In-situ analysis of Os isotopes and highly siderophile element concentrations in metal grains from CB chondrites

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Metal plays a key role in physicochemical processes that fractionate siderophile elements from lithophile elements in the early solar system, generating variable chemical reservoirs before the onset of planetesimal formation. Highly siderophile elements (HSEs: Re, Os, Ir, Ru, Pt and Pd) have refractory nature and a great affinity for Fe-metal relative to silicate. Therefore, HSEs in metals in a variety of meteorites can provide an important clue for understanding of high temperature processes in the nebula. Specifically, the ^{187}Re–^{187}Os isotope system yields chronological information regarding the fractionation of HSEs.

We collected metal samples using a micro milling system equipped with a diamond drill bit (Geomill 326, Izumo-web) from three CB chondrites, Bencubbin (CB_a), Gujba (CB_a), and Isheyevo (CB_b). Osmium isotopic composition was measured by N-TIMS. The concentrations of P, S, Cr, Fe, Co, and Ni in analytical spots adjacent to the sampling pits for Os isotope analysis were determined by EPMA (JEOL-JXA-8530F). The concentrations of HSEs in analytical spots adjacent to the sampling pits were analyzed with fs-LA-ICP-MS (IFRIT, Cyber Laser).

Our Re–Os isotope data are mostly plotted on the 4.567 Ga Re–Os reference line with a limited $^{187}Re/^{188}Os$ (0.35-0.40) and $^{187}Os/^{188}Os$ (0.125-0.127) values. The limited Os isotopic variation suggests that the redistribution of Re and Os during metal formation associated with planetary collision was not significant as are the cases of solidification of liquid metal. A positive correlation of Re/Os ratios calculated from the $^{187}Os/^{188}Os$ ratios and Os/Ir for CB_a metal grains suggests that the condensation of metal grains occurred continuously at an equilibrium condition in a cooling gas until the condensation temperature of Ir (~1600 K). Unlike ultra-refractory HSEs, Pd/Fe and Ni/Fe ratios in CB_a and CB_b metals exhibit a strong positive correlation. This positive correlation cannot be explained by nebular condensation but condensation in extremely high gas pressure (10^7 x solar nebula).