Experimental determination of barium partitioning and isotope fractionation between aqueous fluid and silicate melt

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Fluid exsolution from magmas is a common phenomenon in igneous processes and plays an important role in many geological processes, e.g., the formation of granitoids and magmatic hydrothermal ore deposits. Partition coefficient ($D_{FLUID–MELT} = C_{FLUID}/C_{MELT}$) and isotope fractionation factor ($\Delta^{138/134}Ba_{FLUID–MELT} = \delta^{138/134}Ba_{FLUID} - \delta^{138/134}Ba_{MELT}$) of Ba between fluid and melt are the key for understanding Ba isotope systematics of granitoids and applying Ba isotopes to trace fluid activity in magmatic hydrothermal processes.

We experimentally determined the $D_{FLUID–MELT}$ and $\Delta^{138/134}Ba_{FLUID–MELT}$ between aqueous fluids and silicate melts at 700–900 °C and 200 MPa using cold-seal pressure vessels. The results show that $D_{FLUID–MELT}$ ranges from 0.02 to 0.20 and it is correlated to temperature, the fluid salinity, and melt alumina saturation index (ASI). $\Delta^{138/134}Ba_{FLUID–MELT}$ ranges from -0.62 to -0.15‰, indicating that the fluid is isotopically lighter than the melt in equilibrium. The $\Delta^{138/134}Ba_{FLUID–MELT}$ is also correlated to temperature, the fluid salinity, and ASI.

Our experimental results demonstrate that, due to the low $D_{FLUID–MELT}$ (0.02–0.20), fluid exsolution from granitic melt will not significantly affect the Ba isotopic composition of the residual melt, which is consistent with the prediction from the Ba isotopic data of I-type granites [1]. However, the light Ba isotopic feature in aqueous fluid relative to coexisting silicate melt ($\Delta^{138/134}Ba_{FLUID–MELT}$ of -0.62 to -0.15‰) implies that magmatic hydrothermal fluid may preferentially transfer light Ba isotopes into the hydrosphere, which should be taken into account in global budget of Ba isotopes. Based on the measured isotope fractionation between fluid and melt, the Ba isotope system could potentially be used to trace fluid activities in magmatic hydrothermal environments and explore mineralization associated with hydrothermal activities.

[1] Nan et al., GCA 233 (2018) 33–49.