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Episodic tremors and slip explained by fluid-enhanced microfracturing and sealing

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A combination of seismic (Non-volcanic Tremors) and transient aseismic (Slow Slip Events) behaviours is now commonly observed at plate interface, between locked/seismogenic domain at low depths and stable/ductile creep domain at large depths (Rogers & Dragert 2003). This association defines Episodic Tremors and Slip (ETS), systematically highlighted by overpressurized fluids and low shear stress (Shelly et al., 2006, Audet et al., 2010). Classical models (e.g. rate and state, Liu & Rice, 2007) fail up to now to provide a mechanical explanation for the complex and transient interplay between seismic and aseismic behaviours of ETS. Here we propose a new mechanical approach, guided by field observations, based on a ductile rheology with grain size sensitivity, fluid-driven micro-fracturing and sealing (e.g. grain size reduction and grain growth) and related pore fluid pressure fluctuations. We reproduce slow slip events by transient ductile strain localization as a result of competing fluid-enhanced microfracturing and sealing. Occurrence of macro-fracturing (e.g. tremors) during transient strain localization and local increase in pore fluid pressure are moreover detected. Our study therefore provides a geological explanation of ETS and furthermore allows quantifying the mechanical conditions for ETS occurrence: only quasi lithostatic pore fluid pressures and relative high temperature (400-550°C, depending on the selected rheological parameters).