CHONDRULE RIM INCLUDING ^{16}O-ENRICHED OLIVINE IN CARBONACEOUS CHONDRITE NORTHWEST AFRICA 3118

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Introduction: Chondrules contain ^{16}O-enriched olivine grains [e.g. 1, 2]. Such olivine grains in the CV_{oxA} chondrites would provide information of secondary processes because CV_{oxA} subgroup appears to have been affected by the complex alteration [3]. In this study, we present results of mineralogy, mineral chemistry, and oxygen isotopic distribution in a coarse-grained igneous rim of a chondrule in a CV_{oxA} chondrite.

Sample and Analytical methods: A type I chondrule bearing igneous rim was studied in a polished thin section of NWA 3118 $CV_{oxA}3$ chondrite. Petrographic, chemical and crystal orientation analyses were performed by FE-SEM-EDS-EBSD (JEOL JSM-7000F + Oxford X-Max 150 + Oxford HKL). Isotope mapping for oxygen was applied by an isotope microscope (modified-Cameca ims-1270 + SCAPS).

Results: A coarse-grained igneous rim with the thickness of up to 400 μm was observed around a type I porphyritic olivine chondrule (Fa_{2-5}) of 1.4 mm in diameter. The igneous rim is mostly dominated by olivine grains, which have more FeO-rich compositions compared to those within the host chondrule and are distinguished between two types based on different FeO concentrations and textures. We define them as MgO-rich (Fa_{11-22}) and FeO-rich (Fa_{40-48}) olivine, respectively. The MgO-rich olivine grains are typically euhedral and vary from 100-150 μm in size close to the inner part of the rim to 10-50 μm in size towards the outer part of the rim. FeO-rich olivine grains fill spaces between MgO-rich olivine grains and overgrow around MgO-rich olivine grains. The FeO-rich olivine grains show smooth and porous textures on the polished surfaces. Olivine grains (Fa_{46-51}) in the matrix surrounding the igneous rim have similar chemical composition to the FeO-rich olivine in the rim. MgO-rich olivine grains have Fe-Mg chemical zoning of about 1.3 μm width from their grain boundaries and from the boundary of overgrown FeO-rich olivine.

Olivine grains of the igneous rim show three different oxygen isotopic compositions (δ^{18}O ~ 10 ‰, 0 ‰, -40 ‰). Oxygen isotopic composition of the MgO-rich olivine has ~0 ‰ in δ^{18}O, whereas FeO-rich olivine is δ^{18}O = ~10 ‰. Some MgO-rich olivine crystals contain ^{16}O-rich olivine cores (δ^{18}O = ~-40 ‰) with a sharp isotope boundary less than 2.5 μm width, which is equal to the spatial resolution of O isotope mapping in this study. The ^{16}O-rich part of the MgO-rich olivine grains has the same forsterite composition and the same crystallographic orientation with surrounding olivine.

Discussion: The ^{16}O-rich olivine in the igneous rim is considered to be a relict of precursor materials [1, 2]. The sharp isotopic boundary between δ^{18}O = ~-40 ‰ and ~0 ‰ in MgO-rich olivine grains shows that O isotope diffusion is limited during the MgO-rich olivine formation in the igneous rim formation in the solar nebula and metamorphism on the parent body. The FeO-rich olivine grains are considered to precipitate from an aqueous fluid having the ^{16}O-poor composition on the parent body [4]. The Fe-Mg zoning in the MgO-rich olivine grains shows Fe-Mg diffusion occurred in the metamorphism on the parent body. The diffusion length (1.3 μm) of Mg-Fe interdiffusion shows that O self-diffusion in olivine is limited to be less than 2 nm, because, oxygen self-diffusion in olivine is slower than Fe-Mg interdiffusion [5, 6, 7, 8]. This diffusion relationship between Mg-Fe and O is consistent with observations of the sharp O isotopic boundary for the relict olivine grains. Therefore, the igneous rim of chondrules in the CV_{oxA} chondrite preserves information of the solar nebula and records metamorphic processes on the parent body.

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