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Differential record of pre- and syn-eruptive degassing of a large rhyolitic system recorded by Li, H, and δ^7Li diffusion between quartz, melt inclusions and groundmass glasses

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The behaviour of Li in chemically evolved systems (rhyolites, granites, pegmatites), e.g., the controls on and extent of Li exchange and isotopic fractionation between high silica (rhyolitic) melt, crystals and a magmatic volatile phase are still poorly known. To address this issues, we employed LA-ICPMS and FTIR to determine Li and H concentrations in quartz phenocrysts, and LA-ICPMS, SIMS and FTIR to measure Li and H concentrations and Li isotopic compositions in their melt inclusions (MIs) and groundmass glass from the rhyolitic Mesa Falls Tuff (1.30 Ma; Yellowstone, USA).

Glassy MIs from a fall-out sample span a large range in δ^7Li values from −8.0 to +12.3 ‰ (10–61 ppm Li) and are internally heterogenous in Li and δ^7Li. The δ^7Li in groundmass glass from the same sample ranges from +9.0 ‰ to +14.9 ‰ (32–46 ppm Li) and host quartz of MIs has a relatively homogeneous Li concentration (8–15 ppm). Crystallised MIs from a pumice clast sample have on average higher Li concentrations (8–190 ppm, measured by LA-ICPMS) compared to their groundmass glass (32–51 ppm; δ^7Li = +9.4 ‰ to +20.5 ‰), and their host-quartz shows a distinctive, increase of Li contents from 15 to 24 ppm towards crystal rims. This is mirrored by a decrease in H contents towards crystal rims revealed by FTIR mapping.

MIs and groundmass display different evolutions with decreasing δ^7Li at decreasing Li-H in MIs, and increasing δ^7Li with decreasing Li contents in the groundmass glass. The MI data are partly reproduced by a model of equilibrium fractionation between melt and vapour during an open-system degassing stage occurring at depth, in the reservoir. Groundmass data are reproduced by a model of kinetic fractionation between melt and vapour during a late open-system degassing stage related to magma ascent. Our data therefore highlight, for the first time, two complementary degassing processes related to the evolution of rhyolite reservoirs.