Stress field in the eastern margin of the Japan Sea and its relationship with faults of recent earthquakes

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Introduction

The M_{jma}6.7 Yamagata-oki earthquake (18 June 2019) occurred in the area where the tectonic belt along the eastern margin of the Japan Sea (EMJS) is located. It is known that many active faults and folds exist along the EMJS. Also, many large to moderate-sized earthquakes have occurred. It is thought that the reverse fault slip is caused by the stress field with the maximum compression axis oriented to an approximately east-west direction (e.g., Terakawa and Matsu'ura, 2010; Okamura, 2019). In this study, we investigate the distribution of focal mechanisms and the stress field to find spatio-temporal changes in a newer time window than in previous studies. Also, we focus on the two large to moderate-sized earthquakes; the Yamagata-oki earthquake and the M_{jma}7.5 Niigata earthquake (12 June 1964).

Data and methods

We use focal mechanism and moment tensor data from the NIED (National Research Institute for Earth Science and Disaster Resilience) f-net and focal mechanisms estimated from P-wave initial motions by Okada et al. (SSJ meeting, 2019). For estimating the regional stress field, we use the stress tensor inversion software SATSI (Spatial And Temporal Stress Inversion; Hardebeck and Michael, 2006). For evaluating the suitability of slip, we use "slip tendency" defined by Morris et al. (1996).

Results

Western coastal area in northeast Japan (included in the EMJS belt)

We analyze earthquake data that occurred during the period from 1 January 1997 to 31 December 2019, located in 37°N-42°N, 137°E-141°E, with depths of 0-30km to find that the directions of the P-axes vary in the study area.The direction of the P-axis are oriented to NW-SE to the south of about 40°N (about 39°N at a depth of the 10-20km), while it becomes to be oriented to E-W to the north. In addition, the percentage of strike-slip type focal mechanisms increases in the northern part (about 40°N-41°N) of the study area. Comparison between the Japan Sea areas and Japan inland areas shows that P-axis directions change from NW-SE to E-W as approaching the inland areas.
Next, we estimated the regional stress field using the stress tensor inversion in the study area. The result of the stress inversion shows the change in the stress axis direction. The maximum compressional stress axis direction changes from NW-SE to E-W from south to north. In addition, the stress axis direction changes from to NW-SE to E-W from as approaching the inland areas. We consider that the change in the distribution of the focal mechanisms reflects the change in the stress axis direction.

The slip-tendency analysis for theYamagata-oki earthquake and the Niigata earthquake

For the Yamagata-oki earthquake, we estimate the stress field around the focal area and calculated the slip tendency (Ts) for each focal mechanism. We use focal mechanism data from NIED for Ts analysis and focal mechanism data from Okada et al., (SSJ meeting, 2019) for the stress tensor inversion. For the main shock, the eastward dipping nodal plane shows a high value of Ts. Also, the fault plane with a low dip angle shows high Ts in each focal mechanism of aftershocks. For the Niigata earthquake, we used fault planes from Hirasawa (1965), and we use focal mechanism data from NIED for stress tensor inversion. The eastward dipping fault plane shows a higher value of Ts.

These results are consistent with the idea that these two earthquakes did not occur as reactivation of the high-angle normal faults, which were generated by the tensile stress filed during the Japan Sea formation, but occurred on the reverse faults with low dip angles which generated by the current compressive stress field.

References

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