

Have the prior afterslip areas been barriers to the 2011 Tohoku earthquake?

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Common features of rupture expanding process models of the 2011 Tohoku earthquake (eg, Koketsu et al., 2011; Shao et al., 2011; Suzuki et al., 2011; Yoshida et al., 2011; Yagi and Fukahata et al., 2011; Ide et al., 2011) can be summarized as follows

(1) major rupture of slip of 40m to 50m has continued to expand for around 1 minute in an area between N37.5 to N39 longitudinal lines under the continental shelf.

(2) the major rupture to the north has stopped at N39, where was the southern boundary of the afterslip area associated with the 1992 Sanriku-oki earthquake (Mw6.9).

(3) the major rupture to the south has started to cross N39, where was the northern boundary of the afterslip area associated with the 2008 Fukushima-oki earthquake (Mw6.9), while seismic slip has been a few meters, one order smaller than the major rupture.

Questions arise. Why have the major rupture been blockaded at N39? Why has the major rupture been delayed to cross N37.7?

We remember that some afterslips were discovered in Tohoku-oki area in 1990's and 2000's, which are mapped in the figure below. On the other hand, based on numerical simulations invoking with the frictional law of fault slip, Yoshida and Kato (2003) segmented slip area into four modes (K1) - (K4) as a function of (a-b) and P_n (a-b is friction parameter and P_n is the stress normal to a slip plane) and l (inverse of fault stiffness) as

(K1) $a-b < 0$, l small : asperity.

(K2) $a-b < 0$, l between (K1) and (K3) : stability transition mode, where silent earthquakes recur in the last stage of the seismic cycle.

(K3) $a-b < 0$, l large : substable sliding mode.

(K4) $a-b > 0$: stable sliding mode, where stale sliding is dominant throughout a seismic cycle. When the dynamic rupture occurs in the adjacent asperity, this area act as barrier and if the rupture invade, the rupture is turned into afterslip.

Thus, I would like to propose a hypothesis that the afterslip areas associated with the 1992 Sanriku-oki and the 2008 Fukushima-oki earthquakes have acted as barriers to expansion of major rupture of the 2011 Tohoku earthquake. I also would like to re-emphasize importance of the frictional law of fault slip to understand earthquake physics.

Keywords: 2011 Tohoku earthquake, asperity, afterslip, barrier, friction law

