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Numerical simulations of magma mixing, and constraints to crystal growth and dissolution patterns

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Eruption products of individual volcanic eruptions commonly display heterogeneities that are often interpreted as evidence of short times from new magma arrival to eruption. The time evolution of magma mixing and the degree of homogenization are still not well understood. We present the results of a parametric study through numerical simulations of andesite-dacite buoyancy driven magma mixing, by varying viscosity and volatile contents. The results show that highly efficient buoyancy-driven mixing is followed by a phase where stable convective layers develop, and mixing becomes progressively less efficient. Low viscosity and more volatiles favor mixing and achievement of a higher level of homogenization. On the contrary, high viscosity and lower volatiles give rise to long lived heterogeneities, in some cases preserving the end member compositions. Analysis of the results suggest that during the early transient phase of efficient magma mixing, crystal dissolution dominates; however, for cases where the transient phase takes longer, growth and resorption can act together, likely resulting in multiple resorption surfaces and zoning patterns before stable conditions are reached and euhedral crystal growth takes place. Crystals initially in equilibrium with magma can display a range of textural evolutions depending on their initial composition and individual paths during one single event of magma recharge, convection and mixing. Overall, the numerical simulations suggest that complex patterns of growth and dissolution followed by euhedral rims of various composition can be associated with single recharging events; and that short reaction times do not necessarily reflect comparably short times from recharge to eruption.