Simple Topographic Parameter for Along-trench Friction Distribution of Shallow Megathrust Fault

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In the 2011 Tohoku-Oki earthquake (Mw 9.0), the propagation of coseismic rupture in the subduction megathrust reached the trench axis and triggered a large tsunami. Before this event, it was regarded that such a shallow portion of the megathrust did not cause earthquake rupture and was an aseismic stable zone with low-level locking. Research on the shallow portion of megathrusts has become important for disaster mitigation. Scientific drilling has revealed that shallow megathrust faults are composed of frictionally weak materials. However, it is unclear whether this reflects site-specific geological conditions. In this study, the critical taper model, which most appropriately describes the first-order mechanics of a subduction zone wedge, is improved. In the conventional model, the slope angle α and the décollement dip angle β are necessary for calculating the friction coefficient of the plate boundary megathrust. We found that β has almost no influence on the results, and thus friction can be calculated using only surface topographic parameters such as bathymetry. Therefore, we can obtain a high-density friction distribution using only bathymetry. A comparison of this friction distribution in the Japan Trench based on bathymetry indicates that the coseismic slip distribution of the 2011 Tohoku-Oki earthquake corresponds to the low-friction segment. The epicenter of the 2011 earthquake is located in the low-friction segment; therefore, the earthquake could have overshot, making the slip propagate to the shallow portion of the plate boundary fault, leading to the huge tsunami. The low-friction segment obtained using this method can be considered to be highly related to the tsunami. We developed a method that enables the segment estimation of shallow plate boundary faults in the world’s subduction zone. It could be useful for understanding the mechanism of huge tsunamis.

Keywords: Subduction, Japan Trench, Critical taper model

