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Episodic Creep, Tremor, and Fluid Expulsion at the Updip Edge of the Seismogenic Zone, Costa Rica

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We propose that that coupled ultra-slow "aseismic nearly silent" ruptures and associated seabed flow events and subsurface seismic tremor can originate and propagate up and down dip from the stable/unstable slip transition zone near or at the up dip limit of the seismogenic zone in the off shore regions of the Cost Rica subduction system. Long-term measurements of benthic boundary fluid flow events made across the Nicoya Peninsula, Costa Rica (Pacific), convergent margin have been made utilizing recently developed osmotically driven fluid flow meters that are designed to quantify both inflow and outflow rates on the order of $\sim 10^{-5}$ cm/d to 3cm/d. Significant transience in flow was observed through the surface of the forearc. Three periods of correlated in and out flow signals are seen during a 6 month period on subduction forearc between three instruments located in the near toe of the trench of the subduction zone over along-margin strike distances of $\sim$30 km. Events lasted for a week or more. Seismic noise amplitude recorded on collocated ocean bottom seismometers (OBS) increases during the three correlated flow events. The noise has frequency characteristics that are complex and are still being analyzed but have some features that are similar to volcanic tremor.

We put forward the hypothesis that the episodic seismic noise is generated by transiently accelerated flow though fracture systems around a propagating aseismic rupture dislocation. Fluid flow is accelerated by the loading of pore fluids in the poroelastic stress field imposed around the dislocation. Flow velocities are greatly elevated as a result of the high permeabilties of fractured basement formations either in the hanging wall Nicoya complex and/or the footwall subducting oceanic basement. The tremor is related to non-linear effects associated with momentum changes in the fluid velocity at fracture constriction points similar to the "knocking of pipes" in old buildings. The momentum changes in the migrating fluids at the constriction transmit pressure pulses to the elastic but damped facture walls inducing sustained "vibration tremor". The poro-elastic stress field around the aseismic dislocations also induces flow through the sediment water interface where it is recorded by the fluid flow meters. There is also the potential that liquefaction events are caused by the action of tremor on shallow poorly consolidated sediments. Liquefaction does not, however, seem able to account for the temporally correlated inflow events seen at some flow meter locations.

The creep events have along strike dimensions of $>$30km. More recent continuous land based GPS observations indicate that such creep events do indeed occur along this sections of this margin and that they propagate down dip from the shallower off shore section of the subduction thrust. We hypothesize that we are witnessing similar repeated plate boundary creep events within the toe of the forearc that originate from regions close to the up dip limit of the seismogenic zone and that they also propagate to the toe. There is also the potential that peaks in seismicity along the middle America margin is temporally related to such creep events, if so the creep events off the Nicoya region seem to proceed the seismic peaks by several weeks.