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Magma Intrusion at Mount St. Helens, Washington, from Temporal Gravity Variations

Maurizio Battaglia (1), Mike Lisowski (2), Dan Dzursin (2), Mike Poland (2), Steve Schilling (2), Angie Diefenbach (2), and Jeff Wynn (2)

(1) Dept of Earth Sciences, Sapienza - University of Rome, Rome, Italy (maurizio.battaglia@uniroma1.it), (2) Cascades Volcano Observatory, U.S. Geological Survey, Vancouver WA, USA

Mount St. Helens is a stratovolcano in the Pacific Northwest region of the United States, best known for its explosive eruption in May 1980 – deadliest and most economically destructive volcanic event in US history. Volcanic activity renewed in September 2004 with a dome forming eruption that lasted until 2008. This eruption was surprising because the preceding four years had seen the fewest earthquakes and no significant deformation since the 1980-86 eruption ended. After the dome forming eruption ended in July 2008, the volcano seismic activity and deformation went back to background values. Time-dependent gravimetric measurements can detect subsurface processes long before magma flow leads to earthquakes or other eruption precursors. A high-precision gravity monitoring network (referenced to a base station 36 km NW of the volcano) was set up at Mount St Helens in 2010. Measurements were made at 12 sites on the volcano (at altitudes between 1200 and 2350 m a.s.l.) and 4 sites far afield during the summers of 2010, 2012, and 2014. The repeated gravity measurements revealed an increase in gravity between 2010 and 2014. Positive residual gravity anomalies remained after accounting for changes in surface height, in the Crater Glacier, and in the shallow hydrothermal aquifer. The pattern of residual gravity changes, with a maximum of 57 ± 12 μGal from 2010 to 2014, is radially symmetric and centered on the 2004-08 lava dome. Inversion of the residual gravity signal points to a source 2.5-4 km beneath the crater floor (i.e., in the magma conduit that fed eruptions in 1980-86 and 2004-08). We attribute the gravity increase to re-inflation of the magma plumbing system following the 2004-8 eruption. Recent seismic activity (e.g., the seismic swarm of March 2016) has been interpreted as a response to the slow recharging of the volcano magma chamber.