Interpreting Volatiles in Augustine Volcano Magmas Using Apatite, Melt Inclusions, and Experiments

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Augustine is an island-arc volcano situated 290 km from Anchorage, Alaska; it emits low-K, calc-alkaline magmas containing up to 8 wt% H_2O, 1 wt% S, 0.78 wt% Cl, 0.5 wt% F, and 0.14 wt% CO_2. Eruptions of Augustine during the past 2100 years involved magmas that exsolved vapor ± brine before and upon eruption.

To interpret the behavior of magmatic volatiles and fluids, we analyzed > 300 silicate melt inclusions (MI) and > 80 apatites from 10 Augustine eruptive units (H_2O/OH were estimated by difference and not measured directly). The compositions of the apatites are interpreted with experiments involving rhyolitic melt, apatite, and vapor ± brine at 200 and 50 MPa.

The average concentrations of OH and F in the apatites track linearly with the abundances of H_2O and F in corresponding MI of these 10 eruptive units. For example, the (mole fraction of H_2O in melt) = (1.11) x (the mole fraction of OH in apatite) + (0.05). Apparent relationships for Cl and SO_2 between apatite and MI are less clear, however. Using experiments performed as part of this study allows for computation of the Cl concentrations of vapor or integrated vapor plus brine in these magmas. For comparatively deeper magmas (ca. 200 MPa) the fluids contained up to 30 wt% Cl, but as magma ascended to shallower depths (ca. 50 MPa), much of the Cl in the fluid(s) dissolved back up into melt, and hence, the shallow fluids contain an order-of-magnitude lower Cl concentrations. This behavior is consistent with decreasing (fluid/melt) partition coefficients for Cl with reduced pressure.