

## Spatial Characteristics and Thermal-petrological Conditions of Cascadia-type Slow Slip Events

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Slow slip events (SSE) and/or nonvolcanic seismic tremor are abundantly reported for various tectonic environments, but ETS events – episodic occurrence of both SSE and tremor in the same place, have been confidently observed only at the Cascadia and Nankai subduction zones. The SSE in ETS events are different from other types of SSE for their characteristic week-scale duration and centimetre-scale slip. Their accompanying tremor may also be different from those in other tectonic settings, at least in their frequency content. Here we study the spatial characteristics of the SSE at northern Cascadia in order to understand their thermal and petrological conditions.

We determined the spatial extent of the slip patches from GPS observations and, wherever available, borehole strain-metre data, using dislocation modeling, assuming a bell-shaped downdip distribution of slip proposed by Wang and He (2008). Competing structural models for northern Cascadia, depending on the interpretation of a band of seismic reflectors (the “E layer”), place the plate interface at different depths. We found that a shallower interface requires the slip magnitude to be smaller. However, regardless of the structural model, the slip patches extend to at least 40 km depth, downdip of the intersection of the plate interface with the continental Moho. Slip patches in different slip events have variable along-strike dimensions ranging from >300 km to <90 km, but the maximum slip always occurs in the ~30-40 km depth range. The strike-normal span of the slip patches is very consistent with the locations of their accompanying tremor. Limited borehole strain time series for the 2005 ETS event indicate that the along-strike propagating slip patch had a sharp propagating front, supporting the notion that the slip occurred along a thin slip zone or a single decollement.

Undoubtedly, the slow slip at Cascadia occurs around the tip of the mantle wedge where the temperature is higher than 450° (Wada et al., 2008). Friction models show that episodic slip occurs at a frictional stability transition, e.g., the downdip limit of the megathrust seismogenic zone (Liu and Rice, 2007). But the northern Cascadia SSE are significantly deeper than the thermally defined stability transition (~350°) and the geodetically constrained seismogenic zone. The Nankai seismogenic zone extends to a greater depth, but the Nankai ETS also occur around the mantle wedge tip. We propose that the Cascadia-type (including Nankai) SSE are related to the full serpentinization of the tip of the mantle wedge and the availability of free H<sub>2</sub>O released from the young and warm slab that dehydrates at shallow depths. The buoyant antigorite serpentine formed in the wedge tip may intrude updip along the plate interface owing to its extremely low strength at this depth (Hilariet et al., 2007). Antigorite exhibits velocity-dependent stability transition behaviour (Reinen et al., 1994). The highly nonlinear flow rheology and complex frictional behaviour of antigorite and the very high pore fluid pressure may be responsible for the Cascadia-type SSE. The association with the shallow dehydration of warm slabs also explains the rarity of ETS in cold-slab subduction zones and other tectonic settings.

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