Degassing modeling of sulfur isotope fractionation in apatite

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Recent analysis of sulfur concentrations and isotope ratios in zoned apatite crystals via SIMS yielded a detailed record of sulfur variation in an intrusively crystallized system, the first record of its kind. More than 6‰ variation in $\delta^{34}S_{(CDT)}$ was observed in a single granite hand sample. Crystal zoning shows that magmas went from high sulfate and high $\delta^{34}S_{(CDT)}$ to low sulfate and low $\delta^{34}S_{(CDT)}$ (Economos and Boehnke, 2013). Concurrent magma mixing and sulfur degassing well describe the observed variation.

Degassing modeling was conducted to constrain potential scenarios that could produce observed isotope variations. Isothermal decompression of a rhyolitic melt was modeled at 850 °C between 300 MPa and ~100 MPa as a function of the fraction of S lost by the melt at conditions typical of wet cold felsic systems. Closed system degassing at fO_2 of NNO +2 or lower is the best explanation for the observed isotope variation. The physical model described would be one in which fluids and magmas move up through the crust together and fluids are released when magmas stall at the level of emplacement. This work places a valuable absolute constraint on magma fO_2 and has implications for the excess sulfur problem in volcanic systems and for quantifying sulfur behavior in intrusive igneous systems.