Development of new methods to track magma degassing and fluid fluxing in complex magmatic systems: The study of heavy halogens

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Magma degassing and fluid fluxing within trans-crustal magma reservoirs play an important role in the transport of volatile elements and ore metals. Tracking the migration of magmatic fluids within such systems is challenging, yet essential for the understanding of magmatic-hydrothermal ore genesis and volcanic degassing.

We aim to develop new geochemical tools to track magma degassing and fluid fluxing over a broad melt composition range. We hypothesize that halogen ratios may be useful for this purpose because previous studies have found that the fluid/melt partition coefficients ($D^{f/m}$) of halogens significantly increase with increasing halogenide ion radius (Bureau et al., 2000; Bureau and Métrich, 2003; Cadoux et al., 2018). However, the data available on Br and I partitioning is limited; therefore, we are experimentally studying the $D^{f/m}$ of halogens as a function of melt composition, pressure, and fluid salinity.

The experiments presented here were conducted at *T*=785°C and *P*=200 to 500 MPa. We used synthetic peralkaline, metaluminous, and peraluminous haplogranitic starting glasses and starting fluids with 7 different salinities. The experiments were performed in rapid-quench externally heated René 41 and Molybdenum-Hafnium Carbide (MHC) pressure vessel apparatuses, as well as an end-loaded piston cylinder apparatus with a 19.05 mm diameter assembly.

Halogen concentrations in the run product glasses were determined by Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS) at the University of Geneva and Secondary Ion Mass Spectrometry (SIMS) at the SwissSIMS facility in Lausanne. The concentration of halogens in the equilibrium fluids was then estimated by mass balance calculation using the method by Zajacz et al., 2012 which allowed us to determine the $D^{f/m}$ for Cl, Br and I as a function of fluid salinity, confining pressure, and melt composition. On average, for the metaluminous composition, the $D^{f/m}$ of Br and I are 2 and 5 times higher than that of Cl, respectively. Moreover, the $D^{f/m}$ of all three studied halogens increases by a factor of 3 to 5 with fluid salinity increasing from 0.5 to 32 molal, with Cl > Br > I. Moreover, the effect of pressure on the $D^{f/m}$ of halogens depends on the salinity of the fluid phase. With increasing pressure at low-fluid salinities, all three halogens partition stronger towards the fluid phase but the opposite trend was observed at high-fluid salinities. This difference can be rationalized by taking the much lower compressibility of high-salinity fluids into account. Overall, our results up to date indicate that I/Cl and Br/Cl ratios in the silicate melt will decrease during progressive magma degassing. The I/Cl ratio is more sensitive and thus more applicable during the early stages of magma degassing. Br/Cl is well-suited to address crystallization-driven degassing in more crystalline/felsic systems. The I/Cl ratios may serve as a sensitive indicator of fluid fluxing.

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