Linking fluid flux, fluid chemistry and degassing timescales of incrementally grown plutons: Implications for mineralization and volcanic degassing

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Typical silicic arc magmas are fluid-saturated and degas large quantities of volatiles and metals upon cooling and crystallization within the upper crust. Magma degassing is the main process driving the formation of porphyry copper deposits (PCDs) [1, 2] and plays an important role in controlling the dynamics of volcanic eruptions [3, 4].

Modern views of arc magmatism involve the incremental assembly of magmatic systems within the crust at typical rates of 0.0001–0.1 km^3/yr [5]. Using thermal modelling and statistical simulations, we have modelled the flux and chemistry of outgassed fluids during pluton growth in the upper crust for various magma injection rates and final volumes [6]. Our results show that during magma injection, the volatile flux remains nearly constant and proportional to the magma injection rate. At magma fluxes >0.001 km^3/yr, low flux fluid outgassing persists long after magma injection has ceased. Interestingly, within the range of typical intermediate to felsic arc magma composition, the composition of the computed fluid is similar to that of high-temperature single-phase intermediate-density fluid inclusions measured at PCDs.

Our model suggests that (i) porphyry copper deposits can form from normal arc magmas (no enrichment required), (ii) the size of PCDs correlates with the volume of the pluton at depth and the timescales of magmatic and hydrothermal activity, and (iii) that average volatile flux at volcanoes may be used as first order estimates of magma flux at depth.

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