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Two types of asperities on the Tohoku-oki interplate megathrust

Ichiko Shimizu[1*]

[1]Department of Earth and Planetary Science, Facluty of Science, University of Tokyo

The 2011 off the Pacific coast of Tohoku Earthquake with a magnitude (M) of 9.0 (the M9 Tohoku-oki earthquake) occurred at an intermediate depth (approximately 17-18 km below the sea level) on the subducting plate interface, whereas the M7-class Miyagi-oki earthquake had been occurred at the down-dip side (35-45 km below the sea level). To clarify the difference in frictional properties between the deep and intermediate-depth seismogenic zones, a strength profile of the NE Japan interplate megathrust was constructed across the source region of the M9 earthquake.

In the model, rheological properties of siliceous sedimentary rocks and subducting seamounts at the top of the oceanic plate were represented by those of wet quartz (+ clay minerals) and gabbro, respectively. Depth-dependent changes of pressure, temperature, and pore pressure ratio were taken into account. At the deep (>35 km) part of the thrust fault, siliceous rocks become ductile due to increasing temperature ($> 250^{o}$), whereas gabbroic rocks are brittle and strong. Thus, the asperity of the M7-class earthquakes is considered as a broken seamount, which is surrounded by siliceous sedimentary rocks. A conditionally stable nature of the surrounding region is explained by frictional behaviors of quartz in the brittle?ductile transition zone. In contrast to the deep M7-class asperity, the M9 asperity (i.e., a region that was strongly coupled before the M9 Tohoku-oki earthquake) occupies a large part of the plate interface because shear strength is relatively insensitive to rock types at the intermediate depth. Depth-varying characteristics of seismic radiation patterns found by Lay et al. (2012) reflect these two kinds of asperities. The along-arc extension of the M9 asperity is constrained by fluid distributions on the plate interface.

References

Lay, T., H. Kanamori, C. J. Ammon, K. D. Koper, A. R. Hutko, L. Ye, H. Yue, and T. M. Rushing (2012), Depth-varying rupture properties of subduction zone megathrust faults, J. Geophys. Res., 117, B04311, doi:10.1029/2011JB009133.

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