Feedback between physical and chemical chararacteristics of an evolving open-system magma body

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Energy-Constrained Eruption, Recharge, Assimilation and Fractional Crystallization (EC-ERAFC) is a computational model that tracks the evolution of an open-system magma reservoir undergoing simultaneous eruption, recharge, wallrock assimilation, and fractional crystallization. EC-ERAFC is formulated as a set of coupled, nonlinear differential equations, the solutions of which provide detailed thermal, mass and chemical (trace element/isotope) information about the evolution of melt and solids as all parts of a composite system (host magma, recharge magma, wallrock, eruptive reservoir) approach a common equilibration temperature (T_{eq}). Fundamental to the structure of EC-ERAFC is the premise that changes in physical conditions, such as initial, liquidus and equilibration temperatures, will cause changes in chemical signatures. Mass addition by recharge and removal by eruption also impact geochemistry. Two forward models highlight possible feedback effects. For cases in which other parameters are held constant, increasing the wallrock initial, liquidus Ts from 300°C, 1100°C to 600°C, 1150°C, respectively, yields magmas that have more crustal $^{87}Sr/^{86}Sr$ because, at T_{eq}, wallrock with the higher liquidus T has undergone a smaller degree of partial melting. Because melting is approximated as a fractional process, and Sr is modeled as behaving incompatibly, smaller degrees of partial melting add relatively large masses of crustal Sr to the host magma, thus yielding a more crustal fingerprint. A second example examines the coupling between T_{eq} and chemistry. For a case in which hydrothermal circulation is vigorous and magmatic heat is efficiently transported away from the magma-wallrock boundary, T_{eq} is likely to be low. Such conditions yield more crust-like magmas because the degree of wallrock partial melting is smaller. In contrast, for higher T_{eq}, larger degrees of partial melting add proportionally less crustal Sr to the host magma, yielding magmas that bear a smaller crustal imprint. Numerous other examples provide additional analysis of feedback effects and demonstrate the critical importance of applying integrated computational models to an understanding of how magma plumbing systems evolve.

Reverse zoned feldspars in Suswa Volcano, Kenya Rift: Evidence for magma mixing and eruptions triggered by recharge

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Suswa Volcano is a Holocene volcano in the axis of the Kenya Rift. It is composed of trachytes that culminated in the formation of the caldera, followed by phonolites. We have studied two of the post-caldera phonolites.

The first flow is characterized by phenocrysts of olivine (Fa_{67}), diopside ($En_{31}Fs_{23}Wo_{46}$), ulvöspinel ($Fe_{2.5}Ti_{0.5}O_4$) and zoned feldspars. Some feldspars show oscillatory zoning with K-rich cores ($An_{<10}Ab_{62-66}Or_{28-34}$), followed by euhedral overgrowths with either Ca or K-rich compositions; the An-rich zones are $An_{7-13}Ab_{66-68}Or_{14-20}$ and the Or-rich zones are $An_{7-13}Ab_{67}Or_{19-25}$. A second type of feldspar lacks oscillatory zoning and has trapped melt inclusions with the same glass composition as the matrix. Thin rims on the oscillatory zoned crystals ($An_{56}Ab_{44}Or_0$) show the same composition as these Ca-rich overgrowths.

A second flow has a number of feldspars with Ca-rich cores and another type with K-rich interior and subtle zoning ($An_{<10}Ab_{62}Or_{28-34}$). A third type of feldspar has euhedral overgrowths with internal zones of $An_{12}Ab_{66}Or_{22}$ and rims of $An_8Ab_{65}Or_{28}$. Finally, a fourth type has a Ca-rich part ($An_{50}Ab_{50}Or_0$), also with melt inclusions with compositions similar to the glass in the matrix. This feldspar is very similar to the second type of feldspar in the first flow, both with melt inclusions trapped in the Ca-rich portion.

The zoning in feldspars implies magma mixing of felsic and basaltic compositions. We also interpret the thin rims with $An_{50}Ab_{50}Or_0$ found in most of the feldspars to represent recharge of the chamber by a magma that triggered the eruption. Because melt inclusions are in the portions of the feldspars that have the same composition as the magma, these feldspars most have grown before the eruption.