Geophysical Research Abstracts
Vol. 17, EGU2015-3097, 2015
EGU General Assembly 2015

Predicting km-scale shear zone formation

Christopher Gerbi (1), Nicholas Culshaw (2), Deborah Shulman (1), Maura Foley (1), and Jeffrey Marsh (3)

(1) School of Earth and Climate Sciences, University of Maine, Orono, Maine, United States (christopher.gerbi@maine.edu), (2) Department of Earth Sciences, Dalhousie University, Halifax, Nova Scotia, Canada, (3) School of Earth and Environmental Sciences, Queens College, Flushing, New York, United States

Because km-scale shear zones play a first-order role in lithospheric kinematics, accurate conceptual and numerical models of orogenic development require predicting when and where they form. Although a strain-based algorithm in the upper crust for weakening due to faulting appears to succeed (e.g., Koons et al., 2010, doi:10.1029/2009TC002463), a comparable general rule for the viscous crust remains unestablished. Here we consider two aspects of the geological argument for a similar algorithm in the viscous regime, namely (1) whether predicting km-scale shear zone development based on a single parameter (such as strain or shear heating) is reasonable; and (2) whether lithologic variability inherent in most orogenic systems precludes a simple predictive rule. A review of tectonically significant shear zones worldwide and more detailed investigations in the Central Gneiss belt of the Ontario segment of the Grenville Province reveals that most km-scale shear zones occur at lithological boundaries and involve mass transfer, but have fairly little else in common. As examples, the relatively flat-lying Twelve Mile Bay shear zone in the western Central Gneiss belt bounds the Parry Sound domain and is likely the product of both localized anatexis and later retrograde hydration with attendant metamorphism. Moderately dipping shear zones in granitoids of the Grenville Front Tectonic Zone apparently resulted from cooperation among several complementary microstructural processes, such as grain size reduction, enhanced diffusion, and a small degree of metamorphic reaction. Localization into shear zones requires the operation of some spatially restricted processes such as stress concentration, metamorphism/fluid access, textural evolution, and thermal perturbation. All of these could be due in part to strain, but not necessarily linearly related to strain. Stress concentrations, such as those that form at rheological boundaries, may be sufficient to nucleate high strain gradients but are insufficient to maintain them because the stress perturbations will dissipate with deformation. Metamorphism can unquestionably cause sufficient rheological change, but only in certain rock types: for example, granitoids have much less capacity for metamorphically induced rheologic change than do mafic rocks. The magnitude of phase geometry variation observed in natural systems suggests that morphological change (e.g., interconnection of weak phases) likely has little direct affect on strength changes, although other textural factors related to diffusion paths and crystallographic orientation could play a significant role. Thermal perturbation, mainly in the form of shear heating, remains potentially powerful but inconclusive. Taken together, these observations indicate that a simple algorithm predicting shear zone formation will not succeed in many geologically relevant instances. One significant reason may be that the inherent lithologic variation at the km scale, such as observed in the Central Gneiss belt, prevents the development of self-organized strain patterns that would form in more rheologically uniform systems.