Geophysical Research Abstracts,
Vol. 11, EGU2009-4164, 2009
EGU General Assembly 2009


# Stress - strength relationship in the lithosphere during continental collision and plateau formation: Implications for occurrence of deep Earthquakes

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The understanding of the thermo-mechanical processes forming mountain ranges and plateaus, such as the Tibetan Plateau, is still incomplete. Therefore, the interpretations of the same geophysical observations with respect to lithospheric processes in general and lithospheric rheology in particular vary often significantly. This is, for example, the case for interpretations of the lithospheric rheology based on the relative scarcity of earthquakes in the sub-Moho continental mantle. Lithospheric strength profiles generally predict excessively high differential stresses in the sub-Moho continental mantle, which seems inconsistent with the relative scarcity of earthquakes at this depth. This inconsistency was put forward as evidence for weak lithospheric mantle rheology. However, this argumentation implicitly assumes that strength envelopes are valid in actively deforming lithospheric regions. We test this assumption on two end-member lithospheres with (1) a weak lower crust and strong mantle and (2) a strong lower crust and weak mantle. For this purpose, we compare 1D models with 2D visco-elasto-plastic numerical models of continental shortening. Both 2D models show that strongly heterogeneous deformation typically follows initially homogeneous deformation. Lithospheric-scale buckle folds and shear zones result in strain rate variations of up to three orders of magnitude. Differential stresses in the upper crust are close to the yield strength, as predicted by 1D models. Stresses in deeper lithospheric regions, however, are significantly smaller than in 1D models, especially in actively deforming regions. Systematic numerical simulations as a function of temperature and deformation rate reveal that 1D models are reliable in hot and/or slowly deforming lithospheres only. The relative scarcity of earthquakes at mantle levels should thus be interpreted as an intrinsic consequence of strong lithospheric deformation rather than as evidence for a weak upper mantle rheology.