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プレート境界地震の破壊開始点における破壊エネルギーの推定
Estimation of fracture energies at the rupture nucleation points of large interplate earthquakes

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Numerical simulations of recurrence of large interplate earthquakes at a subduction zone are conducted by using a rate- and state-dependent friction law to estimate fracture energies at the rupture nucleation points of large interplate earthquakes. Shear stress is concentrated near the deeper edge of a locked zone of a plate boundary and seismic rupture occurs when the energy release rate by rupture extension becomes larger than the fracture energy. The stress concentration at the deeper edge is expected to increase with aseismic slip amount at the deep aseismic slip zone, and the aseismic slip amount at the occurrence of a large interplate earthquake is equal to $V_{pl}T_r$, where V_{pl} is the relative plate velocity and T_r is the recurrence interval of interplate earthquakes. The fracture energy G_c at the rupture nucleation point is measured for each simulated earthquake from the relation between shear stress and slip distance. Simulation results for various values of friction parameters and effective normal stress indicate that G_c is proportional to the square of $V_{pl}T_r$, suggesting that G_c of interplate earthquakes can be estimated from $V_{pl}T_r$. The fracture energy G_c at the rupture nucleation points of M8 class Nankai earthquakes, which took place along the Nankai trough, southwestern Japan, every 100 years, is estimated to be 0.1 to 1 MJ/m^2. This estimated value seems to be significantly smaller than the reported G_c values of large earthquakes in the literature. This is probably because the estimated G_c value in the present study is for the rupture nucleation point, while G_c has been estimated from dynamic modeling of developed rupture processes in many cases. The fracture energy may increase as rupture propagates because of off fault plastic deformation and/or secondary ruptures near the propagating crack tip. G_c of the 2011 Tohoku-oki earthquake of magnitude 9.0 is on the order of 10 MJ/m^2, which is much larger than that estimated for the Nankai earthquakes. The region with the large fracture energy controls a very long recurrence interval and enables the accumulation of large strain energy.

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