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Revising the "Excess Siderophile Element Problem" through metal–silicate partitioning at core formation conditions

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Defined by their much stronger affinity for iron than for silicate, the highly siderophile elements (HSEs) are key tracers of planetary differentiation and are used to constrain the mass and nature of Earth's late accretion. However, a dichotomy exists between the observed relatively high HSE abundances in the bulk silicate Earth (BSE) and the predicted lower HSE abundances derived from metal–silicate partitioning experiments, known as the "excess siderophile element problem." Despite the importance of their partitioning behaviors at the extreme pressures (P) and temperatures (T) of Earth's core formation, the HSEs are predominantly defined by their partitioning behaviors at less than 20 GPa and 2800 K [e.g., 1]. Recently, it has been suggested that the HSEs may become less siderophile at higher P–T, resulting in increased HSE concentrations in the silicate [2]. To test this, we performed a suite of laser-heated diamond anvil cell experiments on three HSEs—Pt, Ru, and Rh—at 40–80 GPa and 4,000–5,000 K. Our results confirm dramatic partition coefficient reductions of up to three orders of magnitude for each element. When incorporated with lower P–T literature data into a multi-stage core formation model, our updated partitioning parameterizations can match the observed BSE Ru but tend to significantly exceed the BSE Rh and Pt abundances, potentially replacing the "excess siderophile element problem" with a new "insufficient siderophile element problem" for the BSE.

[1] Mann, Frost, Rubie, Becker & Audédat (2012), *Geochimica et Cosmochimica Acta* 84, 593–613.

[2] Suer, Siebert, Remusat, Da, Borensztajn, Doisneau & Fiquet (2021), *Nature Communications* 12, 2913.

