Mixing and degassing processes in the Skuggafjöll eruption, Iceland: Insights from coincident volatile and trace element melt inclusion analyses.

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In recent years the original, pre-eruptive CO2 contents of magmas have been calculated using CO2/Nb ratios from mid-ocean ridge and ocean island lavas and melt inclusions which are believed to be un-degassed. While this technique has the potential to be powerful for estimating volcanic CO2 fluxes from the solid earth to the atmosphere, very few studies currently exist with coincident measurement of volatile and trace elements in basaltic melt inclusions. Flux calculations are based on the assumption that the CO2 and Nb contents of melt inclusions are only controlled by varying amounts of fractionation and degassing. Here we present recently acquired SIMS data obtained from a suite of olivine-hosted melt inclusions from the sub-glacial Skuggafjöll eruption in the Eastern Volcanic Zone of Iceland, that indicate that the above mentioned assumption may not be valid. The Skuggafjöll melt inclusions show strong correlations between trace element (e.g. Zr, Nb, La, Ce) concentrations and trace element ratios (e.g. La/Yb) indicating variability in the composition of mantle melts supplied to the magmatic system feeding the Skuggafjöll eruption. Both melt inclusions and matrix glasses contain ∼0.38 wt.% H2O, consistent with rapid diffusive re-equilibration of H2O and eruption under ice. However, the CO2 concentration of melt inclusions ranges from 200 to 1200 ppm with CO2/Nb values up to 410. CO2 concentrations correlate negatively with trace element concentrations, linear regression of CO2 on Nb yields r = -0.76, in stark contrast with trends obtained from existing 'un-degassed' datasets. At face value this anti-correlation could be interpreted as a record of concurrent crystallisation and degassing. However negative correlations are also observed between CO2 and trace element ratios such as La/Yb. The most depleted, low La/Yb inclusions have the highest CO2 and the most enriched, high La/Yb inclusions the lowest, suggesting that CO2 behaved differently in parental melts of different composition during the formation of the Skuggafjöll magma. These observations may be accounted for by mixing of variably degassed melts shortly prior to eruption. The most depleted inclusions record entrapment pressures of 2 kbar using H2O-CO2 equilibrium. These melt inclusions are taken here to represent un-degassed melts on the basis of their high CO2/Nb (>350). Consequently, they can be used to estimate total pre- and syn-eruptive CO2 emission from the eruption. The low CO2 in enriched melt inclusions suggests that degassing has taken place to lower their CO2/Nb. This implies that the depleted and enriched components of the Skuggafjöll magma have been stored different pressures, and hence depths, in the crust. These observations have important implications for the interpretation of melt inclusion data and suggest that magma mixing, as well as degassing, may be important in controlling the volatile content of erupted melts.