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Mechanism of large crustal earthquakes in Kanto and Chubu: Influence of structural heterogeneities

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Large inland crustal earthquakes often cause heavy damage to human society. Therefore it is very important to clarify the generation mechanism of the large crustal earthquakes for disaster reduction. It is considered that fluids dehydrated from the subducting Pacific and Philippine Sea slabs affect the nucleation of large crustal earthquakes under the Japan Islands (Zhao et al., 2010). In this study, we focus on the Kanto and Chubu regions, and investigated the cause of large crustal damaging earthquakes (M>6) (Usami et al., 2013; Utsu, 1999) by comparing the earthquake distribution with tomographic images of the crust and upper mantle.

We used high-quality arrival-time data of local earthquakes which occurred during June 3, 2002 to June 26, 2013 complied by the Japan Meteorological Agency (JMA) Unified Catalogue and those during June 3, 2002 to November 10, 2013 compiled by the Tohoku University Data Base. The local events were carefully selected based on the following criteria. (1) All the events were recorded by more than 20 seismic stations; (2) the uncertainty of hypocentral location is smaller than 4 km; (3) to keep a uniform distribution of hypocenter locations and avoid the event clustering, we divided the study area into small blocks (5 km $\times$ 5 km $\times$ 1 km), and selected only one event in each block that was recorded by the maximal number of seismic stations. As a result, our data set consists of 824,742 P-wave and 627,664 S-wave arrival times from 21,831 events recorded by 877 seismic stations in the study area. We applied the tomographic method of Zhao et al. (1992) to our data set. The grid interval is 0.20 deg. in the lateral direction and 15?30 km in depth, which is the resolution scale of the 3-D velocity model we obtained. The final root-mean-square ravel time residual is 0.287 s for the P-wave data and 0.424 s for the S-wave data.

Our results show significant velocity variations in the crust and upper mantle. The subducting Pacific and Philippine Sea slabs are imaged clearly as high-velocity zones. In contrast, low-velocity anomalies are revealed in the crust and mantle wedge beneath active arc volcanoes, which reflect the source of arc magmatism produced by slab dehydration and corner flow in the mantle wedge. Most of the large crustal earthquakes are located in or around the low-velocity zones in the crust and/or the uppermost mantle. These results suggest that the generation of large crustal earthquakes are affected or controlled by the structural heterogeneities. In particular, fluids play an important role in the nucleation of the large earthquakes.

References

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