Upper mantle structure beneath the Arabian Peninsula and Northern Red Sea from teleseismic body wave tomography: Implications for the origin of Cenozoic uplift and volcanism in the Arabian Shield

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Abstract

Upper mantle structure between 150 and 400 km depth is imaged beneath the Arabian Shield and northern Red Sea by modeling P and S travel time residuals from teleseismic events recorded on the Saudi Arabia National Digital Seismic Network, the 1995-1997 Saudi Arabian PASSCAL experiment, and three permanent stations (RAYN, EIL and MRNI). Relative travel time residuals were obtained using a multi-channel cross correlation method and inverted for upper mantle structure using VanDecar's inversion22 method. The resulting images reveal a low velocity region (~1.5% for the P model and ~3% for the S model) trending NW-SE along the western side of the Arabian Shield, and broadening to the northeast beneath the Makkah-Madinah-Nafud volcanic line. We attribute the low velocities to a mantle thermal anomaly that could be as large as 330 K, and that is associated with the Cenozoic uplift of and volcanic centers on the Shield. Our tomographic images are not consistent with models invoking separate mantle upwellings beneath the northern and southern regions of the Shield and instead favor single plume or superplume models. We also find little evidence for low velocities beneath the northern Red Sea, suggesting that there might not be a geodynamic link between rifting in the Red Sea and plateau uplift and volcanism in the Shield.