Metallic partial melting processes on the acapulcoite-lodranite parent body. Y. Hidaka[1], A. Yamaguchi[2, 3], N. Shirai[1], and M. Ebihara[1], [1]Department of chemistry, Tokyo Metropolitan University, Tokyo, Japan, [2]National Institute of Polar Research, Tachikawa, Tokyo, Japan, [3]Department of Polar Science, School of Multidisciplinary Science, Graduate University for Advanced Sciences, Tokyo, Japan.

Introduction:

Metallic partial melting process is the first step of differentiation of the early solar system bodies. To understand this process is important for revealing the evolutionary histories of solar system bodies. As metallic partial melting of chondritic materials, FeNi-FeS eutectic melting is considered to take place at ~980 ºC [1]. Most of primitive achondrites, acapulcoites and lodranites, show the depletion of troilite [2, 3]. These results were interpreted as the evidences of FeNi-FeS eutectic melting on the acapulcoite-lodranite parent body. In bulk chemical composition, depletion of Se is interpreted as the result of FeNi-FeS eutectic melting [4, 5]. To discuss the nature of metallic partial melting processes, metal composition will become powerful tool. However, metal compositions of acapulcoite-lodranites have not been reported yet. Therefore, here we will report metal compositions of acapulcoite-lodranites to investigate the metallic partial melting processes on their parent body.

Samples and methods:

We have determined siderophile and chalcophile element abundances of 4 acapulcoites (MET 01195/01198/01244 paired meteorites and Y-981505) and 2 lodranites (Y-791491 and Y-981725). Several chips weighing 200-300 mg of each meteorite were ground into powder in an agate mortar and sample powders were magnetically separated into magnetic fractions and non-magnetic fractions. Magnetic fractions are dominated by Fe,Ni metals. These magnetic fractions were digested in mixed acid (HF, $HClO_4$ and HNO_3) and assayed to ICP-MS measurement. We could determine the elemental abundances of Fe, Co, Ni, Cu, Ga, Mo, Rh, Pd, Sn, Sb, W, Re, Ir and Pt.

Results and Discussion:

In Fig. 1, elemental compositions of metals in acapulcoites and lodranites are shown. These data are normalized to Ni abundances and CI chondrite values. CI chondrite values are referred from [6]. All of acapulcoite-lodranite metals have the common features that Cu, Sn and Sb are depleted and Co and Pd are rich relative to CI chondrites. Metal compositions of acapulcoites and lodranites are mostly similar with each other, however, highly siderophile element (Rh, W, Re, Ir and Pt) compositions are widely scattered (Fig. 1). Highly siderophile element abundances of a lodranite Y-981725 are similar to those of acapulcoites MET01195/1198/01244. Lithophile element abundances of Y-981725 show the similarity to those of acapulcoites [7]. From a chemical viewpoint, Y-981725 is better to be reclassified as an acapulcoite. Then, the abundances of highly siderophile elements seem to increase from acapulcoite metals to lodranite (Y-791491) metal. Generally, lodranites are considered to have suffered higher degrees of partial melting processes than acapulcoites [8]. Therefore, our results can be interpreted as that partial melting degrees are positively correlated with the increases of highly siderophile element abundances of metals among acapulcoites and lodranites. Metal in an acapulcoite Y-981505 is depleted in Re, Ir and Pt, and shows complementary chemical compositions to those of other acapulcoites and lodranites (Fig. 1). Metal in Y-981505 may represent different component comparing with those of other acapulcoite-lodranites.

We assume that compositional variations among metals in acapulcoite-lodranites are due to the effects of partial melting processes. We calculated chemical compositions of metallic partial melt liquid and residue. In our previous study [7, 9], we found that chemical composition of non-magnetic fractions and magnetic fractions of acapulcoites are similar to those of EL chondrites. From these evidences, we used EL chondrite compositions as the precursor materials of acapulcoite-lodranites in this calculation. We considered FeNi-FeS eutectic partial melting system and Fe-Ni-C partial melting system. Partition coefficients of siderophile and chalcophile elements are according to [10, 11, 12].

EL chondrite-normalized elemental ratios of acapulcoite-lodranite metals, EL chondrite metals [13] and the results of partial melting calculations are shown in Fig. 2. EL chondrite-normalized Pt/Ni vs. Ir/Ni of acapulcoite-lodranite metals show the similarity to those of FeNi-FeS eutectic partial melting calculations and Fe-Ni-C partial melting calculations (Fig. 2a). EL chondrite-normalized Ir/Ni vs. W/Re of acapulcoite-lodranite metals show the similarity to FeNi-FeS eutectic partial melting calculations (Fig. 2b). In this case, chemical compositions of Fe-Ni-C partial melting calculation are not similar to those of acapulcoite-lodranite metals. Therefore, chemically we suggest that metallic partial melting processes on the acapulcoite-lodranite parent body are FeNi-FeS eutectic partial melting processes. From the comparison of measured values with calculated values, we confirm that Y-791491 and Y-981505 metals represent the metallic partial melt residue and the metallic partial melt liquid, respectively.

