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Partitioning of Re and Os between Liquid Metal and Magnesiowüstite at High Pressure

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The partitioning of highly siderophile elements (HSE) between metal and silicates/oxides is important for constraining details of Earth's accretion and core segregation processes. In recent years, experimental studies have been performed of the partitioning of HSE (Pt, Pd, Rh, Re, Ir, Os) between solid metal and silicate melt at 1 atm and between liquid metal and silicate melt at high pressure. Results of most of these studies indicate that metal-silicate partition coefficients for HSE are too high (e.g. 106 for Rh to 1012 for Ir) to be reconciled with single-stage core formation under equilibrium conditions, at least at low pressure. Because metal segregation would likely reduce the concentrations of HSE in the mantle to levels greatly below observed concentrations, the "late veneer" hypothesis, involving the late addition of siderophile elements during accretion, has been invoked. However, most HSE studies to date have been performed on silicate liquid and the effects of crystalline phases on metal-silicate partitioning are poorly known both at upper and lower mantle conditions. In order to obtain preliminary results relevant to metal segregation in the lower mantle, we have therefore investigated the partitioning of Os and Re between magnesiowüstite and liquid Fe-Ni-rich metal at 10 GPa, 1900-2200 C and oxygen fugacities ~1 log bar unit below the iron-wüstite buffer (IW-1).

Multianvil experiments were performed on samples of Fe-Ni-Os-Re-O metal (4-8wt% Os and 4-12wt% Re) contained in MgO capsules. Experimental run durations were 6-30 minutes. During the experiments, the MgO reacted with the liquid metal to form magnesiowüstite. Major elements in the quenched liquid metal and magnesiowüstite were analyzed by electron microprobe. The measurement of Fe, Mg and Ni concentration profiles in the magnesiowüstite adjacent to the metal enabled the composition of the oxide in equilibrium with the metal to be determined. The concentrations of Re and Os in the magnesiowüstite were determined by LA-ICP-MS using a 40µm spot size and a new Re-Os-bearing silicate glass standard (Fortenfant et al., in preparation). Initial experiments were performed with polycrystalline MgO capsules. However, due to penetration of metal along the grain boundaries, analysis of Os and Re in the magnesiowüstite by LA-ICP-MS was not possible without serious contamination by metal. Therefore, in subsequent experiments, capsules fabricated from MgO single crystals were used, which largely overcomes the above problem. The reproducibility of the Re and Os analyses by LA-ICP-MS demonstrates that the analyses were not contaminated by metal.

Os and Re metal-magnesiowüstite partition coefficients deduced from these experiments are 105 and 103 respectively at 10GPa, 2200ºC and IW-1. Compared with metal-silicate melt partition coefficients obtained at one atm and 1300 -1350ºC - 107 for Os (Fortenfant et al., in preparation) and $6x10^6$ for Re (Ertel et al., in preparation) - these values are low. Although they are not sufficiently low to eliminate the need for the "late veneer" hypothesis, the effects of higher pressures and temperatures as well as other mantle minerals on partitioning (e.g. silicate perovskite) have yet to be investigated.