Timing of Earthquakes on Intraplate Active Faults Subjected to Stress Perturbation by Megathrust Earthquakes: Insights from Earthquake Sequence Simulation

*Hiroyuki Noda[1]

1. Kyoto University, Disaster Prevention Research Institute

Estimation of likelyhood of occurrence of intraplate large earthquakes is crutially important because of expected large amplitude of ground motion in nearby cities and short distance between source and human society which makes earthquake early warning difficult. Currently issued National Seismic Hazard Maps for Japan [2018, the Headquarter for Earthquake Research Promotion] adopts assumptions of Poisson process or Brownian passage time distribution depending on available information for each active fault. They yield rather wide distribution of temporal probability density for a timescale of the reccurence interval or the estimation error of history of events. The timelscale is typicaly much longer than recurrence intervals of megathrust earthquakes T_{cyc} which causes semi-periodic stress perturbation to intraplate faults. In the present study, effects of the semi-periodic stress perturbation to an intraplate active fault having a ductile shear zone beneath the seismogenic part [e.g., Shimamoto and Noda, 2014] are investigated by means of dynamic earthquake sequence simulation using a spectral boundary integral method [e.g., Lapusta et al., 2000].

Utsu [1974] pointed out that historical earthquakes in Southwest Japan are concentrated in -50 and +10 years from Nankai trough megathrust earthquakes. Such active periods of intraplate earthquakes may be due to semi-periodic stress perturbation by the megathrust earthquakes [e.g., Hori and Oike, 1996; Shikakura et al., 2014]. An important question is how its duration is scaled for different tectonic settings. T_{cyc} of megathrust earthquakes in Japan trench subduction zone is 500-800 years [e.g., Sawai et al., 2015] and much longer than in Nanka trough. Parameter studies on T_{cyc} and amplitude of the stress perturbation have been conducted to elucidate what controls the timing of intraplate earthquakes.

A 2D numerical simulation of a strike-slip fault [e.g., Lapusta et al., 2000] with ductile shear zone was considered as a model for an intraplate fault, accounting for a friction-to-flow fault constitutive law [Shimamoto and Noda, 2014] composed of the aging law and a quartzite flow law [Hirth et al., 2001], and effective normal stress distribution with maximum value of 50 MPa. The model was drived by far-field shear stress which was perturbed as a sawtooth wave function of variable amplitude about 1 MPa and T_{cyc} from 100 to 1000 years. If the perturbation was perfectly periodic, the system synchronized with the perturbation and the intraplate earthquakes ocurr at a specific phase in the cycle of megathrust earthquakes. If the interval was randomized by Gaussian distribution of 10% standard deviation, then the timing of the intraplate earthquakes distributed more widely, and concentrate in the latter half of the cycle, consistently with the notion of the active period. The shape of the distribution can be explained by a seismicity model based on ΔCFF [e.g., Shikakura et al., 2014], not by a rate-and-state spring-slider model [Dieterich, 1994; Ader et al., 2014]. The result of the parameter study suggests that not only the history of the activity of the fault, but also stress change on it due to recurring megathrust earthquakes or other events may be useful in constrainig the likelihood of intraplate earthquakes.

Keywords: Intraplate earthquakes, Earthquake sequense simulation, Brittle-plastic transition