In Fig. 2, Fe-Ni-C partial melting system can't explain chemical compositions of metals in acapulcoite-lodranite. This indicates that carbons were not related to metallic partial melting processes on acapulcoite-lodranite parent body. Such results may be supported by [14]. They suggested that carbons in acapulcoite-lodranites had exogenous origin and were introduced in their parent body by a late impact with a chondritic body. Although we don't know whether carbons were initially abundant in acapulcoite-lodranite parent body or not, this scenario seems to be consistent with our results.

Summary:

From this work, chemically we demonstrated that metal compositions of acapulcoite-lodranites could be explained by FeNi-FeS eutectic partial melting processes of metals in EL chondrites and that carbon might not related to the first stage differentiation of acapulcoite-lodranite parent body.

References:

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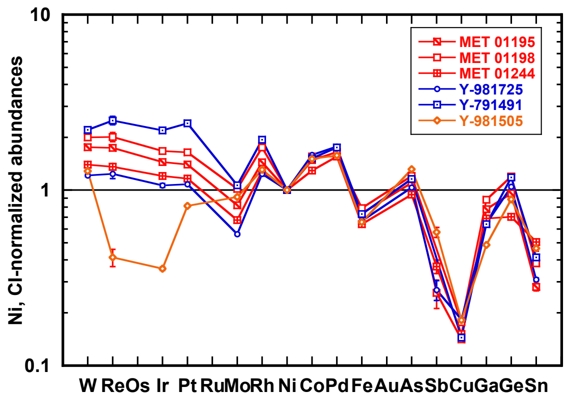

Fig. 1. Ni, CI-normalized siderophile and chalcophile element abundances of some primitive achondrites.

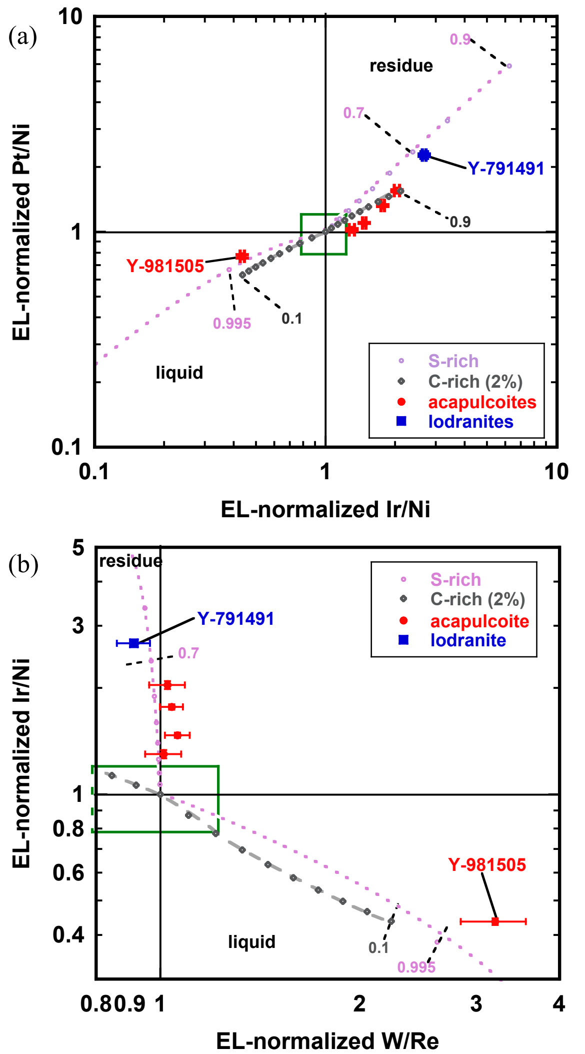

Fig. 2. (a) EL chondrite-normalized Pt/Ni vs. EL-normalized Ir/Ni. (b) EL chondrite-normalized Ir/Ni vs. EL-normalized W/Re. Filled circles and square show acapulcoites and a lodranite, respectively. A box shows EL chondrite composition. Dotted line shows FeNi-FeS eutectic partial melting process, and dashed line shows of Fe-Ni-C partial melting process. The numbers shown in Figs indicate degrees of individual metallic partial melting processes.