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Structural softening of the lithosphere

S.M. Schmalholz (1,2), Y.Y. Podladchikov (2) and B. Jamtveit (2)

(1) Geological Institute, ETH Zentrum, 8092 Zurich, Switzerland, (2) PGP, University of Oslo, 0316 Oslo, Norway

Structural softening is a decrease in the amount of stress needed to deform the lithosphere at a particular rate due to its structural reorganization while all true rheological properties remain constant. Structural softening is fundamentally different than material softening, where the decrease in stress is generated by a change in rheological properties with progressive deformation, such as grain size reduction resulting from large shearing strain. We study structural softening generated by folding of the crust-mantle boundary, which is a structural instability that inevitably develops during compression of the mechanically layered lithosphere. For ductile rheologies, the stress decrease represents a decrease of the effective lithospheric viscosity, which is proportional to the ratio of stress to lithospheric shortening strain rate. We present analytical and numerical results quantifying the decrease in stress and effective viscosity that occur during shortening at a constant rate. The decrease in effective viscosity can be up to tenfold. The presented results have important implications for interpreting the mechanical strength and structure of the lithosphere based on measured stress distributions within the lithosphere.