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Unraveling African plate structure from elevation, geoid and geology data: implications for the impact of mantle flow and sediment transfers on lithospheric deformation

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The aim of our project is to simulate the long-wavelength, flexural isostatic response of the African plate to sediment transfers due to Meso-Cenozoic erosion - deposition processes in order to extract the residual topography driven by mantle dynamics.
The first step of our project consists in computing crustal and lithospheric thickness maps of the African plate considering its main geological components (cratons, mobile belts, basins, rifts and passive margins of various ages and strengths). In order to consider these heterogeneities, we compute a 2D distribution of crustal densities and thermal parameters from geological data and use it as an input of our modeling. We combine elevation and geoid anomaly data using a thermal analysis, following the method of Fullea et al. (2007) in order to map crustal and lithospheric thicknesses. In this approach, we assume local isostasy and consider a four-layer model made of crust and lithospheric mantle plus seawater and asthenosphere. In addition, we compare our results with crustal and lithospheric thickness datasets compiled from bibliography and existing global models.
The obtained crustal thicknesses range from 28 to 42km, with the thickest crust confined to the northern part of the West African Craton, the Kaapvaal craton, and the Congo cuvette. The crust in the East African Rift appears unrealistically thick (40-45 km) as it is not isotatically compensated, highlighting the dynamic effect of the African superswell. The thinnest crust (28-34km) follows a central East-West trend coinciding with Cretaceous rifts and the Cameroon volcanic line. The lithosphere reaches 220 km beneath the Congo craton, but remains globally thin (ca. 120-180 km) compared to tomographic models and considering the age of most geological provinces. As for the crust, the thinnest lithosphere is located in areas of Cretaceous-Jurassic rifting, suggesting that the lithosphere did not thermally recover from Mesozoic rifting.
A new elastic thickness map of the African plate is derived from our lithospheric thickness model and is used to simulate the long-term flexural response of the continent due to thermal relaxation subsequent to rifting. The elastic thickness map is also combined with erosion-deposition record of northwestern Africa and its margins in a thermal-flexural model to infer the African plate's response to sediment transfers during the Meso-Cenozoic. Our results indicate that at least one-third of the long-wavelength vertical rock uplift undergone by the continent may be due sediment transfers, suggesting dynamically supported topography derived from mantle flow models is overestimated.

References:

Fullea J. et al., 2007. Tectonophysics 430, 97-117.