Seismically anisotropic magma reservoirs underlying silicic super-eruptions of Yellowstone and Long Valley calderas

Chengxin Jiang[1], Brandon Schmandt[1], Jamie Farrell[2], Fan-Chi Lin[2], Kevin M. Ward[2]

1. Department of Earth and Planetary Sciences, University of New Mexico, Albuquerque, NM 87131
2. Department of Geology and Geophysics, The University of Utah, Salt Lake City, UT 84112

Seismic anisotropy can illuminate structural fabrics or layering with length scales too fine to be resolved as distinct features in most seismic tomography. Radial anisotropy, which detects differences between horizontally (V_{SH}) and vertically (V_{SV}) polarized shear wave velocities, was investigated beneath Yellowstone and Long Valley calderas. Significant positive radial anisotropy indicating $V_{SH}>V_{SV}$ and low isotropic velocities were found beneath both calderas at ~5-18 km depths. The positive radial anisotropy (>8%) volumes beneath the calderas are anomalously strong compared to the surrounding areas. The absence of a similar anisotropic signal in the wake of the propagating Yellowstone hotspot indicates that the radial anisotropy diminishes after the locus of voluminous silicic magmatism moves. We propose that the anisotropic volumes represent sill complexes of compositionally evolved magma, whose seismic contrast with the crust would largely fade upon crystallization. The similarity of magma reservoir anisotropy in varied tectonic settings suggests that such mid-crustal sill complexes may be ubiquitous features of voluminous silicic magmatic systems, and that anisotropy should be considered to seismically estimate melt content and mobility. The absence of similar radial anisotropy in the lower crust beneath the calderas suggests lower melt fractions or a transition in the geometry of magma pathways.

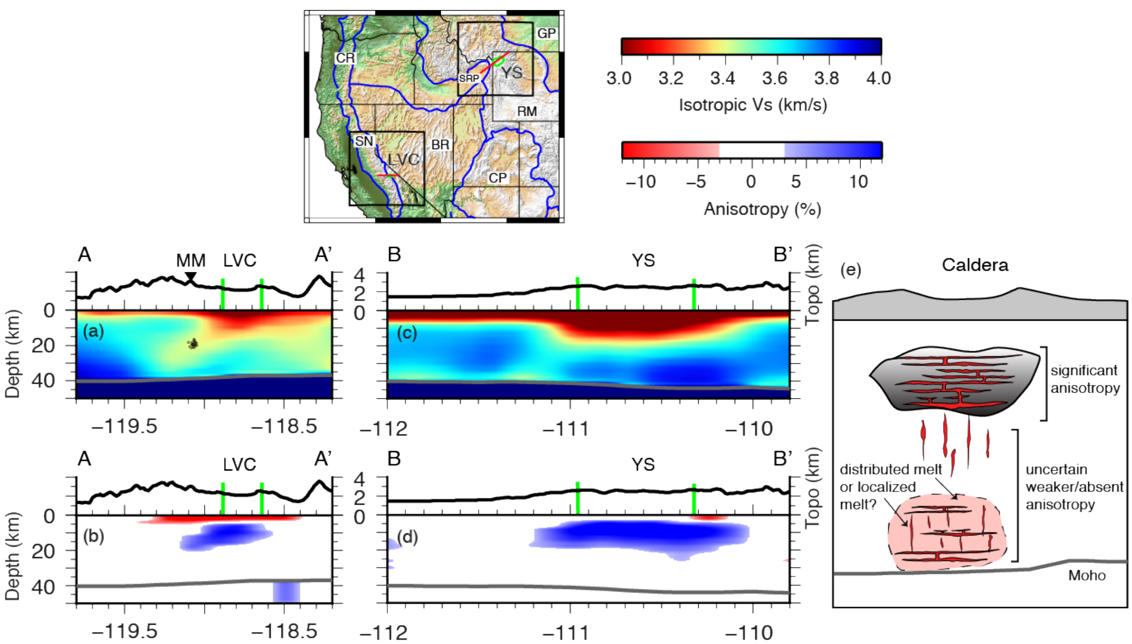

Figure 1. Vertical cross-sections of isotropic Vs and anisotropy. Long Valley caldera (A-B) and Yellowstone (C-D), and an interpretative cartoon (E). The insert map on the top shows the profile locations (red lines), as well as the tectonic surroundings (blue lines), including Sierra Nevada (SN), Cascade Range (CR), Basin and Range (BR), Snake River Plain (SRP), Colorado Plateau (CP), Rocky Mountain (RM) and Great Plains (GP). Grey lines illustrate the Moho. Green lines delineate the calderas. The circles in Fig. 1A are hypocenters from a 2009 earthquake swarm (Shelly and Hill et al., 2011). Note that the depths in the tomography are relative to the local surface, and the cartoon figure is shown with a different scale.

Reference

Shelly, D. R., and Hill, D. P., 2011, Migrating swarms of brittle-failure earthquakes in the lower crust beneath Mammoth Mountain, California: Geophysical Research Letters, v. 38, doi: 10.1029/2011GL049336.