Stress field in the Tohoku region, Japan and its relationship with faults of recent earthquakes

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Introduction

In northeastern Japan, stress fields of east-west oriented compression are widely distributed. Therefore, reverse-fault-type earthquakes tends to occur (e.g., Terakawa and Matsu'ura, 2010). Many high-angle fault planes are distributed in northeastern Japan and the Eastern Margin of the Japan Sea (EMJS). It is known that these fault planes were caused by the tensile stress field during the formation of the Japan Sea (Okamura and Kato, 2002; Okamura, 2010). It is frequently observed that tectonic inversion of old normal faults (with high dip angle) occurs acting as reverse faults (e.g., Okamura et al., 1995).

In our previous studies, we focused on the large to moderated-sized earthquakes that occurred in the EMJS and investigated the relationship with the stress field and fault planes by using the Slip Tendency (ST) method (Tagami et al, JpGU-AGU Joint Meeting 2020; Tagami et al, SSJ meeting 2020). We confirmed that the east dipping nodal plane with a low dip angle has a higher Slip Tendency value than the westward dipping plane with a high dip angle for each of the analyzed earthquake. This is consistent with the fault planes suggested by previous studies.

Old high-angle faults are also distributed in the inland area of the northeastern Japan. In this study, we focused on three large to moderated-sized earthquakes that occurred in the northeastern Japan (the 1998 Shizukuishi earthquake, the 2008 Iwate-Miyagi Nairiku earthquake, and the 2003 northern Miyagi earthquake). We estimated the stress field around the three earthquakes and investigated the relationship between the stress fields and the fault planes.

Data and methods

We use focal mechanism (moment tensor) data from the National Institute for Earth Science and Disaster Resilience (NIED) of Japan and focal mechanisms estimated from P-wave initial motions from Okada et al. (2019). For estimating the regional stress field, we deploy the stress tensor inversion method developed by Michael (1984, 1987). For estimating the likelihood of slip, we use the Slip Tendency analysis (Morris et al., 1996).

Result

We set two timeframes, 1997-2011.3.10 and 2011.3.11-2019, to confirm the influence of the 2011 Tohoku-Oki earthquake.

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・The 1998 Shizukuishi earthquake (M_{jma} 6.1)
The estimated stress field was approximately strike-slip fault type. The maximum horizontal compressional stress was directed the E-W before 2011 and the WSW-ENE after 2011. In the stress field before 2011, the west-ward dipping nodal plane showed a higher ST value than the eastward dipping plane. In the stress field after the 2011 earthquake, the eastward dipping fault plane showed a higher ST values than the westward dipping plane. However, the value was less than 0.6. These indicate an unlikely slip condition.

・The 2008 Iwate-Miyagi Nairiku earthquake (M_{jma} 7.2)
A reverse-fault type stress field was estimated. The maximum horizontal compressional stress directions were WNW-ESE before 2011 and the NE-SW after 2011. The eastward dipping nodal plane showed a higher ST value (0.7 or more) than the westward dipping plane.

・The 2003 northern Miyagi earthquake (July 26 7:13 M_{jma} 6.4)
The stress field showed a reverse fault type. The maximum horizontal stress directions were the E-W before 2011 and the NE-SW after 2011. The eastward dipping nodal plane showed a higher ST value (0.7 or more) than the westward plane.

Previous studies have shown that each of three large to moderated-sized earthquakes occurred on the westward dipping fault plane. In this study, all the westward dipping planes showed lower ST values suggesting these earthquakes occurred along the fault planes unlikely to slip in the estimated stress fields. High pore fluid pressure and/or low friction coefficient could cause the unfavorable slip.

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