



Numerical subduction zones: advances in geodynamic and geochemical modeling

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Subduction zones are a challenge to model numerically. Over long periods of time the system can be modeled as a viscously deforming single, solid phase with a cold down-going slab driving deformation in the hotter mantle wedge. As the slab descends it releases aqueous fluids, which migrate into and across the wedge. This happens on time-scales much faster than the solid deformation but may still influence it. The aqueous fluids cause flux melting in the wedge and, ultimately, arc volcanism. Modeling these processes requires a multi-phase description that incorporates chemical reactions between the phases, including de- and re-hydration of the solid, melting and freezing, and fluid and solid compositional changes. Even a simple single-phase model of the thermal structure is computationally expensive, requiring large amounts of resolution, but fully-coupled multi-phase models are additionally highly non-linear, requiring robust solution strategies to even converge.

Despite these challenges even single-phase thermal models have done much to advance our understanding of the dynamics and chemistry of subduction. For example, assuming chemical equilibrium and initial compositions, modeled slab temperature and pressure have been mapped onto phase diagrams to give the depths of aqueous fluid release. These maps have been used to place bounds on subduction zone fluid budgets and explain the locations of intra-slab earthquakes. They have also provided the starting point for more complicated, though not yet fully-coupled, multi-phase models that include the dynamics of the aqueous fluids. These have demonstrated potential focussing mechanisms that explain the offset between the locations of fluid release along the slab and melting beneath the arc. However, other significant discrepancies remain and much work remains to be done advancing these models further.

We aim to present an overview of published geodynamic subduction zone models – from single-phase thermal models to those that have started to include multi-phase interactions. We will discuss the geochemical observations that these models can be used to explain and the remaining discrepancies between them. Finally, as much of the geochemistry in these models relies on equilibrium assumptions we will mention some ongoing work aimed at including a more complete dynamic geochemical description using disequilibrium thermodynamics.