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Constraining strength/depth profiles using laboratory experiments and field structural observations

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Strength/depth profiles are often used as standard models to constrain treatments of lithosphere-scale geodynamics. Such profiles have virtue because they are motivated by our understanding of inelastic deformation of rocks, and because they can be used in complex numerical calculations. But, by attempting to construct simple, generic mechanical models, often while lacking detailed descriptions of the sub-surface, such treatments may ignore important issues, including spatial heterogeneities in rock composition, in strain displacements, or in other thermodynamic parameters, including temperature, fluid pressure and composition. Further, these profiles usually assume constitutive equations that reflect combinations of a simple yield criterion with steady-state creep. Thus, transient mechanical behavior is neglected. Fortunately, a plethora of recent laboratory, field structural, and computational studies may now be used to shed light on mechanical behavior at a much broader range of temperature, pressure, strain rates, and strain. For example, new experiments provide a description of creep in minerals at pressures greater than 2 GPa, of friction at seismic velocities, and of strains larger than 5. Observations of field microstructures, coupled with mechanical descriptions gleaned from laboratory experiments and theoretical treatments of the thermodynamics and mechanics of deformation, provide important insights into the way that localization occurs in natural shear zones. Finally, Earth scientists have gained an improved understanding of the subtle, yet important, interplay among fluids, transport properties, and rock deformation, which are capable of producing rich patterns of deformation. Among several important and challenging issues that need work is spatial scaling of properties; it is particularly important to consider differences in length scales that are embedded in the various techniques of field and global geophysics, field geology, and experiments. Our more detailed understanding of mechanical behavior of rocks presents both opportunities and obligations. In addition to considering more refined constitutive behavior, both forward and inverse calculations are needed to reconcile geophysical observations taken at widely varying scales.