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The role of thermo-mechanical feedback in the generation of shear zones in the lithosphere

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The collision between continental plates results in the development of orogenic belts. Ongoing collision is responsible for the localisation of deformation and the development of shear zones. The presence of shear zones is well documented within orogens and their importance for the exhumation of high-grade (HG) metamorphic rocks is well accepted; their role in the formation of HG units is however debated.
State of the art geodynamic modelling of continental collision is often used to model the genesis and exhumation of HG rocks. Nevertheless, it is a common approach to model collision by predefining shear zones and/or by employing constitutive models that can introduce mesh dependency. Mesh size dependency leads to difficult comparison between physical models and natural data since pressure and temperature cannot be accurately computed within the modelled shear zones.
In this contribution, we employ thermo-mechanical modelling to study the formation of shear zones in the lithosphere. Our approach takes into account the coupling between momentum and energy balance by including viscous dissipation and temperature/stress dependant viscosity. We show that this methodology allows for the spontaneous development of shear zones around a cylindrical weak heterogeneity. Systematic simulations showed that this approach produces mesh-insensitive results. The modelled shear zones are hence characterised by a finite-width, which is independent on the numerical mesh resolution. Additional test were performed to constrain the physical parameters that control shear band thicknesses, the results highlight the role of thermal transport properties rather than the initial heterogeneity dimensions.
Moreover, we demonstrate that these results can be achieved by using two different numerical methods, which are both popular methods in the geodynamic modelling community (Lagrangian finite elements and Eulerian-Lagrangian finite differences). Such models may therefore be reliably used to quantify stresses, pressure and strain rates within shear zones in numerical models of continental collision and may bring new insights in the processes that drive the formation of HG metamorphic rocks.