Discussion Seminar

Physics of Slow Slip

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Large scale slow slips have been observed in several subduction zones (e.g., Cascadia, Tokai, Mexico, Boso, Costa Rica etc). In the subduction zone of NE Japan, slow slips tend to occur in association with brittle seismic events. This variation is schematically shown in Figure 1.

In general, slow slips are interpreted using the rate-state dependent friction mechanism, and combinations of temporal and spatial variation of velocity-weakening and velocity-strengthening frictional characteristics have been invoked to explain slow slips (e.g., Yoshida and Kato, 2003; Shibazaki and Iio, 2003; Liu and Rice, 2005). Or, slow crack propagation due to stress corrosion can be a viable mechanism, though it has not been extensively discussed. We will discuss the implications of these mechanisms for slow slip.

Mechanically, slow slip and regular earthquakes can be viewed in a simple stress release model like the slip weakening model. Regular earthquakes and slow tsunami earthquakes can be interpreted as stress release processes with different "fracture energy" (Figure 2). In this view, slow slip is the extreme case in which the frictional stress always balances the crack driving stress. Good examples have been shown by Miyazaki, Segall, McGuire, Kato, and Hatanaka (2006) (Figure 3). Then, the key question is what observations are needed to distinguish the different mechanisms.

Another important question is "What is the implication of slow slip for earthquake premonitory processes?" The recent GPS observation associated with the 11/26/2007 Fukushima-Oki (M=6.0), 05/08/2008 Ibaraki-Oki (M=6.9), and 07/19/2008 Fukushima-Oki (M=6.9) earthquakes provides an interesting case for discussion (Figure 4.)

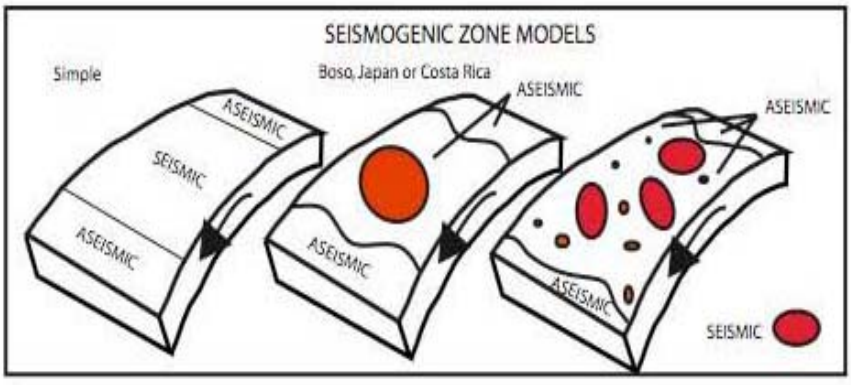

Figure 1. Cartoon of the plate interface at different types of subduction zones. (Schwartz, 2007)

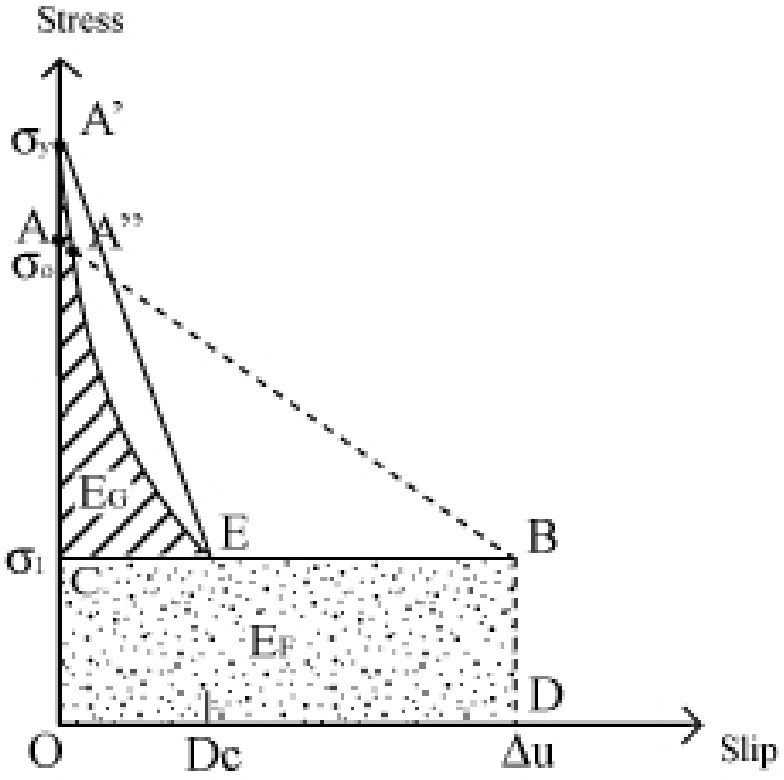

Figure 2. Slip weakening model.

