# Revealing asthenospheric rheology beneath continental regions

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Seismic anisotropy is often used as a proxy for investigations of past and present-day deformation of the lithosphere and to understand flow patterns in the sub-lithospheric mantle. Beneath continents, poor depth constraints on seismic anisotropy measurements make it challenging to distinguish between shallow, lithospheric sources and deeper, asthenospheric contributions. Madagascar, the easternmost segment of the East African Rift System, provides a study region where the source(s) of seismic anisotropy can be investigated with geodynamic modeling. In Rajaonarison et al. (2020), we tested the hypothesis that observed seismic anisotropy across the continental island arises from either asthenospheric flow driven by thermal perturbations that arise from variations in lithospheric topography or mantle flow derived from mantle wind interactions with lithospheric topography. Using the geodynamics code ASPECT, we simulated the two modes of mantle convection to a depth of 660 km and used them to calculate the lattice-preferred orientation (LPO) that develops along mantle flow pathlines. The predicted LPO was then used to calculated synthetic splitting parameters, which were compared with the azimuths of available seismic anisotropy across the island. Through a series of comparisons, we found that asthenospheric flow resulting from undulations in lithospheric topography is the dominant source of the seismic anisotropy, but fossilized structures from an ancient shear zone may play a role in southern Madagascar. Our results suggest that the rheological conditions needed for the formation of seismic anisotropy, dislocation creep, may dominate the upper asthenosphere beneath other continental regions. ■

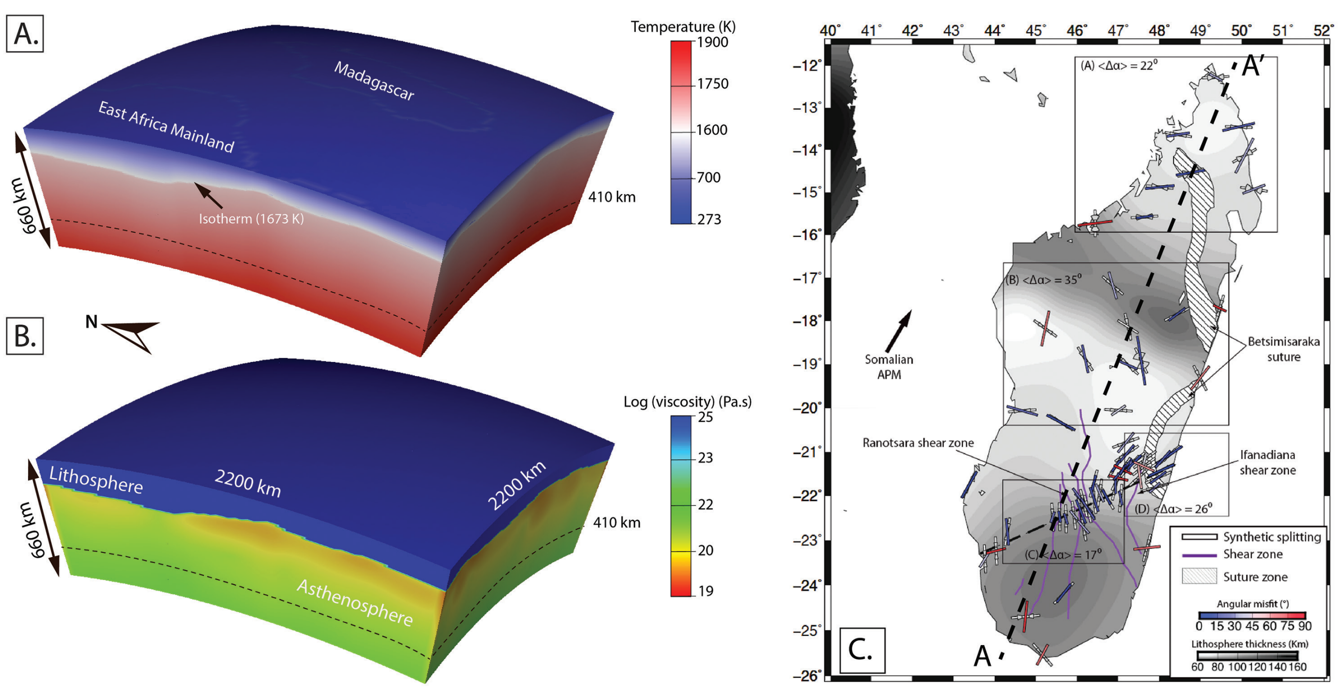


*Figure 1. A. Initial temperature condition for numerical model set-up. B. Initial viscosity model for numerical model set-up. C. Comparison of seismic anisotropy for preferred mantle convection model derived from lithospheric topography variations.*

