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Influence of an ocean on the propagation of magmas within an oceanic basaltic shield volcano

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Basaltic shield volcanoes are a common feature on Earth and mostly occur within oceans, forming volcanic islands (e.g. Hawaii (USA), Galapagos (Ecuador), and recently Niijima (Japan)). As the volcano grows it will reach and emerge from the water surface and continue to grow above it. The deformation affecting the volcanic edifice may be influenced by the presence of the water level. We investigate how the presence of an ocean affects the state of stress within a volcanic edifice and thus magma propagation and fault formation.
Using COMSOL Multiphysics, axisymmetric elastic models of a volcanic edifice overlying an elastic lithosphere were created. The volcanic edifice (height of $\sim$6000 m and radius of $\sim$ 60 km) was built either instantaneously or iteratively by adding new layers of equivalent volume on top of each other. In the later process, the resulting stress and geometry from the one step is transferred to the next as initial conditions. Thus each new layer overlies a deformed and stressed model. The water load was modeled with a boundary condition at the surface of the model. In the case of an instantaneous volcano different water level were studied, for an iteratively growing volcano the water level was set up to 4000 m. We compared the deformation of the volcanic edifice and lithosphere and the stress orientation and magnitude in half-space and flexural models with the presence or not of an ocean.
The preliminary results show 1- major differences in the resulting state of stress between an instantaneous and an iteratively built volcanic edifice, similar to the results of Galgana et al. (2011) and McGovern and Solomon (1993), respectively; 2- the presence of an ocean decreases the amount of flexural response, which decreases the magnitude of differential stress within the models; and 3- stress orientation within the volcano and lithosphere in also influence of an ocean. Those results provide new insights on the state of stress and deformation of oceanic basaltic volcanic edifices.

Galgana, G. A., P. J. McGovern, and E. B. Grosfils (2011), Evolution of large Venusian volcanoes: Insights from coupled models of lithospheric flexure and magma reservoir pressurization, J. Geophys. Res., 116(E3), E03009.
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