Goldschmidt Medal Abstract

The Testimony of Zoned Crystals from Volcanic Rocks

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Zoned plgaioclase crystals are ubiquitous in volcanic rocks. Their zoning patterns are hold clues to the magmatic processes that shaped their host rocks. An enduring question is whether this information pertains to kinetic process, changes in intensive variables, open system behaviour, or comibinations thereof. The challenge is to unpick the mute testimony of zoned plagioclase as an archive of pre-eruptive magmatic processes. This challenge has been lessened by the advent of SIMS microbeam techniques capable of high spatial and analytical resolution, thermodynamic models for plagioclase-melt equilibrium and element partitioning, and numerical models of intracrystalline diffusion.

Using phase equilibrium experiments on Mount St. Helens (MSH) dacites to parameterise plagioclase composition as a function of pressure (*P*), temperature (*T*) and melt fraction (*F*), we have developed a numerical method to invert zoned MSH plagioclase phenocrysts for their core-rim evolution in *P*-*T* space prior to eruption. We remove ambiguity in the family of plausible *P*-*T* paths by solving simultaneously for *F* using the Sr and Ba contents of the plagioclase as measured by SIMS. This approach is valid at MSH because of the relative monotony of magma composition and the absence of ssignificant magma magma inputs to perturb the bulk compsition. Data from a representative sample of crystals from the 1980-86 eruption record the same evolution – an abrupt change from core crystallisation at 12 km depth to rim growth at 4 km.

Simultaneous with crystal growth, trace element diffusion occurs in an attempt to restore chemical potential equilibrium. We show that the cores are >10,000 yrs old, whereas the rims pre-date eruption by ≤3 yrs. The core-rim interface, that is relate to the time of magma ascent from 12 to 4 km, has been precisely dated using high-resolution NanoSIMS Sr profiles. A picture emerges of a long-lived, vertically extensive magmatic system that became abruptly destabilised, probably gravitationally, in the months to years before eruption, a timescale commensurate with volcanoc monitoring.