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Some brief remarks on interpreting microstructure and understanding the strength of rocks during orogenic processes

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The observation and interpretation of microstructures in naturally deformed rocks have been important tools used by field structural geologists for over one hundred years to understand orogenic processes. Since 1975, many workers undertaking mechanical experiments on metals, ceramics, and rocks have suggested that some aspects of microstructure may provide direct indication of the conditions of deformation. In particular, the assertions that grain size and dislocation density achieve steady-state values that are characteristic of the stress applied to a creeping material have led to the use of these parameters to interpret the strength of rocks *in situ.* The converse view of this relation is also useful: That is, the strength of a creeping rock is a function of a set of mechanical and thermodynamic state variables, some of which are directly observable aspects of microstructure. The ways that the material state variables change during deformation are called the evolution equations; and piezometers may be viewed as a special, balanced case of these equations. Several models have been developed to understand the physics of the piezometers or evolution equations, and these are typically based on the equilibration of intracrystalline forces, the minimization of internal free energy, or the balance of the kinetics of competing processes. Semi-quantitative agreement between laboratory mechanical tests of monomineralic rocks and the posited model relations provides a method for order of magnitude estimates of stresses during natural processes, but, uncertainties in the extrapolation of these models to natural conditions are still substantial. For more complex, multi-phase aggregates, i.e., most rocks, several competing effects may operate to produce an evolution of strength over

a large strain or time interval, even when strain rate, temperature, and chemical fugacities are relatively constant. To obtain improved understanding of the evolution of state variables in polyphase aggregates, it will be necessary to understand the competing effects of varying second-phase content, solid-solution impurities, and lattice preferred orientation on the mobility of grain and interphase boundaries and on the deformation mechanisms that operate.