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Does regional-scaled vigorous fluid fluxes reconcile thermal segmentation and interplate coupling variations at the Ecuadorian subduction zone?

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In subduction zones, questioning the causes for variations in interplate coupling and interplate slip behavior implies deciphering how much deep fluid content and flux influence thermo-mechanical features along the plate interface. A key-question in fluid-rich subduction zones is: how ventilated and insulated hydrothermal systems in basaltic aquifer influence interplate frictional properties and seismogenesis? This requires, in the first place, identifying zones of intense fluid flux at depth; challenging task!

The oceanic aquifer is an uppermost basaltic layer, where interconnected porosity is many orders of magnitude greater than in overlying trench sediment, subduction channel and underlying dike complex. This basaltic aquifer thus proved to be a very efficient pathway for fluids with thermal influence depending on the fluid exchange efficiency with surroundings. In ventilated aquifer, widespread fluid pathways favor heat advection from the ocean to the basement triggering hydrothermal cooling that results in unexpectedly low heat flow at the margin outer slope. In contrast, in insulated aquifer, less permeable sedimentary trench fill restrict heat advection and deep fluids flowing updip along the plate interface generate heat-flow higher than expected at the deformation front. Thus, dense heat-flow and seismic data may provide constraints on fluid flux at depth by deciphering the heat convection influence onto the margin thermal structure.

In Ecuador, 104 Multichannel seismic lines show Bottom Simulating Reflectors (BSRs) along segments that all together extend over more than 2200 km. BSR-derived heat-flow provide an unprecedentedly detailed heat-flow map from south Ecuador to central Colombia. This map reveal the margin thermal segmentation. 50-70-km-large (along strike) margin segments show heat-flow values of 140-200 mW/m², thus 160-200% higher than expected at the margin front. In contrast 20-30-km-large margin segments show heat-flow values of 60-80 mW/m², 50-60% lower than expected. These “anomalously” high and low heat flow are typical of ventilated and insulated hydrothermal circulation respectively. These thermal variations provide evidences about major questions in subduction zones and in Ecuador in particular.

1. The Ecuadorian subduction zone undergoes a fluid-rich hydrothermal circulation, which is the first example to be documented, worldwide, at such a regional scale.
2. Insulated hydrothermal circulation fronts the rupture zones for the Pedernales (2016) and, possibly, for the 1942 earthquakes, while, to the south, the poorly coupling interplate zone corresponds with conductive heat-flow. Fluids flowing updip of the rupture zones along the interplate contact may thus favor interseismic coupling and co-seismic stick-slip behavior at greater depth.
3. The subducting Atacames seamounts correspond with a poorly coupling interplate patch that shows unexpectedly low heat-flow at the deformation front. The subducting seamounts and the related deep pervasive margin fracturing are likely to provide efficient fluid pathways within the upper plate, interrupting the insulated circulation and favoring interplate decoupling.