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Grain size in lithospheric-scale shear zones: Chicken or Egg?

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Lithospheric-scale shear zones are commonly defined as regions inhomogeneous and localized deformation. Strain softening has been demonstrated to be necessary for localization in those shear zones, but there is still debate about the physical cause of this softening. As natural shear zones typically have a significantly reduced grain size, it has been proposed that grain size reduction provides the necessary strain softening to localize deformation. As grain size reduces, the dominant deformation mechanism switches from dislocation to diffusion creep, thus requiring less stress to deform the rock. Until recently, the equilibrium grain size has been thought to follow a piezometric relationship, thus indicating the stress under which a shear zone deformed. More recent work (Austin and Evans (2007), Rozel et. al. (2011)) suggests that the equilibrium grain size is not dependent on stress, but rather on the deformational work. Using this relationship, we use numerical models to investigate the effect of grain size evolution on lithospheric deformation. We focus on the question if grain size provides sufficient weakening to effectively localize deformation under lithospheric conditions or if it's effect is rather passive and as such a marker for the deformational work done in a shear zone. We then compare the localization potential of grain size reduction to shear heating and investigate the interplay between the two weakening mechanisms.