

Subsurface Images Retrieved From Ambient Noise Using Seismic Interferometry

Deyan Draganov*, Xander Campman**, Jan Thorbecke*, Arie Verdel**, and Kees Wapenaar*

*TUDelft, **Shell International Exploration and Production B.V.

In recent years, the process of generating seismic traces from the crosscorrelation of existing traces (Seismic Interferometry or SI) has gained rapidly in popularity among academia and industry. One application of SI is the retrieval of the Green's function from the crosscorrelation of ambient seismic noise. The complete Green's function is retrieved when the noise sources illuminate the recording stations from all directions. When the predominant recorded noise represents surface-wave arrivals, then the crosscorrelation will retrieve only the surface-wave part of the Green's function. To retrieve body-wave arrivals, like reflections, one needs to correlate noise arrivals that have propagated in the deeper subsurface. The retrieval of the reflection part of the Green's function has proven more challenging as the surface-wave noise normally drowns out the more subtle body-wave noise. On the other hand, retrieval of reflections is very desirable, as they afford the construction of subsurface velocity models and subsurface reflection images with higher resolution than provided by surface-wave tomography.

At the end of 2007, Shell carried out a passive seismic experiment recording approximately 11 hours of ambient noise in a desert in North Africa. The field geometry consisted of 8 parallel lines with 50 m station spacing and 500 m spacing between the lines. The recorded noise was dominated by strong surface waves, concentrated mainly below 6 Hz, which were caused by a traffic road that crossed the survey at its Northern section.

We apply SI to the ambient noise with the aim to retrieve the reflection part of the Green's function. For this reason, we suppress the surface-wave energy before crosscorrelation. The result of the crosscorrelation is a so-called common-shot gather, i.e., a response from one virtual shot recorded by all receivers on a line. We use all the retrieved common-shot gathers in a processing scheme commonly used in the exploration seismics to extract velocity information of the subsurface and enhance reflection arrivals. The end result of the processing consists of stacked time-migrated subsurface sections showing the subsurface structures. Our results exhibit several laterally coherent events. We compare these sections to sections obtained from an active seismic reflection survey along the same lines. The comparison shows that several shallow marker events have been adequately reconstructed from the noise.

Having confirmed that the coherent events are subsurface reflectors, we use the retrieved common-shot gathers in a more advanced processing step, so-called prestack depth migration. In this processing we use a constant-gradient subsurface velocity model, which is based on the velocities that we estimated from the retrieved common-shot gathers. The end result is an image of subsurface volume below the survey lines.