Geophysical Research Abstracts
Vol. 19, EGU2017-15919, 2017
EGU General Assembly 2017
© Author(s) 2017. CC Attribution 3.0 License.

Mantle convection patterns reveal the enigma of the Red Sea rifting

Alexey Petrunin (1,2,3), Mikhail Kaban (2,3), Sami El Khrepy (4,5), and Nassir Al-Arifi (4)

(1) Goethe University of Frankfurt, Faculty of Earth Sciences, Section Geophysics, Frankfurt am Main, Germany (alexei@gfz-potsdam.de), (2) German Research Centre for Geosciences (GFZ) Potsdam, Germany, (3) Schmidt Institute of Physics of the Earth RAS, Moscow, Russia, (4) King Saud University, Riyadh, Saudi Arabia, (5) National research Institute of Astronomy and Geophysics, Helwan, Egypt

Initiation and further development of the Red Sea rift (RSR) is usually associated with the Afar plume at the Oligocene-Miocene separating the Arabian plate from the rest of the continent. Usually, the RSR is divided into three parts with different geological, tectonic and geophysical characteristics, but the nature of this partitioning is still debatable. To understand origin and driving forces responsible for the tectonic partitioning of the RSR, we have developed a global mantle convection model based on the refined density model and viscosity distribution derived from tectonic, rheological and seismic data. The global density model of the upper mantle is refined for the Middle East based on the high-resolution 3D model (Kaban et al., 2016). This model based on a joint inversion of the residual gravity and residual topography provides much better constraints on the 3D density structure compared to the global model based on seismic tomography. The refined density model and the viscosity distribution based on a homologous temperature approach provide an initial setup for further numerical calculations. The present-day snapshot of the mantle convection is calculated by using the code ProSpher 3D that allows for strong lateral variations of viscosity (Petrunin et al., 2013). The setup includes weak plate boundaries, while the measured GPS velocities are used to constrain the solution.

The resulting mantle flow patterns show clear distinctions among the mantle flow patterns below the three parts of the RSR. According to the modeling results, tectonics of the southern part of the Red Sea is mainly determined by the Afar plume and the Ethiopian rift opening. It is characterized by a divergent mantle flow, which is connected to the East African Rift activity. The rising mantle flow is traced down to the transition zone and continues in the lower mantle for a few thousand kilometers south-west of Afar. The hot mantle anomaly below the central part of the RSR can be explained either by the asthenospheric upwelling due to the Red Sea floor spreading or by a secondary plume rising from the transition zone. According to our model, there is no obvious evidence for a direct connection of the hot anomaly below the central part of the RSR and the Afar plume in the upper mantle. In the northern part of the RSR, we found the ridge-axis aligned downstream flow contradicting the hypothesis of the intra-continental rifting in this area. Likely, the tectonics of this area implies a complex interplay of the Dead Sea transform fault development and the Sinai and Mediterranean tectonics.

Kaban, M. K., S. El Khrepy, N. Al-Arifi, M. Tesauro, and W. Stolk (2016), Three dimensional density model of the upper mantle in the Middle East: Interaction of diverse tectonic processes, J. Geophys. Res. Solid Earth, 121, doi:10.1002/2015JB012755.

Petrunin, A. G.; Kaban, M. K.; Rogozhina, I.; Trubitsyn, V. (2013). Revising the spectral method as applied to modeling mantle dynamics. Geochemistry Geophysics Geosystems (G3), EDOC: 21048.