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# Effect of deformation induced nucleation and phase mixing, a two phase model for the ductile deformation of rocks.

Benoit Bevillard, Guillaume Richard, and Hugues Raimbourg
Institut des sciences de la terre d'Orléans, Geodynamics, ORLEANS, France (benoit.bevillard@cnrs-orleans.fr)

Rocks are complex materials and particularly their rheological behavior under geological stresses remains a long-standing question in geodynamics. To test large scale lithosphere dynamics numerical modeling is the main tool but encounter substantial difficulties to account for this complexity. One major unknown is the origin and development of the localization of deformation. This localization is observed within a large range of scales and is commonly characterized by sharp grain size reduction. These considerations argues for a control of the microscopical scale over the largest ones through one predominant variable: the mean grain-size. However, the presence of second phase and broad grain-size distribution may also have a important impact on this phenomenon. To address this question, we built a model for ductile rocks deformation based on the two-phase damage theory of Bercovici & Ricard 2012. We aim to investigate the role of grain-size reduction but also phase mixing on strain localization. Instead of considering a Zener-pining effect on damage evolution, we propose to take into account the effect of the grain-boundary sliding (GBS)-induced nucleation mechanism which is better supported by experimental or natural observations (Precigout et al 2016).
This continuum theory allows to represent a two mineral phases aggregate with explicit log-normal grain-size distribution as a reasonable approximation for polymineralic rocks. Quantifying microscopical variables using a statistical approach may allow for calibration at small (experimental) scale. The general set of evolutions equations remains up-scalable provided some conditions on the homogenization scale. Using the interface density as a measure of mixture quality, we assume unlike Bercovici & Ricard 2012 that it may depend for some part on grain-size . The grain-size independent part of it is being represented by a "contact fraction" variable, whose evolution may be constrained by the dominant deformation mechanism. To derive the related evolution equations and account for the interdependence of thermodynamic state variables, we use Onsager's thermodynamic extremum principle. Eventually, we solve for our set of equations using an Anorthite/Pyroxene gabbroic composition. The results are used to discuss the interaction between grain-size reduction and phase mixing on strain localization on several simple cases.

Bercovici D, Ricard Y (2012) Mechanisms for the generation of plate tectonics by two phase grain damage and pinning. Physics of the Earth and Planetary Interiors 202-203:27–55

Precigout J, Stunitz H (2016) Evidence of phase nucleation during olivine diffusion creep: A new perspective for mantle strain localisation. Earth and Planetary Science Letters 405:94-105