

DETERMINATION OF OSMIUM ISOTOPE COMPOSITIONS IN METAL PHASES FROM CB CHONDRITES USING A MICRO SAMPLING TECHNIQUE. N. Nakanishi¹, T. Yokoyama¹, and T. Usui¹.

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Introduction: Metal is one of the important constituents of chondrites. In some chondrites, metal is a significant reservoir of Fe than the silicates and sulfides. Distribution of Fe in meteorites among metal-silicate-sulfide is an important factor to represent the chemical states of their parent bodies. Thus, metal have played a major role in the fractionation of Fe and siderophile elements from Si and lithophile elements, generating different chemical reservoirs in the early solar system. In particular, metal in chondrite has recorded a history of thermal and chemical processing in the solar nebula.

Highly siderophile elements (HSEs: Re, Os, Ir, Ru, Pt and Pd), which have a great affinity for Fe-metal relative to silicate, are very refractory and exist as gas only at high temperature. Therefore, HSEs in metals in a variety of meteorites can provide important clue to understand the high-T processes in nebula, as well as planetary differentiation. Specifically, the ¹⁸⁷Re-¹⁸⁷Os isotope system gives chronological information about HSE fractionation.

The origin of chondritic metal has been extensively studied based on the HSE data obtained by LA-ICPMS [1]. Of all chondrites, CB and CH are a group of very metal rich (60-70 vol. %) and thus are interesting target to be investigated. The CB chondrites are divided into two subgroups (CB_a and CB_b) depending on the metal abundances, chondrule sizes and chemical compositions [2]. The origin of CB metals are debated. Campbell et al. [3] argued that CB_a metals may be the product of an impact plume or other non-nebular event [1], while those in CB_b and CH chondrites are thought to be a condensation product in the solar nebula [4]. However, [5] raised a possibility that the metal in CB_b was formed by condensation in a gas of non-nebular origin, such as an impact plume.

In this study, we present Os isotopic compositions in metal phases from three CB chondrites with a high spatial resolution. Although concentrations of HSEs in chondritic metals have been analyzed using LA-ICPMS in previous studies, in-situ analysis of Os isotopes was not available because of the interference of ¹⁸⁷Re. The ¹⁸⁷Re-¹⁸⁷Os systematics in chondritic metals will provide the chronological information if closed system has been preserved. Even with a recent open system behavior, the time-integrated ¹⁸⁷Os/¹⁸⁸Os ratios give clues to probe the Re-Os fractionation during metal formation. Furthermore, the spot Os isotope

analysis in chondritic metals makes it possible to see the variation of ¹⁸⁷Os/¹⁸⁸Os ratios within a single metal grain as well as among different types of metals coexisted in a single meteorite. Our approach will help to understand the origin of various types of metal phases in chondrites.

Experimental: Metal samples were collected from multiple metal grains in three CB chondrites, Bencubbin (CB_a), Gujba (CB_a), and Isheyevo (CB_b), using a micro milling system equipped with a diamond drill bit (Geomill 326, Izumo, Japan). To evaluate the performance of the sampling technique, we also examined an iron meteorite, Chinga (IVB-an), which is thought to have a homogeneous HSE concentrations and Os isotope ratio. A sliced meteorite specimen (~0.5 mm thickness) was set under the drill bit, and drilling was carried out with a single drop of Milli-Q water, constrained in a lab film, which cools and lubricates the drill bit, and prevents the fine sample dust from being dispersed over the sample surface. The drilled metal powder was recovered in a glass vial together with Milli-Q water. In order to obtain sufficient amount of Os for isotopic analysis using TIMS, one or two conic pits with a radius of 500 μm and depth of 550 μm was dedicated for a single measurement (Fig.1). Some spots G6 were collected from individual single grains in Bencubbin (B1 to B3, B4 and B5; Fig. 1) and Gujba (G1 and G2, G3 and G9, G5 and G6).

The Os isotope ratios and relative abundances of HSE were determined by using the isotope dilution method with TIMS for Os and ICP-MS for the rest of HSEs. The sample was digested using a 2:1 mixture of concentrated HNO₃ and concentrated HCl in a sealed Carius tube that heated at 240 °C overnight. Osmium was separated by solvent extraction into CCl₄ and back-extraction into HBr [6], subsequently purified by the microdistillation technique [7]. Rhenium, Ir, Pt, Ru and Pd were separated using anion exchange resin in nitric and hydrochloric acids. The relative concentrations of P, S, Cr, Fe, Co and Ni were measured by EPMA where analytic spots were adjacent to the sampling pits.

