Origin of large chlorine isotope variability in Icelandic rhyolites

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Stable chlorine isotope ratios (reported as δ^{37}Cl) can potentially be used in conjunction with other stable isotopes to gain insights to magmatic volatile sources and processes that control their behavior in silicic melts, such as crystallisation, assimilation, exsolution of magmatic vapour phases and degassing. However, available δ^{37}Cl data for silicic rocks are very limited. We present preliminary δ^{37}Cl and δ^{18}O data for well-characterised rhyolites, dacites and trachytes and corresponding basalts erupted at rift, propagating rift and off-rift settings in Iceland.

The silicic samples (SiO_2 = 62-77 wt.%) have highly variable Cl contents (280-1500 ppm) and δ^{18}O values (–0.5 to +6.1 ‰). The δ^{37}Cl values also span a large range of –1.9 to +0.9 ‰, which exceeds the range of Icelandic basalts [1]. Interestingly, the silicic rocks are generally shifted towards more negative δ^{37}Cl values compared to basalts from the same magma suites. Largest negative δ^{37}Cl shifts of up to –2.8 ‰ are observed in the propagating rift suites, while the rift zone samples display smaller negative shifts of up to -0.8 ‰. In contrast, the off-rift samples do not record shifts outside of error. On a δ^{37}Cl-δ^{18}O plot, distinct fields are occupied by silicic rocks from the rift, propagating rift and off-rift samples. The rift rhyolites show a trend from negative δ^{18}O (–0.5 ‰) and basalt-like δ^{37}Cl (–0.6 ‰) to basalt-like δ^{18}O (+4.4 ‰) and negative δ^{37}Cl (–1.7 ‰) values.

The negative δ^{37}Cl shifts occur independent of eruption type (effusive or explosive), indicating that chlorine isotopes are fractionated by a process taking place within crustal magma reservoirs prior to eruption. However, the large negative δ^{37}Cl shifts can not be explained by equilibrium degassing or fractional crystallisation models, which can only cause a maximum δ^{37}Cl shift of -0.5 ‰. As rhyolite genesis at both rift and propagating rift settings in Iceland is known to be infuenced by crustal assimilation, we tentatively assign the observed negative δ^{37}Cl shifts to assimilation of chlorine-rich material with light δ^{37}Cl values. Our results emphasise that negative δ^{37}Cl shifts are an inherent part of rhyolite genesis in Icelandic rift and propagating rift settings.

[1] Halldórsson et al. (2016) Geology 44:8.