INVESTIGATING PERCOLATIVE PROPERTIES OF COMPLEX METALLIC LIQUID IN A MANTLE SILICATE MATRIX USING A PLATINUM TRACER. Y. Fei[1], K. Prissel[2], L. Wang[3], M. Mouser[1]. [1]Earth and Planets Laboratory, Carnegie Institution for Science, Washington D.C. 20015. [2]Jacobs, NASA Johnson Space Center, Houston, TX. [3]Bayerisches Geoinstitut, University Bayreuth, Germany. (yfei@carnegiescience.edu)

Introduction: Planetary core forms through metal-silicate differentiation and its composition would be strongly influenced by the physical processes of liquid metal separation from the surrounding silicate materials. The liquid metal could separate from silicate matrix when silicate is at solid state, partially molten, or completely molten. For planetary bodies that only reach the melting temperature of metal core, but below the melting temperature of silicate, percolative core formation is the main mechanism for metal-silicate separation [1]. We have investigated the percolative properties of liquid metal in silicate matrix by measurements of the dihedral angle of the recovered samples, including Fe-C or Fe-S-C liquid percolation in San Carlos olivine-pyroxene matrix [2], Fe-Ni-Si-S-C liquid percolation in San Carlos olivine matrix [3], and Fe-S liquid percolation in a partially molten mantle silicate [4]. Recently, we have developed a method to track metallic network in a silicate matrix using a platinum (Pt) tracer [5,6]. The method has been successfully used to examine stress-induced percolative core formation through a bridgmanite matrix [6].

In this study, we continue to examine the percolative properties of liquid metal under different core formation scenarios. Using the newly developed tracer method, we investigate complex systems by tracking the melt network and determine the connectivity threshold. The emphasis is to link the early differentiation process under different thermal evolution scenarios to the final chemical composition of the planetary core by understanding the physical process of the metal-silicate separation and determining element partitioning between metal and silicate in a range of temperature domains for different sizes of bodies.

Methods: We conducted percolation/partitioning experiments up to 6 GPa in the temperature range of 1200-1700˚C. All experiments below 3 GPa were carried out in the piston-cylinder apparatus whereas the percolation experiments up to 6 GPa were performed in the multi-anvil press using an 18/11 cell assembly (18-mm octahedron edge length and 11-mm truncated edge length of tungsten carbide). Typical run time ranges from 6 to 48 hours depending on the targeted temperatures. The silicate matrix is a synthetic peridotite (KLB-1) which consists of olivine, pyroxenes, and spinel/garnet [7]. The KLB-1 peridotite sample was synthesized by sintering a pre-conditioned mixture of oxides in an Au capsule and ¾" talc-Pyrex assembly at 1 GPa and 1000°C for 24 hours. The metal mixture was prepared from Fe, Ni, C, Fe-Si alloy, and FeS powders. Three metal proportions were prepared (4 vol.%, 10 vol.% and 18 vol.%) to investigate the percolation threshold, and metal-silicate mixtures were ground under ethanol for 30 minutes. Using the Pt-tracer method to determine percolation threshold in the mantle silicate matrix, we loaded three starting materials with different metal/silicate ratios in the single experiment to efficiently track the threshold under identical P-T conditions. Recovered experimental charges were imaged with high-resolution field-emission SEM and analyzed with a JEOL JXA-8530F electron microprobe.

Results and discussion: The experiments are aimed to simulate real planetary interior conditions. Experiments include Fe-Ni-Si-S-C-O liquid percolation in a peridotitic mantle consisting of major mantle minerals. Typically, the measurements of the dihedral angle are used to assess the extent of metal melt connectivity. This becomes less meaningful when multiple minerals coexist in the silicate matrix. We observed broadening of the apparent dihedral angle distribution attributed to variable interfacial energies of the interfaces involving multiple phases. Using tracer Pt migration as an indicator of melt interconnection, we directly determined whether metallic melt networks formed during the experiment by mapping the Pt distribution in the sample. Compared to the conventional methods, this method can conclusively demonstrate melt connectivity.

The Pt-tracer method is also a powerful tool for determining the minimum percolation threshold by varying the metal/silicate ratios of the starting materials. A percolation threshold between 4 and 8 vol.% is generally consistent with results from other methods such as electrical conductivity measurements and X-ray tomography, but its precision can be significantly improved by using refined initial metal/silicate ratios. Our experiments conducted so far provide not only the percolation pathway and minimum threshold, but also element partitioning between metal and silicate which is critical to assess chemical evolution associated with physical processes of metal-silicate separation.

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