Fault-parallel shear fabric in the ductile crust of Southern California imaged using receiver functions

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We present results on deep crustal deformation fabric from a new receiver function method. The method uses the azimuthal variation of P-to-S converted arrivals on the radial and transverse component of receiver functions. Dipping isotropic velocity contrasts and anisotropy contrasts with a plunging symmetry axis generate receiver function arrivals with two polarity flips with backazimuth. The azimuthal position of the polarity changes relates directly to the strike of the dipping contrast or dipping foliation. Unlike shear wave splitting, the converted arrival method carries depth information since the delay time of the conversion scales to the depth of the dipping or anisotropic contrast. Also unlike shear wave splitting, the method only requires contrasts involving weak (a few percent) Vp anisotropy over a narrow (~2 km or more) zone of deformation to generate a robust signal. Applying this new method to stations with data available at the IRIS DMC in Southern California, we find strikes of foliation or dipping contrasts that are strongly aligned with surface fault traces. Some of the largest arrivals are seen immediately adjacent to or beneath major, active faults. The depths of the imaged structures extend well below the base of the seismogenic crust, suggesting that fault-aligned shear fabric is present in the lower crust and possibly in the uppermost mantle. Our observations support deformation models that predict faults root into wider shear zones continuing through the ductile lower crust. Fault-parallel strikes are seen along the San Andreas and other major strike slip fault branches, in the Eastern California Shear zone, and across the Salton Trough. Differently oriented strikes parallel thrust faults bordering the Transverse Ranges and the Garlock fault. Weaker, similarly aligned fabric appears to be pervasive in much of Southern California between active faults in areas that are thought to be moving as a rigid block (e.g., San Diego County). Possible future analysis using the denser coverage provided by all three-component broadband and short-period stations in the area with data available at SCEDC as well as IRIS would help answer the following questions: How narrow are the fault-related shear zones at depth and do they continue into the upper mantle, what is their geometry, and does the observed fabric match recent models of deep crustal strain)? Is pervasive weaker fabric away from major faults related to distributed deformation in the current transform regime, or to fossil fabric in subducted Orocopia and Pelona schists? The work could provide constraints for SCEC5's proposed efforts to develop a Community Rheological Model of rock lithology and fabrics through Southern California.

Figure: Preliminary map of receiver function mapped strikes and depths using a subset of available networks. Bar color shows depth, bar length is amplitude of the azimuthal degree-1 arrival in units of horizontal to vertical ratio. The largest amplitude arrival at each station is shown. Black lines are fault surface traces.