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The importance of mechanical heterogeneities on stress redistribution from and to volcanoes

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Magma intrusions and earthquakes dislocate the crust and may cause a significant redistribution of the stress. Understanding the modes of stress transfer is of vital interest. In fact, volcanic eruptions may be triggered by earthquakes but also may encourage earthquakes. The interaction of volcanoes and tectonic earthquakes is commonly studied using geodetic and seismic data, combined with numerical models of elastic stress changes. While those studies are thought to reflect stress changes quantitatively, most modeling attempts are made in isotropic elastic half-space where material heterogeneities are neglected.

Here we study the importance of the mechanical layering on the stress redistribution. We simulate volume changes in magma chambers, responsible for surface deformations and changes on stress field in volcanic areas. We compare common analytical solutions, such as mogi source, yang source, and the penny-shaped crack source, to axisymmetric finite element models. Then, introducing material heterogeneities, we recalculate the stress field. We show that layering imply significant differences on surface displacements and stress distribution. Our study suggests that layering affects the amount of stress transferred due to magma chamber inflation to active faults and vice versa.

The results are important to understand geodetic data (InSAR, GPS), as well as the interactions between volcanic and tectonic events.