Combined plate motion and density-driven flow in the asthenosphere beneath Saudi Arabia: Evidence from shear-wave splitting and seismic anisotropy

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ABSTRACT

We analyzed mantle anisotropy along the Red Sea and across the Arabian Peninsula using shear-wave splitting recorded by stations from three different seismic networks—the largest, most widely distributed array of stations examined across the Arabian Peninsula to date. Stations near the Gulf of Aqaba display fast orientations aligned parallel to the Dead Sea transform fault, most likely related to the strike-slip motion between Africa and Arabia. However, most of our observations across Arabia are statistically the same (at a 95% confidence level), with north-south–oriented fast directions and delay times averaging _1.4 s. Since end-member models of fossilized anisotropy and present-day asthenospheric flow do not adequately explain these observations, we interpret them as a combination of plate- and density-driven flow in the asthenosphere. The combination of northeast-oriented flow associated with absolute plate motion with northwest-oriented flow associated with the channelized Afar upwelling along the Red Sea produces a north-south resultant that matches the observations and supports models of active rifting.

Keywords: Arabia, Red Sea, anisotropy, shear-wave splitting, continental rifting, mantle flow.