Trace element partitioning between fluorite and liquid

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Minerals can be used to reconstruct the compositions of the fluids or melts from which they grew, given that minerals record the compositions of these liquids through characteristic element partitioning. This is especially important for studies where fluid/melt chemistry is crucial but direct sampling of the fluid or melt is not possible, e.g. ore deposits. Fluorite (CaF_2), in particular, is of interest because it readily incorporates trace element and occurs widely in magmatic and hydrothermal systems. When the partition coefficient of an element between fluorite and fluid/melt is known, the concentration of this element in the liquid can be calculated from the concentration of this element in the mineral.

Partition coefficients can be predicted using the Lattice Strain Theory approach. Lattice Strain Theory indicates that elements including Na, Sr and rare earth elements (REE), which have similar ionic radius to Ca, would be preferentially incorporated into the fluorite structure, consistent with what we observe in natural fluorites. Constraining the sensitivity of the three Lattice Strain parameters -- ionic radius of an ideal-sized cation (r_o), the partition coefficient of this ideal cation (D_o) and the elastic constant of the lattice site (E) [1] – with respect to temperature, pressure and fluid/melt composition will allow for predicting the partition coefficient for any element at any set of physicochemical conditions.

To build such a predictive model, we are performing fluorite-synthesis partitioning experiments in aqueous fluids and silicate melts, as starting points for interpolation and extrapolation. The experimental data from aqueous experiments at low (60 °C) and medium (up to 450 °C) temperature can be directly applied to hydrothermal ore deposits including MVT and epithermal deposits where fluorite is commonly present. The fluorite-melt experiments are performed on a natural fluorite-bearing granite from the Strange Lake rare metal deposits, Canada, and will not only allow us to explore the impact of lattice relaxation at high temperature on partitioning, but also to better understand the ore-forming processes in this rare metal deposit.

[1] Blundy & Wood (2003)*Earth Planet. Sci. Lett.* 210, 383–397.