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Piton de la Fournaise, elasto-plastic models of stresses and deformation accounting for the topographic load and a magmatic injection

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Building on previous work aimed at identifying and characterizing the potential mechanical trigger controlling eruptions and destabilization at Piton de la Fournaise, we study the mechanical behavior of the volcanic edifice on a crustal scale. Do the recurrent earthquake pattern correspond to a destabilization structure, precursor of a large-scale flank sliding? Or instead to a reactivated area of magma storage (partially crystallized “sill”)? To answer these questions, we design numerical models which estimate the stress field associated with the volcanic complex. We use the ADELI finite element method in three dimensions, which handles elasto-visco-plastic rheologies. In these models, we take into account 1) the topographic load, 2) the major density and resistance heterogeneities within the volcano obtained from previous studies, and 3) the overpressure induced by the intrusion of a dike of arbitrary geometry.
The modeled dike injection generates deformation and stress fields such that their isocontours highlight an ellipsoidal cup structure extending from the central cone to a depth close to 0 and reaching the ends of the eastern flank. This zone could be assimilated to the zone of seismicity observed and described previously. Together with several systematic test cases, we will discuss the significance of these results, such as whether it reveals a rheological delimitation zone of the hydrothermalized bedrock, resulting from the combined influence of the topographic load and that of a magmatic injection.