論文 / 著書情報
Article / Book Information

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Title(English)	Spatiotemporal complexity of fault rupture for crustal earthquakes in Japan
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種別(和文)	論文要旨
Type(English)	Summary

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論 文 要 旨

THESIS SUMMARY

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要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

A fault rupture complexly propagates during an earthquake, which generates a seismic waveform. As the spatiotemporal rupture complexity affects the aftershock activity and the strong ground motion, it is important to understand how complex a rupture is. In this regard, the slip distribution and the rupture mode are factors to characterize the rupture propagation or complexity. Therefore, we focus on the waveform inversion method that can estimate a spatiotemporal slip distribution including slip directions. In contrast, the waveform inversion has a limitation of the applicability to small-to-moderate earthquakes and earthquakes in a region where a detailed seismic velocity structure does not exist. In addition, although the extraction of rupture modes requires comparing a slip direction with a rupture propagation direction, the rupture propagation direction is not obvious in the slip inversion images. Thus, we developed approaches of the waveform inversion and the estimation of rupture propagation directions to overcome these limitations and explored the fault rupture complexity and its cause.

In Chapter 2, we added the radiation correction to the empirical Green's function (EGF) to expand the applicability of the waveform inversion method. To validate this method, we first conducted on the synthetic test with the theoretical waveforms and confirmed that the assumed slip model was mostly reproduced. Next, we applied the new method to the real data of Japanese crustal earthquakes that were investigated in previous studies. Here, we assumed a simple velocity structure to confirm the applicability of this method to earthquakes that occurred in a region with a low-resolution velocity structure. As a result, we obtained slip models which were consistent with the previous studies. Then, we investigated the inversion stability using the other EGF candidates. As a consequence, although the slip distributions for each candidate event were similar to the slip model with the best estimation, there were subtle differences due to the difference in the station coverage. Finally, the uncertainty of the inversion results was investigated using the bootstrapping test. By these tests and validations, we confirmed the validity and stability of the waveform inversion with the radiation-corrected EGF.

We then introduced a metric to evaluate the rupture propagation direction, named the rupture propagation intensity in Chapter 3. The rupture propagation direction was converted to the rupture-mode angle by comparing it with the slip direction. By this metric, we can obtain the distribution of the rupture-mode angle at each subfault at 1-s intervals. We applied this metric to the obtained slip models in Chapter 2. As a result, we confirmed the various rupture-mode distributions among the crustal earthquakes in Japan. Because these analyses utilized the semicircle with a radius of 4 km to evaluate the rupture propagation intensity, we checked the geometrical effect on the estimation of the rupture propagation direction. As a consequence, although we confirmed that a larger radius than the travel distance of the rupture front was required for the accurate estimation, the results were stable between the radii of 3 and 4 km. In addition, we investigated the uncertainty of the rupture propagation direction derived from the error of the inversion results and confirmed that most of the rupture-mode angles had an uncertainty less than 30º.

In Chapter 4, we discussed the various kinds of fault rupture complexity. First, we found that the variety of the spatial complexity of the slip distributions had common features. Specifically, the maximum slip location was not likely to overlap the hypocenter and the large slip region was near the hypocenter. We interpreted that such a spatial complexity can be explained by the hierarchical structure model. Regarding the aftershock distribution, we found that there is an anti-correlated relationship between the slip amount and the number of aftershocks, which can be affected by the stress change of the mainshock slip. In addition, some aftershocks occurred in a region with a large slip regardless of the anti-correlation, which can be caused by the slip deficit due to frictional heterogeneity. Such an investigation of the relationship between the aftershocks and the slip distribution is important for the aftershock seismicity prediction. Finally, we focused on the rupture propagation intensity at mode-II and -III directions to reveal the spatiotemporal complexity of the fault rupture. As a result, the preferability of the mode-II and III ruptures has no significant bias except for the 2008 Iwate Miyagi Inland earthquake, which is consistent with the theory of fracture mechanics. In contrast, there is a bending on the source fault of the 2008 Iwate Miyagi Inland earthquake, which could work as a barrier of rupture propagation. Such a barrier caused the strong bias of the preferability of the mode-II and -III ruptures.

To conclude, we developed methods to estimate source processes and rupture modes during the rupture propagation to reveal the spatiotemporal complexity of the fault rupture, and we discussed the various rupture complexity, such as the slip distribution, aftershock pattern, and rupture propagation for large crustal earthquakes in Japan. We believe that the results revealed by this study certainly contribute to a better understanding of the mechanism of fault rupture growth from views of both kinematics and fracture mechanics.

備考 ： 論文要旨は、和文 2000 字と英文 300 語を 1 部ずつ提出するか、もしくは英文 800 語を 1 部提出してください。
Note : Thesis Summary should be submitted in either a copy of 2000 Japanese Characters and 300 Words (English) or 1copy of 800 Words (English).

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