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Dynamics of magma recharge, ascent and convection in magmatic reservoirs

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Shallow magmatic reservoirs are periodically rejuvenated by new magma inputs bringing volatiles and contributing to volcano degassing. Quite often, such new magmatic inputs shortly precede a volcanic eruption, likely as a consequence of increased pressure in the hosting reservoir. In spite of their relevance for both understanding the evolution of magmatic bodies and forecasting the hazard related to the occurrence of a new eruption, the dynamics of magma injection in shallow chambers are poorly known to-date. Here we present the results of numerical simulations through which such dynamics are investigated in details. We consider a 2D magmatic system that extends vertically for several km, representing a deep volatile-rich reservoir hosting less chemically evolved magma connected through a dyke to a shallow, smaller, volatile-depleted chamber hosting a more differentiated magma. The relevant properties density and viscosity, and the non-ideal equilibrium between dissolved and exsolved H_2O+CO_2 volatiles, are computed locally as a function of $P-T-X$ conditions. The numerical code that we have developed solves the Navier-Stokes equations for the 2D homogeneous multi-component system through finite elements and by making use of robust numerical schemes adequate for incompressible-to-compressible conditions. An initial interface between the two magma types, that further differ for their chemical composition, is destabilized by buoyancy forces, giving rise to complex patterns of magma convection and mixing. We analyze the convective patterns associated to plume ascent dynamics and the corresponding pressure variations at various levels in the simulated system, in a parametric study where simulations are repeated by varying only the geometry of the shallow magma chamber or the contrast in volatile contents of the two magma types. Among several other aspects, the results show that oblate (sill-like) chambers are much less effective than prolate (vertically extended) chambers in developing overpressure, suggesting a physical reason for the widespread occurrence of sill-like intrusions not associated with volcanic eruptions.