Geophysical Exploration with Seismic Interferometry (1) - Application to inverse VSP data

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The imaging method using the so-called 'seismic interferometry' is based on a Green's function retrieved from passively observed seismic responses at different receivers. Claerbout (1968) developed the synthesis of a reflection response by applying auto-correlation to transmission responses in one-dimensional multilayered medium. This technique was developed into three dimensional acoustic inhomogeneous medium by Wapenaar (2003) using the cross-correlation of different traces. Wapenaar (2004) and Wapenaar and Fokkema (2006) also derived the retrieving of the Green's function in an elastdynamic case. Independently this idea has been developed in a case of diffusive medium (Derode et al., 2003; Lobkis and Weaver, 2001; Malcolm et al., 2004). Bakulin and Calvert (2004, 2005) proposed the idea of virtual source. Also the interferometric imaging technique has been applied to ultrasonics (Weaver and Lobkis, 2002), to the earthquake seismology (Campillo and Paul, 2003; Shapiro et al., 2005, Snieder et al., 2002; Gret et al., 2005), to the drill bit data (Schuster, 2004), and to the helioseismology (Rickett and Claerbout, 1999).

We applied this technique to the case of one point source in the ground. It is valuable and important issues to confirm the effectiveness of migration for the seismic interferometry in case of one source as an extreme condition. The source is exploded below the civil construction site and above a targeted major subsurface structural boundary. The receivers were located on the ground surface with 2D survey layout. At first, we simulate the pseudo shot records by cross-correlation of the observed transmission records from the single explosion. The great advantage of the seismic interferometry is that we can simulate the pseudo shot records with improved signal to noise ratio, once many receivers are deployed on the survey line. After we simulated shot records, we can process them by conventional work flow of reflection seismic data. We carried out the velocity analysis and estimated a reasonable velocity model on CMP gather of the simulated reflection gather data. After stacking and migration process, we can identify a horizontal and a dipping structure. These are interpreted as the concave structure under the flat layers. The concave structure indicates the boundary between the sedimentary rock and the basement. The result from the seismic interferometry shows quite similar structural features to the section of the conventional reflection survey. We can conclude that a reasonable subsurface image was obtained even from one explosive source by applying the seismic interferometry technique.