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Numerical simulation of magma chamber dynamics.

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Magma chambers are characterized by periodic arrivals of deep magma batches that give origin to complex patterns of magma convection and mixing, and modify the distribution of physical quantities inside the chamber. We simulate the transient, 2D, multi-component homogeneous dynamics in geometrically complex dyke+chamber systems, by means of GALES, a finite element parallel C++ code solving mass, momentum and energy equations for multi-component homogeneous gas-liquid ($\pm$ crystals) mixtures in compressible-to-incompressible flow conditions. Code validation analysis includes several cases from the classical engineering literature, corresponding to a variety of subsonic to supersonic gas-liquid flow regimes (see http://www.pi.ingv.it/$\sim$longo/gales/gales.html). The model allows specification of the composition of the different magmas in the domain, in terms of ten major oxides plus the two volatile species H_2O and CO_2. Gas-liquid thermodynamics are modeled by using the compositional dependent, non-ideal model in Papale et al. (*Chem.. Geol.*, 2006). Magma properties are defined in terms of local pressure, temperature, and composition including volatiles. Several applications are performed within domains characterized by the presence of one or more magma chambers and one or more dykes, with different geometries and characteristic size from hundreds of m to several km. In most simulations an initial compositional interface is placed at the top of a feeding dyke, or at larger depth, with the deeper magma having a lower density as a consequence of larger volatile content. The numerical results show complex patterns of magma refilling in the chamber, with alternating phases of magma ingression and magma sinking from the chamber into the feeding dyke. Intense mixing takes place in feeding dykes, so that the new magma entering the chamber is always a mixture of the deep and the initially resident magma. Buoyant plume rise occurs through the formation of complex convective patterns, giving origin to a density-stratified magma chamber.