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Improved treatment of asthenosphere flow and melting in 2D numerical solutions for continental rifting: embedded vs nested modeling approaches.

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This work focuses on improving current 2D numerical approaches to modeling the boundary conditions associated with computing accurate deformation and melting associated with continental rifting. Recent models primarily use far-field boundary conditions that have been used for decades with little assessment of their effects on asthenospheric flow beneath the rifting region. All are extremely oversimplified. All are likely to significantly shape the pattern of asthenospheric flow beneath the stretching lithosphere which is associated with pressure-release melting and rift volcanism. The choice of boundary conditions may lead to different predictions of asthenospheric flow and melting associated with lithospheric stretching and breakup. We also find that they may affect the mode of crustal stretching.

Here we discuss a suite of numerical experiments using a Lagrangian formulation, that compare these choices to likely more realistic boundary condition choices like the analytical solution for flow associated with two diverging plates stretching over a finite-width region. We also compare embedded and nested meshes with a high-resolution 2-D region within a cartesian ‘whole mantle cross-section’ box.

Our initial results imply that the choice of far-field boundary conditions does indeed significantly influence predicted melting distributions and melt volumes associated with continental breakup. For calculations including asthenospheric melting, the ‘finite width plate spreading’ and embedded rifting boundary condition treatments lead to significantly smaller BC-influenced signals when using high-resolution calculation regions of order ∼1000 km wide and 600 km deep within a lower resolution box of the order of >5000 km wide and 2800 km. We recommend their use when models are attempting to resolve the effects of asthenosphere flow and melting. We also discuss several examples of typical numerical ‘artifacts’ related to ‘edge convection’ at the sides of the stretching region whose evolution is very sensitive to choices of far-field boundary conditions – and whose melting implications should be mistrusted.