T51B-2576

# Rapid Lateral Variation of Seismic Anisotropy Across the Salton Trough, Southern California

*Alex Kinsella (alexk15@stanford.edu), Shahar Barak, and Simon L. Klemperer*

*Department of Geophysics, Stanford University*

## 1. Introduction:

The Salton Trough is an active magma-dominated rift or "leaky transform fault" linking the Gulf of California mid-ocean-ridge spreading system to the San Andreas strike-slip fault system. Because the rift is buried beneath a thick pile of Colorado River sedimentary rock, little is known about the total volume of igneous intrusion into the crust and the magma distribution within and beyond the rift margins. However, very young volcanics (<10,000 yrs) and numerous geothermal power plants attest to ongoing activity. Our Broadband Salton Seismic Imaging Project is deploying 42 broadband seismographs across the Salton Trough from San Diego to the Colorado River that record earthquakes from around the globe. We have used the first 14 months of these data to study the anisotropy of the Salton Trough through shear wave splitting.

### Salton Seismic Imaging Project (SSIP)

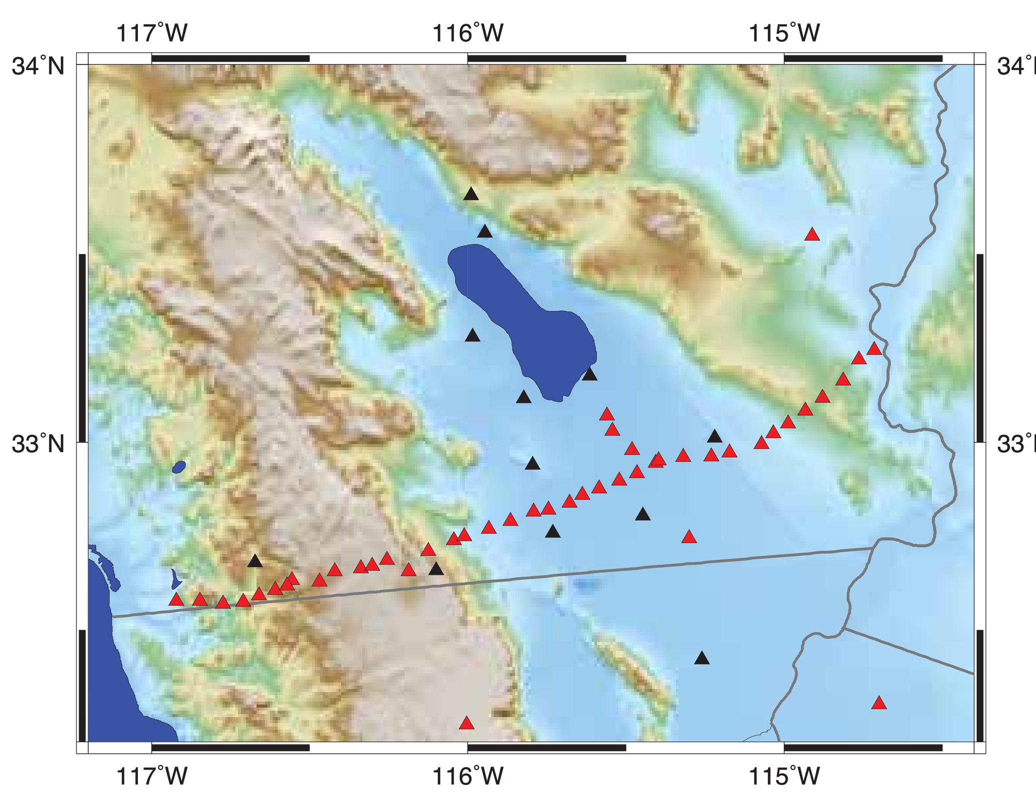


**Fig. 1** Map of the Salton Trough region with color-coded topography. Red triangles indicate stations that are part of our broadband array. Black triangles indicate permanent stations used by Monteiller and Chevrot (2011), a similar study.