Results and Discussion: The ¹⁸⁷Os/¹⁸⁸Os ratios of Chinga (0.14014 ± 0.00011) is in agreement with that reported in [8] within the analytical error. This confirms the accuracy of our technique. The ¹⁸⁷Os/¹⁸⁸Os ratios in Bencubbin metals have a varia-

tion ranging from 0.1257 to 0.1270 (Fig. 2). The variation is rather small in a single metal grain (e.g., B1-B3, B4-B5). The Ni/Fe ratios in individual sampling spots, measured by EPMA, very approximately 30%, although there seems no correlation with Os isotopes. Abundance ratios of Pt -Ir -Os in these samples are generally in good agreement with a previous study [3]. In contrast, the $^{187}\text{Os}/^{188}\text{Os}$ ratios in Gujba metals seems to be homogeneous (0.1264 \pm 0.0004) except for G4 which has markedly low $^{187}\text{Os}/^{188}\text{Os}$ compared to the other spots (Fig. 2). The $^{187}\text{Os}/^{188}\text{Os}$ ratios in Isheyevo metals can be categorized to two groups: $^{187}\text{Os}/^{188}\text{Os}$ \sim 0.1250 for I-1 and I-2 and $^{187}\text{Os}/^{188}\text{Os}$ \sim 0.1265 for I-3 and I-4, although the average of four points do not match the $^{187}\text{Os}/^{188}\text{Os}$ ratio in bulk HaH 237 (CB_b) reported in [9].

All the $^{187}\text{Os}/^{188}\text{Os}$ ratios of CB metals obtained in this study fall within the range of bulk carbonaceous chondrites (0.1251-0.1273) excluding Karoonda (CK) which has an exceptionally low value [9]. Interestingly, the majority of CB metals have $^{187}\text{Os}/^{188}\text{Os}$ ratios close to the bulk CI chondrite (0.1264-0.1265), while the rests have lower values. Because $^{187}\text{Os}/^{188}\text{Os}$ variations in CB metals reflects the variation of Re/Os in individual grains at the time of their formation, Os isotopic deviation from the CI value would suggest Re-Os fractionation from a putative bulk nebula composition, most likely in a hot nebula. As discussed in Walker et al. [9], early removal of a high-temperature condensate may have generated a reservoir with Re/Os less than CI, assuming that Re has been preferentially incorporated into high temperature condensates relative to Os. If this is the case, CB metals with sub-CI $^{187}\text{Os}/^{188}\text{Os}$ ratios would be products that formed after a certain magnitude of Re-Os fractionation in the nebula. Alternatively, if much lower temperature process, such as oxidation and subsequent volatilization of metals, are responsible for the observed variation, some processes that produce the nearly uniform Re/Os ratios must be needed to reconcile with the observed $^{187}\text{Os}/^{188}\text{Os}$ variation in CB metals.

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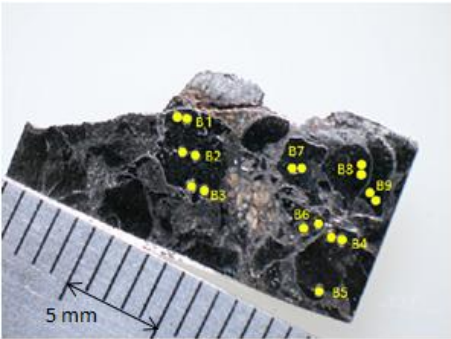


Fig. 1 Image of Bencubbin. Micro sampling spots presented as yellow circles

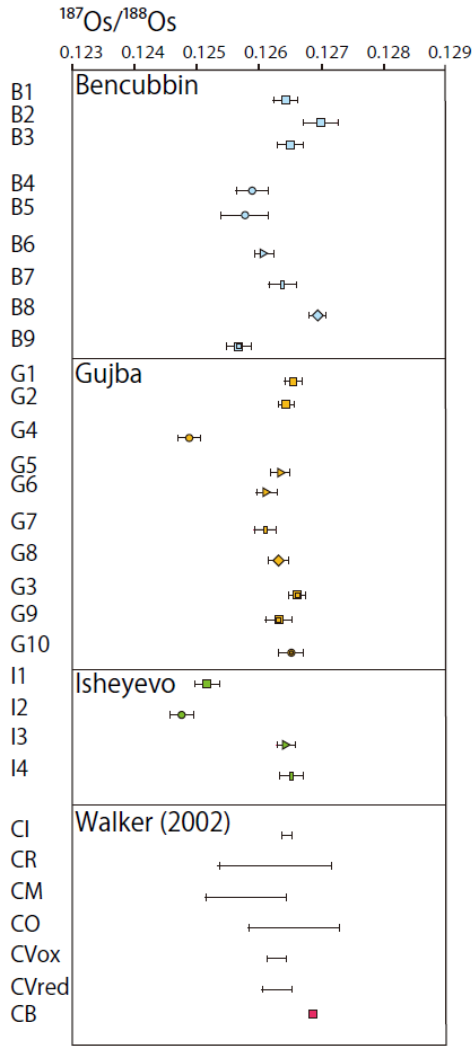


Fig.2 Osmium isotope data from metal in CB chondrites obtained in this study. Those for bulk carbonaceous chondrites [9] represent the range of multiple analyses of individual chondrite groups.