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Magma reservoirs from the upper crust to the Moho inferred from high-resolution Vp and Vs models beneath Mount St. Helens, Cascades, USA

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Mount St. Helens is currently the most active volcano along the Cascadia arc. Though several studies investigated the magmatic system beneath Mount St. Helens following the May 18, 1980 eruption, tomographic imaging of the system has been limited to ∼10 km depth due to the distribution of earthquakes in the region. This has made it difficult to estimate the volume of the shallow magma reservoir beneath the volcano, the regions of magma entry into the lower crust, and the connectivity of this magma system throughout the crust. The latter is particularly interesting as one interpretation of the Southern Washington Cascades Conductor (SWCC) suggests that the Mount St Helens and Mount Adams volcanic systems are connected in the middle crust (Hill et al., 2009).

The multi-disciplinary iMUSH (imaging Magma Under St. Helens) project is designed to investigate these and other fundamental questions associated with Mount St. Helens. Here we present the first high-resolution 2D Vp and Vs models derived from travel-time data from the iMUSH 3D active-source seismic experiment. The experiment consisted of ∼6000 seismograph stations which recorded 23 explosions and hundreds of local earthquakes.

Directly beneath Mount St. Helens, we observe a high Vp/Vs body, inferred to be the upper/middle crustal magma reservoir, between 4 and 13 km depth. We observe a second high Vp/Vs body, likely of magmatic origin, at roughly the same depth beneath Indian Heaven Volcanic Field, which last erupted 9 ka.

Southeast of Mount St. Helens is a low Vp column extending from the middle crust, ∼15 km depth, to the Moho at ∼40 km depth. A cluster of deep long-period events, typically associated with injection of magma, occurs at the northwestern boundary of this low Vp column. We interpret this as the middle-lower crust magma reservoir. In the lower crust, high Vp features bound the magma reservoir directly beneath Mount St. Helens and the Indian Heaven Volcanic Field. One explanation for these high Vp lower crustal features is that they are lower crustal cumulates associated with Tertiary ancestral Cascade volcanism. Seismicity immediately following the May 18, 1980 eruption of Mount St. Helens terminates near the top of the inferred middle/lower crustal cumulates and directly adjacent to the inferred middle/lower crustal magma reservoir. These spatial relationships suggest that the boundaries of these high-density cumulates play an important role in both vertical and lateral transport of magma through the crust.