Longevity of crystal cargo vs. transience of melts in magma systems

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Volcanic plumbing systems, particularly in continental arcs, have long been recognized as sites of open system processes. Disequilibrium textures or zoning in phenocrysts result if crystallization is coeval with assimilation or mixing. Radiometric dating measures a crystal's residence time in the plumbing system, but not necessarily its residence time in the host melt [1]. Indeed, the relative amount of time spent by melts vs. crystals in any particular crustal reservoir may be very different.

At Parinacota Volcano (central Andes), eruptions transitioned from tapping of a stagnant, silicic, crystal-rich mush to a more dynamic, mafic, crystal-poor magma over ca. 30 k.y. when recharge increased and mafic magmas transited the crust much faster [2]. Bulk lava chemistry and isotopic composition during initial stages of this transition (47-28 ka) indicate that the magmatic system was compartmentalized: one part evolved to more silicic compositions consistent with fractional crystallization, whereas the other became slightly more mafic by recharge. Despite heterogeneity of host melts erupted during this change in magmatic regime, the crystal cargoes in these magmas are homogenous in terms of mineral phases present, their major and trace element chemistry, age, and recorded P-T conditions and thus are likely to be derived from the same long-lived crystal-rich reservoir.

Bulk composition of lavas varied on timescales of hundreds to thousands of years – evidence that melts reside in the system relatively briefly. In contrast, U-Th dating indicates the crystal cargo is much older (up to 350 k.y.), especially in the case of zircon. Reconciling these two lines of evidence suggests that: (1) the same cohort of crystals remains in the magma reservoir for periods of time much longer than it takes to build a volcano, (2) the presence of any given melt is ephemeral, and (3) the capacity of melts to transport crystals to the surface is limited and varies with magma flux. At Parinacota, several k.y. of mafic recharge were still not sufficient to completely purge the persistent old crystals from the reservoir(s).

[1] Cooper & Kent (2014) *Nature* **506**, 480-483. [2] Hora et al. (2009) *EPSL* **285**, 75-86.