## 2. Method

When a seismic shear wave travels through an anisotropic medium, it splits into two orthogonal components that travel at different speeds. We measure the time delay of the slow component (δt) and angle of polarization of the fast component (φ) to characterize the anisotropy beneath each seismograph. To measure these parameters, we used SplitLab, a Matlab-based GUI environment (Wustefeld 2007). We used SplitLab to analyze about 60 earthquakes per station with Mw > 6.0, but due to the high seismic noise environment, we only found between zero and seven useful earthquakes per station (Figures 2 and 3). We stacked the results to find the best parameters for each station using the method of Restivo and Helffrich (1999).

## Acknowledgements

AK was supported by a Stanford VPUE grant. Broadband-SSIP was funded by NSF-Geophysics-0911743 to SLK. Thanks to IRIS PASSCAL (and CalTech) for providing instrumentation and support. CICESE (Ensenada) helped with site installation in Mexico and provided data from MBIG. The UC-Desert Research & Extension Center, Holtsville, hosted our instrument center. Numerous students from Stanford, SF State, IVC, UCLA and SDSU assisted with station installation and maintenance. Many private landowners as well as BLM, Cal-FIRE, CDCR, State Lands Commission, USN, SD Water, and Anza-Borrego State Park allowed access to their land.

### Shear Wave Splitting Measurements

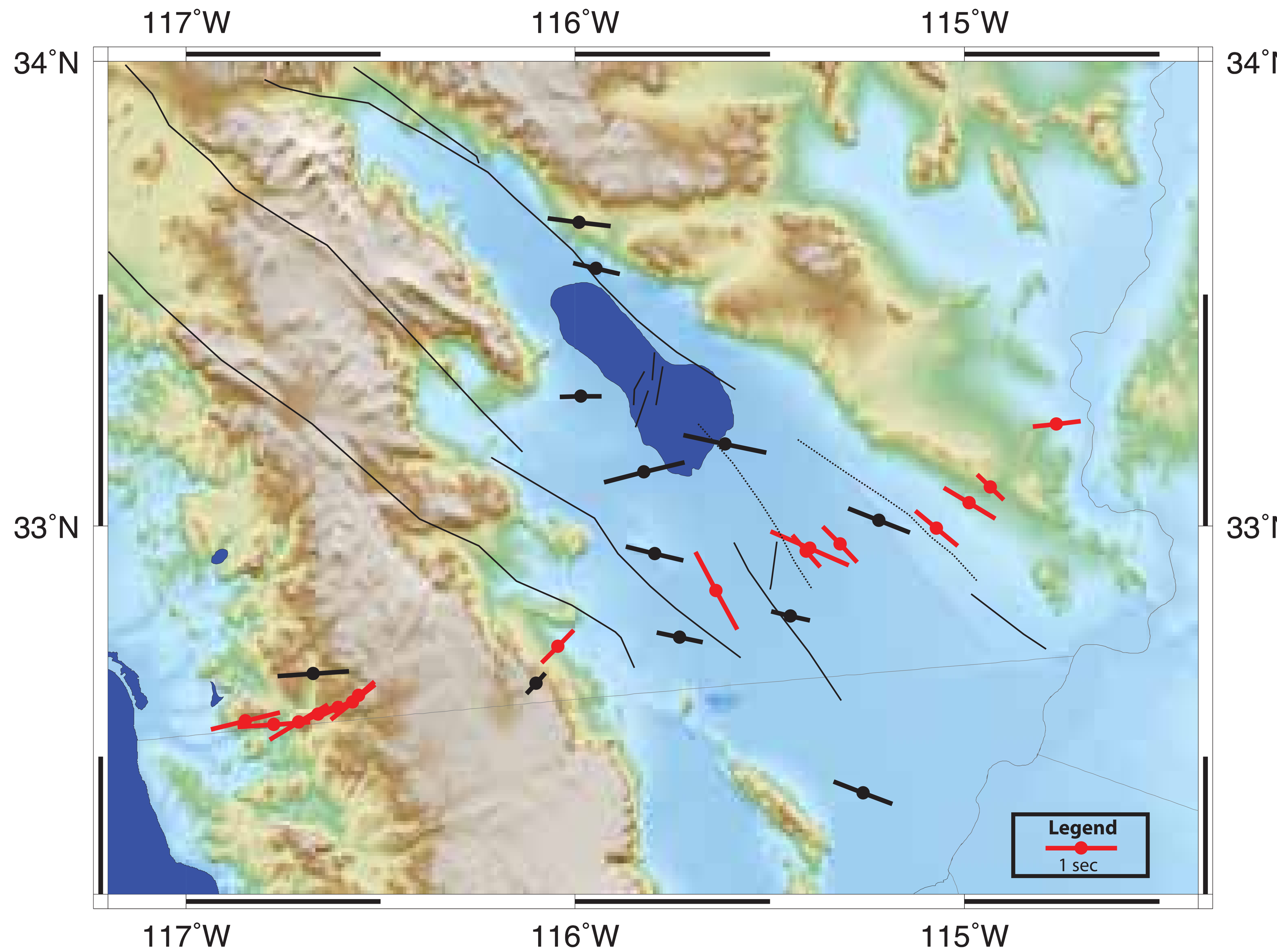


**Fig. 2** Map of splitting measurements. Direction of bar indicates orientation of fastest wavespeed ("fast axis") and length of bar indicates delay time. Measurements in red are our stations (only those with >3 good earthquakes), whereas stations in black are from Monteiller and Chevrot (2011).

