Experimental investigation of Na, Cs and Rb distribution between planetary core and mantle

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Earth's mantle is depleted in moderately volatile elements such as alkali elements (Na, K, Rb and Cs) relative to chondrites, suggesting an accretion of volatile-depleted material or loss of volatile elements during Earth's accretion. Mars being more enriched in volatile elements than the Earth suggests that the protoplanetary disk could be chemically zoned with higher concentrations of volatile elements at high heliocentric distances. However, elevated concentrations of volatile elements (S, K, Na, C, Cl) were measured on Mercury's surface. Here we investigate whether volatile alkali elements, such as Na, Cs and Rb, were sequestered in planetary cores during their differentiation, in order to retrieve bulk planetary abundances.

We conducted experiments to determine partitioning of Na, Rb and Cs among silicate, sulfide and metal at high pressure and temperature using multi-anvil press and piston cylinder apparatus. We found a weak effect of pressure and temperature up to 5 GPa and 1900˚C. Rb is more lithophile than Na and Cs. Our results combined with a previous study [1] show that sulfur and oxygen enhance alkali partitioning into metals and sulfides. These effects are in agreement with previous results on K partitioning [e.g. 2]. Our results have important implications for the distribution of volatile elements within planetary interiors during accretion and differentiation of terrestrial planets. The relatively high partition coefficients (0.3 to 0.5) indicate that the accreted alkali elements could be incorporated into a sulfide phase if it enriched in O. Immiscibility in Fe-S-Si and Fe-S-O systems suggests that S-rich planetary embryos could have contained a sulfide layer between core and mantle, which might have acted as an important geochemical reservoir for alkali elements.

[1] Mills et al. (2007), GCA 71, 4066-4081 ; [2] Corgne et al. (2007), EPSL, 256, 567-576.