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The role of lateral strength variation in the lithosphere in intra-plate compressional deformation: an experimental approach

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Lateral variation of strength in the lithosphere has been proven to be an important factor controlling the localization of intra-plate deformation. Pre-existing heterogeneities in the lithosphere can become reactivated both in extension and compression, governing the spatial and temporal development of intra-plate deformation.
Analogue models investigating the deformation pattern and topography development characterizing compressional intra-plate settings are presented. The modeled lithosphere consists of a three-layer brittle-ductile rheological structure and has been deformed in normal gravity field. The behavior in compression of two laterally uniform end-members of lithospheric structure (weak vs. strong ductile lithospheric mantle) has been tested.
The presence and vertical location of a rheological heterogeneity (Disturbance Zone, DZ) in the lithosphere, which is striking perpendicular to the compression direction, has been the main investigated parameter.
Experimental results show that the presence of lateral strength heterogeneities in the lithosphere affects the deformation pattern in compressional settings. Different styles of deformation depend on the bulk strength contrast between adjacent lithospheric blocks.
A small strength contrast between a DZ and the surrounding blocks results in a) localization of the deformation at the DZ boundaries and b) an undeformed region with flat Moho in correspondence to the DZ. In the absence of a DZ the deformation history of a relatively weak lithosphere is characterized by early occurrence of pop-up and pop-down structures in the central part of the model. The presence of a stronger lithospheric mantle does not prevent the boundaries of the DZ to localize deformation in the brittle crust and allow buckling of the lithosphere. Distribution of pop-up and pop-down structures in the brittle crust appears to correlate with the position of synforms in the ductile lithosphere.
The analysis of topographic profiles extracted from the DEM (Digital Elevation Model) acquired during the experiments confirms the role of the lateral rheological heterogeneity in strain localization. For a model with uniform lithosphere positive relief regions show similar uplift rate during deformation process, while for a laterally heterogeneous lithosphere the main active uplifting regions are the ones related to the DZ boundaries.
Analogue experiments are compared with 2D numerical simulation performed with similar kinematic settings and material properties and based on a finite elements method. Preliminary results are consistent with the localization of deformation observed in laboratory models.
The presented modelling results provide valuable insight for the transfer of strain in intra-plate settings under various rheological configurations and are applicable to natural areas.