A new pathway for chemical fractionation resulting from SO_2 - basaltic glass reactions

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$SO_{2(g)}$ is a highly reactive gas species which is abundant in magmatic systems on Earth and other planetary bodies. Recent work has shown that key major elements (Na, Fe, Mg and Ca) are effectively and rapidly mobilized by high temperature reactions between $SO_{2(g)}$ and silicate minerals and glasses over time scales of minutes [1]. We have used chemical profiles and maps to determine how major and trace elements are redistributed when a trace element enriched basaltic glass is reacted with $SO_{2(g)}$ for 1 hour at 600°C. Analysis techniques included SEM-EDS, LA-ICPMS, SIMS and nanoSIMS.

We identified that sulfate coatings, formed during reactions betweeen silicates and $SO_{2(g)}$, are host to a wide range of major and trace metals which are mobilized from the basaltic glass substrate. Calcium, Na and Mg are the key major elements in sulfate phases (e.g., $CaSO_4$, Na_2SO_4, $Na_2Ca(SO_4)_2$, $MgSO_4$) which coat the surfaces of the reacted basaltic glass [1, 2]. We also show that Fe and Ti form oxide minerals in the coating [1, 2]. Chemical depth profiling (LA-ICPMS and SIMS) in addition to isotopic mapping in cross section (nanoSIMS) allowed us to probe the behaviour of trace elements K, Rb, Sr, Nb, Ba, Pb, Th, U during gas-solid reactions. We found that Sr, Ba and Pb are incorporated into sulfate phases in the reaction product coating, K and Rb migrate to form an enrichment at the 'interface' between the sulfate-oxide coating and the modified glass, while Th and U remain in the modified basaltic glass.

We show that existing models for element fractionation, such as element volatility and partitioning in silicates, cannot be used to predict how elements behave during $SO_{2(g)}$-basalt reactions. These results provide evidence for a new pathway for major and trace element transport in volcanic systems, which may strongly inflence element abundances in crust where persistent, high-temperature SO_2-rich degassing occurs.

[1] Renggli and King (2018) Rev. Mineral. Geochem. 84, in press. [2] Palm et al. (2018) Rev. Mineral. Geochem. 84, in review.

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