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Potassium solubility into the Earth's core at the base of the magma ocean -Implication for the heat source of the core

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Since the densities of the Earth's inner/outer cores are smaller than pure iron at the core conditions, the core has been thought to include light elements, such as H, C, S, O, Si (e.g., Poirier, 1994). Although the light element(s) in the core has not been decided yet, high-pressure experiments and cosmochemical estimations suggested that Si and O are plausible light elements. The energy causing the geodynamo is derived from the accretion energy at the early stage of the Earth, the latent heat of crystallization of the inner core, the gravitation energy associated with the exclusion of light materials from the inner core, and the radioactive decay of radioactive elements which are potentially present in the core. The Earth's core might contain long-lived radioactive elements such as U, Th, and K. In particular, potassium (K) is more depleted in the mantle than other volatile elements. Thus, potassium may be included in the core. In order to verify the amount of potassium in the core, we have performed potassium partitioning experiments under high pressure and temperature.

We studied partitioning of potassium between aluminosilicate (adularia, $KAlSi_3O_8$) and metal containing oxygen and silicon, and partitioning of potassium without light elements (Fe-O, Fe-Si, pure Fe) at pressures up to 50 GPa and 3500 K using a double-sided laser-heated diamond anvil cell. Our results for the pressure, temperature, and compositional effects on the partitioning coefficient of potassium, D_K (i.e., the content of potassium in metal [wt%] divided by the content of potassium in silicate [wt%]), reveal that the temperature effect is slightly positive but weaker than that reported previously, whereas the pressure effect is negative and oxygen in metal increases the potassium content in metal, although silicon in metal has the opposite effect. According to the effects on potassium partitioning, we estimated that the amount of potassium in the core is less than 32 ppm and that it generates less than 0.14 TW heat in the core. This amount of heat is small compared with the heat flux at the core-mantle boundary (5-15 TW).

Keywords: Potassium, magma ocean, high pressure, high temperature, Earth's core