Dynamic Earthquake Sequence Simulations of a Fault in a Viscoelastic Material with a SBIEM

Miyake, Y.[1], Noda, H. [2]

1. Graduate school of Science, Kyoto University, Kyoto, Japan

2. *Disaster Prevention Research Institute, Kyoto University, Kyoto, Japan*

A seismogenic zone exists in the upper crust, underlain by a zone where slow slip events (SSEs) and tremors are observed, and seismicity disappears in a deeper part of a fault. The transition between seismogenic and aseismic behavior may be caused by changes in frictional properties of the fault or changes in viscoelasticity of the surrounding medium. Although SSEs were numerically generated in previous studies by changing the frictional properties [e.g., Liu and Rice, 2005], the effect of viscoelasticity on the transition remains to be studied. In this study, we implemented the interseismic viscoelastic stress relaxation to an anti-plane fully dynamic earthquake sequence simulation code based on a spectral boundary integral method [Lapusta et al. 2000]. In the implementation, we developed a suitable algorithm in which the viscoelastic relaxation is calculated by evolution of effective slip, stress change on the fault deconvolved by a static Green's function.

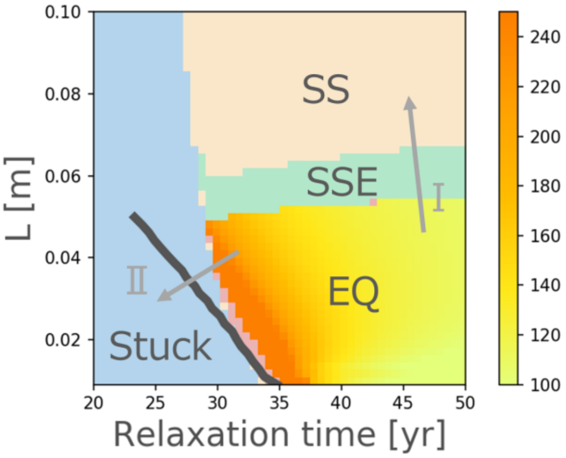

Figure 1. Phase diagram of behaviour of a rate-weakening patch (EQ: earthquakes, SSE: slow slip events, SS: steady sliding, Stuck: permanently locked). Recurrence intervals of earthquakes are colour contoured. A black line represents t_{crit}.

We conducted parameter studies for a fault with a rate-weakening patch, which is seismogenic in an elastic limit, on two parameters. one is viscoelastic relaxation time t_c, and the other is characteristic length L of state evolution in the rate-and-state friction (RSF) law. The parameter studies on the two parameters enable us to draw a phase diagram (Figure 1), by classifying all the results into four classes, earthquake (**EQ**), **SSE**, stable sliding (**SS**), and **Stuck**, where a part of the rate-weakening patch has diminishing slip rate and looks to be 'permanently locked'.

The diagram reveals that there are two different types of seismic-aseismic transition as we change the parameters. In one of them **(I)**, an **EQ** patch changes to a **SSE** patch before becoming a **SS** patch. This transition is typical when we increase L. The other type of the transition **(II)** is mainly caused by decreasing t_c where an **EQ**, **SSE**, or **SS** patch changes to a **Stuck** patch. As decreasing t_c, the recurrence intervals of earthquakes become longer as $1/(t_c - t_{crit})$, where t_{crit} is critical relaxation time, and seismicity ultimately disappears. Although we observed that an **EQ** patch in the elastic limit changes to a **SSE** patch before it becomes **Stuck**, it is the case only in a limited range of L. This indicates that the change in the frictional property is primarily important in the seismic-aseismic transition associated with SSEs.