Geophysical Research Abstracts
Vol. 15, EGU2013-12590, 2013
EGU General Assembly 2013

Dynamics of tectonic nappes: Numerical models and implications for the mechanical behaviour of the lithosphere

Stefan Markus Schmalholz
University of Lausanne, Institute of Earth Sciences, Lausanne, Switzerland (stefan.schmalholz@unil.ch)

Nappes and shear zones are common structures in orogenic belts. In the western European Alps many nappes exhibit a considerable internal deformation expressed by structures such as folds or penetrative foliation. Such internal deformation is observed in basement nappes as well as in sedimentary nappes of the Helvetic nappe system. Overthrust nappes such as the Glarus or Diablerets nappe have been displaced on detachment layers (e.g. limestone or shales) and observed structures (e.g. foliation, S-C structure, crystallographic preferred orientation) suggest that a significant amount of the deformation in these layers was effectively ductile. Also, a number of field and modelling studies suggest that many Alpine basement nappes formed as a result of ductile shearing. However, the mechanical processes generating tectonic nappes are still incompletely understood. 2D numerical simulations are performed to investigate the formation of tectonic nappes. The applied numerical algorithm is based on the finite element method. The boundaries between model layers are defined by contour lines containing finite element nodes. A Lagrangian mesh with re-meshing is used. During re-meshing the nodes on the contour lines are not modified so that the boundaries between model units are accurately followed and resolved during the entire large strain deformation. A series of simple systematic simulations with a power-law viscous flow law is performed to investigate the transition between overthrusting and folding. The results are applied to the Helvetic nappe system and show that significant overthrusting is possible for viscous layers. To study the evolution of basement nappes and to quantify the pressure and temperature evolution a more elaborated algorithm with a viscoelasticplastic rheology is applied. The stress is limited by a Mohr-Coulomb failure criterion. Thermo-mechanical coupling by shear heating is considered. The governing partial differential equations are solved numerically in dimensionless form to reduce the number of model parameters. Simulations of 2D lithospheric shortening are performed with a weak circular inclusion in the lower crust to localize the deformation and slightly different temperatures at the left and right half of the lithospheric bottom are applied to generate a small initial asymmetry. During the simulations a shear zone develops around the inclusion and strain is localized on this shear zone due to shear heating. Deviatoric stresses in and around the shear zone can be significantly smaller than pressure deviations from lithostatic values. The results show that significant tectonic overpressures are not necessarily linked to high values of deviatoric stresses. The pressure gradient along the shear zone is a possible driving mechanism for the nappes. The numerical results and the observations in Alpine nappes suggest that the lithosphere behaved dominantly ductile during nappe formation.