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Waveform correlation analysis of small repeating earthquakes using high sampling-rate seismograms

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Repeating earthquake sequence is a series of earthquakes with nearly identical waveforms which occur at the same location repeatedly and they are thought to represent repeated ruptures of small asperities on a fault plane. Since there are many unknown features about asperities such as detailed structures, reproducibility and fluctuation of rupture patterns, it is very important to reveal such features to understand the generation process of interplate earthquakes.

Numerical simulations of the repeating earthquakes with rate- and state-dependent friction laws reveal that stress disturbance caused by postseismic slip of a large earthquake near the repeater can change rupture pattern of the repeater's asperity. Actually, some observations show systematic changes in the magnitudes of small repeating earthquakes immediately after large earthquakes. Such rupture pattern changes will make difference especially in high-frequency components of the waveforms. Therefore, in order to verify the rupture pattern changes of small repeating earthquakes, we have to perform detailed analysis on the differences in high-frequency components of the waveforms.

In this study, we performed 1 kHz sampling-rate seismograph observation at permanent borehole stations along Sanriku coast, Japan for the period from April to November 2011, immediately after the Tohoku-Oki earthquake. We investigate the waveform correlations of small repeating earthquakes using waveform data. We make a pair of earthquakes belonging to the same group of repeating earthquakes and calculate their coherences. The results show that in high-frequency band, there are both high-coherence pairs and low-coherence pairs even in the same repeating earthquake group, although all the pairs show high coherence in low-frequency band. Furthermore, frequency bands in which the coherences are low are nearly the same for all the pairs. These results suggest rupture pattern changes in the asperity.

We also find that earthquakes which show low coherence in high-frequency band for all the counterparts occur immediately after events in the vicinity of the repeater's asperity. This observation implies that rupture pattern changes in the asperity, which make difference in high-frequency components of the waveforms, are caused by stress disturbance due to the nearby earthquakes.

Keywords: repeating earthquake, asperity, high sampling-rate seismogram, waveform correlation analysis, Tohoku-Oki earthquake