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Retrieving reflection arrivals from seismic background-noise field data using seismic interferometry

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The construction of a good image of the Earth's interior requires a regular and dense distribution of seismic sources. In regional and global seismology, where mostly earthquakes are used as seismic sources, this distribution is limited mainly to active faults. Furthermore, the earthquakes primarily provide transmission information, which obstructs the use of reflection imaging methods. In exploration seismology, the increased demand for oil and gas pushes the exploration activities to new frontier areas, where no previous exploration activities have taken place, and sometimes to areas where no conventional seismic sources, such as seismic vibrators and dynamite, can be used. The limitations on the distribution of seismic sources on global and regional scale as well as the desire for cheaper exploration methods have motivated researchers to look for alternatives. One such alternative is the retrieval of the reflection response from seismic background-noise measurements using Seismic Interferometry (SI). SI is the process of creating new seismic records from the (time) cross-correlation of existing records.

In recent years, the SI methods have been gaining popularity. Several researchers derived relationships for the retrieval of the seismic impulse response (Green's function) from crosscorrelations of diffuse fields and of controlled-source experiments. *Campillo and Paul* (2003) and *Shapiro et al.* (2004) successfully retrieved surface waves between seismological stations from crosscorrelation of diffuse coda waves and of ambient seismic noise, respectively. *Roux et al.* (2005) also used ambient seis-

mic noise and retrieved not only surface waves, but also turning P-wave arrivals. The theory shows, though, that also reflection arrivals could be retrieved.

In 2005, a small field experiment was carried out with Shell's technical advice and support with the idea to test the applicability of the SI method for retrieval of reflections. Ten hours of background-noise data were recorded along an array of 17 3-component geophones. The specific place for the array was chosen to be along a line of an active exploration survey.

We correlated the ten hours of recorded seismic background noise. The SI results showed the retrieval of several coherent events – inclined and nearly horizontal. We compared the data retrieved through SI with the data from the active exploration survey. The comparison of the two data sets confirmed that the retrieved nearly horizontal arrivals are indeed reflection arrivals; the retrieved inclined arrivals were confirmed to be surface waves.

The retrieval of reflections from the correlation of seismic background noise has promising applications in regional seismology, frontier exploration and long-term monitoring of processes in the Earth's subsurface.