

Recent results from the iMUSH active-source seismic experiment

The imaging Magma Under St. Helens (iMUSH) project was designed to image the magmatic system beneath Mount St. Helens from the subducting Juan de Fuca slab to the surface. The active-source seismic component of this project took place in the summer of 2014 and included two deployments of ~2,500 Texan Reftek 125A data loggers with 4.5 Hz geophones, one deployment of ~900 1-component nodal seismometers with 10 Hz geophones, and 23 1000-2000 lb. borehole shots. Initial 2D tomography results using this data set showed the general locations of inferred upper and lower crustal magma reservoirs that feed Mount St. Helens. In this presentation, recent work that has focused on the 3D velocity structure and reflectivity associated with this magmatic system will be shown.

In order to model the detailed structure of the shallow Mount St. Helens magma reservoir, approximately 62,000 P wave travel time picks have been combined with a finite-frequency tomography method to model V_p in the upper 15 km beneath the volcano. These results show a low V_p anomaly between 3.5 and 14 km depth that is inferred to represent the magma reservoir that feeds Mount St. Helens. This feature is complex and at most depths has a central location that is offset to the south/west from the volcanic edifice. Using a calculated relationship between V_p and melt fraction, it is estimated that anomalously high melt fractions of 10 to 12 % occur between 4 and 6 km depth within the inferred magma reservoir. A majority of the magma source depths of major eruptions at Mount St. Helens over the past 4 kyr fall within this same depth range. This relationship suggests persistent properties of the magma reservoir that focus magma accumulation within this depth range over multiple eruptive episodes.

In addition to V_p modeling, recent work on the iMUSH data has focused on determining the reflectivity properties of the magmatic system. Recordings of shots, micro-earthquakes and noise have been autocorrelated to generate vertical incidence reflectivity P-wave functions along two lines of the iMUSH data set. These images show strong reflectors near the Moho within a low velocity region inferred to be a lower crust magma reservoir. We interpret these reflectors as the MASH (Magma Assimilation, Storage, and Homogenization) zone where magma ponds in the lower crust. Strong reflectors are also observed in the shallow magma reservoir, which may be associated with the internal structure of this body.