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Source Modeling of the Ibaraki-ken-oki Earthquake of May 8, 2008 (M7.0), Using the Empirical Green's Function Method

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1. Introduction

The Ibaraki-ken-oki earthquake (hereafter mainshock) with a JMA magnitude of 7.0 occurred at 1:45 on May 8, 2008 (JST) in the offshore of Ibaraki prefecture, Japan. This earthquake occurred in the interface of the Pacific Plate subducting beneath the North American Plate and was a thrust type plate boundary earthquake. In this area, M7-class earthquakes have occurred with approximately 20 year intervals (The Headquarters for Earthquake Research Promotion, 2002), so in order to investigate the seismic properties of this area it is important to estimate the source rupture process of those earthquakes. In this study, we estimate the source rupture process of the mainshock from the broadband strong motion simulation using the empirical Green's function method (Irikura, 1986).

2. Data and Method

The small earthquake record used for the empirical Green's function and the mainshock record should include the similar path and site effects. If the small earthquake record is like that, we can estimate the source spectral ratio from dividing observed spectra of the mainshock by that of the small earthquake. We therefore used the earthquake occurring at 14:22 on December 14, 2004 (M_{JMA}5.1), which had the similar focal mechanism and hypocenter distance to the mainshock. The hypocenters of those earthquakes were determined routinely by JMA and depths were assumed from the result of the relocation of hypocenters using three-dimensional velocity structure model (Katsumata, 2008). For the mainshock, we chose the west-dipping fault plane because it matched with the direction of subducting oceanic plate. The strike and the dip angles of the plane were determined by the NIED F-net moment tensor solution. From the ratio of the observed spectra, we estimated the corner frequencies of both earthquakes, the fault size of the small earthquake and the ratio of the stress drops between the mainshock and the small earthquake. Among K-NET and KiK-net stations located within 150km of the hypocenter of the mainshock, we used four of them (CHB010, IBRH19, IBRH14, FKSH14) so that the range of the azimuth from the source to the station might be as wide as possible. The data of KiK-net were of downhole seismometers. We searched the parameters (the fault size of small earthquake, the position of rupture starting point in the fault of the mainshock, the risetime, and the rupture velocity) by trial and error and estimated the source model that minimized the residual evaluated by the formula of Miyake et al. (1999). The data used in these analyses were band-pass filtered between 0.3 and 10 Hz and were picked up for 20 seconds from 1 second before S-wave arrival and 19 seconds after that.

3. Results

The observed spectral ratio approximately satisfied the omega-square source model, and the ratio of the fault sizes and the stress drops were 6 and 1.86, respectively. Using these values, we synthesized mainshock waveforms and obtained the source model that had one Strong Motion Generation Area (hereafter SMGA, the area characterized by a large uniform slip velocity within the total rupture area (Miyake et al., 2003)). The rupture propagated from southwest to northeast in SMGA. The size of SMGA was 81.0km^2, the risetime was 0.72 s, and the rupture velocity was 3.3km/s. These values are consistent with the result of Suzuki and Iwata (2007) that SMGA of plate boundary earthquake tended to be smaller than that of inland crustal earthquake.

We will estimate the SMGA of the earthquake which occurred in the same area on July 23, 1982 (M_{JMA}7.0) in the same way and compare the source models of these two earthquakes.

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