Researchers find evidence for a cold, serpentinized mantle wedge beneath Mt. St. Helens

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Looking into the summit crater from the north side. Along one of the many canyons that have managed to carve their way into the 1980 eruption deposits. Credit: University of New Mexico

It's been more than 35 years since the last major eruption of Mount St. Helens. Since that blast, much research has been conducted with scientists learning a great deal about one of the most active volcanoes within the Cascade arc, a North-South chain of volcanoes in the Pacific Northwest that formed above the subducting Juan de Fuca plate.

Mount St. Helens is known as a composite volcano or stratovolcano, a term for steep-sided symmetrical cones that are constructed of alternating layers of lava flows, ash and other volcanic debris. Composite volcanoes tend to erupt more explosively and pose considerable danger to nearby life and property such as Mount St. Helens did in the 1980 eruption. Its location, however, is unusual because it lies approximately 30 miles due west of Mount Adams and the main axis of arc volcanism.

Much has been learned since that eruption. Petrologic and geophysical research at Mount St. Helens that suggests most of the eruptive products were derived from one or more upper-crustal magma chambers located between depths of three to 12 kilometers (approximately two to 7 miles).

Volcanic eruptions are caused by magma, a mixture of liquid rock, crystals and dissolved gases. Arc magmas are the end result of complex series of processes involving the interaction between the overlying crust and melts that ascend from the mantle wedge source region.

Despite the previous research, the structure of the deep magmatic plumbing system beneath Mount St. Helens and its context within the broader Cascadia subduction system remain poorly resolved despite the genetic link between subduction and arc volcanism.

Recently, researchers including postdoctoral researcher Steven Hansen, along with mentor and Assistant Professor Brandon Schmandt at The University of New Mexico, have been searching for additional answers surrounding the magmatic system of Mount St. Helens as part of a multi-year collaborative research project involving several institutions.

The overarching goal of the research, released today in Nature Communications, is to illuminate the architecture of the greater Mount St. Helens magmatic system from slab to surface.

The collaboration, titled iMUSH (Imaging Magma Under St. Helens), supported by the GeoPrisms and the EarthScope Programs of the US National Science Foundation, also involves researchers from the Department of Earth Science at Rice University, the Department of Earth and Space Sciences from the University of Washington, and the Department of Earth and Atmospheric Sciences from Cornell.

Samantha Cafferkey removing a seismometer near Loowit Falls during the array demobilization. Credit: University of New Mexico

"Thermal models of the subduction zone indicate the down-going slab is decoupled from the overriding mantle wedge beneath the forearc," said Hansen. "This results in a cold mantle wedge that is unlikely to generate melt. Given the unusual location of Mount St Helens, we think that this raises questions regarding the extent of the cold mantle wedge and the source region of melts that are ultimately responsible for volcanism."

In an ambitious attempt to constrain the deep structure of the crust and mantle below Mount St. Helens, which has proven tough to resolve in previous seismic studies, the researchers, along with a handful of students from the collaborating institutions, conducted a large-scale, active-source seismic experiment as part of the iMUSH collaboration to determine where the melt is located in the subsurface and where it is sourced from.

Hiking more than 20 miles a day while carrying up to 12, five-pound seismic sensors at a time, the group deployed an array consisting of 900 autonomous seismographs all within 15 kilometers of the Mount St. Helens summit crater. Active source explosions followed to create seismic energy similar to that produced by small 2.0 magnitude earthquakes.

"All sensors were deployed along the road and trail system at Mount St. Helens with an average spacing of 250 meters," said Hansen. "After deploying the seismographs, 23 active source explosions were conducted by the Rice group, headed by Alan Levander and Eric Kiser."

The resulting tremors were recorded by three arrays of vertical-component geophones deployed in two phases which together contained about 4,800 individual channels. The resulting dataset provides a unique opportunity for high-resolution seismic imaging of deep crustal structure beneath this active arc volcano.

"Using high-resolution active-source seismic data, we show that Mount

St. Helens sits atop a sharp lateral boundary in Moho reflectivity," Hansen said. "Weak-to-absent PmP reflections to the west are attributed to serpentine in the mantle-wedge, which requires a cold hydrated mantle wedge beneath Mount St. Helens (

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