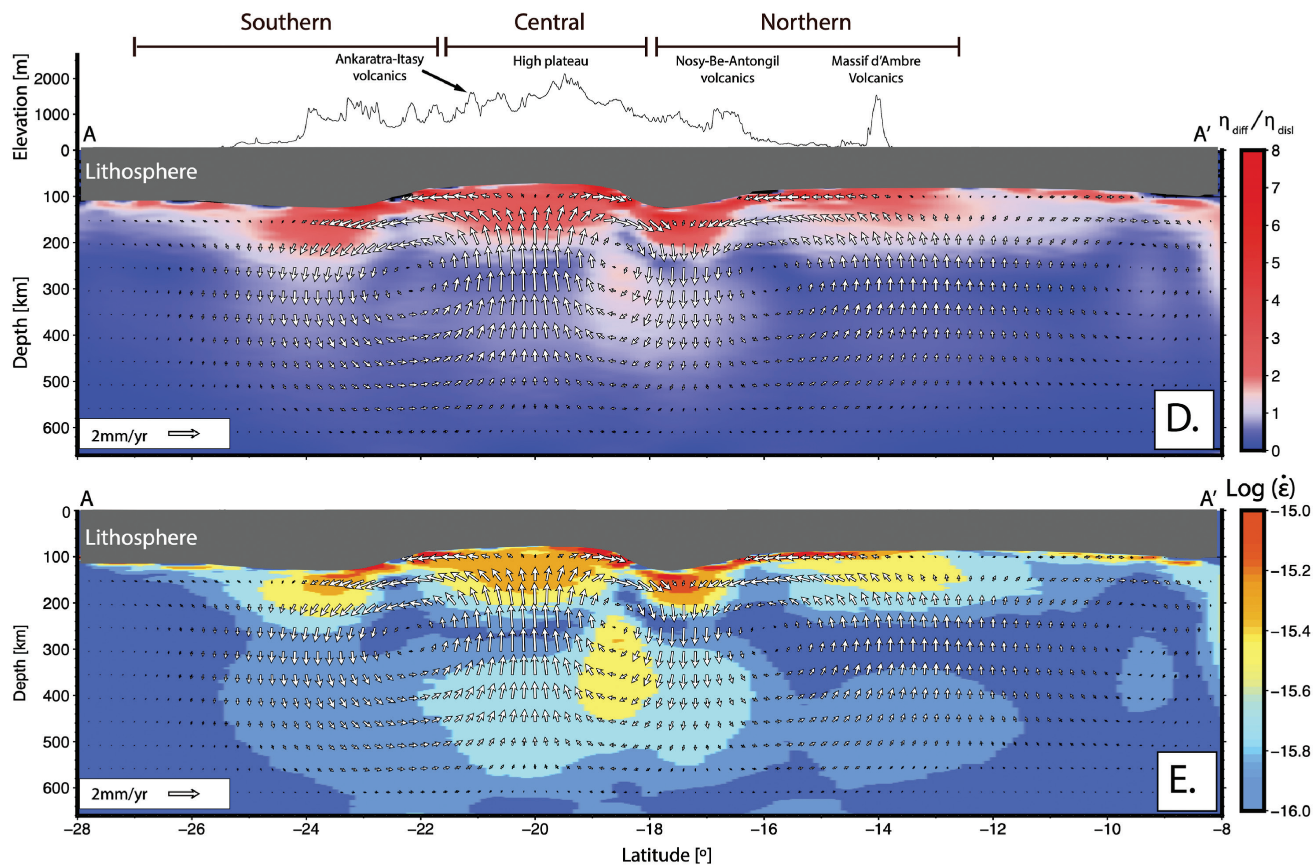


*Figure 2. D. Ratio of diffusion creep to dislocation creep along profile A-A' shown in B overlain by white vectors indicating flow patterns. E. Logarithmic scale of strain rate magnitudes overlain by white vectors indicating flow patterns.*

## Reference


*Rajaonarison, T.A., D.S. Stamps, S. Fishwick, S. Brune, A. Glerum, J. Hu (2020). Numerical Modeling of Mantle Flow Beneath Madagascar to Constrain Upper Mantle Rheology Beneath Continental Regions. J Geophys Res: Solid Earth, 125, 2, doi.org/10.1029/2019JB018560*


THE EASTERN NORTH AMERICAN MARGIN represents the final product of continental rifting to form a passive margin, and records the full history of rift evolution and post-rift processes. The ENAM encompasses large variations in fundamental rift parameters, including the volume of magmatism, the pre-existing lithospheric template, and the duration of rifting. In particular, rifting along the southeastern United States was associated with voluminous magmatism, whereas the northernmost portion of this margin offshore of Nova Scotia and Newfoundland is distinctly magma-poor. ENAM also captures an extensive post-rift evolution of the passive margin sedimentary prism as well as the cooling and further evolution of the mantle lithosphere below.