneous rim that is enriched in 16O relative to that of core, these results suggest that the 16O-rich Si-rich gas reservoir exists in the chondrule formation region. This might be caused by the fluctuation of oxygen isotopic compositions in the solar nebula [3].

The 26Mg$*$distribution among core minerals suggests that formation of this chondrule started at least 2Myr after CAI formation having the canonical values and continued several Myrs. After the barred olivine chondrule formation, the igneous rim was formed in the 16O-enriched nebular environment. This suggests that 16O-rich reservoir existed in the chondrule formation region at several Myrs after the CAI formation.

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