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Factors Controlling Slab Roll-Back and Back-Arc Extension: Insights from Numerical Models

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Although subduction is a first order plate tectonic process, the factors controlling the dynamics of slab roll-back and back-arc formation are still not very well understood. The major driving forces for subduction and slab roll-back are well established as the slab pull and ridge push forces, their relative importance and the relative importance of forces resisting these driving forces is, however, not very clear.

We use thermo-mechanical models to study oceanic subduction, slab retreat, and back arc formation. We focus on two aspects of the subduction process: 1) factors that control retreat of the subduction zone, and 2) those that control the opening of the back arc. The model evolution is calculated using 2D plane strain thermo-mechanical finite element techniques for the finite element solution of incompressible viscous-plastic creeping flows (Fullsack, 1995). The models extend from the surface to 660 km depth. The upper surface of the model is free to move. Upper mantle rheology is linear viscous, whereas the rheology of the subducting slab is either linear viscous or combined linear viscous and von Mises plastic. Reflective and periodic boundary conditions are used.

We investigate interaction of the subducting slab with the overlying plate and focus on factors that may control the opening of a back-arc basin. The down going plate is driven by a kinematic boundary condition, far from the zone of subduction. After an initial stage of far-field driven contraction, the negative buoyant down welling of the mantle lithosphere may drive continued formation of the subduction zone leading to mature subduction. The models suggest that two primary factors are required for slab retreat and the formation of an extensional back-arc system: 1) Processes weakening the back arc, and 2) the ability of material below the slab to flow out of the model.