

Experimental investigation of rapid Li diffusion in feldspars and application to ignimbrite-forming eruptions on Tenerife (Canary Islands)

MR. MARTIN OESER¹, RALF DOHMEN², FLORIAN POHL¹, STEVEN HENRY SCHAAK¹, CHRISTIAN SINGER¹
AND STEFAN WEYER³

¹Leibniz University Hannover

²Ruhr-Universität Bochum

³Leibniz University Hannover, Germany

The high diffusivity of Li in plagioclase has been used in several studies – employing diffusion chronometry – to quantify the timescales of short-lived magmatic processes, such as degassing, or decompression-induced crystal growth [e.g. 1,2]. However, experimentally determined diffusion rates of Li in K-feldspar (K-fsp) have not been published yet, hindering its use as a diffusion chronometer. Furthermore, previous studies indicate that Li in feldspars and other silicate minerals may show a complex diffusion behavior, with diffusion along interstitial sites as well as along metal sites, producing a characteristic isotope effect [e.g. 3,4].

Here, we performed a series of diffusion couple experiments using oriented K-fsp crystal cubes (Or₇₂, Or₈₀, Or₉₄) in contact with synthetic, Li-doped glass cubes of K-fsp composition (Or₆₀), in order to quantify the (chemical) diffusion rate of Li in K-fsp and its dependence on the feldspar composition and the crystallographic orientation. The experiments were conducted in rapid-heat / rapid-quench cold seal pressure vessels at temperatures between 540°C and 940°C and pressures between 50 MPa and 200 MPa. In the run products, Li concentration and Li isotopic profiles ($\delta^7\text{Li}$) were analyzed using femtosecond-laser ablation-sector field-ICP-MS and femtosecond-laser ablation-multicollector-ICP-MS, respectively. Our results show that Li diffuses significantly faster in Or₇₂- and Or₈₀-crystals than in Or₉₄-crystals: values of D_{Li} for Or₇₂ are almost 1.5 orders of magnitude higher than D_{Li} for Or₉₄ at a given temperature. The experimentally-produced diffusion-driven $\delta^7\text{Li}$ zoning in our K-fsp crystals indicates that two diffusion mechanisms operate simultaneously, i.e. via interstitial sites and A sites. Furthermore, we have been investigating the Li chemical and isotopic zoning in natural plagioclase and K-fsp crystals from the Abrigo ignimbrite (Tenerife, Canary Islands), which represents the last major caldera-forming eruption of the Las Cañadas volcano, in order to determine magma mixing-to-eruption- and degassing timescales using the recently determined Li diffusion rates in feldspars [this study, 4].

References:

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