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Pressure and deformation patterns associated with magma chamber refilling.

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Magma chambers, or zones of temporary residence of magma beneath volcanoes, are the site of intense physical and chemical processes that may deeply modify magma composition and properties and create the conditions for a new eruption. Several evidences show that volcanic eruptions are commonly preceded and accompanied by new magma injection into a pre-existing chamber. Magma injection triggers efficient convection and mixing between the incoming and resident magmas, and may produce the conditions for dyke propagation and further magma rise, eventually leading to an eruption. Although new magma injection in a magma chamber is a potentially hazardous event, volcano monitoring techniques have not yet progressed to a level where such events are systematically detected and recognized. Here we present innovative numerical simulations of magma convection and mixing in chamber+dyke systems that disclose the complex dynamics associated with buoyant magma injection. The simulations are performed with GALES, a finite element C++ parallel code that solves the mass, momentum and energy equations for multiphase, homogeneous, multi-component fluids in the compressible-to-incompressible flow regimes. Our results reveal pressure oscillations in the Ultra-Long-Period (ULP) range of minutes, related to the generation of discrete plumes of rising magma. Very large oscillation wavelengths translate into comparably ULP ground displacements with amplitudes of order 10^{-4}-10^{-2} m, as determined by integrating the Green's functions in homogeneous infinite medium from the stress field generated at magma-wall boundaries. Such ULP signals are increasingly emerging at many volcanoes where broad-band networks are being deployed. We suggest therefore that new magma injection in magma chambers beneath volcanoes can be revealed from ULP ground displacement measured at the surface.