Models for Seismic slip and Fluid Flow along the Subduction Interface

*Donald M Fisher[1], John N Hooker[1]

1. Pennsylvania State University

A numerical model for slip along the subduction interface shows that coupling between fluid flow and fault healing is important for the spatial, temporal and size distribution of slip events. Field observations of exposed plate boundary fault zones from ancient subduction zones such as the Shimanto belt and the Kodiak accretionary complex have several first-order features that must be accounted for in models for the slip behavior during subduction. 1) Subduction fault zones record stratal disruption along a compactive strain path in the form of wide zones of mélange. 2) The slip occurs through development of a scaly fabric in mudstones and hydrofracturing of stronger blocks. 3) At depths and temperatures associated with the seismogenic zone, deformation is characterized by dissolution and continuous metamorphic reactions in the scaly fabric and diffusion to cracks in the blocks, with veins that have evidence for crack seal deformation, and 4) veins record evidence for both local and external fluids, suggesting events of fluid infiltration. We interpret these features as a record of plate boundary deformation at rates too slow to accommodate plate motions that occurs in the interseismic period between earthquakes. Importantly, this interseismic deformation, marked by pressure solution and a linear viscous rheology, is capable of healing the subduction interface through development of increased contact area and reduction in crack porosity. To investigate this process, we develop a 2-D block-slider cellular automaton that allows for temperature dependent fault zone strengthening. The same cellular automaton grid also functions as a darcian flow model that includes fluid production at depth and venting at the trench. The two models are coupled through (1) a failure law based on effective stresses that account for fluid pressures, and (2) the process of mineral redistribution, by which healing and increase in contact area coincide with reduction in permeability, whereas failure of the interface leads to restoration of greater permeability. These models show that the slip behavior of the plate interface and the time evolution of the fluid flow system are controlled by the balance between fluid production, fluid flow, and the rate law for fault strengthening.

Keywords: subduction, seismogenic zone, mélange, cellular automaton, scaly fabric, permeability

