Partioning of water between peridotite minerals and basaltic magma has a significant influence on the initiation of melting in the mantle and on the rheological structure of the lithosphere. To investigate mineral/melt and mineral/mineral partitioning of $H_2O$ applicable to the mantle, we have conducted multiple saturation experiments consisting of hydrous basalt+ol+opx+cpx in a piston-cylinder apparatus at pressures of 1-2 GPa, temperatures of 1230-1300°C and bulk initial water contents of 4 to 6 wt.%. Minerals are similar in composition to those expected in spinel peridotite. We measured $H_2O$ in melts and minerals (ol, opx, cpx) by SIMS using methods described by [1].

Resulting liquids have 3.6-10 wt.% $H_2O$ and average mineral/melt partition coefficients as follows: $D_{ol-melt}=0.0012±0.0003$ (n=10), $D_{opx-melt}=0.014±0.006$ (n=9), and $D_{cpx-melt}=0.018±0.008$ (n=3). Mineral/mineral partition coefficients are $D_{ol-opx}=0.10±0.03$ (n=6), $D_{opx-cpx}=0.08±0.02$ (n=3) and $D_{cpx-opx}=1.3±0.1$ (n=2). Observed partition coefficients are reproducible between experiments and systematic variations with pressure, temperature or concentration of $H_2O$ are not apparent, possibly because of the relatively small range of pressures and compositions examined. For a peridotite consisting of 58% ol, 30% opx, 10% cpx, and 2% spinel (assumed nominally anhydrous) the calculated bulk sol-liq $D$ is 0.007±0.002 confirming that water is highly incompatible in mantle minerals.

Compared to conventional trace elements, water has a behavior between that of $La$ and $Ce$, in accordance with studies on natural basaltic glasses (e.g. [2]). If this bulk $D$ is applicable to the deeper parts of the MORB melting regime, then following [3], we can estimate the effect of $H_2O$ on peridotite partial melting: for a water concentration of the source of 200 ppm, the near-solidus melt would contain 2.9 wt. % water. For a $\Delta H_{fusion}$ of 50 kJ/mol, the freezing point depression is $\sim 40°C$, which corresponds to initiation of melting 15 km deeper than the anhydrous solidus, somewhat less than previous estimates ($\sim 50$ km, [4]).

References