Hydrogeologic responses to subduction zone temperature variability

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Fluid pressure affects the strength of faults by controlling effective stress. Within subduction zones, low-grade metamorphic reactions and increasing effective stress likely control the transition from stable sliding to the seismogenic zone. In the Nicoya margin of Costa Rica, along-strike differences in the thermal state of subducting crust lead to large differences in temperatures, fluid properties, and the distribution of diagenetic fluid sources within the subduction zone [Spinelli and Saffer, 2004]. As a result of thermally-controlled differences in diagenetic reaction progress and hydraulic conductivity, fluid pressures along the Nicoya margin plate boundary fault are higher where the subducting crust is colder [Spinelli et al., 2006]. The higher fluid pressures, and therefore lower effective stresses, along the plate boundary on cold portions of the margin are consistent with along-strike offsets in both micro-seismicity and locking on the plate interface; the onset of micro-seismicity on the plate boundary coincides with locations where modeled fluid overpressures on the plate boundary fault dissipate (Figure). Additionally, along-strike differences in fluid pressure resulting from temperature differences drive considerable trench-parallel fluid flow within the subduction zone that should be considered when inferring the source of fluids sampled from boreholes or seeps [Spinelli and Saffer, 2007].

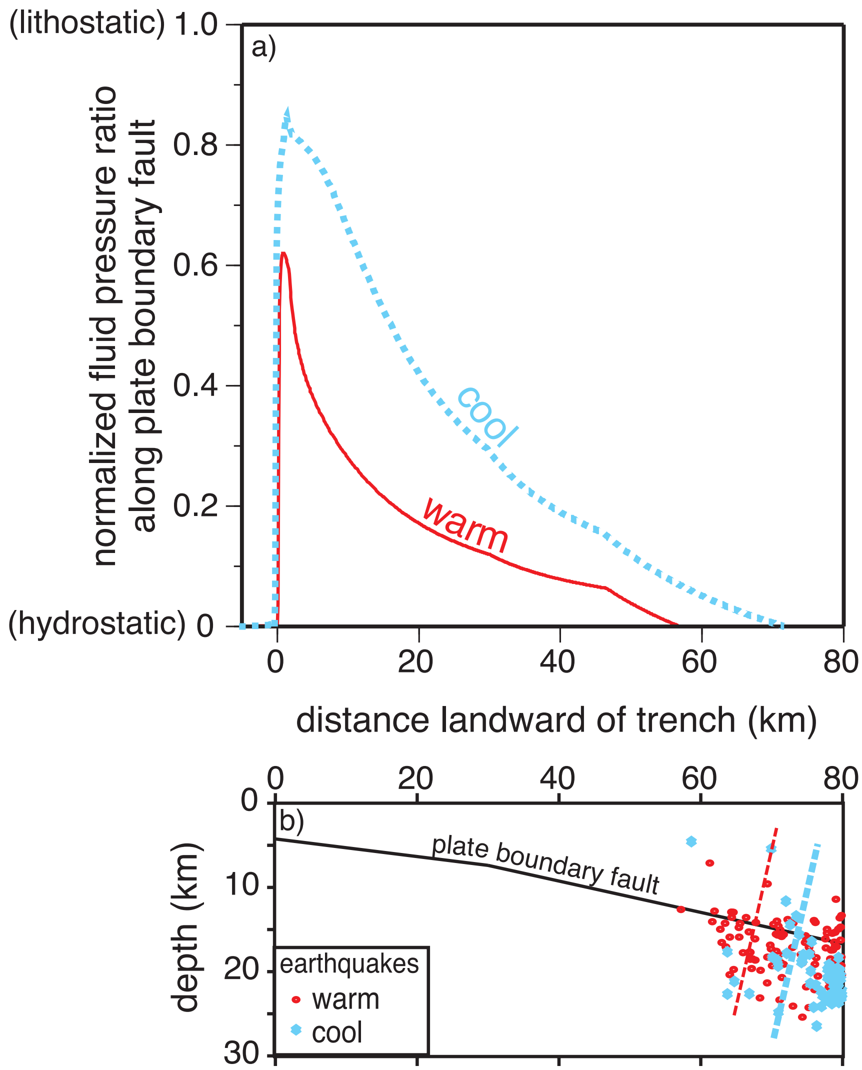

Figure: a) Where cool crust subducts on the Nicoya margin, modeled fluid pressures along the decollement are higher than where warm crust subducts; fluid pressures on the cool side of the system remain elevated relative to hydrostatic farther into the subduction zone. b) The onset of seismicity along the plate interface on both the warm and cool sides of the margin may correspond closely to the location at which elevated fluid pressures are dissipated. On each side of the margin, 90% of the earthquakes located by Newman et al. [2002] occur downdip of the dashed lines.

Spinelli, G.A., Saffer, D.M., 2004. Along-strike variations in underthrust sediment dewatering on the Nicoya margin, Costa Rica related to the updip limit of seismicity. Geophysical Research Letters, 31, doi:10.1029/GL018863.

Spinelli, G.A., Saffer, D.M., 2007. Trench-parallel fluid flow in subduction zones resulting from temperature differences. Geochemistry, Geophysics, Geosystems, doi:10.1029/2007GC001673.

Spinelli, G.A., Saffer, D.M, Underwood, M.B., 2006. Hydrogeologic responses to three-dimensional temperature variability, Costa Rica subduction margin. Journal of Geophysical Research, 111, B04403, doi:10.1029/2004JB003436.