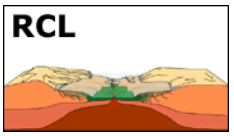
A Mechanically-Consistent Approach to Dikes in Continental Rift Models



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Rather than treating a dike as a uniformly pressurized crack in an elastic half-space, we developed a new approach in which we consider reasonable lithospheric stress distributions. Another new feature is that we calculate the dike top and bottom using the stresses for the opening dike (Weertman, 1973)* and do not assign the dike an arbitrary height. We applied this method to the general problem of dike opening in two papers looking at problems somewhat removed from continental rifts: the width of dikes seen at spreading centers (Qin and Buck, 2008) and the depth of cracks on the surface of icy satellites of Jupiter (Qin et al, 2007). The method has been adapted to look at the evolution of continental rift with a given rate of magma supply. We couple the stress and deformation with a thermal calculation for an evolving rift. The model rift deformation is calculated in two stages. First we use a fairly standard (FLAC numerical) approach to simulate the slow changes in stress, viscous flow and plastic strain driven by pulling the sides of the lithosphere at a fixed velocity. Then at set time intervals we take the stress field at the axis and use a boundary element code to calculate dike opening given a set flux of magma. Any excess magma can then be extruded on the surface. As the thermal structure evolves the force required for continued tectonic rifting goes down and it is possible that rifting may continue without further input of magma.

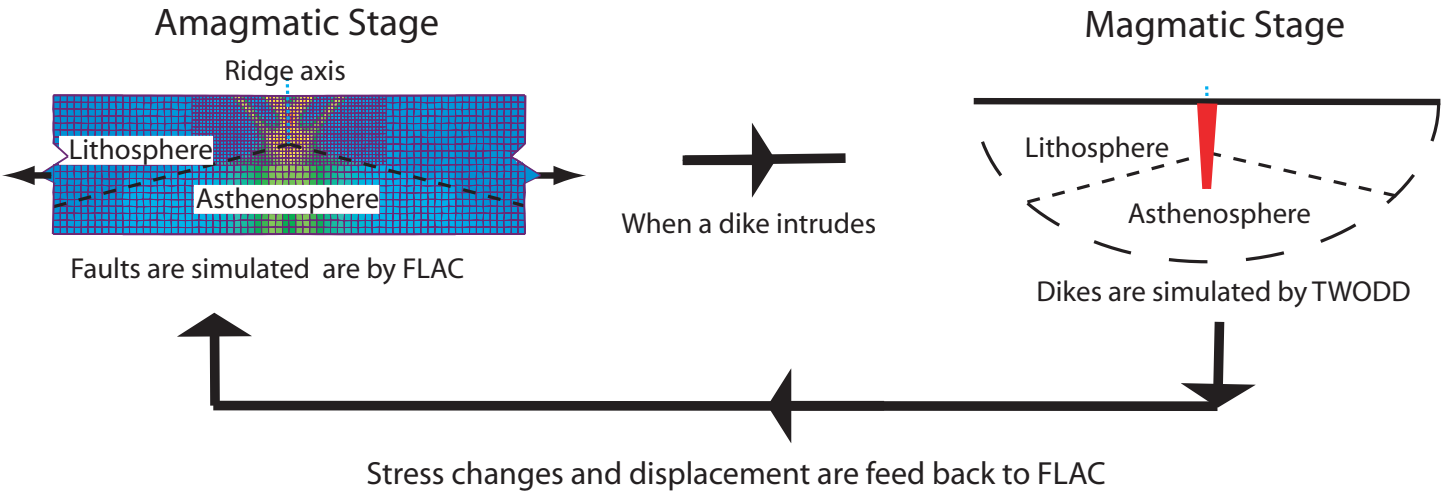

Figure: Illustration of the two steps in our model of continental rift extension with dike intrusion events. The stress level may or may not be be too low to allow tectonic extension (with no magma), but fairly modest stress levels allow dike events that carry considerable heat and so weaken the lithosphere. The figure on the left shows the model stage of long-term lithospheric stressing and deformation simulated with a FLAC based code. The right panel illustrates a boundary element calculation of the injection of a single dike.

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*References listed in appendix A.