Experiments on OH-F-Cl exchange partitioning between biotite and silicate melt and calibration of compositional effects

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Partitioning of hydroxyl (OH), fluorine (F) and chlorine (Cl) between biotite and silicate melt has been experimentally investigated under H_2O-saturated conditions at 100–500 MPa and 850–975 °C using an internally heated pressure vessel. A variety of starting glasses was used, covering basalt, trachyandesite, trachyte, tephriphonolite and dacite, in order to investigate the compositional effects of both melt and biotite on the partitioning behaviors. Biotite and silicate melt (quenched as glass) in fifty-one successful experimental runs were measured using electron microprobe analyis for their major element contents and F and Cl concentrations. F concentrations in biotite and silicate melt are ranging within 0.2–8.2 wt% and 0.1–4.8 wt%, respectively, and partition coefficient $D_{\mathrm{F}}^{\mathrm{Bt-melt}}$ are between 1.5 and 10. Compared to F, Cl concentrations in both biotite and silicate melt are much lower and ranging within 0–0.15 wt% and 0–1.3 wt%, respectively, resulting in $D_{\mathrm{Cl}}^{\mathrm{Bt-melt}}$ within 0.02–0.4. Depending on the nature of exchange partitioning of OH-F-Cl between biotite and hydrous silicate melt, the exchange partitioning coefficient $Kd_{\mathrm{F/OH}}^{\mathrm{Bt-melt}}$ varies within 3–50. $Kd_{\mathrm{Cl/OH}}^{\mathrm{Bt-melt}}$ is much lower and varies within 0.03–0.5, showing that the compatibility of volatiles in biotite is decreasing strongly from F to OH and to Cl. The experimental data demonstrate that biotite composition and silicate melt composition are important factors controlling the OH-F-Cl the partitioning between biotite and silicate melt. Temperature has a positive but weak effect on both $Kd_{\mathrm{F/OH}}^{\mathrm{Bt-melt}}$ and $Kd_{\mathrm{Cl/OH}}^{\mathrm{Bt-melt}}$. The effect of pressure is negligible.

The experimental data reveals that, given other conditions being equal, phlogopite component ($X_{\mathrm{Mg}}^{\mathrm{Bt}}$) of biotite favors the incorporation of both F and Cl in biotite with respect to silicate melt. $Kd_{\mathrm{F/OH}}^{\mathrm{Bt-melt}}$ tends to increase if melt ASI is close to 1, reflecting the strong effect of melt ASI on the solubility of F in melt. Melt composition exerts a strong effect on $Kd_{\mathrm{Cl/OH}}^{\mathrm{Bt-melt}}$ and the highest values are obtained for melts with the highest Cl solubility.