Li in rhyolites: What's up with that?

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A large mass difference between isotopes and high affinity for fluids have made lithium an increasingly well-studied element. For investigating magmatic and deeper processes, such properties are both the blessing and the curse of Li. In volcanic systems, all effusive deposits, and many explosive deposits, reside on the surface after emplacement at high temperatures for an extended period. During this time, both degassing and crystallisation are ubiquitous.

To investigate the effect of such post-eruptive processes on the Li within rhyolitic deposits, we studied a number of welded ignimbrites from the Yellowstone province. These welded ignimbrites, which were emplaced at high temperature, show quenched glassy margins at the top and base (where the deposit rapidy cools against the ground and air) and a microcrystalline interior, which experienced slower cooling rates. By comparing the vitrophyres with the crystalline interior of the same units, we can understand the behaviour of Li in the post-depositional realm.

In terms of bulk abundances, crystalline samples have less Li than glassy samples (21 vs. 16 ppm). Feldspar (both plagioclase and sanidine) is consistently higher (2x to >7x) in Li in the microcrystalline samples than in the glassy samples from the same unit, yet identical in all other trace elements.

Bulk samples from the crystalline rhyolite have much higher δ^7Li than those from the glassy portions (δ^7Li 14.4‰ vs. 7.6‰) with groundmass mimicking this behaviour. By contrast, plagioclase in the crystalline portion (which are enriched in Li) are isotopically lighter than their glassy counterparts (δ^7Li 1.8‰ vs. 5.5‰).

Taken together, we interpret these results as reflecting the post-eruption redistribution of Li driven by degassing of the deposit and crystallisation of a rhyolitic melt on the surface. These results illustrate the effects of post-depositional processes in modifying both the distribution of Li within a sample and the isotopic compositions of different portions of the same sample (e.g. feldspar vs. groundmass). We suggest that, when sampling volcanics for Li isotopes, glassy materials provide the best proxy for the distribution of Li when the material left the vent.