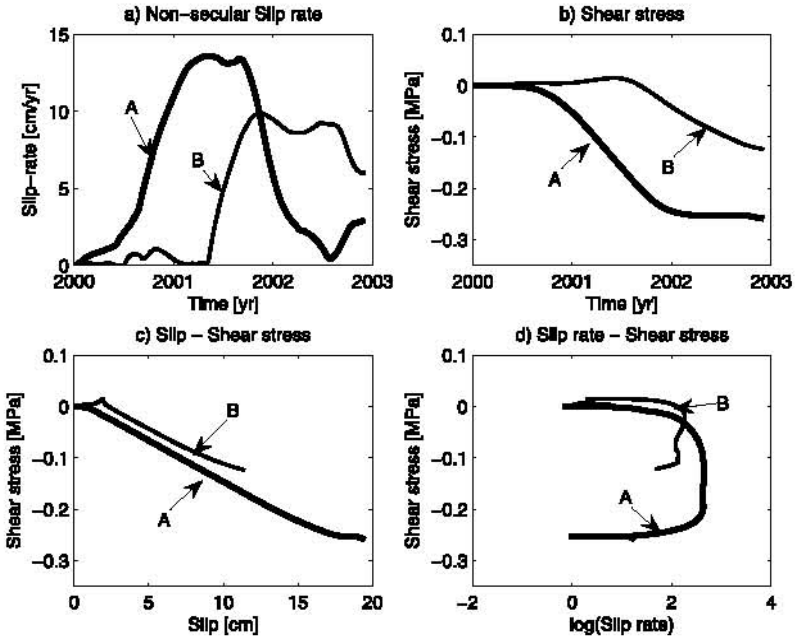

Figure 3. Slip, slip rate, and shear stress at selected points in the Tokai subduction zone. Note the relation between shear stress vs. slip diagram (c). (Miyazaki et al., 2006)

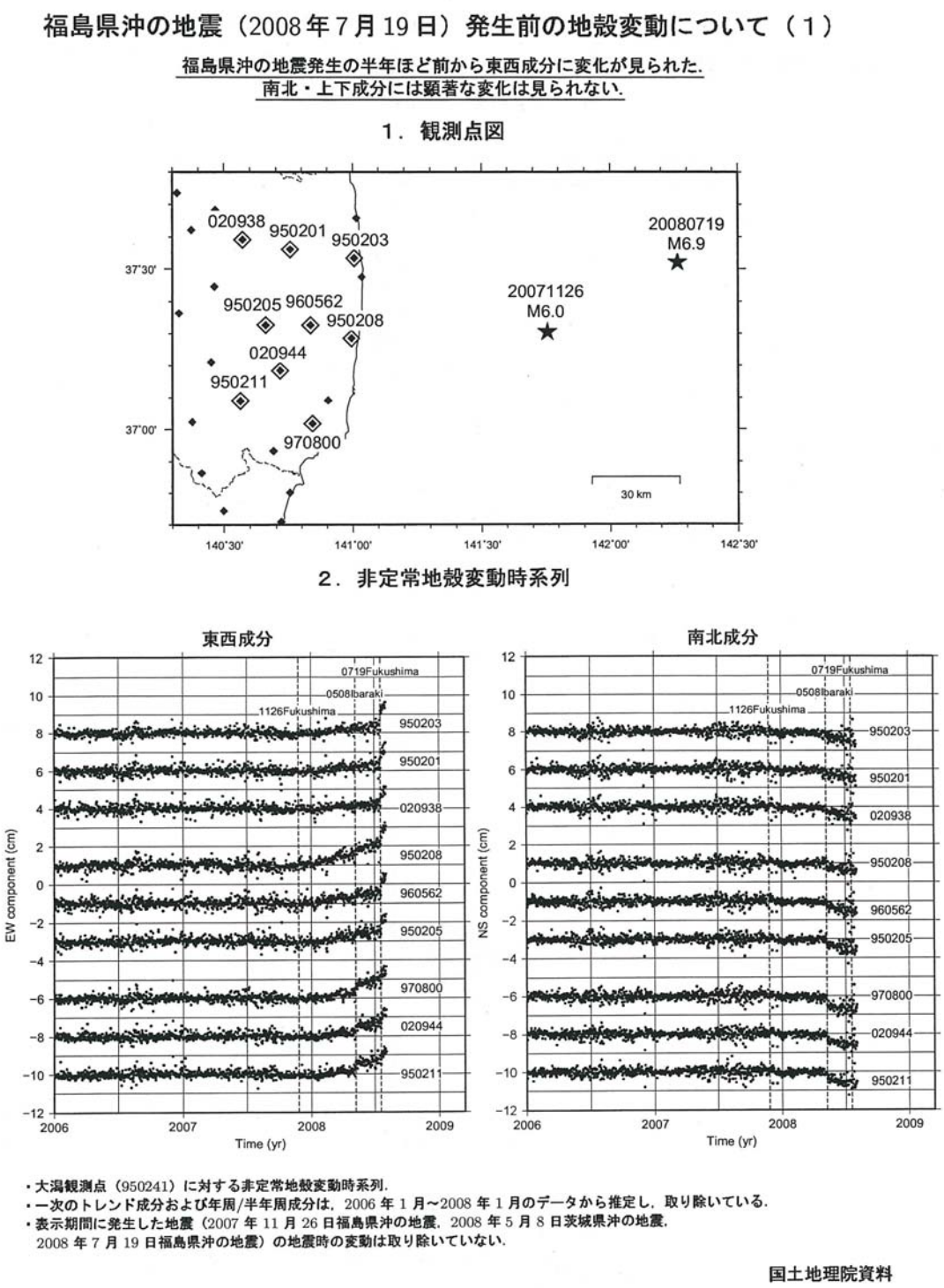

Figure 4. Slow slip (over 6 months) associated with the Fukushima-Oki earthquake.