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Metal-silicate partitioning of lithophile elements and implications for potassium and light elements in the core

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The partitioning of lithophile elements (K, O, Si, Mg, Al, and Ca) between liquid metal and silicate melt were investigated up to 138 GPa and 5450 K in S-free/S-bearing Fe + K-doped pyrolite system, in order to constrain the amounts of radioactive 40K and other light elements in the core. The obtained iron-potassium exchange coefficients show strong temperature (T) dependence but negligible effects of pressure (P) and sulfur content, not supporting the transition-metal-like behavior of potassium at high pressure. As a consequence, present experiments suggest only ~10 ppm potassium in the core, which yields present-day heat production of ~0.1 TW, even when we assume the entire core-mantle chemical equilibrium at 136 GPa and 5300 K (liquidus of pyrolitic mantle). On the other hand, the core dissolves substantial amounts of silicon and oxygen as a consequence of reaction with a basal magma ocean at 4500-5000 K, which account for the 10% core density deficit. In addition, quenched liquid iron obtained in relatively high-temperature experiments included certain amounts of Mg, Al, and Ca, suggesting that these elements may have been once incorporated into the core at the time of giant impact. A more realistic model for the Earths core must consider the combined effects of material that equilibrated at modest P-T with the material that was added at very high P-T, and the effect of latter components are focused in this study.

Keywords: metal-silicate partitioning, high pressure, core formation, magma ocean, potassium, light elements