Geophysical Research Abstracts
Vol. 18, EGU2016-10370, 2016
EGU General Assembly 2016

A geological perspective on the source(s) of slow slip and tremor

Ake Fagereng
Cardiff University, School of Earth & Ocean Sciences, United Kingdom (fagerenga@cardiff.ac.uk)

Slow slip events (SSEs) represent transient fault slip velocities slower than earthquakes but faster than steady, average plate motion. SSEs are detected geodetically and do not emit detectable seismic waves, although they are commonly, but not always, accompanied by tectonic tremor. Tremor is defined as persistent, low-frequency (< 10 Hz) arrivals lacking impulsive body waves. Within the tremor signal are low and very low frequency earthquakes, interpreted as shear slip on faults subparallel to, and kinematically consistent with, the hosting fault. An increasingly common interpretation is that SSEs are a form of transient fault creep, and associated low frequency seismic phenomena represent shear failure of asperities embedded in the creeping fault segment. A geological analogue to the coupled phenomena of slow slip and tremor is then a brittle-ductile shear zone where frictional failure occurs in scattered locations within a dominantly viscous matrix.

Where slow slip and tremor spatially and temporally coincide, the total seismic moment of tremor and superimposed low frequency seismic events is negligible compared to the geodetic moment of the SSE. Thus, the geological analogue is restricted to brittle-ductile shear zones where the majority of finite strain is accommodated by ductile deformation. Also, the geodetic moment of an SSE is representative of the elastic strain in the rock volume surrounding the fault, that is converted to finite fault zone displacement by the SSE (centimetres), whereas tremor represents coincident frictional failure with small (sub-mm) slip magnitudes. This interpretation assumes that SSEs, like earthquakes, represent a form of stick-slip motion associated with elastic strain build-up and release in the surrounding elastic rock volume. If this assumption is correct, and geological analogues implying SSEs may form by viscous shearing flow are also correct, then SSE source parameters can be considered in terms of viscous deformation of a tabular shear zone.

Analogous to 'characteristic earthquakes', SSEs repeating at the same location have approximately characteristic slip magnitude and duration. Contrary to earthquakes, however, average slip relates to neither duration nor area, and average slip velocity is considerably greater in shallow events than in deep events. If the rheology of the SSE source is related to the viscosity of a tabular shear zone, SSEs may be controlled by microscale deformation mechanisms other than cataclasis. In the matrix of brittle-ductile shear zones, deformation structures imply diffusion and dislocation creep as possible microscale deformation mechanisms, and these mechanisms may allow slow slip strain rates if shear is distributed. There is also field evidence for a widening of the subduction thrust shear zone with increasing depth, leading to increased effective viscosity where deep SSEs have longer and slower average slip rate than shallow SSEs.