

Timescales of degassing in rhyolitic magmas tracked by Li in plagioclase

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Lithium (Li) is one of the most rapidly diffusing elements in feldspar at magmatic temperatures, allowing to estimate timescales of fast geological processes that would otherwise remain obscured.

Plagioclase crystals of Mesa Falls Tuff (MFT, 1.30 Ma), one of three major caldera-forming eruptions in Yellowstone, show evidence for depletion of Li concentration towards their rims (~25 ppm in cores versus ~3-5 ppm in rims). The lack of correlation between Li and any other major/trace element precludes the low-Li rims to result from a late-stage magma mixing event. Instead, these low Li rims record degassing of magma shortly prior to, or during, the eruption. The volatility of Li in silicic magmas is supported by Li concentrations measured in groundmass glass of MFT (avg. 43 ppm), a factor of five lower than the Li concentrations in quartz-hosted melt inclusions.

The plagioclase phenocrysts have bulk $\delta^7\text{Li}$ values ranging from -2.3 to -1.4‰ (relative to LSVEC). However, the observed concentration gradients indicate a potential for large intra-mineral Li isotopic variability. This can occur due to kinetic Li isotopic fractionation in the plagioclase crystals as a result of degassing. This hypothesis was tested by measuring. Guided by Li concentration maps (generated by LA-ICPMS), Li isotopic profiles were measured across the plagioclase grains. Additionally, Li concentration profiles were measured by LA-ICPMS along the fs-LA-MC-ICPMS profiles, to combine $\delta^7\text{Li}$ with different concentration zones within the crystal. These analyses reveal that cores (mean $\delta^7\text{Li} = -4.3\text{‰}$) are, on average, 4-5‰ lighter than rims (mean $\delta^7\text{Li} = +0.1\text{‰}$). The heavier $\delta^7\text{Li}$ in rims is interpreted as a result of diffusive fractionation during degassing. From diffusion modelling of Li concentration gradients and $\delta^7\text{Li}$ profiles between rims and cores it can be estimated that these processes happened within tens of minutes.