Injection-driven failure and fault mechanics in high fluid flux faulting regimes

*Stephen Francis Cox[1]

1. Research School of Earth Sciences, The Australian National University

Fault zones formed in overpressured, high fluid flux regimes typically are characterized by a predominance of dilational damage over wear damage, and contain abundant fault-fill veins, dilational breccias and lateral damage zones that are dominated by extension vein arrays. Development of vein-rich fault zones is associated typically with extensive hydrothermal alteration and disturbance of isotopic, major and trace element systems due to flux of large volumes of externally-derived, overpressured fluids through rupture zones developed in intrinsically low permeability host rocks. Vein arrays in high fluid flux faults provide insights about the dynamics of fluid pressure variations and stress states during repeated rupture cycles in these settings. Rupture events are driven predominantly by fluid pressurization at low differential stress.

Contemporary injection-driven swarm seismicity provides novel insights about the dynamics of formation, timescales of activity, and flow rates in high fluid flux fault zones. Results from fluid injection experiments and natural, fluid-driven seismic sequences demonstrate that swarm seismicity is the characteristic response to injection of large volumes of overpressured fluids into low permeability rock. Injection-driven swarm seismicity and related permeability enhancement typically involves repeated sequences of thousands of ruptures with moment magnitude M_w mostly in the range $-2 < M_w < 2$. Individual ruptures within each swarm sequence usually have diameters much less than 100m and slips less than a few millimetres. Cumulative rupture areas during a single swarm seldom exceed several km^2. Diffusion-like migration of a seismicity front away from the injection source at rates up to approximately 100m/day is a key characteristic of injection-driven seismicity and correlates with migration of a fluid pressure pulse along activated faults. Fluid injection rates in excess of tens of $L.s^{-1}$, and total injected volumes of 10^4 - 10^5 m^3 produce swarms with cumulative moment magnitudes in the range 4 - 5. Recurrence intervals of natural injection-driven swarms indicate that net slips of approximately 100m can accumulate on timescales as little as 10^4 to 10^5 years.

Keywords: fault mechanics, high fluid flux regimes