### Example of Results from Shear Wave Splitting

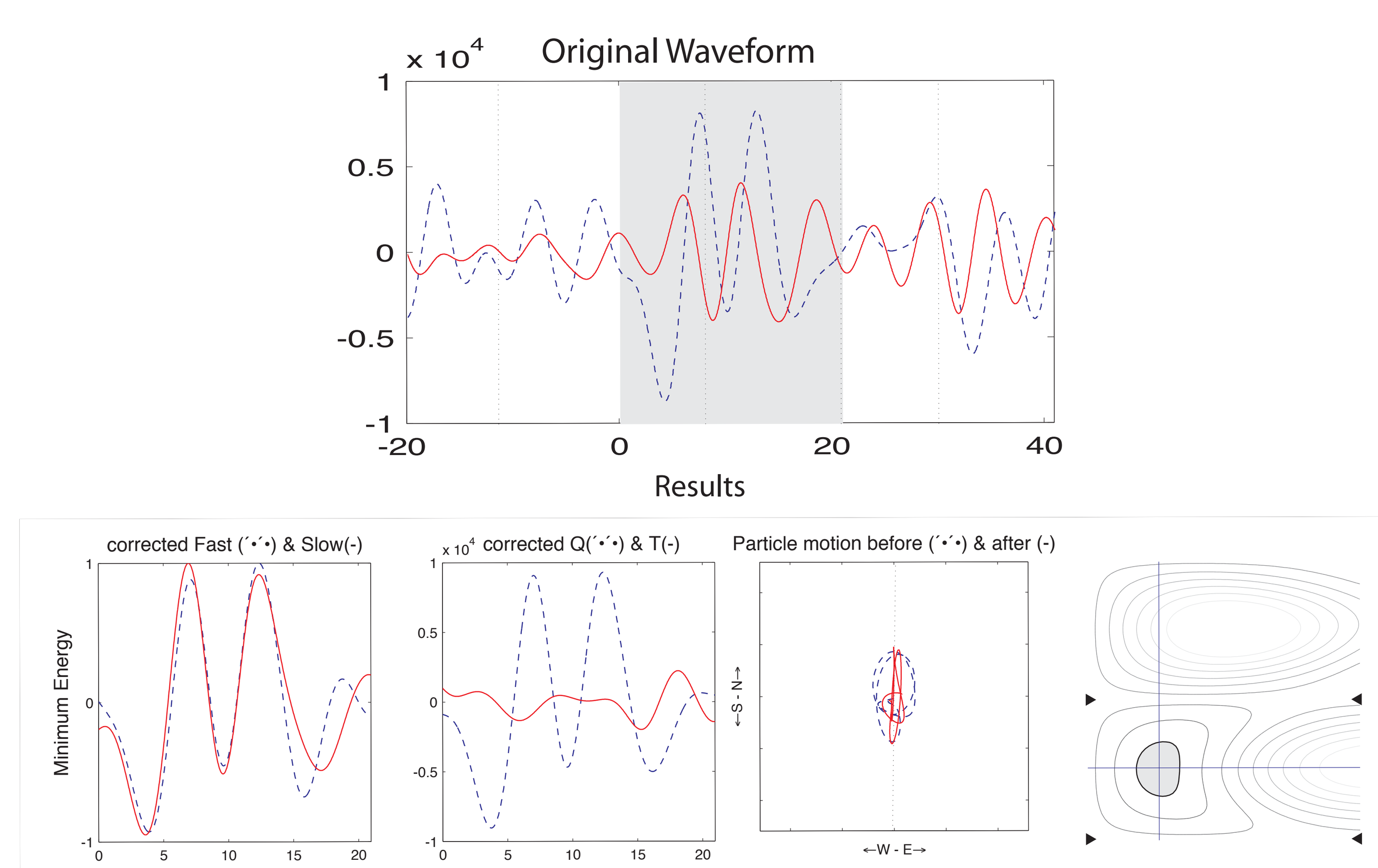


**Fig. 3** Typical results from SplitLab. The top image is the original waveform split into its radial (blue) and transverse (red) components (the two orthogonal components of ground movement registered by the seismograph). The gray-highlighted area is the portion of the waveform used for the splitting measurement. The leftmost image in the bottom row is a plot of the fast and slow components of the corrected waveform. To its right is a plot of the radial and transverse components of the corrected waveform. To the right is a plot of the particle motion, where the dotted line represents the fast axis. The rightmost image is a plot of the contours on a φ-δt grid, where the gray area represents 95% confidence.

## 3. Results

- Single-layer models show fast axes aligned roughly W-E at stations in the Peninsular Ranges west of the Salton Trough, as recognized by many previous studies.
- In the center and east of the trough, our fast axes are roughly NNW-SSE, parallel to the axis of the Salton Trough (Figure 2).
- These NNW-SSE fast axes have not previously been recognized before in this area.

## 4. Discussion

- Relatively large delay times (0.5-1.5 s) indicate the mantle is likely the dominant source of the anisotropy.
- The W-E anisotropy to the west has previously been interpreted as due to either movement of the trailing edge of the Farallon plate over the last 20 million years or Cenozoic N-S compression in southern California.
- We propose that the NNW-SSE fast axes within and east of the trough are caused by either (or both) shearing associated with the San Andreas and related strike-slip faults, or by local magmatism (Figure 4).
- Because other studies have shown the San Andreas fault does not have a strong anisotropic signature, we prefer the magmatic interpretation. This is exciting because it would represent the first direct detection of magma beneath the Salton Trough.

