Imaging Ruptured Lithosphere Beneath the Red Sea and Arabian Peninsula

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Abstract

The Red Sea Rift, an archetype of a newly formed ocean basin, is an ideal environment in which to study the controversial processes associated with continental rifting. Different models have been proposed to explain how rifting in the Red Sea evolved; however, accurate constraints on lithospheric structure have not been available to discriminate rifting models. We use the S-wave receiver function technique to produce the first images of the lithosphere-asthenosphere boundary (LAB) structure along the Red Sea and throughout the Arabian Peninsula. Lithospheric thickness varies considerably, with thin lithosphere centered on the rift axis, thickening toward the Arabian interior. Gravity data are well fit by our structural model and indicate that high surface topography along the rift flank is not in isostatic equilibrium, requiring dynamic compensation for its support. While our derived structure is consistent with active rifting processes, previous studies demonstrated that the Red Sea initiated as a passive rift. Therefore, our results suggest a two-stage rifting history, where extension and erosion by flow in the underlying asthenosphere are responsible for variations in LAB depth. LAB topography guides asthenospheric flow beneath western Arabia and the Red Sea, demonstrating the important role lithospheric variations play in the thermal modification of tectonic environments.

Keywords: Arabia, Red Sea, rifting, lithosphere-asthenosphere boundary, S-receiver functions