# Estimating the location and volume of shallow magma storage at Kīlauea Volcano from observations of episodic ground deformation

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A variety of geophysical observations suggest the presence of at least two long-lived magma reservoirs beneath the summit of Kīlauea Volcano. Although the locations of the reservoirs are known generally, their volumes are poorly constrained. Episodic pressure perturbations in the shallow magmatic system, however, generate cycles of ground deformation that provide valuable constraint on the location and volume of the more shallow of the two reservoirs. These cycles of ground deformation, divided into three different classes based on their temporal histories, have been labeled deflation-inflation (DI) events. Recorded by tilt, GPS, InSAR, and strain data, a typical DI cycle consists of deflation of the summit region over a period of roughly 8 hours to 3 days, in many cases at a quasi-exponentially decaying rate, followed by a recovery over hours to a few days to roughly the original level. Since the opening of Kīlauea's summit vent in 2008, the rate of DI event occurrence has increased, and DI-related ground deformation has also closely tracked the level of the summit lava lake. Cyclic deformation at the summit is also often reflected, after a pause of roughly one-half to three hours, at the Pu‘u ‘Ō‘ō eruptive vent 20 km from the summit, suggesting that DI events reflect perturbations of magma flow and pressure conditions throughout much of Kilauea's interconnected shallow plumbing system.

We invert deformation data recorded during more than 400 individual DI events to estimate the location of Kīlauea's shallow magma reservoir (the Halema‘uma‘u reservoir) and look for changes associated with eruptive activity. We find that the three classes of DI events share a common source region, located near the east margin of Halema‘uma‘u Crater, which has moved little if at all in more than ten years (the time span of the most accurate deformation records). The depth of this source is shallow but poorly resolved from the tilt data alone; however, GPS, InSAR, and strain data can provide additional constraint. The volume change associated with individual DI events is probably less than one million cubic meters, although the estimate is correlated with source depth. While the deformation data cannot constrain the total volume of the Halema‘uma‘u reservoir, we are able to estimate volume by assuming that the summit lava lake is in magmastatic equilibrium with the reservoir such that its surface height may be used as a manometer. Using probabilistic estimates of host rock rigidity and magma density together with volume change obtained from inversion of the deformation data, we estimate that the Halema‘uma‘u reservoir has a volume of several cubic kilometers.