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Experimental determination of highly siderophile element diffusivities in silicate melt: Implications for core formation

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Constraining core formation and evolution is an important goal in Earth and planetary sciences, as the segregation of the metallic core had a large impact on the composition of the remaining bulk silicate Earth. The highly siderophile elements (HSEs; the platinum group metals plus Re and Au) are sensitive tracers of core formation due to their extreme preference for iron metal over silicate phases. However, while experimentally determined HSE partition coefficients predict that core formation should effectively remove most HSEs from the silicate Earth, primitive upper mantle (PUM) estimates for the HSEs show these elements are only modestly depleted relative to chondrites[1]. Although this problem is often explained by the addition of chondritic material to Earth after the majority of core formation has occurred[2], the relative contributions of metal-silicate equilibrium and this "late veneer" remain debated.

Interpreting PUM HSE abundances with partition coefficients assumes chemical equilibrium between silicate melt and metal during core formation, however, geochemical and geophysical models indicate this equilibrium was likely not complete[3,4]. In this case, the diffusivities of HSEs in silicate melt may exert an important control on the degree of metal-silicate equilibration that is achieved. Due to a paucity of experimental HSE diffusion data for silicate melts, we have begun piston-cylinder experiments to measure these values. HSEs are well known to form dispersed metal inclusions in reducing silicate melts that complicate LA-ICPMS analyses. To overcome this problem, we are employing methods previously used in HSE solubility experiments to suppress inclusion formation. Preliminary experiments for Ir show clear diffusion profiles, and additional experiments for Re are currently underway. Results to date represent the first measurements of HSE diffusivity in silicate melts at high P-T and under reducing (~IW+0.3) conditions. Our newly determined diffusivities will be coupled with geophysical models of metal-silicate segregation to evaluate the role of diffusion in modulating metal-silicate exchange during core formation.

References

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