Analysis of Highly Siderophile Elements in metal phases from CR chondrite, NWA 801.

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Introduction: Metal is one of the main components of chondritic meteorites and coexist with various meteorite components (i.e., CAI, chondrule, and matrix). Possible models for metal formation in the early Solar System include direct condensation in the protoplanetary disk, condensation during chondrule formation, and chemical reaction on their parent body. Highly siderophile elements (HSEs: Re, Os, Ir, Ru, Pt and Pd) have a great affinity for Fe-metals relative to silicates. HSEs are very refractory and exist as gas only at high temperatures. Therefore, geochemical investigation of HSEs in metal phases in a variety of meteorites can provide an important clue to understanding high temperature processes in the solar nebula.

CR chondrites have a unique characteristics for the high abundances of chondrules (50-60 vol. %) and metal grains (5-8 vol. %). Metal grains are found in three different locations of CR chondrites; chondrule interior ("interior grain"), chondrule surficial shells ("margin grain"), and the matrix ("isolated grain"). Jacquet et al. [1] proposed that the three types of CR metals have formed via melting of precursor materials during chondrule formation [1]. By contrast, Connolly et al. [2] argued that the margin and isolated metals have formed by the recondensation of surrounding vapor. Consequently, the origin of metal phases in CR chondrites is still debated. Here we present HSE analyses for metal phases in the CR chondrite NWA 801 to understand their formation.

Experimental: We prepared a thick section of NWA 801 (0.8 x 1.5 cm) and polished the surface with 1 µm diamond paste. The petrography and the mineral compositions of this section were examined with SEM-EDX (Hitachi 3400; Bruker Xflash5010). We selected two interior (~200 µm), three margin (~1.5 mm), and one isolate (~800 µm) grains, and analyzed the abundances of HSEs and major-minor elements (P, S, Cr, Fe, Co, and Ni) for the multi-spots of these grains using the fs-LA-ICPMS (IFRIT, Cyber Laser) and EPMA (JEOL-JXA-8530F), respectively.

Results and Discussion: The Re/Os ratios in the margin grains have a large variation ranging from 0.03–0.16. Because Re and Os have similar 50% condensation temperatures (Re: 1821 K, Os: 1812 K), this variation cannot be explained by the condensation from a chemically uniform gas. Meanwhile, the Pd/Ir ratios in metal grains decreased rapidly with the increase of Ir concentration (Fig. 1). This trend can be best explained by the mixing of two phases that have high and low Ir concentrations (red curve in Fig. 1); these two phases have formed during the cooling of an initially homogeneous liquid metal. We found a chemical zoning of HSEs except for Pd within an isolate grain (Fig. 2), which is consistent with the growth of Fe-Ni alloy by condensation from a gas metal as suggested by Campbell et al. [3]. Therefore, three types of metal grain in NWA 801 could not have formed from a common precursor or by a single process.

References: [1] Jacquet et al. (2013) MAPS, 48, 1981-1999. [2] Connolly et al. (2001) GCA, 65, 4567-4588. [3] Campbell et al. (2001) GCA, 65, 163-180. [4] Horan et al. (2009) GCA, 73, 6984-6997.

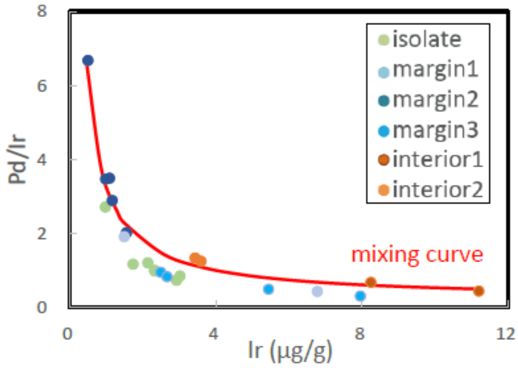

Fig. 1. Plot for Pd/Ir ratio versus Ir abundance in metal grains from NWA 801. Also shown is a mixing curve of two end-member components that have the maximum and minimum Ir concentrations.

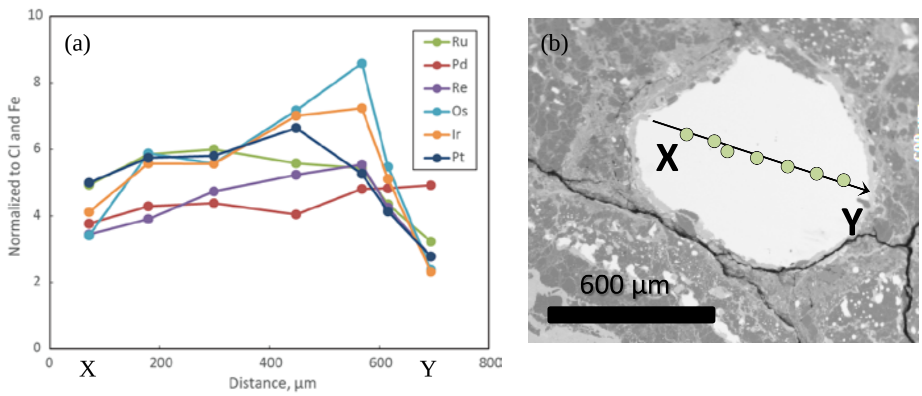

Fig. 2. (a) Line profiles of HSEs across an isolated grain in NWA 801. Data are normalized to CI chondrite abundances [4] and Fe. (b) BSE image of the zoned isolated metal in CR chondrite. Circles are the points analyzed by fs-ICP-MS (spot size = 50 µm).