Chemical exchange between core-forming metal and magma ocean in the early differentiating Earth

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The differentiation of the Earth into its metallic core and silicate mantle and crust was among the most profound events shaping the planet in its early history, and the geochemical consequences of this event remain today, recorded in the composition of minor and trace elements in the core and mantle. Inferences can be made on the nature of the physical and chemical aspects of planetary differentiation by experimentally investigating metal-silicate partitioning of these elements under the range of thermodynamic conditions that are appropriate to the core-forming event. We report metal silicate partitioning of several key elements at high pressure, high temperature conditions. The experiments were performed using laser heated diamond anvil cells, and the samples were recovered and analyzed using focused ion beam / high resolution electron microscopy (FIB/SEM). Heat producing elements such as uranium partition into the metallic melt at high P,T conditions to a higher degree than previously observed, but still only produce <2 TW of heat in the core 4.5 Gyr ago. Partitioning of tungsten, a moderately siderophile element, places additional constraints on the range of P,T conditions that best describe the trace element composition of the modern mantle. Light lithophile elements including magnesium can dissolve into a metallic core-forming melt at sufficiently high temperature, and their exsolution can contribute to buoyant energy release as the early core cooled. These observations contribute to models of the early thermal and chemical evolution of the Earth's deep interior.

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