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The Role played by Shear Modulus Contrast in Earth Materials on Facilitating Shear Localization in the Lithosphere

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Viscoplasticity has been considered to be a dominant element in causing the nucleation of shear instability leading to shear localization. Here we propose that a simple contrast in shear moduli may be sufficient for explaining the fast timescale asymmetric shear instability in a bi-material setting. Up to now, no studies have been made on asymmetric shear instability induced by elastic modulus contrast. Thermal-mechanical numerical simulations based on high resolution finite-element methods were performed to understand the effects of shear modulus contrast on inducing asymmetric instabilities. Strain-rate and stress dependent rheology are used with a wide range of activation energy 0-850 kJ/mol for all models. Numerical results with enough shear modulus contrast show the asymmetric shear instability, which is generated around the interface and then propagates across the interface. We also examined the role of activation energy (0–850 kJ/mol) on the geometrical pattern and the initiation time of asymmetric shear localization. The shear modulus contrast has to be close to 2 for triggering asymmetric shear instability and is found to be by far a more important controlling factor in causing shear instability than activation energy of the creep law. Our work suggests that initiation of lithosphere-scale asymmetric instability would be faster than previous considerations. In a view of the stored energy and its release as shear heating, the network between the various contrasts in yield strength and shear moduli controls the developing feature of asymmetric instability . Higher yield strength contrast induces severe deformation and a small temperature increase. It may hold the key for resolving the heat flow paradox question. Our finding stresses that naturally occurring shear modulus contrast have also important impact on many geological problems related to shear zone formation.