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Elliptical Versus Cylindrical Magma Conduits

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By modelling the magnitude and spatial distribution of surface displacement induced by different representations of magma conduits, more informed decisions can be made for the deployment of real-time monitoring devices, such as tiltmeters, and aid interpretations of stress changes within the subsurface. The existence of varying forms of magma conduit is widely known, despite this, the effect of laterally elongated conduits on magma flow processes and resulting surface deformation at volcanoes has not been systematically explored.

By varying the ellipticity of the volcanic conduit cross-section we assess the relative importance of laterally elongated conduits when considering flow processes and surface deformation. The scenario of magma ascent through a dyke that changes into a cylindrical conduit closer to the surface is also considered, herein referred to as a complex conduit. Both shear stress on the conduit walls due to viscous magma flow resistance and the pressurisation of conduits are used as source mechanisms.

When considering the pressurisation of different conduit geometries, the displacement field induced by an elongated conduit (where semi-axes a and b of the elliptical cross-section equal a=10b) is an order of magnitude larger than that of a cylindrical conduit. Moreover, for the case of the complex conduit, the displacement field is dominated by the dyke form of the deeper conduit, with little influence from the transition region between elongated and cylindrical conduit. When considering shear stress as a source mechanism, the displacement field induced is primarily vertical and radially symmetric even at the smallest spatial scales (<1 km), independent of ellipticity of conduit origin. The ellipticity of conduits with equal cross-sectional area has a significant control on the flow rate, and therefore, the magnitude of shear stress achieved under equal pressure gradients. The deformation resulting from shear stress on the conduit walls is also influenced by the depth of rheological changes within the magma and the inter-dependency with conduit geometry.