### Faults and Magmatism in the Salton Trough

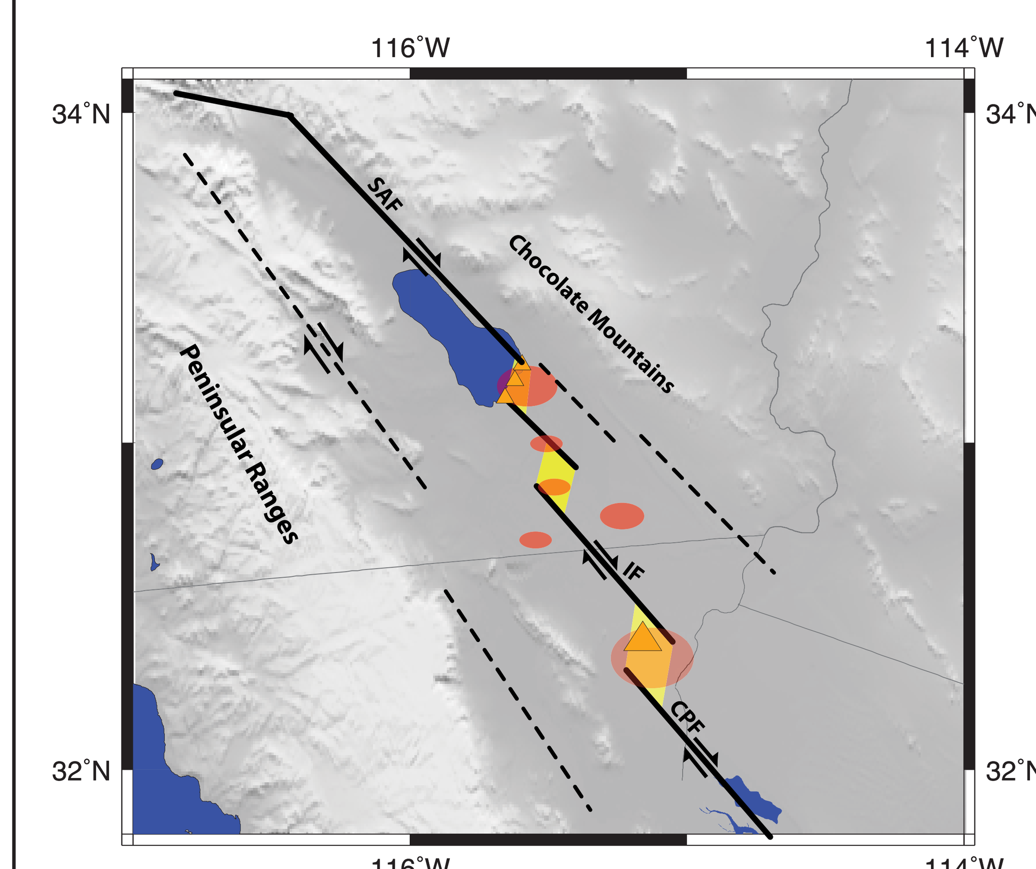


**Fig. 4** Fault and magmatic activity in the Salton Trough. Black lines: SAF: San Andreas fault; IF: Imperial fault; CPF: Cerro Prieto fault. Red ellipses are commercial geothermal developments, and triangles are Quaternary eruptive centers – both marking areas of likely intra-crustal magmatic activity today. Yellow parallelograms are a conceptual model of extension/ formation of new crust by magmatism implied by the offset strike-slip faults at the surface.

## References

- Wüstefeld, A., Bokelmann, G., Zaroli, C., & Barruol, G. (2008). SplitLab: A shear-wave splitting environment in Matlab. Computers & Geosciences, 34(5), 515-528.
- Monteiller, V., & Chevrot, S. (2011). High-resolution imaging of the deep anisotropic structure of the San Andreas Fault system beneath southern California. GJI, 186(2), 418-446.
- Restivo, A. (1999). Teleseismic shear wave splitting measurements in noisy environments. GJI, 137(3), 821-830.
- Fuis, G., Mooney, W., & Healy, J. (1984). A seismic refraction survey of the Imperial Valley region, California. JGR, 89, 1165-1189.
- Ichinose, G., Day, S., Magistrale, H., Prush, T., Vernon, F. and Edelman, A. (1996). Crustal thickness variations beneath the Peninsular Ranges, southern California. GRL, 23(22)
- Parsons, T., & McCarthy, J. (1996). Crustal and upper mantle velocity structure of the Salton Trough, southeast California. Tectonics, 15(2), 456.

