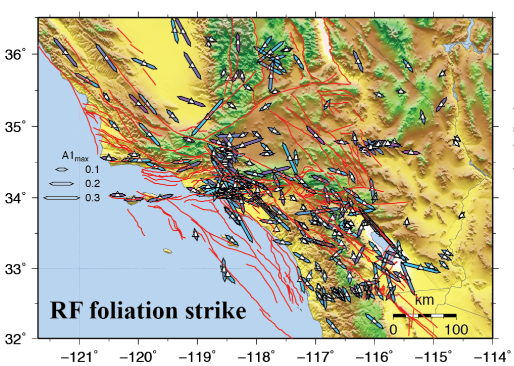
Tectonic inheritance via the influence of crustal composition and deformation fabric on deformation response and the geometry of faults and anisotropic shear zones in California

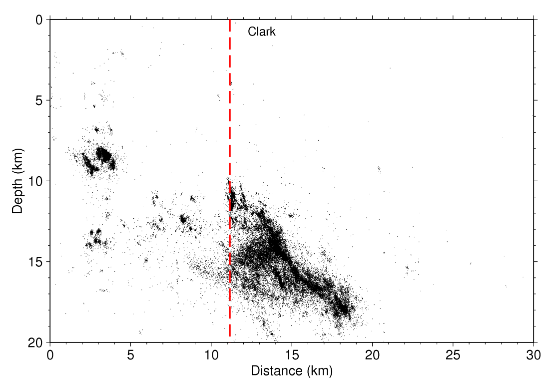
Vera Schulte-Pelkum, University of Colorado Boulder; Sarah Brownlee, Wayne State University; Kai Wang, University of Toronto; Chengxin Jiang, Harvard University; Zachary Ross, Caltech; Yehuda Ben-Zion, University of Southern California

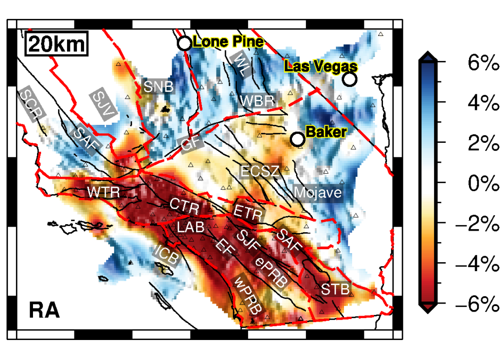
We investigate the rheology, anisotropic structure, and fault and shear zone geometry near the Southern California transform plate boundary and consider the influence of crustal composition and preexisting deformation fabric via modeling of the elastic response based on rock samples.

We use three types of observations. First, receiver functions from stations across the region show a strong signature from contrasts in anisotropy with a plunging symmetry axis (dipping foliation). On a regional scale, the strikes of the steeply dipping foliation are parallel to those of mapped surface faults. This dipping or listric geometry is a surprising result, since an optimally oriented strike-slip fault would have a vertical geometry. Second, dipping fault and shear zone geometries at depth are supported by precise mapping of microseismicity, which suggests listric geometries of transform fault branches as they approach the brittle-ductile transition. Third, surface wave tomography shows a very unusual strong negative radial anisotropy (Vsv > Vsh) across large portions of the middle to lower crust on the Pacific side of the San Andreas Fault, accompanied by high average seismic velocities.

The seismic observations can be explained by steeply dipping foliation in garnet-bearing or amphibolite schists, or by shallowly dipping possibly magmatic foliation in a plagioclase-rich lower crust. We use a compilation of elastic tensors from crustal rock samples to calculate average seismic velocities and anisotropic elasticity for comparison with the seismic observations. If the regions of negative radial anisotropy and high average velocity in the mid- to lower crust represent restite from pluton emplacement, their position may have influenced the course of the transform plate boundary during its subsequent development. If the observations point towards a pervasive dipping schist fabric, the latter may have developed during previous extensional and compressional events and control the observed present-day listric geometry of faults. Either case suggests that tectonic inheritance plays a significant role in present-day deformation behavior.







(top left) Pervasive fault (red) parallel dipping foliation strikes (arrows) from receiver functions. (top right) Depth profile of microseismicity (dots) across the San Jacinto Fault (red = surface trace) suggesting listric geometry (Ross et al., 2017, Sci. Adv.; 2019, Science). (bottom left) Radial anisotropy from surface waves showing strong negative anisotropy (Vsv>Vsh; red) concentrated SW of the San Andreas Fault (Wang et al., 2019, submitted; see poster in this session).