Use of active source geophones for passive source imaging: Examples from the Bighorn Arch Seismic Experiment, Wyoming, USA

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We explore deep seismic imaging using continuous wavefield recordings from a dense array of petroleum industry-style geophones. The data in this study were acquired during the EarthScope FlexArray Bighorn Arch Seismic Experiment (BASE) in central Wyoming, USA. In addition to traditional active- and passive-source seismic data acquisition, BASE included a deployment of 850 Reftek RT125 "Texan" dataloggers that produced continuous recordings over 14 days. Ground motion was recorded via Geospace GS-11 4.5 Hz single-channel vertical component geophones. The geophones were deployed in a grid of three E–W lines and two N–S lines across the Bighorn Mountains. Along the main E–W line, geophones were deployed at intervals of 100 m to 1 km along a 300-km transect.

We find that the high frequency geophones effectively record the P waves of teleseismic earthquakes (events occurring greater than 1000 km from the survey area). During the 14 days of continuous recording we observed 57 teleseismic events with pickable P-wave arrivals across the array, including P, PKiKP, Pdiff, and Pn phases. The full waveforms can be used to extract additional information about the subsurface. We have successfully used teleseismic receiver-side crustal reverberation phases as virtual sources to mimic crustal reflection profiles (Yang et al., 2012). After depth conversion, we find a coherent phase that correlates well with the top of the Early- to Middle-Mississippian Madison Formation under the Powder River and Bighorn Basins that flank the Bighorn Mountains.

Following Haines (2011), we have explored the use of interferometric processing of active source blasts, but with limited success to date. We are now pursuing options involving autocorrelating the teleseismic P-wave coda (residual reverberation after the first arrivals). We use 30 teleseismic earthquakes at epicentral distances from 36 to 113 degrees and magnitudes ranging from 4.2 to 5.6 recorded on the BASE geophones. For each teleseismic event we calculate an autocorrelation function at each receiver, and then stack the autocorrelations of all events at a given receiver (station). We use synthetic seismograms to identify arrival times of reflections and are able to identify a Moho reflection with the autocorrelations. Our results to date indicate that active- and passivesource data and processing schemes provide complementary, but not redundant, results for the BASE data set.