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Buoyancy-driven convection and mixing in magma chambers - the case of Phlegraean Fields caldera

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Ascent of primitive magmas from depth into shallow, partially degassed reservoirs is commonly assumed to be a viable eruption trigger. At Phlegraean Fields (Southern Italy), processes of convection and mixing have been identified as taking an active part both in pre- and syn-eruptive stages in many eruptions of different size. We performed numerical simulations of magma chamber replenishment referring to an archetypal case whereby a shallow, small magma chamber containing degassed phonolite is invaded by volatile-rich shoshonitic magma coming from a deeper, larger reservoir. The system evolution is solely driven by buoyancy, as the magma entering the shallower chamber is less dense than the degassed, resident phonolite. The evolution in space and time of physical quantities such as pressure, gas content and density is highly heterogeneous; nonetheless, an overall decreasing exponential trend in time can be observed and characterizes the whole process. The same exponentially decreasing trend can be observed in the amplitude of the ground deformation signals (seismicity over the whole frequency spectrum) calculated from the results of the magmatic dynamics. Exponential decay in the efficiency of the mixing process has been also observed experimentally, albeit on much smaller length and time scales (Morgavi et al., Contrib. Min. Petr. 2013). Depending on the initial and boundary conditions explored, such as chamber geometry or density contrast, the time constant thus the duration of the process can vary. Independently, the evolution of pressure in the magmatic system also depends on the initial and boundary conditions, leading either to eruption-favourable conditions or not. Relating the time scales for convective processes to be effective with their outcomes in terms of stresses at the chamber boundaries can substantially improve our ability to forecast eruptions at volcanoes world-wide.