Initial Rupture Process of the 2004 Parkfield, CA, USA, Earthquake

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1. Introduction

One of the most important and interesting problems in earthquake seismology is to understand the initiation and growth of a seismic rupture. *Uchide and Ide* [submitted to J. Geophys. Res.] proposed a new slip inversion method using a multiscale source model, and revealed the detail of the initial and the main rupture processes of the 2004 Mid-Niigata prefecture earthquake (M_W 6.6). It is also important to study earthquakes with different magnitude or different tectonic conditions. Therefore we apply a multiscale analysis to the 2004 Parkfield earthquake (M_W 6.0).

2. Seismic Data

As the first step to reveal the growth process of the 2004 Parkfield earthquake, we carry out deconvolution from the first few seconds of the mainshock waveforms by records of small earthquakes (M 2.0 - 3.7) Although many seismic networks were in operation, few records are available for our purpose. High-sensitivity seismographs of HRSN (High-Resolution Seismic Network by UC Berkeley) and NCSN (Northern California Seismic Network by USGS, Menlo Park) scaled out immediately after the P arrivals of the mainshock. CGS (California Geological Survey) strong-motion network recorded no events smaller than M 5. GEOS (General Earthquake Observation System by USGS) [*Borcherdt et al.*, 1985] recorded both the mainshock and small earthquakes by a combination of velocity transducers and accelerometers. In the frequency band from 1 Hz to 20 Hz, these two sensors provide consistent records after instrumental response correction, which we prove using the records of a commonly observed M3.2 earthquake. Therefore, we deconvolve accelerograms of the mainshock from velocity seismograms of small events to investigate the initial rupture process of the mainshock.

3. Deconvolution Analysis

We select eight small events as empirical Green's function (EGF) events, which are located within 2.5 km of the mainshock hypocenter, based on the result of the double-difference tomography and event relocation [*Thurber et al.*, 2006]. Using these EGFs and the first 2 or 3 s of the mainshock, we determine apparent moment rate functions by the time-domain deconvolution. All records are bandpass-filtered between 1 Hz and a corner frequency of each EGF event.

Most of the apparent moment rate functions using different EGF are consistent. Several pulses in the moment rate functions suggest the complexity of the rupture process during the first 2 or 3 s. At around 0.3 s after the P arrival, we find a distinctive pulse in the moment rate function at the southeastern stations, while, at the northwestern stations, the first one is overlapped by the second one. This observation implies the northwestern directivity of the rupture process. The second pulse around 1 s is narrower at the northwestern stations than at the southeastern ones. This also suggests the northwestern directivity. Since the rupture propagation direction of the main rupture process was northwestward [e.g., *Liu et al.*, 2006], the mainshock did not change the principal rupture propagation direction with its growth.

4. Discussions

The result implies that the principal rupture propagation direction did not vary within the first second of the dynamic rupture process. In contrast, the principal rupture direction has been found to be varied in the initial rupture process of the 2004 mid-Niigata prefecture earthquake [*Uchide and Ide*, JPGU meeting, 2006; submitted] and the 2005 Western Off Fukuoka Prefecture earthquake [*Yamamoto et al.*, JPGU meeting, 2006; *Uchide and Ide*, SSJ Fall meeting, 2006]. Further studies are required to quantitatively recognize the variety of the initial stage of the dynamic rupture process of earthquakes.

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