Potassium as a heat source in the core? Metal-Silicate partitioning of K and other alkali metals

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The alkali metals (Li, Na, K, Rb, and Cs) are depleted to varying degrees in the Earth's upper mantle. This is generally assumed to be due to volatility of these elements during accretion of the Earth. However, it is also often argued that some amount of K may have partitioned into the core and act as an additional heat source for the core dynamo. If K could partition into the core, it is not unreasonable to assume that the other alkali metals might also do so. Therefore, we have begun an experimental study of the partitioning of K and the other alkali metals between metals and silicates at lower mantle conditions using the laser-heated diamond anvil cell.

Our samples consisted of either pure Fe-metal or an Fe-S mix containing 10 wt. % S surrounded by either a K-silicate glass, a (Li, Na, K, Rb, Cs)-silicate glass, or a mixture of a (Na, K, Rb, Cs)-silicate glass and San Carlos olivine and overlain by an Al_2O_3 disk (to act as an optical window and to insulate the sample from the diamond). Pressures for the runs ranged from 23 to 110 GPa, and the temperatures for each sample were above the melting point of Fe for that pressure. Samples were recovered, polished and analyzed with the electron microprobe.

Experiments with pure Fe-metal and K-silicate glass in the pressure range 38-77 GPa showed no pressure dependence for the partitioning of K into metal. They also implied a maximum of 5 ppm K in the core.

Results from the experiments with the alkali-silicate glass or alkali–silicate glass mixed with olivine and Fe or Fe-S mix suggest that all the alkalis partition more readily into a sulfide than pure metal, and we found the general trend that $D_{MET/SIL}$ for Na > K ≥ Cs > Rb. However, under all conditions all the alkalis remained distinctly lithophile, and even at 110 GPa and 3200 K with 5 wt. % S and 1.5 wt. % O in the metal, the results suggest no more than 10 ppm K in the Earth' core. Thus, K could only be responible for less than 1% of the core's heat budget.

Helium isotope studies in seismically-active regions of Turkey and California

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He isotopes in groundwaters and geothermal fluids are sensitive indicators of crustal-mantle interaction. Here, we present new He isotope (and associated carbon) data from two of the world's great fault systems - the North Anatolian Fault Zone, Turkey (NAFZ) and the San Andreas Fault, California (SAF) - to further utilize He isotopes in regions of crustal unrest.

Following the catastrophic earthquakes in 1999, we initiated a periodic monitoring program (4 times/yr for 3 yrs) targeting geothermal fluids at 9 localities along an 800-km stretch of the NAFZ. $^3He/^4He$ ratios vary between 0.29 R_A (Yalova, Gozlek) and 2.2 R_A (Mudurnu) (R_A – air $^3He/^4He$) indicating a magmatic He contribution throughout. There were no large earthquakes over the monitoring period and little variation in $^3He/^4He$ values at individual localities. However, there are significant changes in the $CO_2/^3He$ ratio and especially $\delta^{13}C$. We discuss these changes with respect to the regional stress pattern in Turkey.

Mantle-derived He is also pervasive in the vicinity of the SAF: $^3He/^4He$ reaches 0.11 R_A (Mojave River Basin); 0.26R_A (East Morongo Basin) and 3.4 R_A (Monterey Bay). The whole region adjacent to the SAF is therefore leaking mantle-derived He to the surface albeit heavily diluted with crustal He. At Monterey Bay, cold seep fluids collected in long Cu-coils preserve temporal variability in He isotopes. This technique has enormous potential in future monitoring studies of earthquake-prone regions as it produces a continuous record of He isotope and gas chemistry variations.