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iMUSH Autocorrelation Reflectivity and Active Seismic Imaging of the Magma Plumbing System under Mount St Helens, Washington, USA

Alan Levander¹ and Eric Kiser²

¹Rice University, Earth Science, Houston, TX, United States of America (alan@rice.edu)

²University of Arizona, Department of Geosciences, Tucson, AZ, United States of America (ekiser@email.arizona.edu)

We have developed a 3D model of the Mount St Helens (MSH) magmatic plumbing system extending from the upper magma storage zone (> 3.5 km bsl) to Moho depths (40-45 km) by combining results from 2D and 3D active source seismic tomography and reflection imaging, and autocorrelation reflectivity imaging. The data are from the ~6000 high frequency seismographs used in the 2014 iMUSH active seismic experiment.

We developed a 3D Vp tomography model of melt distribution in the upper-middle crust (Kiser et al, 2018). The model suggests the plumbing system is a complex sill structure consisting of several interconnected bodies that lie beneath MSH at 3.5-14 km depth and that extend ~25 km laterally. Bright reflections in 3D autocorrelation reflectivity depth migrations are strongly correlated with the melt model, illuminating its interior as well as a system of more geographically extensive thin sills that are invisible to the tomography. High amplitude reflectivity occurs near the top of the sill complex, suggesting the system grows by successive emplacement at the top of the complex. Inversion of the autocorrelation reflection volume for melt content suggests melt concentrations exceed 30% locally in the sill complex. The highly reflective center of the sill complex is likely the magma storage zone that feeds dacitic composition MSH eruptions. We speculate that some of the more geographically widespread dikes feed the Indian Heaven basalt fields.

Deeper reflectivity trends to the northeast of MSH and intersects the Lower Crustal Conductor in Bedrosian et al's (2018) MT interpretation. They interpret high conductivity values as indicative of 3-10% interconnected melt in the crust at depths > 20 km, which is consistent with our reflectivity images. We also observe asymmetric crustal thickening toward and thinning away from MSH along the strike of the Cascades. Moho reflectivity is weak directly beneath MSH, agreeing with previous studies (Kiser et al, 2016; Hansen et al, 2016). Zones of strong autocorrelation and wide-angle reflectivity cross the refraction Moho and extend some distance into the upper mantle.