## Additional Work in Progress...

### 1. High-Resolution Ambient Noise Tomography

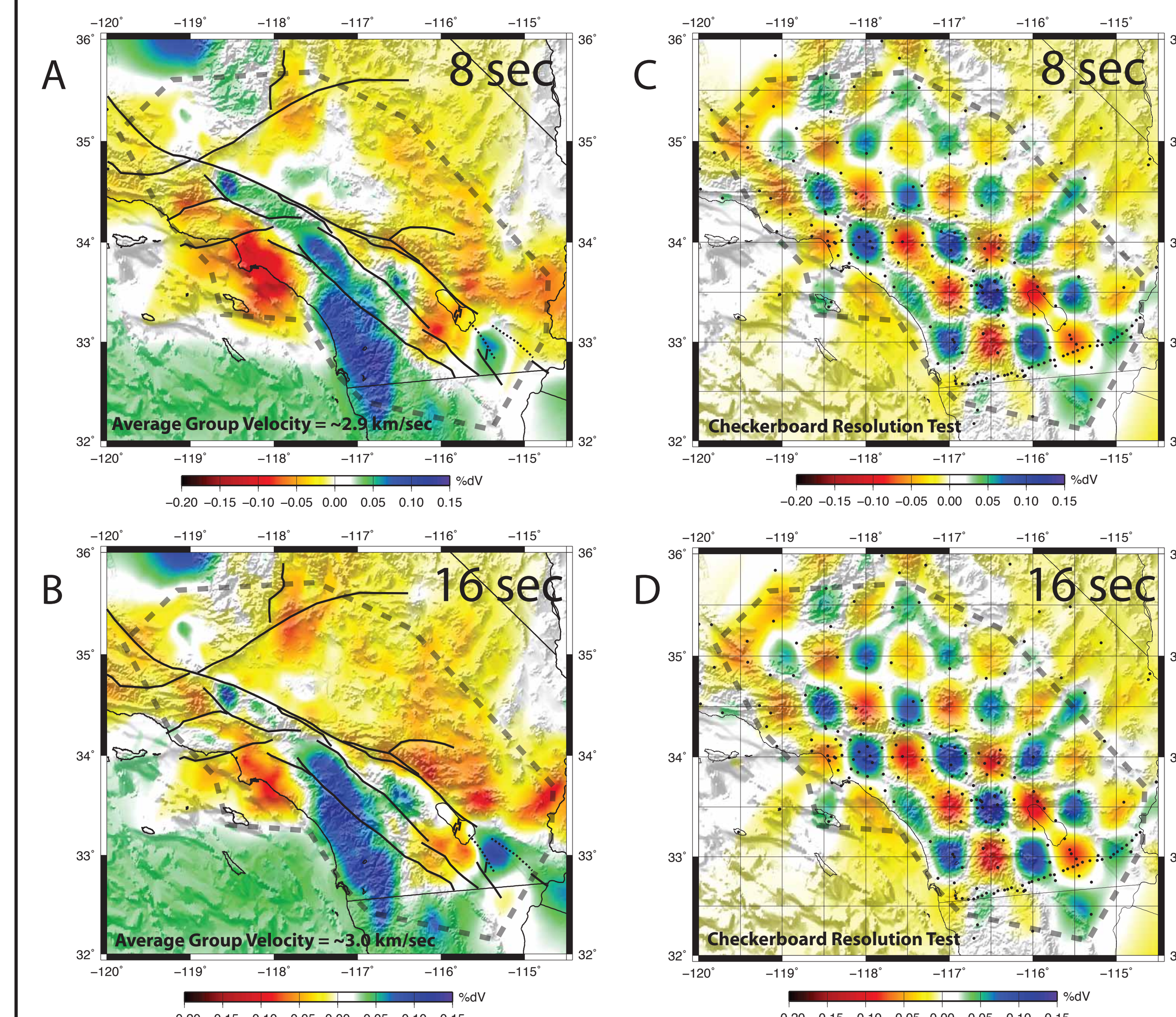


Fig. A-B: Rayleigh-wave group-velocity models of southern California at periods of 8 and 16 seconds. C-D: Checkerboard resolution tests. Dashed lines bound limit of good resolution, continuous black lines are major faults and black dots are station locations used for the cross-correlations (a few stations are outside the bounds of these maps).

