

Afterslip revisited: Scaling relation of slip rate versus mainshock magnitude and possible expansion of the definition

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We discuss two topics about afterslip events at a subduction plate boundary, based on GPS data before and after the 2011 Tohoku-oki Earthquake.

Mitsui and Heki (in revision) estimated the amount of afterslip off-Sanriku during almost 30 minutes just after the 2011 Tohoku-oki Earthquake, separately from the subsidence amount by tsunami propagation. We found that the mean slip velocity of the early afterslip reached on the order of 0.1 mm/s. This value greatly exceeds those of previous afterslip in the neighborhood: after the 1994 Sanriku-haruka-oki Earthquake, the 2003 Tokachi-oki Earthquake, and the 2011 Miyagi-haruka-oki Earthquake (2 days prior to the Tohoku-oki Earthquake). Also we can read an increasing trend of the afterslip velocity for the mainshock magnitude (M_w), e.g., a scaling relation of the after slip velocity proportional to 10^{M_w} (see the figure below). The value of 0.1 mm/s may imply the maximal slip rate of afterslip phenomena. That fact corresponds to a change in velocity dependence of steady-state frictional coefficient based on rock experiments (Weeks (1993)).

Heki and Mitsui (2013, EPSL) found that landward velocity of GPS stations increased near segments adjacent to the ruptured segments after the 2003 Tokachi-Oki and 2011 Tohoku-Oki Earthquake, respectively. These enhancements of the plate coupling seemed synchronizing increases in trenchward velocity of GPS stations (so-called afterslip) near the ruptured segments. A similar phenomenon of the landward velocity increases was also observed after the 2012 Karafuto-Oki deep earthquake at GPS stations around eastern Hokkaido (Heki and Mitsui, this meeting). Based on the observations, we proposed a hypothesis of temporary subduction acceleration of the pacific plate associated with resistance loss for plate motion. This subduction acceleration can be interpreted as "afterslip" in a broader sense. In a previous narrowly-defined sense, afterslip is a relaxation process of stress concentration at edges of coseismic fault slip (e.g., Heki et al., (1997)). By contrast, in the new broader sense, afterslip is an adjusting process to balance forces of plate subduction. Monitoring this newly-defined afterslip may allow us to obtain original information about plate subduction processes.

Keywords: GPS, afterslip, frictional property, 2011 Tohoku-oki earthquake, plate subduction acceleration, deep earthquake

