Investigating the formational mechanism of the Nīnole hills on Mauna Loa, Hawaii, through gravity surveys

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Mauna Loa´s high eruption rates have extensively repaved its surface with over 90 % of its surface younger than 4000 years. This creates problems when attempting to understand the evolution of Hawaiian volcanoes as features that once existed have been buried under younger lavas. To obtain a window into Mauna Loa ´s past, it is necessary to locate fault scarps, anomalous structural features, or drill. One anomalous topographic feature, the Nīnole hills, protrudes from the flank of Mauna Loa and is the oldest exposed subaerial rocks on the edifice (100-300 ka).
There has been much discussion as to what the Nīnole Hills are and how they formed. The first proposed formation mechanism of the hills was a proto-volcanic edifice. This interpretation is based on the slope of the lavas in the Nīnole hills pointing to a source which is offset from the summit or the Southwest Rift Zone. This interpretation is problematic as rotation due to rift zone migration or faulting can change the slope of the ground. Later studies showed that the basalt that makes up the hills are geochemically identical to those of Mauna Loa suggesting that the Nīnole Hills are not a separate volcanic edifice. Rather, it has been proposed that erosional valleys due to gravitational slumping and mass wasting are a more reasonable mechanism to explain the morphology of the hills. Recently, seismic tomography studies have suggested that the Nīnole Hills are the remnants of a failed rift zone likely active before Kilauea buttressed Mauna Loa ´s south flank.
In order to address these disparate formation mechanisms, we present Bouguer gravity collected in April, 2013 and 3D gravity inversions. To remove the effect of density anomalies that are too deep or outside the Nīnole Hills, a regional gravity data is used through a two-step inversion process. Removal of the regional field enables high resolution images of density contrasts at depth which can be used to directly test the three different formational mechanisms. If the series of hills and ridges are created by a proto-Mauna Loa, then one would expect a central, somewhat shallow (less than 4 km depth), gravity high due to dense intrusions somewhere within the hills. If created by an active rift zone, we would expect to see a shallow, roughly linear, gravity high tracing out the highest point of the ridges similar to what is observed for Kilauea; corresponding to dense intrusions along the ridge axis. If created by a combination of fault zones, mass wasting, and erosion, then the gravity data will show no significant shallow signal but rather just the regional field.