- High velocities are observed under the the Peninsular Ranges, Transverse Ranges and the southern edge of Sierra Nevada, relative to low-velocity sedimentary rocks in the Imperial Valley, LA Basin, Ventura Basin, Santa Maria Basin, and Mojave Desert.
- Distinct lateral velocity variations coincide with major faults such as the San Andreas Fault, San Jacinto Fault, Elsinore Fault, Garlock Fault, and Owens Valley Fault, at the observable depth. Abrupt contrasts indicate vertical dip, at the resolution of our model.

### 2. Receiver-Function Analysis of a dense array

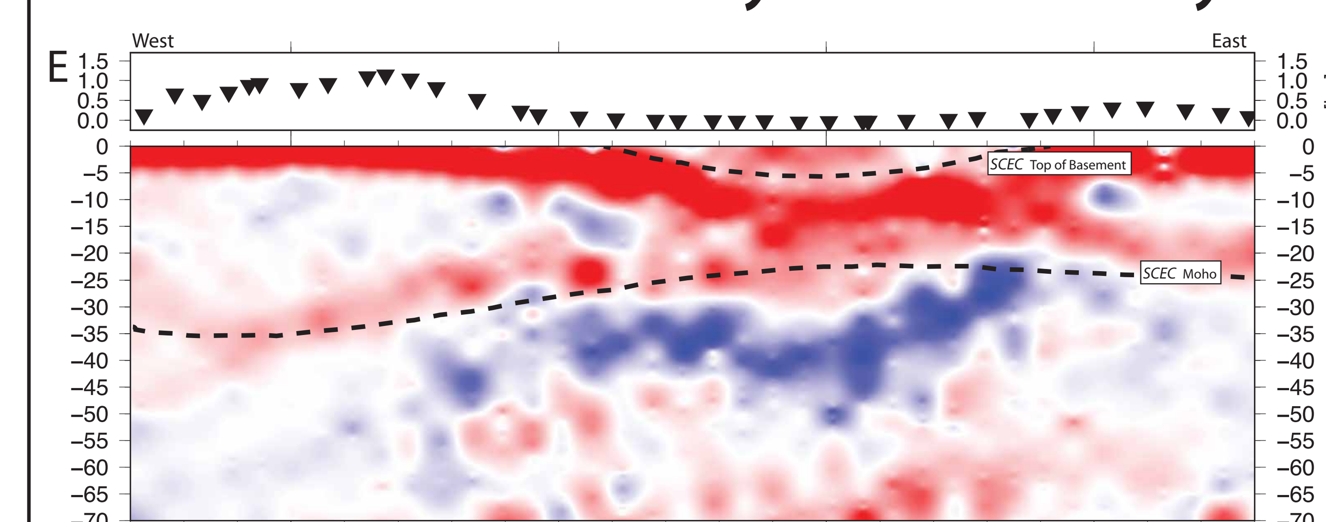


Fig. E: Vertical slice of a 2D CCP back-projection along our array (SSIP line 2) using a simple 1D velocity model (iasp91). Red and blue colors represent positive and negative impedance contrasts, respectively. Dashed lines represent top of basement and Moho elevation, extracted from SCEC's Community Velocity Model (scec.usc.edu/scecpedia/CVM-H).

- Positive (red) converter at 10-15 km under the Salton Trough is either a delayed first arrival or abrupt basin-basement transition unlike gradational transition inferred by Fuis et al. (1984).
- The Moho, observed as a continuous positive (red) converter, is in general agreement with previous studies (e.g., Ichinose et al., 1996; Parsons and McCarthy, 1996), but has more structural detail than the smoothed SCEC Moho.
- Prominent negative (blue) mantle converter under the Salton Trough is hot (low-velocity) mantle as previously observed by Parsons and McCarthy (1996), but could also be a basement or Moho reverberation, yet to be modeled at this stage.