Seismic Interferometry at a Large, Dense Array: Imaging the Source Physics Experiment

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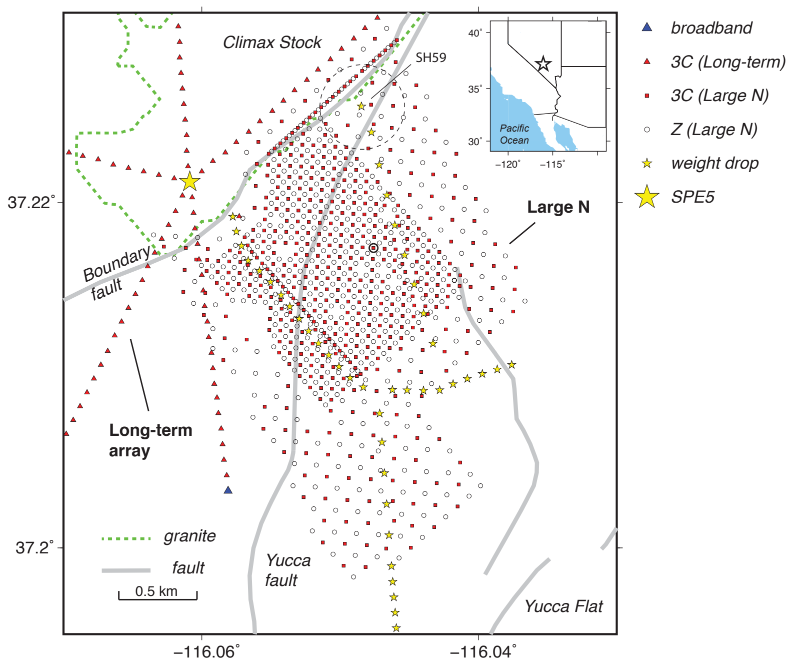
The cross correlation of the energy recorded at a pair of stations results in an estimate of the Green's Function (GF) and is equivalent to the record of a simple source located at one of the stations as recorded by the other. This allows high resolution imagery beneath dense seismic networks even in areas of low seismicity. The power of these inter-station techniques increases rapidly as the number of seismometers in a network increases. For large networks, the number of correlations computed can run into the millions and this becomes a "big-data" problem where data-management dominates the efficiency of the computations.

In this study, we use several methods of seismic interferometry to obtain highly detailed images at the site of the Source Physics Experiment (SPE). The objective of SPE is to obtain a physics based understanding of how seismic waves are created at and scattered near the source. In 2015, a temporary deployment of 1,000 closely spaced geophones was added to the main network of instruments at the site. We focus on three interferometric techniques: Source interferometry (SI) uses the SPE chemical explosions as rich sources of high frequency, high signal energy. Coda interferometry (CI) isolates the energy from the scattered wavefield of distant earthquakes. Ambient noise correlation (ANC) uses the energy of the ambient background field. In each case, the data recorded at one seismometer are correlated with the data recorded at another to obtain an estimate of the GF between the two. Within the geophone network we obtain high quality signals between 2-40 Hz. The large network of mixed geophone and broadband instruments at the SPE allows us to calculate over 260,000 GFs, which we use to characterize the site and measure the localized wavefield.



The Large-N array at SPE reveals a complex structure in the alluvium south of the shot point. We measure large variations in seismic velocities and amplitudes in the top 100 meters. This heterogeneous shallow layer scatters seismic energy as it moves across the array, resulting in the complex waveforms seen in records of the SPE shots.

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