Rupture processes of the 2004 Southeast off Kii-Peninsula Earthquakesinverted from far-field body waves and strong motion data

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In the offshore area southeast to the Kii Peninsula, several major earthquakes have occurred since Sept. 5, 2004. The hypocenters are located near the plate boundary between the Eurasian Plate and the Philippine Sea Plate. The northwestern movement of the subducting Philippine See Plate may account for the reverse faulting mechanism. It is interesting to note that the hypocenters were located in the slab.
We collect the up-down components recorded at 29 GDSN stations for the fore shock and 35 stations for the main shock. Each record with duration of 70 sec is re-sampled at 2Hz and bandpass filter from 0.02Hz to 0.5Hz. To take into consider the effects of velocity structure in the source area, we add a 3-km water layer and a 3-km sedimentary layer to a subducting oceanic crust structure .
The strong motion data are mainly from Kik-net and K-net operated by NIED. Records with three components from 21 stations are used for the foreshock and 26 stations for the main shock. In the case of Kik-net records, we use those underground channels deployed in the boreholes, with the observation waveforms being corrected into north-south (NS) and east-west (EW) components for those components that do not correspond to due NS or EW directions. In the case of the foreshock, each acceleration seismogram with duration of 40sec is then integrated into velocity seismogram, whereas the seismograms with duration of 60 sec are included for the main shock. We apply a 0.025Hz-0.5Hz bandpass filter to the velocity waveforms and re-sample the waveforms at 4 Hz. We use the one-dimensional velocity structure to calculate the Green's functions. The sedimentary layer and the water layer above the hypocenters are neglected in this velocity structure. The wave field obtained from the structure model cannot explain those transformed at water-solid boundary(e.g. pS wave). 3-D velocity structure model should be considered for further studies.
The rupturing model proposed for the main shock is featured with a 10-second initial rupturing event, which occurred on the fault plane different from the main rupture. Besides that the waveform inversion using this model gives the best waveform fittings, such a rupture pattern is also supported from the aftershock distribution. Under the compressional stress field caused by subducting Philippine Sea plate, such a strike-slip faulting initial event suggests a complex geological structure in this area. Note that both the foreshock and the main shock started their rupture near the boundary of the oceanic slab crust and the oceanic mantle. This point is similar to the other two in-slab earthquakes: the 2001 Geiyo, Japan, earthquake, and the 2003 Miyagi-ken Oki earthquake (Kakehi, 2004, JGR; Wu and Takeo, 2004, GRL). These two in-slab earthquakes indicate that unlike the continental mantle the slab oceanic mantle is relatively brittle and prone to earthquake rupturing.

In conclusion, we inverted the rupture processes of the 2004 Southeast off Kii-Peninsula Earthquakes using far field waves and strong motion data, respectively. On the basis of the aftershock distribution and the improvement of the waveform fittings, we propose that the main ruptures of the foreshock and the main shock both occurred on the N75E fault, featured with reverse faulting. These two earthquakes started their ruptures near the crust-mantle boundary. In the case of the foreshock, the rupture was mainly confined in the hypocentral area with the maximum slip of 2.4 m. It further propagated to the northern shallow portion. The seismic moment of was released in 20 seconds. In the case of the main shock, an initial rupture was observed in the beginning 12 seconds. This initial event occurred on the N130E fault plane and was strike-slip-dominant. The main rupture with the thrust faulting mechanism occurred with larger slip on the N75E fault from 12 seconds on.