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Spatial heterogeneity of stress and friction in and around the source area of the 2008 Iwate-Miyagi Nairiku earthquake

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1. Introduction
A large earthquake with a magnitude of 7.2 occurred around the border between southwest part of Iwate Prefecture and northwest part of Miyagi Prefecture on June 14, 2008. The moment tensor solution of this earthquake shows reverse fault type and the P-axis trends WNW-ESE. This earthquake occurred in the Ou backbone range, northeastern Japan. The contraction deformation is prominent in this region including focal area of the earthquake (Miura et al., 2002, 2004). GPS observation shows the area with large coseismic slip was located to the SSW from the main shock hypocenter (Ohta et al., 2008; Iinuma et al., 2009). In this study, we determined focal mechanism solutions using observed P-wave first motions at the temporary and the routine stations, and estimated the stress field and coefficient of friction in the focal region.

2. Data and Method
From 2760 aftershocks (6/14/08-9/30/08) which was located by the Group for the aftershock observations of the Iwate-Miyagi Nairiku Earthquake in 2008, we selected events having more than 30 first motion polarities and determined the focal mechanism solutions using the one-dimension velocity structure (Hasegawa et al., 1978). 317 of these focal mechanisms are well-constrained. We estimated stress field by stress tensor inversion method of Ito et al.(2009) using 3 17 well-constrained focal mechanisms. Finally, we estimated the coefficient of friction and the stress ratio for the whole area and the north area using these focal mechanisms and the stress parameter assuming that the coefficients of friction are constant in the target regions (Kubo and Fukuyama, 2004).

3. Focal Mechanisms
First, we sorted focal mechanisms of aftershocks. We labeled the focal mechanisms which have the plunge of P, T, and B axis more than 45 degree as normal fault, reverse fault, and strike-slip fault type, respectively. Most of focal mechanisms (226) are reverse-fault type. Some of them (61) are strike-slip fault type. P-axis of focal mechanisms tends to orient to E-W or ESE-WNW direction. In the central part of the focal area where large coseismic slip occurred, most of events have P-axis is oriented to ESE-WNW direction.

4. Spatial distribution of orientation of principal axes estimated by stress tensor inversions
We performed stress tensor inversion based on focal mechanisms in the whole area. The maximum principal stress direction is ESE-WNW. This corresponds to the direction of horizontal principal-strain in this area (Miura et al., 2002), and P-axis direction of the moment tensor solution of the mainshock.
Furthermore, we divided the focal area, and performed stress tensor inversion in each subarea. We performed damped stress tensor inversion for all subareas simultaneously minimizing the difference in stress between adjacent subareas (Hardebeck and Michael, 2006).

The most maximum principal stress direction seems to orient ESE-WNW especially in the region where the coseismic slip was large (Iinuma et al., 2009). However the maximum principal stress direction orients ENE-WSW in the edge of the large coseismic slip area.

5. Estimation of friction coefficient and stress ratio

We estimated the coefficient of friction and the stress ratio (= (sigma1-P)/(sigma3-P); P: pore pressure) in the whole area and the northern area using the focal mechanisms and the stress parameter determined in each subarea, assuming that the coefficient of friction is constant in each area (Kubo and Fukuyama, 2004).

For the whole area, the coefficient of friction and the stress ration are estimated as 0.4-0.65 and 3.0-7.0. This possibly means that the pore pressure is high, which must relate with the occurrence of the earthquake (e.g. Sibson, 2009, Okada et al., 2009).

For the northern area the coeffient of friction amd stress ration are estimated as 0.05-0.3 and 1.2-3.5. The asesmic slip induced by the mainshock (Iinuma et al., 2009) in this northern area might be due to this low friction.

Keywords: focal mechanism, friction, stress tensor inversion, inland eathquake,
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