Abstract for 2019 SAGE/GAGE Workshop

Session: Earth Rheology and Structure: New Approaches, Applications, and Implications for Dynamics

Talk Title: Surface-wave Radial Anisotropy Illuminates Magma Storage and Migration at Okmok caldera, Alaska

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Okmok caldera is one of the most active volcanoes in the Aleutian Arc, and has erupted eleven times in the last century. Ten of these events originated at Okmok's cone A, which is located on the SW periphery of the caldera. Eruptions at cone A have historically resulted in smaller volumes of mafic material being released. The most recent eruption in 2008 broke this historic pattern. The event did not originate from cone A, but instead built a new cone, Ahmanilix, located near the center of the caldera. The total volume of material released during the 2008 event was much larger than previous, historic events. Also, the majority of the erupted materials were compositionally evolved basaltic andesites.

To explain the compositional and volume differences observed between eruptions at cone A and the 2008 eruption at Ahmanilix, we determine the radial anisotropy structure of Okmok. First, we carry out the inversion of both permanent and temporary seismic data recorded at Okmok volcano in 2015/2016 in order to solve for the Ralyleigh and Love wave derived shear wave velocity models, Vs. Using these two models of Vs, we are then able to quantify the seismic radial anisotropy of the volcano. Our model of radial anisotropy reveals that Okmok is composed of a pervasive stacked sill complex centered within the caldera and circumscribed by an extensive vertical dike system. One magma pathway within this dike system is illuminated by overlaying patterns of seismicity at Okmok between 2003 and 2008. We find that this magma pathway extends from beneath the surface of cone A and terminates immediately adjacent to the sill complex at the geodetically determined depth of the long-term volcanic deformation source (Figure 1a). This long term deformation source is indicative of an active region of magma storage where melts are stored for only short periods of time before migrating towards cone A or into the overlying region of stacked sill storage. We infer that such short residence times explain why erupted materials at cone A are always mafic in composition. Pre- and co-eruptive seismicity associated with the 2008 eruption are also overlain on the anisotropy model of Okmok and display a vertical path of seismicity sampling through the volcano's stacked sill complex (Figure 1b). Thus, the path of magmatic fluid migration for the 2008 eruption allowed for tapping of more evolved melts hosted within sill storage. This explains why the 2008 event released more compositionally distinct materials during its eruption relative to the mafic eruptions hosted at cone A. Also, since the 2008 eruption was able to tap these additional regions of sill storage, it was able to produce a larger volume of erupted materials relative to eruptions at cone A.

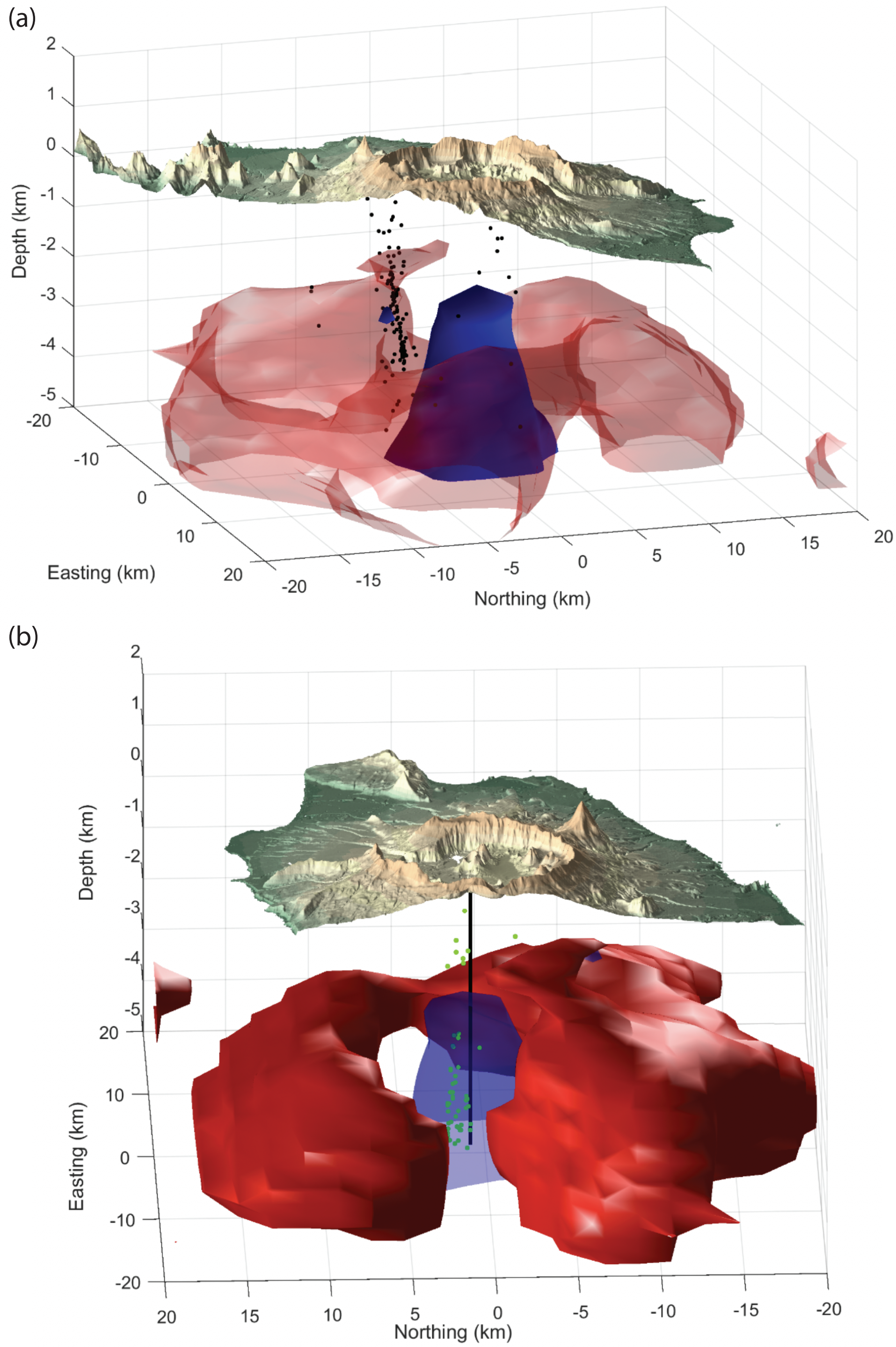

Figure. 1. The anisotropy model of Okmok volcano is displayed where blue and red regions indicate areas of sill storage and pervasive vertical diking, respectively. (a) Inter-eruptive seismicity between early 2003 and July 6, 2008 is shown as black, filled circles. (b) Plotted pre- and co-eruptive seismicity are from July 6 to July 13, 2008 (green filled circles). The solid black line projects the position of Ahmanilix onto the grid. All plotted seismicity is from Ohlendorf et al. (2014).