The influence of magmatism on the evolution of continental rifts

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Both of the original MARGINS RCL focus sites show abundant evidence that magma has influenced rift initiation and evolution. Massive flood basalts at the southern end of the Red Sea and dike intrusions in the north that coincide with the earliest stage of rifting, suggest that magma played an important role in the initiation of rifting in this region. Moreover, in the Gulf of California, a MARGINS-sponsored seismic refraction experiment by Lizarralde et al. [Nature, 2007]* found large differences in the style of rifting, which are directly correlated with changes in magmatism. Though magmatism plays a key role in rifting, few geodynamical models have fully incorporated the effects of magma intrusion on rift architecture. Variations in the rate and depth distribution of magma emplacement at the rift axis will likely influence the style of faulting during rifting. The goal of this study was to develop new geodynamic models to assess the effect of dike intrusion on (1) the pattern of faulting across a rift; (2) the tectonic force for rifting; (3) the pattern of subsidence and uplift during rift evolution. To accomplish these goals we developed 2-D elastic-visco-plastic models for dike injection that incorporate both the thermal and mechanical effects of magma intrusion on rift initiation and evolution. Our models have been applied to a number of geologic environments, including mid-ocean ridges [Tucholke et al., 2008; Behn & Ito, in press; Ito & Behn, in review] and ridge-jumps into old ocean lithosphere associated with hotspot magmatism [Mittelstaedt et al., 2008]. We are now using these models to quantify the amount of magmatism that is necessary to initiate rifting in continental lithosphere.

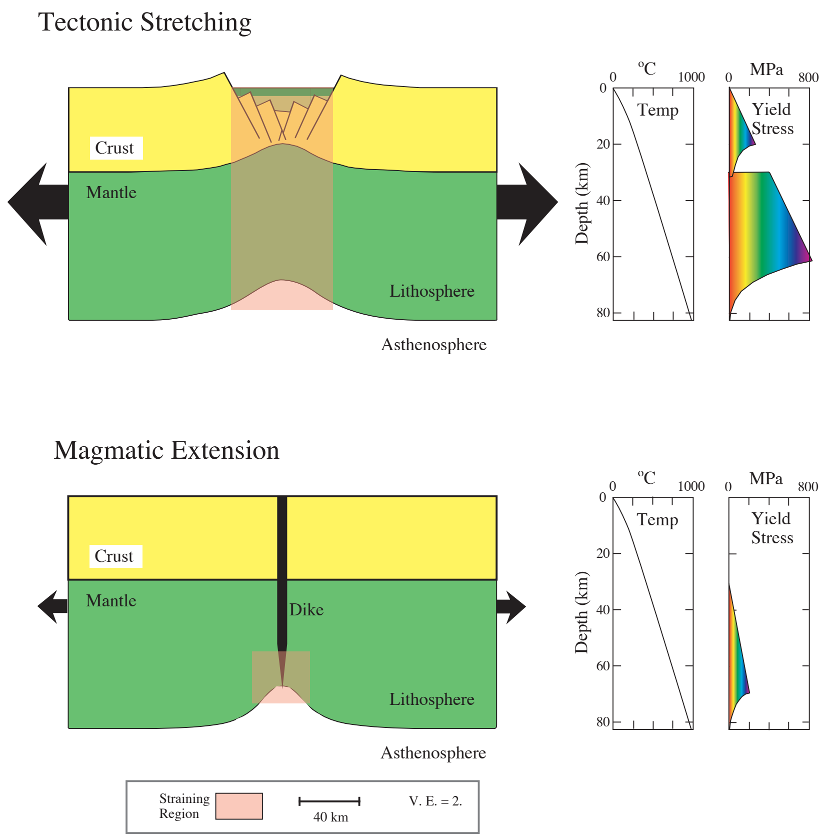

Figure: Schematic of two possible ways to extend normal thickness continental lithosphere. Note the large difference in the yield stress, the stress difference needed to get extensional separation of two lithospheric blocks (a) without and (b) with magmatic intrusion. From Buck (2006)

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*References listed in appendix A.