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Estimating the stresses within the lithosphere: parameter check with applications to the African Plate

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Several mechanisms control the state of stress within plates on Earth. The list is rather long, but well-known and includes ridge push, mantle drag, stresses invoked by lateral variations of lithospheric density structure and subduction processes. We attempt to quantify the influence of these mechanisms and to construct a reliable model to understand modern and palaeo-stresses using the African plate (TAP) as an example. Previous studies explained stress patterns and their evolution solely by assigning different rheological properties to sub-domains and their boundaries. Such an approach often leads to unrealistically high variations of properties within a modeled plate. In our approach we find the best possible agreement with observations before differentiating between sub-domains of TAP. The finite-element based suite ProShell was utilized to calculate stresses on the real geometry of TAP (non-planar). The approach allows us to combine several data sets and to estimate stresses caused by lateral and vertical distribution of properties within the lithosphere, to quantify the in-plane and bending stresses, to account for forces due to ridge push and mantle heterogeneities and mantle flow. The modeled results are tested and iterated to match the observed stress pattern and potential fields as good as possible. The starting model is based on the CRUST2 data set to construct the model crust and half-space cooling model to approximate properties of the lithospheric mantle. The results however, are not satisfactory, and might be related to oversimplifications in the uniform model of lithosphere or/and to the unrealistic representation of the CRUST2 model in certain areas of TAP. The latter was also shown by simple evaluation using gravity forward modeling of the model boundaries. The model implementation of the crustal structure calculated from simple gravity inversion or derived through isostatical considerations agree better to today's observed stress pattern.