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Magma convection and mixing dynamics as a source of Ultra-Long-Period oscillations

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Many volcanic eruptions are shortly preceded by new magma injection into a pre-existing, shallow ($<$ 10 km) magma chamber, causing convection and mixing between the incoming and resident magmas. These processes may trigger dyke propagation and further magma rise, inducing long-term (days to months) volcano deformation, seismic swarms, gravity anomalies, and changes in the composition of volcanic plumes and fumaroles, eventually culminating in an eruption. Although new magma injection in shallow magma chambers is a potentially hazardous event, its occurrence is still not systematically detected and recognized. Here we present the results of numerical simulations of magma convection and mixing in geometrically complex magmatic systems, and describe the multi-parametric dynamics associated with buoyant magma injection. Our results reveal unexpected pressure trends and pressure oscillations in the Ultra-Long-Period (ULP) range of minutes, related to the generation of discrete plumes of rising magma. Very long pressure oscillation wavelengths translate into comparably ULP ground displacements with amplitudes of order 10^{-4} – 10^{-2} m. Thus, new magma injection in magma chambers beneath volcanoes can be revealed from ULP ground displacement measured at the surface.