PETROGRAPHY AND OXYGEN ISOTOPE DISTRIBUTION OF OLIVINE FROM COARSE-GRAINED IGNEOUS RIM AROUOND CHONDRULE IN NWA3118 CV3 CHONDRITES.

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Introduction: Coarse-grained igneous rims record thermal histories after chondrule formation [1-3]. Olivine with ^{16}O-rich composition was reported in coarse-grained igneous rims from CR chondrites, suggesting that these ^{16}O-rich parts are relict and correspond a low degree of melting of fayalitic rim [4, 10, 11]. Existence of ^{16}O-rich olivine in the rims indicates that the chondrule rims preserve isotopic information about chondrule precursor and chondrule formation environment [5]. In addition, chemical zoning in olivine allows the determination of time and temperature of thermal metamorphism on the parent body [6]. Here we report on petrology and oxygen-isotope distribution of olivine from coarse-grained igneous rim around chondrule in NWA3118 CV3 chondrite.

Experimental: The sample used in this study is a polished thin section from NWA 3118 CV3 chondrite. The petrographic observation and chemical analysis were performed by FE-SEM-EDS (JEOL JSM-7000F + Oxford X-Max 150). Crystal orientation analysis was studied by EBSD (Oxford HKL). Isotope imaging for oxygen was obtained using an isotope microscope (Cameca ims-1270 + SCAPS).

Results and discussion: The chondrule studied here has 1.4 millimeters in diameter and Mg-rich (type I) porphyritic texture mainly composed of forsterite, low-Ca pyroxene and feldspathic mesostasis. The chondrule is surrounded by rim with the thickness of up to 400 micrometers that shows evidences of igneous process.

The rim is mostly dominated by ferromagnesian olivine and also contains low-Ca pyroxene, high-Ca pyroxene, nepheline, Fe-Ni metal and sulfide. The olivins in the rim have two types of compositions: (1) Mg-rich grains that show higher FeO content (about Fa_{12-37}) than olivine in host chondrule and, (2) Fe-rich grains (Fa_{40-50}). The Mg-rich olivine displays Fe-Mg zoning and contains Fe-rich veins [7]. The Fe-rich olivine is located as rim around Mg-rich olivine and along interstitial area between Mg-rich olivine grains. Fe-rich olivine and vein often show crystallographic continuity with the Mg-rich olivine in contact [8].

Seven ^{16}O-rich olivine grains with 10-30 micrometers in diameter were found in the igneous rim. ^{16}O-enrichments are observed in core of Mg-rich olivine crystals and the olivine also has Fe-Mg zoning. The existences of ^{16}O-enrichments does not find in Fe-rich olivine. The oxygen isotope heterogeneity, therefore, survived metamorphism on the parent body [9].

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COOLING SPEEDOMETER FOR CHONDRULES: EUTECTIC STRUCTURE OF METALLIC IRON AND IRON SULFIDE.

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Chondrules are sub-millimeter sized silicate spherules formed by instantaneous heating of solid precursors at the early stage of the solar system evolution [e.g., 1]. Many heating models have been proposed such as nebular shock wave, lightning, X-wind, and asteroidal impacts, but there is not yet a consensus about the formation mechanism of chondrules. In order to constrain the chondrule formation mechanism, it is important to understand the thermal history of chondrules. Dynamic crystallization experiments have shown that chondrules were heated up to 1800–2200 K and cooled at the rate of 10–1000 K/h [e.g., 2]. The absence of fractionation of sulfur isotopes in chondrule sulfides indicates that chondrule precursors were heated at the rate of $>10^4$ K/h [3]. However, there is no tight constraint on the cooling rate of chondrules at lower temperatures (below the solidus of silicates) although it would provide information on formation environments of chondrules.

Chondrules contain opaque phases consisting of metallic Fe-Ni and troilite. The eutectic melt of these phases solidify below their eutectic temperature (988°C for Fe-FeS) with supercooling. The eutectic solidification texture depends on the degree of supercooling, i.e., the cooling rate at or below the eutectic temperature. Therefore the solidification texture of metal-troilite mixture may be used as a cooling speedometer of chondrules below the solidus of silicates.

In this study, we conducted cooling experiments of the Fe-FeS eutectic melt to evaluate the relation of the eutectic texture with the cooling rate. Powders of metallic Fe and FeS with a molar ratio of S/(Fe+S) of 0.46 (slightly S-richer than the eutectic composition) were heated at 1400°C in a sealed evacuated silica glass tube, in which graphite was put as a reducing agent. The mixture was then quenched in water and was ground into particles of 50-300 μm to be used as a starting material. The ground particles were loaded onto silica wool and placed in a silica glass tube with graphite and a mm-sized FeS grain. Large FeS grains were added in the tube to make sulfur-rich vapor conditions that suppressed evaporation of sulfur from the starting material. The silica glass tube was evacuated and sealed under vacuum, and were heated at 1330°C for 3 hours and cooled at different cooling rates (25, 100, 500 K/hr, and quench in air). Run products were observed with a laser microscope and FE-SEM (JEOL JSM7000F) with EDS and electron backscattered diffraction (EBSD).

Metallic iron in the eutectic textures of samples shows differences in morphology and size depending on the cooling rate. The metal grains observed on cross sections of run products are spherical for the samples with controlled cooling rates of 25, 100, and 500 K/h while dendritic or fan-shaped grains are observed for quenched samples. The size distribution of metal grains shows that metal grains cooled at 25 and 100 K/h are typically larger than 1 μm and those cooled at 500 K/h are smaller than 1 μm.

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