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An experiment of subsidence monitoring in the quarry area by a seismic source during two months: near source observation

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Introduction

We tested to monitor temporal changes in the subsurface at the quarry area. At this quarry, there is a subsidence warning system to detect micro-earthquakes associated with the subsidence measured by seismometers. At the past subsidence, seismic vibrations were repeatedly observed during several months, but the 2014 subsidence showed only four vibration events preceding to the subsidence. It is thought that if we can observe any other temporal changes of the subsurface before the vibration, we could help to find subsidence. Therefore we carried out ”seismic time-lapse observation”. We used a control seismic source on the ground at fix location, and tested whether any changes of the subsurface changes during the observation period was caught or not.

Field test

We carried out one-week experiments twice in July and August of 2014. The first and the second experiments were from 16 to 21 in July and from 21 to 25 in August, respectively. We used electro-magnetic vibrator developed by Kawasaki Geological Engineering Co. Ltd as the seismic source. We set 100-second sweep from 10 to 50 Hz and 5-second rest with the GPS time accuracy and repeated 32 sweeps with 5 second rest in an hour. We operated the vibrator 12 hours consecutively at night (20:00 - 08:00).

We recorded accelerations signals of reaction-mass and base-plate with desired signals, and seismic waves at east of the source, south of the source, and near the source. Local warning system of 97 geophones also recorded these artificial seismic data.

Analysis

We carried out FFT conversions of observed data. We transformed two sweep sequences of seismic records to the frequency domain and stacked 16 sets of data in 1 hour. We calculated source signature using the reaction-mass and the baseplate accelerations of the vibrator. The transfer functions between the source and a receiver were obtained by the division of observed spectra by source signature. After applied window function in spectral domain, we inverse-transformed the data into a time domain.

Results

In this paper we report the characteristics near the source. When we set the amplitude of seismometer beside the source was 100, that of eastern seismometer (ca. 35m east of source) was 5, and that of southern seismometer (ca. 45m south of source) was 2 (vertical axis). The transfer function of 18 and 19 of July showed a change in comparison with others periods. There were few changes of the transfer functions during an experiment period of August.

Discussion and conclusions

We checked the weather condition during experimental periods. On July 18 03:00-04:00, 28mm/hour rainfalls measured by the neighboring precipitation observatory, and intense thunderstorm was recorded at the test field. In other periods, such heavy rainfalls were not observed. From these data, it is thought that the near surface layers including the water by rainfalls changed the transfer function of the test field.

Acknowledgements

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