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Global effective elastic thickness, mechanical anisotropy and the supercontinent cycle

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The Wilson cycle of ocean basin closure and opening, leading to supercontinent assembly and breakup, implies that continental margins are repeatedly weakened by thermal rejuvenation and fault reactivation during subduction, orogeny and rifting, leaving continental cores un-deformed. Such partitioning of deformation has led to the hypothesis of tectonic inheritance resulting from the combined effects of rheological heterogeneity and mechanical anisotropy. However, these parameters are poorly constrained on a global scale. One method that provides high-resolution maps of plate rigidity (expressed in terms of an effective elastic thickness, Te) and its directional variations is based on the analysis of the coherence between Bouguer gravity and topography. We present the first global maps of Te and Te anisotropy over continents from the gravity-topography coherence using the wavelet transform. We find that the distribution of Te is weakly bimodal with peaks at 30 and 150 km, corresponding to the distribution of Phanerozoic belts (Te<40 km) and Proterozoic and Archean cratons (Te>100 km). Variations of Te with surface heat flux and seismic velocity anomalies are consistent with predictions from a steady-state conductive thermal regime, with Te following the 260 $\pm$40 °C isotherm. We show that directions of minimum rigidity consistently align with directions of large Te gradients, perpendicular to major tectonic boundaries and sutures, indicating that Te anisotropy is controlled by pre-existing structure. These results provide the first global observational constraints supporting the thesis that rheological heterogeneity and mechanical anisotropy play a dominant role in the deformation and evolution of continents by concentrating strain at pre-existing zones of weakness, thus stabilizing continental interiors during repeated supercontinent cycles.