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陥没地域における時間変動イメジング
Imaging of temporal changes at the surface subsidence area

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Introduction

We have carried out seismic studies to monitor the temporal change of subsurface in CCS, EOR and oil/gas reservoirs. For these studies, we have used ultra-stable seismic source called ACROSS (Accurately Controlled and Routinely Operated Signal System) (Kunitomo and Kumazawa, 2004). Because ACROSS seismic source is usulally installed in heavy concreate block, it is difficult to rellocate from one place to another. Instead, we used a conventional seismic source for this study. We carried out the time lapse experiments at one of quarry sites in Japan.

Method and Field observation

A conventional electro-magnetic seismic source with the modification of ACROSS methodology (Kubota et al., 2014) was used. A set of 100-second sweep from 10 to 50 Hz and 5-second rest with the GPS time accuracy was repeated 32 times in an hour. Seismic data of 97 15-Hz vertical geophones buried at 20 m depth and two 4.5-Hz borehole seismometers at 70 m and 200 m depths were sampled every 1 ms by the GPS time base too.

We repeated two observations in July and August in 2014. The first and the second one were between 16 and 21 in July and between 21 and 26 in August 2014, respectively. The size of the quarry is 2 km x 4.4 km. The experiments were only during the night time from 8 PM to 8 AM.

Analysis

We used similar analysis as the ACROSS processing (Kasahara et al., 2014). Observed data (1 or 12 hours) were stacked. Transfer functions between source and receivers are obtained by division of observed records by source signature calculated by accelerations on reaction mass and base plate. By 210 seconds (two sweeps) data for first stage stacking, we could estimate noise spectra. As the final stage, the residual waveforms of P portion were back-propagated by the method developed by Kasahara et al (2011).

Results

We obtained transfer functions for all datasets. By use of one hour data, we can clearly identify P arrivals up to 1.7 km distance. The transfer functions are quite stable though the seismic source is conventional type because we kept the seismic source at the same condition at the fixed point. However, if we compare the waveforms obtained in December 2013 with ones obtained in July or August 2014, we can notice large changes due to the differences of source installations.

Even within each week in July or August, the residual waveforms show changes just after P first arrivals. The P coda might be changed by temporal change of very shallow layers. By the back-propagation, we obtained the time-lapse image of the changing area. The changing areas are in two directions such as NW and SWW and they seem similar to the previous subsidence zone since 2000.

Acknowledgements

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