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Fluids release mechanisms, vein formation, and earthquake localization in subduction zones: a dynamic numerical modeling study

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Considering the localization of seismogenic zones during subduction processes, two factors are generally accepted for their determination: temperature and fluid pressure. Beneath large sedimentary accretion wedges the transition to aseismic stable sliding is temperature controlled. In this case the maximum temperature for seismic behavior in subducted crustal rocks is limited by $\sim$350˚C. In addition, great earthquake ruptures initiated at less than this temperature may propagate with decreasing slip to where the temperature is $\sim$450˚C.

Although, links between seismic activity and release of fluids in the subduction zone remain poorly understood, fluid pressure can strongly influence the mechanical behavior of rocks; such fluid may origin from in situ dehydration or may be derived externally. Experiments, conducted in numerous systems, have shown that rocks undergo sudden weakening and embrittlement (a change from ductile to brittle behavior) during their dehydration. In addition, conditions that support decreased rock permeability, will contribute to an increase of fluid pressure. In the presence of an externally derived fluid, embrittlement is independent of whether the same rock exhibits stable or unstable state of sliding.

Abundance of synmetamorphic segregations in a varity of exhumed metamorphic rocks testifies to the importance of fluid-rock interactions at all depths. These segregations are created throughout the different stages of the tectono-metamorphic evolution.

In subduction zones dehydration reactions during metamorphism represent a substantial source of fluid. We investigated the parameters that control fluids production and vein formation in the forearc wedge and in the slab by employing thermodynamic modeling. Our study confirms the hypothesis that the fluids involved in vein formation originate from the local rocks itself. No external fluids are involved. The quantity of released fluids is controlled by the thermal structure of the subduction as well as by the chemistry of the sediments involved in the wedge.

We also show as already proposed by Delany & Helgeson (1978), that volume changes, which are accompanied by dehydration reactions during subduction contribute significantly to earthquake generation.