Magma flow between summit and Pu‘u ‘Ō‘ō at Kīlauea Volcano, Hawai‘i

Chiara P Montagna, Helge M Gonnermann

Rice University, U.S.A.

E-mail: chiara@rice.edu

Volcanic eruptions are often accompanied by spatiotemporal migration of ground deformation, a consequence of pressure changes within magma reservoirs and pathways. We model the propagation of pressure variations by eruptive magma withdrawal during the early episodes of the ongoing Pu‘u ‘Ō‘ō-Kupaianaha eruption of Kīlauea Volcano, Hawai‘i. Tilt measurements show that the onset of fountaining episodes at Pu‘u ‘Ō‘ō was typically accompanied by abrupt deflation and followed by a sudden onset of gradual re-inflation, once the eruptive episode ended. Tilt at Kīlauea’s summit underwent similar patterns of deflation and inflation, albeit with time delays of several hours during most episodes. The observed delay times for different episodes vary between 3 and 12 hours. These can be reproduced by modelling the space-time evolution of pressure variations within an elastic-walled dike that connects Kīlauea’s summit to its east rift zone. As pressure changes travel through the dike, the interplay between elastic response of the dike wall and viscous resistance of the fluid determines the delay time. Magma withdrawal beneath Pu‘u ‘Ō‘ō causes a decrease in pressure and deflation. The resultant increase in magma flow rate causes deflation of the Halema‘uma‘u magma reservoir at the summit, although delayed in time because of the finite propagation velocity of both the pressure changes and the surge in magma flow rate within the dike.

The time delay depends on dike dimensions, elasticity of the wall rock, magma viscosity, as well as magnitude and duration of the pressure variations themselves. The dike width is the most important parameter in determining delay times: pressure changes propagate noticeably faster (slower) in a slightly wider (narrower) dike, as a consequence of smaller (larger) viscous dissipation. It is unlikely that the east rift zone magmatic pathway is of uniform dimensions: variation of its width could represent spatially localized changes, possibly due to removal of a constriction or partial collapse of wall-rock during repose periods. A transport efficiency for the dike system can be defined, providing a measure of the ease of flow for magma along the east rift zone and its variations in time, and thus an insight on the evolution of the magmatic system of Kīlauea Volcano.