Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SCG74-P01 Room:Convention Hall Time:May 24 17:15-18:30

Perturbation of small repeating earthquake depending on frictional properties

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Owing to recent development of seismological observation network, small repeating earthquake analysis has been confirmed as an effective approach to estimate slip history or coupling ratio on subduction plate boundaries, especially near source regions of megathrust earthquakes where inland GPS network would have difficulty estimating it with high precision. Some of repeating earthquake analyses shows that estimated slip amount tends to be smaller than that estimated from GPS analysis. This discrepancy is thought to be caused by failure in detecting non-similar earthquakes with low cross-correlation coefficient due to stress perturbation around the source regions. Ariyoshi et al. [2007 GRL] pointed out that slow slip events temporarily occur in the deeper source region of a repeating earthquake during the passage of large postseismic slip. However, this is only one example of non-similar earthquakes, and other types of them may occur with different conditions of effective normal stress or constitutive friction law. In order to investigate it, we perform numerical simulations of non-similar earthquake with stress perturbation.

In case of slowness-law, our simulation shows that slow slip events usually occur but regular earthquakes temporarily occur under the same frictional properties and lower effective normal stress due to shallower focal depth or higher pore pressure, which is the opposite result from Ariyoshi et al. [2007 GRL]. In case of moderate effective normal stress, repeating earthquakes usually occur and become temporarily active in the passage of large postseismic slip. In case of slip-law, similar characteristics are shown but its range of effective normal stress between regular and slow earthquake is significantly narrower than that of slowness-law. The temporary activation with moderate effective normal stress could not have been reproduced by many trial simulations we have done so far. For deeper focal depth, no slip events occur for a long period before and after a large interplate earthquake. We think that such differences come from the narrow range of effective normal stress generating slow earthquake for slip-law [Ampuero and Rubin, 2008 JGR], which would be applied to stress perturbation due to large postseismic slip.

Comparing with observational results, we think that actual condition of subduction zone of the Pacific plate may obey slowness-law or slip-law under moderate effective normal stress being nearly constant over a wide depth range. Considering the fact that repeating earthquakes occur three times just after the 2011 Tohoku-oki Earthquake, we conclude that slip-law can not be applicable to the actual plate interface. In this presentation, we will discuss the validity of several types of friction laws including composite-law [Kato and Tullis, 2001 GRL] or PRZ law [Perrin et al. 1995 JMPS] as well as slowness-law and slip-law, toward developing evaluation of crustal deformation accompanied by megathrust earthquakes such as the 2011 Tohoku-oki Earthquake by analyzing repeating earthquakes and numerical simulations based on the friction law.

Keywords: non-similar earthquake, slip estimation by repeating earthquake analyses, numerical simulation based on friction law, postseismic slip propagation, effect of geofluid and focal depth, interplate earthquake, interplate earthquake