MODELING STRAIN LOCALIZATION, ZENER PINNING, AND PHASES NUCLEATION IN TWO-MINERALS AGGREGATES

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Strain localization involved in mylonites formation remains a widely discussed question. Indeed mylonitization requires both dynamic recrystallization to reduce grain-size and stress weakening through diffusion accommodated grain-boundary sliding [1], but these two creep processes do not occur in the same portion of the stress/grain-size space [2]. To address this problem at a lithospheric scale, Bercovici and Ricard [3] built a self-consistent model involving grain-damage in a two phases medium. Based on non equilibrium thermodynamics, their model produces rheological weakening synchronous with grain-size reduction through pinning of the interfaces between the two phases [4]. Deformation reduces pinning surfaces (increase interface roughness) which in turn facilitates grain damage. In order to adapt this model to Earth crust deformation at lower scales, this interpretation of the Zener pinning influence is discussed. Indeed, taking in account Zener pinning implies a limited range for initial interface roughness to ensure that the initial aggregate is energetically balanced. This necessary initial condition induces important differences in the model evolution, particularly concerning the importance and brevity of the stress drop (see figure 1). Furthermore, in mantle and crustal rocks, increasing phase mixture with increasing strain-rate is observed in mylonites in addition to grain-size reduction. To explain this phenomenon, a nucleation process occurring in the diffusion creep domain is proposed and its potential implications on the physical model and on strain localization are explored.

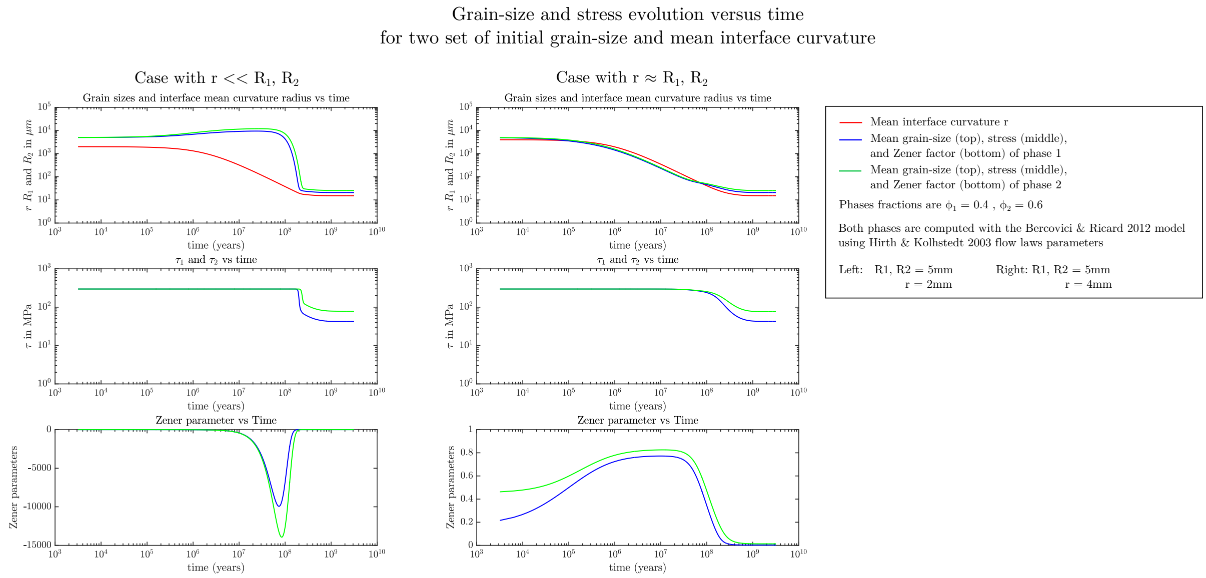

Figure 1. Grain-size, stress, and Zener factor evolutions versus time for two different set of initial grains parameters in ductile deformation conditions. *This figure illustrates the different model behaviors with respect to initial grain parameters. Grain-size of two mineral phases* R_1 *and* R_2 *are computed through competition of coarsening and damage. The Zener pinning factor models the impact of the interface pinning by small grains during grain coarsening, limiting it if* $0 < Z < 1$ *or supposedly promoting it if* $Z < 0$*. It depends on the two grain-sizes and on the mean interface curvature radius* r *representing the roughness of the interface between the phases. When the initial mean interface curvature radius* r *is fixed below a size limit given by the "pinned" state (where* $Z = 0$*), the Zener factor remains negative during the whole computation, therefore inducing strong grain-sizes and stresses drop. However, this case may not be relevant because it is the grain growth which leads small surrounding grains to pin the interface and slow down coarsening. Zener pinning can't induce grain-size evolution as it is a passive process. Thus, the case where* r *stay close to* R_1*, and* R_2 *demonstrates the expected behavior as the Zener pinning factor, stays between values of* 0 *("pinned" state no grain-growth) and* 1 *(no pinning effect). As a consequence, the softer grain-sizes and stress drops should be due to some nucleation process occurring in diffusion creep conditions.*

References

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