Geophysical Research Abstracts
Vol. 18, EGU2016-8133, 2016
EGU General Assembly 2016

Faults and Shear Zones: Constraints on the Extrapolation of Laboratory Tests

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Geological structures and processes often show strong geometric and physical similarities if observed on different scales. Examples range from fractures, faults and shear zones to seismic characteristics such as b-value or seismic source properties. Laboratory tests on small-scale rock samples allow studying aspects of processes that govern earthquake nucleation and rupture propagation, strain localization in shear zones, and high-temperature rheology. However, upscaling of laboratory results to the field scale requires that dominant deformation processes remain the same on vastly different scales, and that potential effects of changing kinematic and thermodynamic boundary conditions may successfully be accounted for by appropriate constitutive equations. A key observational strategy relies on analysis of deformation processes on different scales. In this presentation we will illustrate the approach with two examples from very different geological environments: 1. Scaling of earthquake mechanisms observed in the laboratory, in mines and along major fault zones and 2. High-temperature creep processes governing the deformation in highly localized shear zones in the lower crust and upper mantle. Our results show that constitutive models capturing fundamental physical processes on the laboratory scale may be successfully applied to model deformation on the field scale.